Annual Report 2004

European Space Agency
Agence spatiale européenne

The Activities

The Means

The Resources Management

Annexes

Foreword

An Annual Report for an organisation with as many long-term programmes and projects as ESA will always be a snapshot, and can in no way mirror the entire scope of the Agency's activities during the year.

Looking back over the events of the past year, 2004 was another great year for space science. The success of the Huygens probe and its exploration of the atmosphere and surface of Saturn's largest moon Titan is a magnificent achievement for European science and technology. The Rosetta spacecraft launched on 2 March by an Ariane-5 from Kourou is now well into its 10-year flight to the comet Churyumov-Gerasimenko. Smart-1, Europe's first lunar mission arrived in orbit around the Moon after its thirteen-month journey. Mars Express, which has been in polar orbit around Mars since 2003, delivered stunning pictures of the planet's surface. Europe, the Agency and all of its Member States can be proud of these great achievements.

I would also like to highlight the enormous amount of work that has been put into the Ariane flight recovery programme during 2004. With the subsequent successful flight of Ariane-5 ECA on 12 February 2005, we now know that all of the effort that industry and the agencies put into the preparation of this critical launch for Europe's space ambitions has paid off. With this success, a weight has been lifted from the shoulders of Europe's space community.

December's tsunami in the Indian ocean highlighted the need for setting up a global warning system for this and other kinds of natural disasters, in which data from Earth-observation satellites can make an important contribution.

Another important issue for the Agency's future is its relationship with the European Union. The 'Space Council', bringing together representatives from 27 European Union members and ESA, met in Brussels on 25 November for the first time. This meeting represented an important political milestone and provided the first opportunity to discuss the definition of an integrated European space programme, which should serve as a common framework for ESA and the EU, and on the basis of which future space activities and programmes will be undertaken.

Among the many issues that Council had do deal with, one of the most crucial was the approval in December of the Agency's budgets for 2005. The December Council

also approved a far-reaching ranging agreement between the Agency and Russia on long-term cooperation and partnership in the field of launchers, which sets the stage for a reinforced role for Russia in the European space programme, and perhaps the joint development of future launchers.

ESA is also looking to reinforce cooperation with the new Eastern European members of the European Union. In addition, the Agency is about to sign a new space-cooperation agreement with China, which is intended to broaden scientific and industrial ties between China and the European countries that are part of ESA.

Next year will be a special one for the Agency as it will be celebrating its 30th Anniversary. But there are many challenges ahead. A Council Meeting at Ministerial Level is planned in Berlin on 5-6 December 2005, at which the Ministers responsible for space activities in ESA's 17 Member States and Canada will be charting the course for Europe's space programme for the years ahead. It will be a very important moment not only for the development of ESA, but for Europe's space community as a whole.

Per Tegnér
Chairman of Council

The Year in Review

When I look back on 2004, it was a year that began with a certain degree of uncertainty in terms of unfinished business from the previous December's Council, which was reconvened on 4 February to address a number of unresolved issues concerning the Launcher Programme. At that meeting, however, the long-term future of Europe's guaranteed access to space was put on firm ground, with the approval of the Ariane-5 EGAS Programme and the Future Launcher Preparatory Programme. The launching of Soyuz vehicles from Kourou was also given the go-ahead at that same meeting.

The fact that the December 2003 Council was only completed in February meant that, exceptionally, the Council met five times in 2004, and there were important decisions to be taken on every occasion. In March, the Council approved the accession of two new Member States, Greece and Luxembourg, to the ESA Convention, as well as appointing the new team of Directors who will manage the Agency for the next four years. In June, it unanimously voted to unblock the remaining funds for the International Space Station Exploitation Programme. It also voted a Resolution providing guidelines for the important reform of the ESA financial and budgetary system as well as of the industrial procurement process, preparing the ground for the more efficient implementation of ESA programmes.

The meeting in December 2004 was equally crucial with the discussion, and submission for Member States' approval, of the Agency's budgets for 2005. At that last meeting of the year, Council adopted, almost all unanimously, the proposed Science budget, the General budget, the budgets for the Optional Programmes (52 in all, including that for the new Aurora Exploration Programme), and the budget for the Guiana Space Centre (CSG). Another important at decision at the December Council was its approval of an agreement, again with unanimity, between ESA and Russia on long-term cooperation and partnership in the development and use of launchers. This endorsement, together with a bank loan to Arianespace guaranteed by the French Government, gave the green light for the associated industrial activities, with the first launch of Soyuz from Kourou now foreseen to take place at the end of 2007.

As noted by the ESA Council Chairman in his Foreword to this Report, there was also the historic first meeting of the 'Space Council' in Brussels on 25 November. As the first joint meeting of the European Union's Council and the ESA Council at Ministerial Level, it brought 28 Ministers together around the table to discuss 'space'.

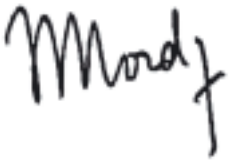
If the December Council brought to an end a very busy year in terms of political decision-making regarding future programmes, it was no less busy or eventful as far as the Agency's on-going programmes were concerned. It began with the launch of Rosetta by Ariane-5 on 2 March, followed by the flight of André Kuipers to the International Space Station in April, the arrival of Cassini-Huygens in orbit around Saturn in June, the launch of the second Double Star satellite in July, and the opening of the Columbus Control Centre in Oberpfaffenhofen in October. In November, we put our first satellite into orbit around the Moon, SMART-1, which also established a new world record in terms of fuel consumption with its electric-propulsion system consuming just 1 litre of xenon per 2 million kilometres.

The year also saw the entry into force of the Framework Agreement between ESA and the European Community, and the Czech Republic became the second ESA European Cooperating State after Hungary.

During the second half of the year, due to the Dutch Presidency of the European Union, ESA's political profile was raised considerably, with many important visitors to

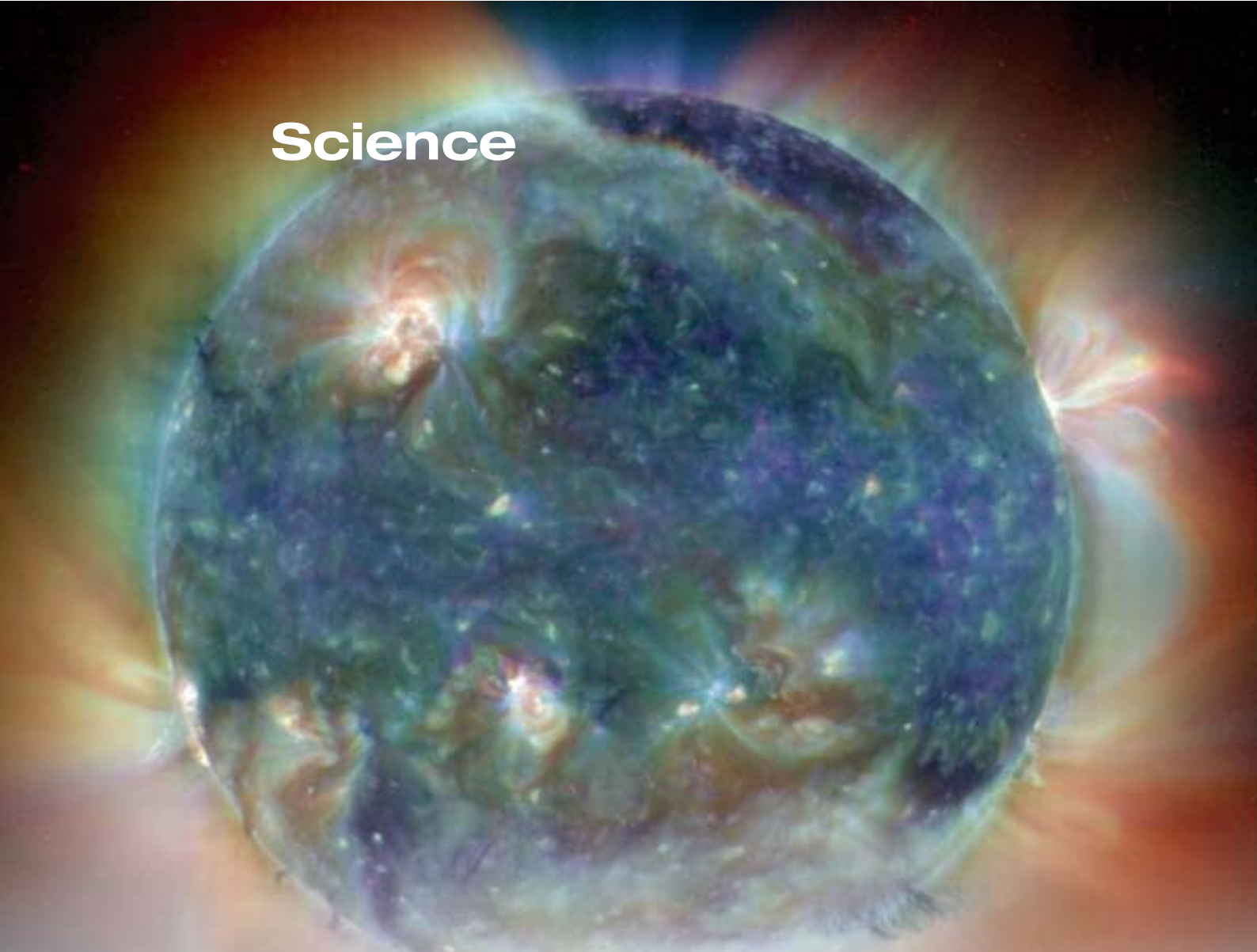
ESTEC, including the Prime Ministers of Russia and China, and the Ambassadors of many European countries.

So it was definitely a very busy year, but I would certainly see it as a very successful one, due in no small part the dedication of the staff and their unstinting efforts, often under very challenging circumstances, on behalf of the organisation. This success is also a testimony to the virtue of the collective international endeavour that is ESA. Our continued success is also founded on an intense and regular dialogue with the Member State Delegations, with our counterparts in the European Union, and with the industrial, scientific and technological communities with whom we work throughout Europe. We look forward to working closely and constructively with all of them again in 2005 and for many years to come.



Jean-Jacques Dordain
Director General, ESA

Science



The winning image from the SOHO Top Ten Images Competition

In the last two years, ESA's planetary exploration activities to the Moon, Mars, Titan and Comet Churyumov-Gerasimenko have attracted unprecedented public attention and the astronomical observatories, Integral and Newton, have gone from strength to strength. At the same time, because of a very low commercial market, the ESA Science Programme has kept a larger fraction of Europe's spacecraft-building capacity working than for years. It has also made a small but significant contribution to its launchers and gone into debt to do so.

Indeed, the Science Programme has had two 'anni mirabilis' in a row, i.e. 2003 and 2004. In spite of all of the problems, which were illustrated in the 2003 yearly report to Council, the Science Programme is still regularly launching spacecraft, with Integral in 2002, Mars Express, SMART-1 and the first Double Star satellite in 2003, and Rosetta and the second Double Star satellite in 2004. Moreover, until the Huygens probe smoothly left the Cassini spacecraft on 25 December before plunging into its descent through the clouds of Titan on 14 January 2005, the Science Programme had fifteen spacecraft operating, more than ever before.

Every decade, the Programme gathers the space-science community and maps the mid-term path of research. This exercise was done for the first time in 1984-85, and produced the plan Horizon 2000, which changed the way of doing space research in Europe. The exercise was repeated in 1993-94, and Horizon 2000 Plus was produced. Finally, in 2003 the Cosmic Vision exercise was begun, and it continued in 2004. It is scheduled to be concluded by summer 2005.

Instead of missions, the objective of Cosmic Vision is that of identifying themes, of the points of growth of knowledge. The high point of the exercise was the 'Cosmic Vision 2015-2025' Workshop, held at UNESCO (Paris) on 15-16 September 2004. The Workshop was an unqualified success, well beyond the expectations of many, including the organisers. It clearly showed that Europe is richer than ever in ideas regarding what should be done in space science in the coming years. Attended by 386 participants (a record in itself), it brought us

a major step forward in developing the vision of the future for Europe's space science. Each working/advisory group identified three major themes out of a wide response (151 proposals, another record in itself) to a call for ideas for themes issued back in the spring.

The themes selected were:

- Other Worlds and Life in the Universe
- Life and Habitability in the Solar System and Beyond
- The Early Universe
- The Evolving Violent Universe
- The Gravitational-Wave Universe
- From the Sun to the Earth and Beyond
- Tracing the Origin of the Solar System
- Towards Quantum Gravity
- Beyond the Standard Model.

Perhaps it is time to ask for recognition. Could science and performance be recognised for their own sake, this coming year? There will be an opportunity in that 2005 will see an ESA Council of Ministers at which the Level of Resources for the period 2006-2010 will be set for the Science Programme. After the two 'anni mirabilis', it would be nice to see some recognition from Ministers that performance merits reward.

Scientific Projects Department

The Long-Term Space Science Plan will now include the following missions to be prepared for launch in the coming years:

Rosetta

Launched: March 2004

Rosetta was launched flawlessly on 2 March 2004 into its escape orbit, which will take it in ten years' time to comet Churyumov-Gerasimenko. The spacecraft had remained in Kourou since the launch postponement in January 2003. The Ariane launch was nominal and the injection accuracy almost perfect, with little need for any correction manoeuvres.

After the launch all the spacecraft subsystems were checked out and reported to be working correctly, which enabled the launch and early-

The lift-off of Rosetta on 2 March 2004

The Venus Express spacecraft in launch configuration for vibration testing at Intespace in Toulouse (F)

orbit phase to be declared complete within three days. The payload commissioning then started and all instruments have been reported to be working well including the lander.

Venus Express

Launch: October 2005

The year was a crucial one for the Venus Express project to prove that the extremely short development time planned could indeed be achieved. With great credit to the ESA engineering teams, the contractor teams in Astrium and Alenia, as well as the many subcontractors involved, the spacecraft progressed from being a metal shell to a fully integrated and functional spacecraft system. The Principal Investigator teams also performed well in providing their flight-model instruments in a remarkably short time.

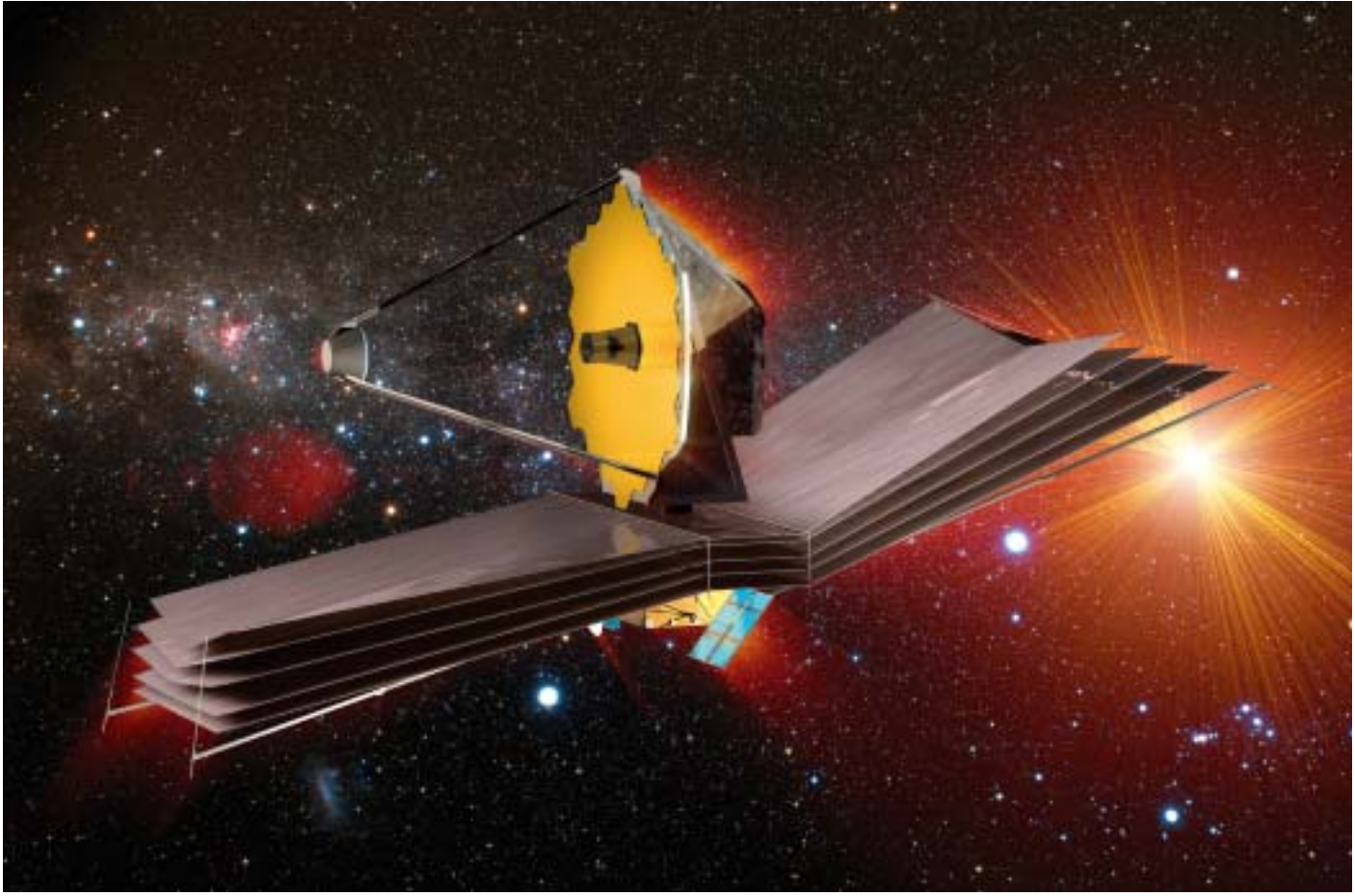
The ground-system development at ESOC progressed very well and the construction of the new ground station at Cebreros in Spain, which will become the primary station for Venus Express, advanced to the point where the 35-metre dish has been installed and the supporting equipment is now being integrated.

The qualification model of the Planck payload module, with its primary and secondary reflectors, at Alcatel Space in Cannes (F) prior to acoustic testing

Herschel/Planck

Launch: August 2007

2004 was a rather eventful year for Herschel/Planck, which started and ended with two major project milestones. In February the build-up of the complete industrial consortium for the spacecraft was finalised, and the results of the procurement campaign were presented to ESA's Industrial Policy Committee (IPC). The System Critical Design Review (CDR), which took place in the last quarter of the year, permitted one to get an overall picture of the project status, to highlight the technical and managerial difficulties and to take appropriate corrective actions. The overall development schedule that takes into account the actual status of the hardware production and delivery now shows a launch date of August 2007.



Artist's impression of the James Webb Space Telescope

Lisa Pathfinder/SMART-2

Launch: end-2008

LISA Pathfinder, the second of the Small Missions for Advanced Research and Technology (SMART), is dedicated to demonstrating key technological aspects of the Laser Interferometer Space Antenna (LISA), a spaceborne gravitational wave detector. The technologies to be demonstrated are the inertial sensors, made of two test masses contained into two vacuum cavities and free to float and follow a 'geodesic' in space and associated metrology, called LTP or LISA Technology Package, the proportional micro-thrusters (both field-effect emission and cold gas), and the so-called 'drag-free attitude control system'. The spacecraft also hosts an equivalent system provided by NASA-JPL, called the Drag Reduction System (DRS).

James Webb Space Telescope (JWST)

Launch: August 2011

The James Webb Space Telescope is the follow-on mission of the Hubble Space Telescope. It is a large observatory-class mission with the primary objective of exploring the early Universe back in time to the epoch of ignition of the very first stars and galaxies. Apart from providing an Ariane-5 launcher, ESA is responsible for the Near-Infrared Spectrograph (NIRSpec) and the Optical Assembly of the Mid-InfraRed Instrument (MIRI).

Gaia

Launch: 2012

The preparatory work for the implementation phase of Gaia picked up speed in 2004. Whilst the two competitive industrial contracts continued and reached the level of early Phase-B type work, the management structure was transferred from a study environment to a project structure.

BepiColombo

Launch: April 2012

The BepiColombo definition phase continued in order to finalise the mission definition and the payload accommodation. The optimised mission scenario foresees a single launch in April 2012 on a Soyuz-Fregat 2-1B of the Mercury Planetary Orbiter and of the Mercury Magnetospheric Orbiter (to be provided by Japan).

The selection process for the scientific instruments on the Mercury Planetary Orbiter was kicked-off with the issue of the Request for Proposals on 26 February. A total of 20 proposals were received and an international Payload Review Committee thoroughly evaluated the scientific, technical and programmatic aspects, together with Agency staff. Their recommendation for payload selection was unanimously adopted by ESA's Science Programme Committee (SPC).

LISA

Launch: 2013

The Laser Interferometer Space Antenna (LISA) is a spaceborne gravitational-wave detector consisting of three spacecraft flying in formation. Discussions with NASA in the first half of the year led to an inter-Agency programmatic agreement for LISA. Valid for the initial mission-formulation phase, it recognises the two Agencies as equal partners in the project.

Composite image of the Hubble Ultra-Deep Field (Courtesy of S. Beckwith, the HUDF Team and NASA)

Research and Scientific Support Department

Missions in Operation and Archival Phase

Ulysses

Ulysses continues to explore the Sun's environment, from the unique perspective of a solar polar orbit. Data return has remained excellent (97% on average over the 14-year mission, with an average of 98.2% over the last 5 years). In February, the Science Programme Committee unanimously approved the funding to continue operating Ulysses until 31 March 2008. This third extension in the mission's history will enable Ulysses to acquire observations during a third set of polar passes with a key goal of observing as fully as possible the influence of the recent polarity change in the Sun's magnetic field on the high-latitude heliosphere. In March, Ulysses successfully completed the Jupiter Distant Encounter (JDE). During this 50-day period, 24 hour per day real-time coverage by the Deep Space Network enabled the on-board tape recorders to be switched off, allowing the majority of the scientific payload to be operated continuously without the need for power-sharing. In September, Ulysses survived its most operationally challenging conjunction (i.e. when the spacecraft is positioned almost directly behind the Sun when seen from the Earth). During such periods of close conjunction, the radio path between the spacecraft and the Earth travels through the solar corona, introducing noise into the uplink and downlink that can potentially disrupt commanding and degrade data. Ulysses is currently involved in multi-spacecraft studies of the transient solar-wind features together with SOHO. All Ulysses data are now in the public domain.

Hubble Space Telescope

The Hubble spacecraft is operating nominally, with the exception of the Space Telescope Imaging Spectrograph (STIS), one of the five on-board science instruments, which failed on 3 August. Amongst its many scientific achievements, HST has obtained the deepest view yet of the remote Universe (ACS Ultra Deep Field) and has observed the most distant supernovae SNIa. Using them as distance indicators has confirmed previous HST measurements that suggest that the Universe's expansion continues to accelerate. HST has also made the first direct measurement of the mass of a single star other than our own Sun, by measuring a small red star located some 1800 light-years from Earth, and is responsible for the discovery of a possible new planet in our Solar System, known as Sedna. Following the cessation of the Shuttle servicing missions, in June NASA announced its intention to pursue the feasibility of a robotic servicing mission, which is now being developed. In the meantime, Hubble scientists and engineers have begun to study every option to prolong HST's life. In the event that HST has to be operated with only two gyros, instead of the normally required three, development of a Two-Gyro Science Mode continued throughout the year.

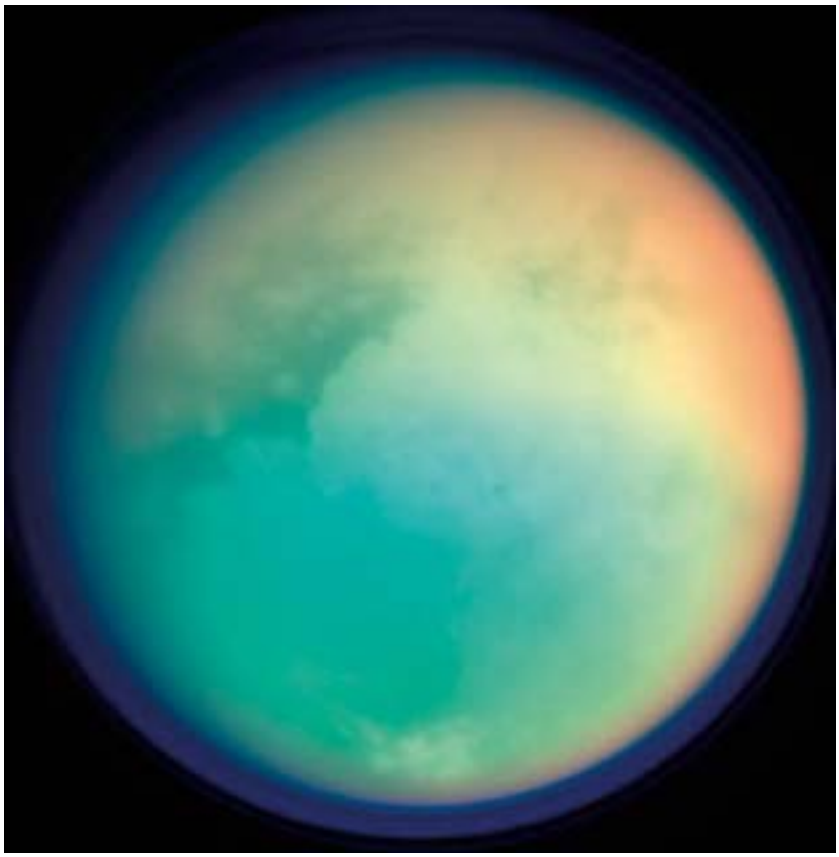
Infrared Space Observatory (ISO)

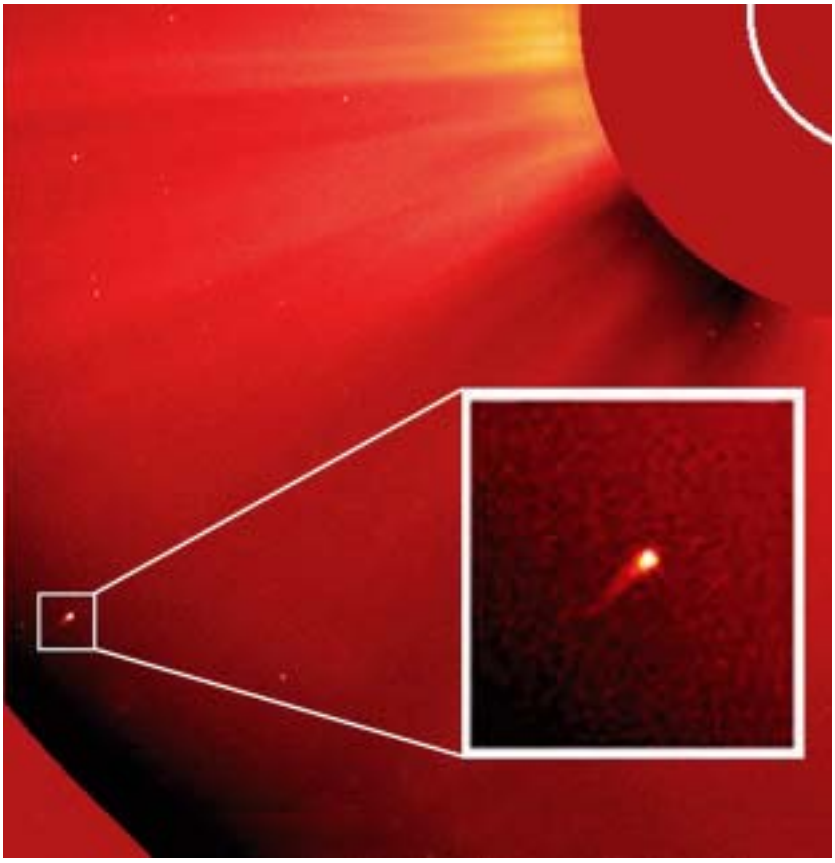
The ISO Data Centre Active Archive Phase activities continue to run smoothly. The mid-term Review was held in June and the Board, composed of external data providers and users, was impressed with the achievements of the past two and a half years. A major new version of the ISO Data Archive was released on 8 June, including enhanced-quality information, a link to the ISO Catalogues based at the Centre de Données Astronomique in Strasbourg (F) and an improved postcard server. ISO continues to have a significant presence in the refereed literature with 1214 papers published to date (130 in 2004). A special issue of Space Science Reviews summarising the major achievements of ISO was edited and posted on the ISO web site in December (http://www.iso.vilspa.esa.es/science/SSR), prior to its publication by Springer. The book, of over 450 pages, organised into 17 chapters, embraces all areas of infrared astronomy and serves inter alia as a reference for the preparation of proposals solicited for the 2nd Call of the Spitzer Space Telescope.

Cassini-Huygens

Cassini-Huygens entered orbit around Saturn on 1 July as planned. Coming from below the rings, it crossed them with its high-gain antenna oriented so as to shield the most delicate parts of the spacecraft from being hit by ring particles. After the first ring crossing, the main engine fired for 96 minutes to slow down the spacecraft and put it into orbit around the ringed planet. Unique pictures of the rings were obtained. Coming from above the rings, Cassini-Huygens crossed them a second time about 4 hours after the first crossing. Within 36 hours of Saturn orbit insertion, a series of distant observations of Titan were made. Within 2 months, the Titan data set had been carefully analysed together with the relevant latest ground-based observations to validate the Titan atmosphere engineering model used for the design of Huygens. The observations confirmed that the atmospheric structure was well within the envelope of the engineering model. On 23 August, the third largest manoeuvre performed by Cassini-Huygens near the apoapse of the first large orbit around Saturn, placed the spacecraft on its nominal trajectory for the first close encounter with Titan on 26 October. The second one occurred on 13 December. Data obtained by Cassini's orbiter instruments during the two close Titan encounters further confirmed the engineering model of Titan's atmosphere. Huygens was successfully released from Cassini on 25 December.

Composite image of Titan taken by Cassini on 26 October. Blue colours highlight the moon's high atmosphere and detached hazes (Courtesy of JPL/Univ. of Arizona)





Comet 750 as seen with SOHO's LASCO C2 instrument on 22 March

SOHO

SOHO remains the flagship mission of solar and heliospheric research, sending thrilling images daily from which scientists, and increasingly also space-weather experts, can learn about the Sun's nature and behaviour. In March, SOHO discovered its 750th comet since its launch in December 1995. It was discovered in images from the LASCO instrument by a German amateur astronomer who is one of the most successful of the SOHO comet-hunters. More than 75% of comet discoveries come from amateur comet hunters around the World watching the readily available SOHO images on the web. The very successful series of SOHO Workshops continued with the 14th and 15th taking place in 2004, and there are now over 1700 papers based on SOHO in the refereed literature. SOHO images appeared on the cover of the July issue of National Geographic, which featured a 32-page story on recent developments in solar science and space weather.

XMM-Newton

The XMM-Newton mission has been routinely providing high-quality, high-impact science data since its launch in 1999. Observations in 2004 included the detection of the tidal disruption of a star by a massive black hole. There were two new releases of the Newton Science Archive (XSA) offering the currently registered 1300 users on-the-fly data extraction and processing. Exceptionally high usage of the archive was registered in November with about 5500 downloads of data sets. Response to the Call for Observing Time (AO-4) produced 657 proposals, an oversubscription of 7 times the time available. The upgrading of the XMM-Newton ground segment to SCOS 2000 is continuing on schedule, with first operations expected early 2005. 719 papers based either completely or in part on XMM-Newton observations have now been published in the refereed literature, 306 in 2004 alone.

Cluster

The four Cluster spacecraft are working well and data return from their instruments is averaging 98%. The 5th set of constellation manoeuvres were carried out in June-July, and the spacecraft are now 1000 km apart. Cluster has now provided both evidence and direct in-situ observations of reconnection in the magnetic tail and dayside high-latitude magnetopause. It has also confirmed the existence of large-scale boundary waves and vortices at the magnetopause. The importance of Cluster data to space physics is underlined by the development of the Cluster Active Archive (CAA), which provides the entire scientific community with free access to the full, calibrated, high-resolution Cluster data set.

Integral

Integral operations continue to run smoothly with the spacecraft, instruments and ground segment all performing well. A total of 108 proposals were received in response to the third Announcement of Opportunity for observing proposals (AO-3). Preparations for the move of the Integral Science Operations Centre from ESTEC to ESAC are on schedule for the ESAC team to assume responsibility for mission planning at the start of AO-3 observations in February 2005. The Integral Science Data Centre

(ISDC) continues to routinely dispatch scientific data products to observers within 6-8 weeks of their observations. The on-line ISDC public archive includes data and science products from the first year of operations. By the end of 2004, a total of 69 refereed papers based on Integral data had appeared. Integral's spectrometer (SPI) has produced the first all-sky map of the emission produced when electrons and their anti-matter equivalents, positrons, meet and annihilate. This information provides clues as to the source, or sources, of anti-matter – one of the key goals of Integral. An Integral-discovered gamma-ray burst, GRB 031202, turned out to be the closest and faintest GRB ever observed, leading to speculation that there may well be a yet unknown population of very faint GRBs.

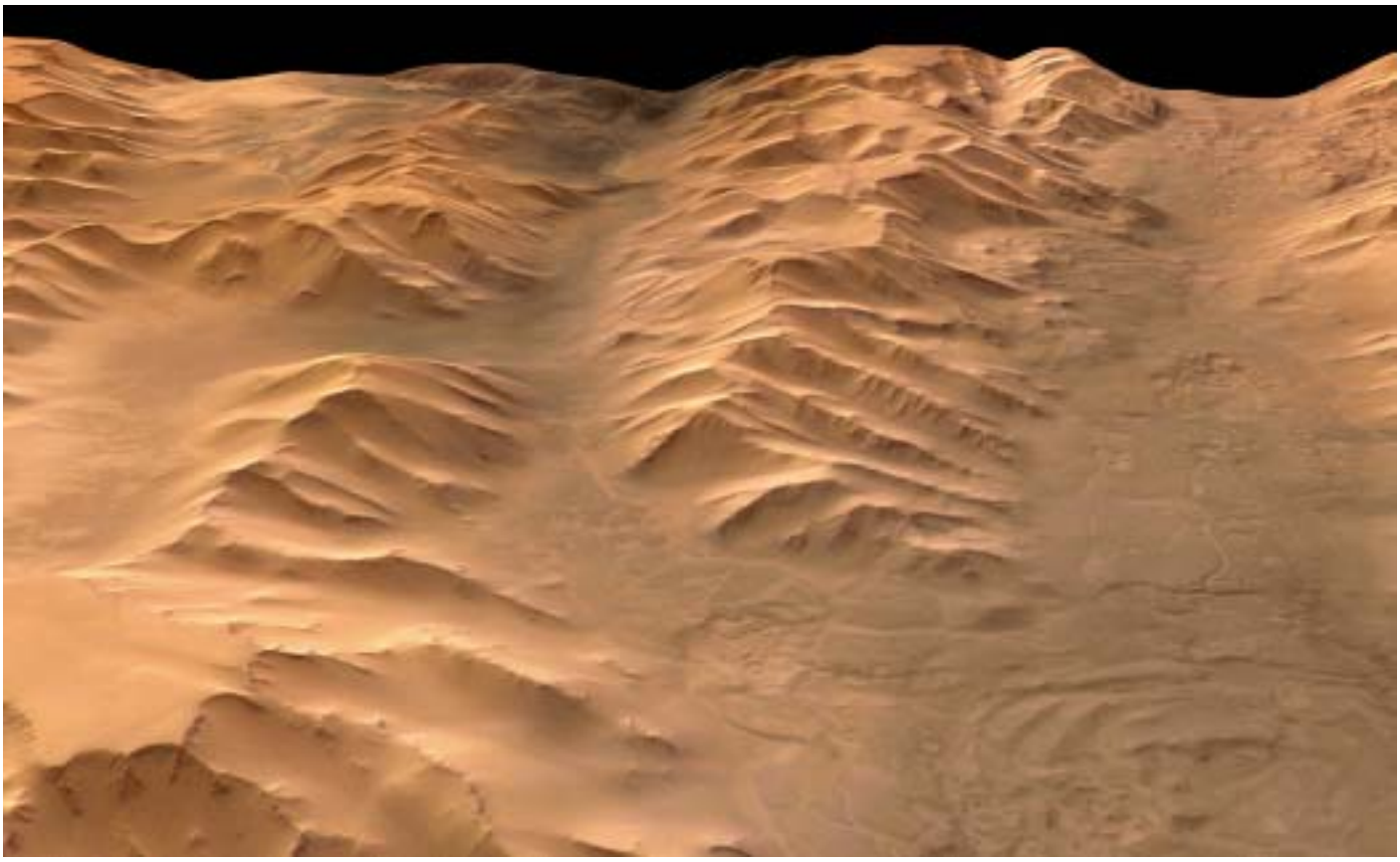
Double Star

The second Chinese Double Star satellite (TC-2) was launched on 26 July. Unfortunately, its attitude and orbit control computer failed shortly after launch. Then, during the largest geomagnetic storm of 2004, the redundant attitude computer on TC-1 also failed, which means that both spacecraft have non-functioning attitude computers. Their attitude can still be determined, however, by using data from the European-provided magnetometer. Fortunately, both spacecraft are spinning at 15 rpm and are therefore stable. All European instruments are operating nominally, and the data return is better than 90% for both spacecraft. Very promising results have been presented on magnetic reconnection, bow-shock structures and surface waves in the magnetosphere. The data are complementing Cluster data, and the observations being made are creating much interest within the scientific community.

Mars Express

The first eclipse season at Mars required careful planning, with the longest eclipses occurring from February to April. Payload operations during the latter period were very successful and allowed for a good number of science observations. Shortly before the expected activation of the MARSIS experiment in April, a no-go on the boom deployment was declared. Studies on the safe deployment of its radar antenna are expected to lead to clear

The Titonium Chasma canyon on Mars, part of a canyon system that is the result of a variety of geological processes. Tectonic rifting, water and wind action, volcanism and glacial activity have probably all played major roles in its formation and evolution

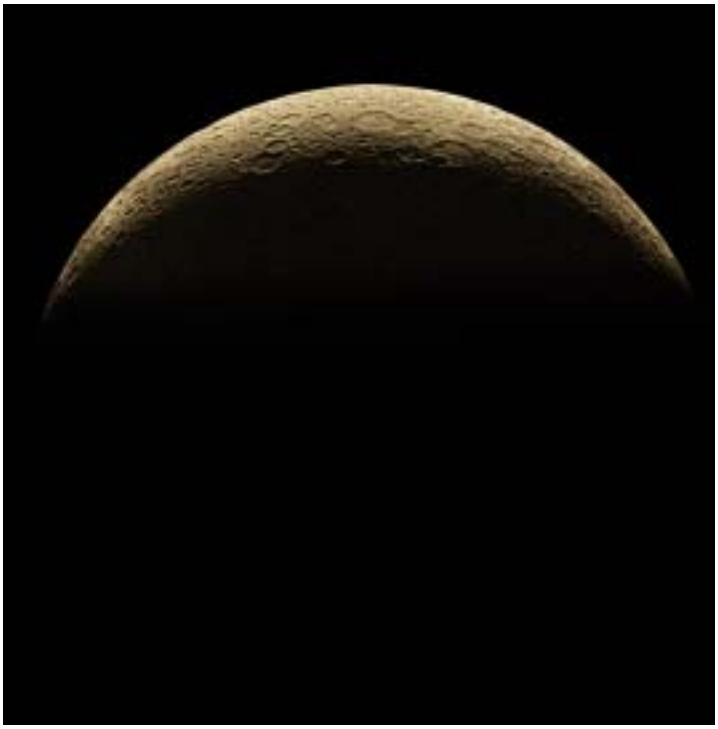


conclusions in early 2005. The solar conjunction period (August to September) was carefully prepared for, requiring a few weeks with no on-board science operations, but no problems were encountered. Multiple scientific discoveries were reported in *Nature, Science,* etc. shedding light on crucial elements related to the history and evolution of Mars. The First Mars Express Science Conference will take place in February 2005.

SMART-1

ESA's first mission to the Moon has been a technological success right up to lunar capture and is now commencing its science phase. Payload commissioning was completed in April and the cruise phase, during which all instruments were demonstrated, lasted from May to October. The final firing of the electric-propulsion system took place on 25 October, achieving a total of 3648 thrust hours, before the lunar approach and crossing of the Lagrangian gateway occurred on 11 November. Just before lunar capture, which occurred on 15 November, the SMART-1 camera took the first European image of the north pole and far side of the Moon. Electric propulsion was subsequently resumed to obtain the first close-up images on 29 December.

Image of the Moon's north pole taken by SMART-1's AMIE camera on 12 November



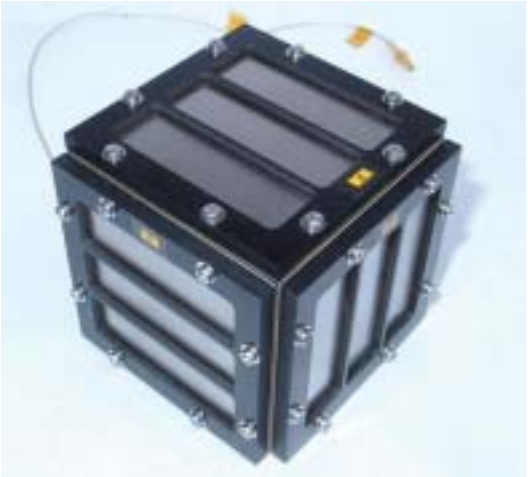
PRODEX / PECS

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, Denmark, and the Czech Republic. The projects being developed range from small Earth-observation data-analysis programs to fully-fledged instruments for scientific payloads.

The major event in 2004 was undoubtedly the launch of Rosetta, to which PRODEX has contributed substantially by supporting the ROSINA instrument (DFMS and RTOF). Another major undertaking was the Chinese launch of Double Star, the NUADU instrument for which has been heavily supported by PRODEX.

The 12th PRODEX Programme Participants meeting on 9 November in Paris addressed the renewal of the PRODEX Declaration for the period 2006-2010, and the necessary funding was secured for the next five-year period.

In the course of 2004, the experiments or experiment subsystems in the accompanying table were finalised and/or launched.



Rosetta's three-dimensional Dust Impact Monitor (DIM) sensor (Courtesy of KFKI-AEKI, Budapest)

Experiments and Subsystems Developed within PRODEX/PECS in 2004

Rosetta

• *DFMS, RTOF*	*Drs. Balsiger and Nevejans*	*Berne (CH) & Brussels (B)*
• *MIDAS*	*Dr. Riedler*	*Graz (A)*
• *ESS*	*Dr. McKenna-Lawlor*	*Maynooth (IRL)*
• *Lander PSU*	*Dr. Gschwindt*	*Budapest (H)*
• *SPM*	*Dr. Apathy*	*Budapest (H)*
• *DIM*	*Dr. Peter*	*Budapest (H)*
• *CDMS*	*Dr. Szegö*	*Budapest (H)*
• *RPC*	*Dr. Szegö*	*Budapest (H)*

Double Star

• *NUADU*	*Dr. McKenna-Lawlor*	*Maynooth (IRL)*

Demeter

• *Multi-Channel Converter*	*Dr. Travnicek*	*Prague (CZ)*

NetLander

• *SEIS Bridging Phase*	*Dr. Giardini*	*Zurich(CH)*

International Space Station

• *PromISS-3*	*Dr. Legros*	*Brussels (B)*
• *Neurocog*	*Dr. Chéron*	*Brussels (B)*
• *Cardiocog*	*Dr. Aubert*	*Leuven (B)*

36th Parabolic Flight Campaign

• *Grip force in collisions*	*Dr. Thonnard*	*Brussels (B)*
• *Heamodynamic changes*	*Dr. Aubert*	*Leuven (B)*

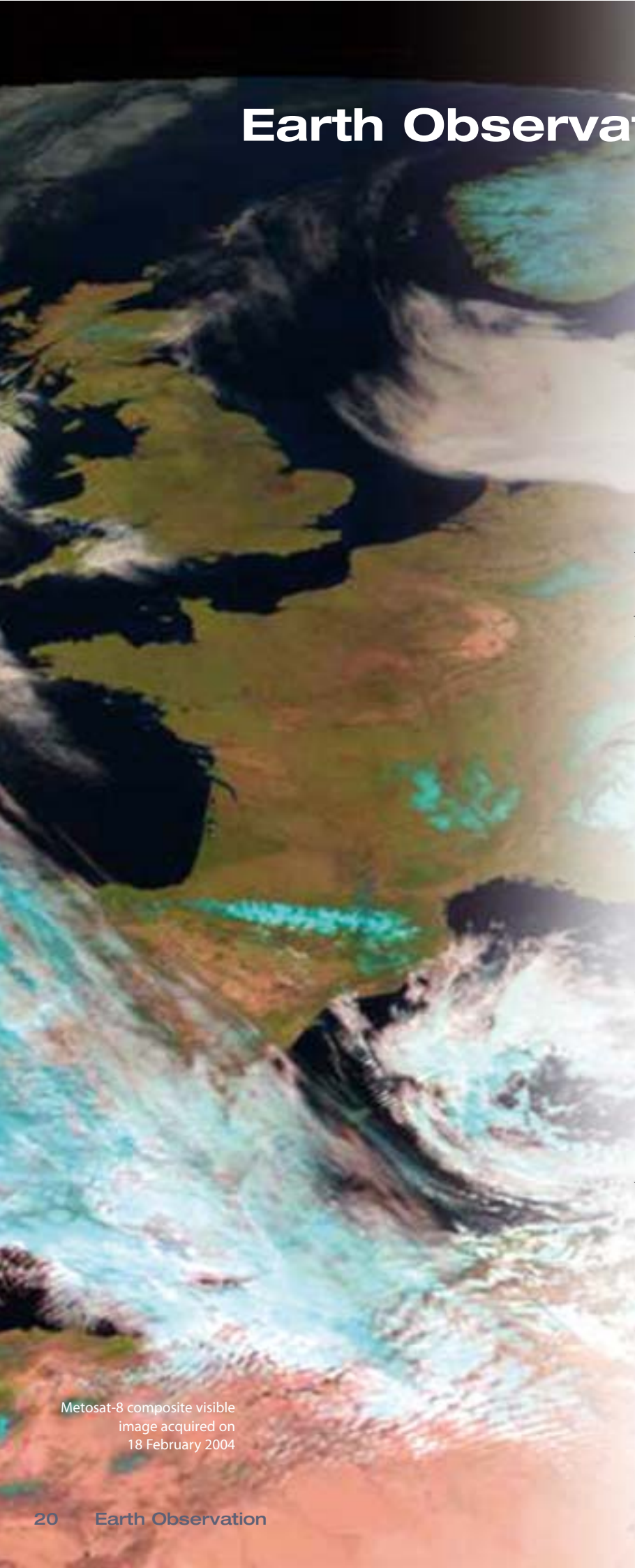
38th Parabolic Flight Campaign

• *Enhanced condensers*	*Dr. Legros*	*Brussels (B)*
• *Role of visual feedback*	*Dr. Thonnard*	*Brussels (B)*
• *Gravity simulator*	*Drs. Heglund and Willems*	*Leuven (B)*
• *Bones environment*	*Dr. Hinsenkamp*	*Brussels (B)*
• *Stewart platform*	*Dr. Preumont*	*Brussels (B)*

In addition, 168 scientists in the PRODEX participating States received support in the framework of European (mostly ESA) missions.

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 to join this programme. In November, the Czech Republic became the second by signing the PECS Charter. Poland and Romania, both declared admissible to PECS by ESA, have now declared their intention to start negotiating their participation.

Earth Observation



Metosat-8 composite visible image acquired on 18 February 2004

Missions in Operation

Envisat and ERS-2

2004 will remain the year of the tsunami tragedy that hit Southern Asia on 26 December. Around 200 images were provided through the Charter mechanism from the Envisat, IRS P6, Spot, Radarsat and CHRIS/Proba satellites. Once more, the International Charter on Space and Major Disasters earned itself worldwide recognition as an efficient mechanism for providing satellite imagery during emergencies.

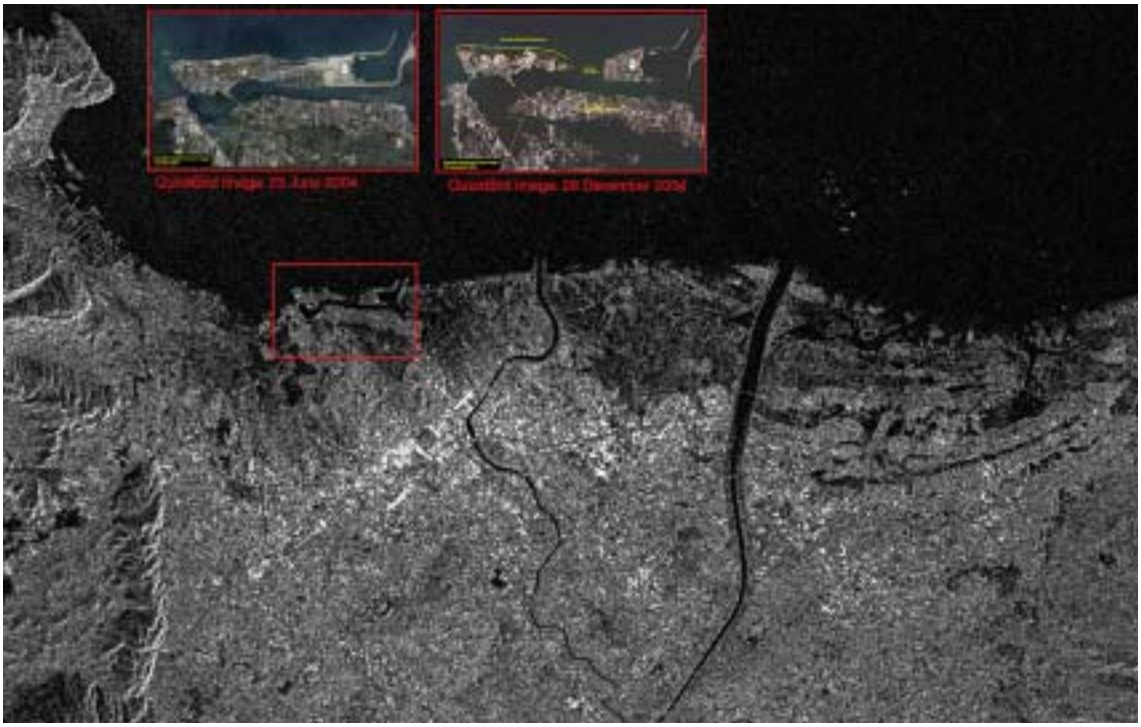
The Charter was started in 2000 by the European, French and Canadian space agencies joined later by the USA, India, Argentina and Japan. With an average of one call every two weeks, the Charter consolidated its level of activity in 2004.

Seventy-nine activation requests have been honoured since the beginning of Charter activities. The calls originated from civil-protection agencies in countries that are signatories of the Charter, the European Commission's Monitoring and Information Centre, and the specialised UN agencies.

All types of disasters were addressed on all Continents during 2004, including five earthquakes, three hurricanes, floods, landslides, volcanic eruptions or tremors, forest fires in South America, and the humanitarian emergency in Darfur.

After more than nine years, the ERS-2 mission is still fully operational, providing high-quality data to more that 7000 scientific users, meteorological offices and commercial users. The demand for ERS High-Resolution data has steadily increased over the years, accounting for 14 000 of the products shipped in 2004.

In its third year of operations, the Envisat mission is serving an ever-growing user community. By the end of the year, more than 700 scientific projects were regularly accessing Envisat data, while the commercial users (served through the EMMA and SARCOM distributing entities) are increasingly receiving their data via direct downlinks to non-ESA stations. The number of



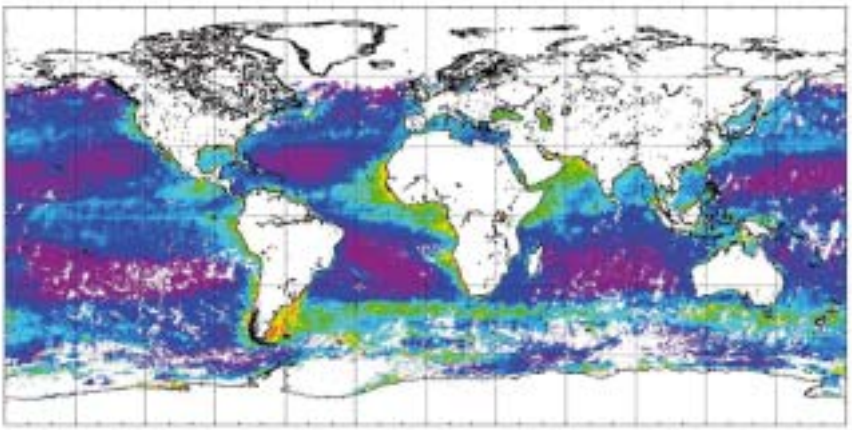
Post-Tsunami image of the Banda Aceh area (Sumatra) produced by ESA using Envisat ASAR data. The two small inserts are QuickBird optical images taken before and after the disaster, showing damage to the island along the shoreline similar to the ASAR imagery. Because it is all-weather and has an extended swath, ASAR has the capacity to detect damage at any time of the day or night throughout the area observed (Copyrights: Envisat data - ESA, QuickBird data - DigitalGlobe)

ASAR scenes acquired at the specific request of users has quadrupled in one year.

The Envisat Symposium in Salzburg (A) in September was by far the largest EO event organised by ESA. Attended by almost 1000 participants, it established the Envisat mission as one of the major tools available to the Earth Science community.

Major achievements from the exploitation of 14 years of ERS and Envisat data include:

- confirmation of global climate change
- impact of anthropogenic activities measurable from space
- European global-monitoring capability for atmosphere, ice, oceans and land change.



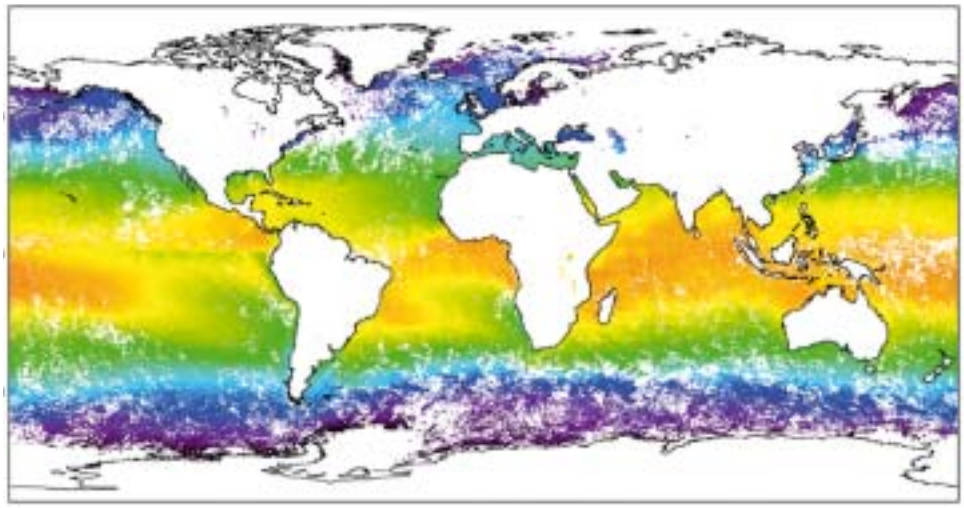
ATSR/AATSR measurements show an upward trend in sea-surface temperature of 0.13±0.03°C/decade (Courtesy of David Llewellyn Jones, Univ. Leicester (UK))

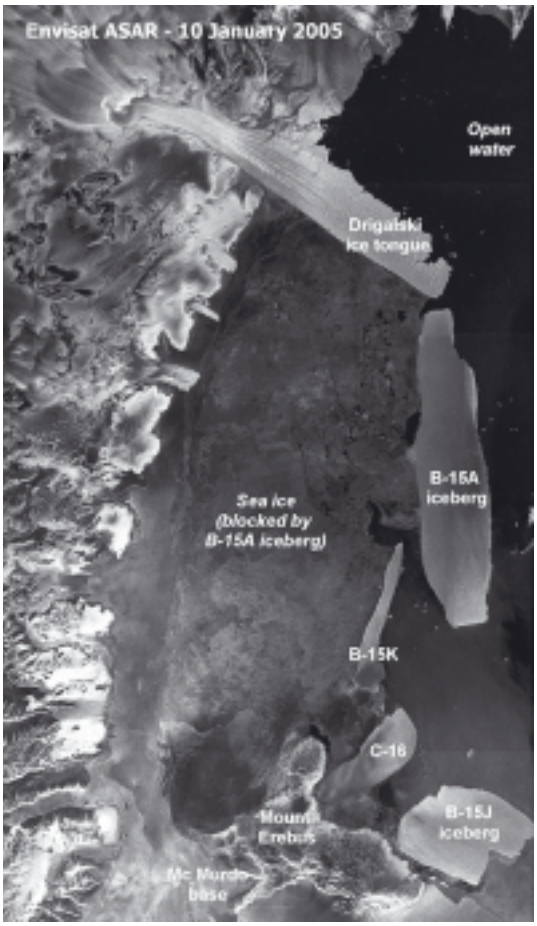
Some of the most spectacular results presented at the Symposium were on:

- *Climate change*: Global sea-level rise of about 3 mm/year and a seasurface temperature increase of about 0.13°C over 10 years. The AATSR series provides 14 years of consistent data with an accuracy of 0.1 K on a global scale.

- *Atmosphere:* Worldwide monitoring of air pollution, with evidence of fast growing air pollution in China since 1995. Emissions from vessels on the main shipping routes have been observed from space for the first time.

Global NO_2 measurements from Sciamachy for the period January 2003 to June 2004 (Courtesy of Steffen Beirle, Univ. Heidelberg (D))



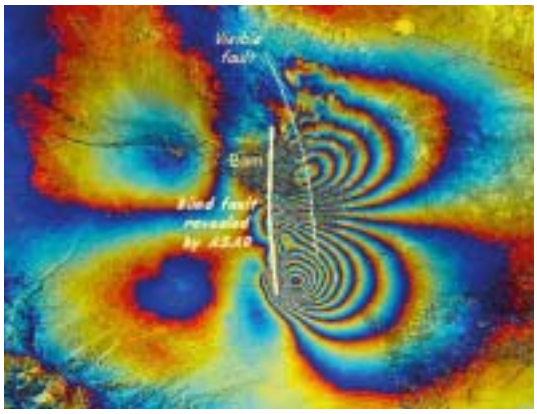


The motion of the B-15 iceberg

- *Polar areas*: Daily monitoring of sea-ice motion and observation of ice-shelf collapse in Antarctica.

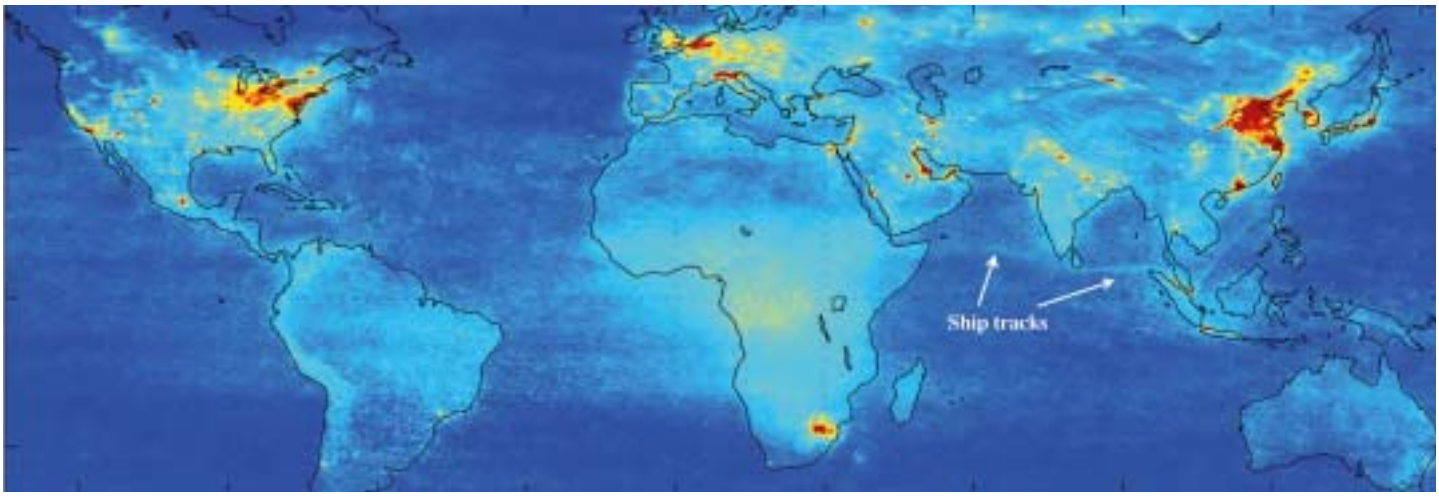
- *Oceanography*: Quantification of global chlorophyll concentration. The latter is a measure of phytoplankton biomass, which plays an important role in fixing CO_2 through photosynthesis.

The origins of the Bam earthquake analysed using ASAR data (Courtesy of A. Monti-Guarnieri, POLIMI (I))



- *Tectonics*: Identification of the blind tectonic fault at the origin of the Bam earthquake (Iran) in December 2003 using ASAR interferometry. The results were surprising, establishing that while Bam lies in a seismic belt, this particular quake had originated from a point no one had expected. The fault revealed by ASAR showed up as a distinct band of discontinuity in the interferogram, with motion on either side of it ranging from as little as 5 cm to as much as 30 cm.

Global chlorophyll coverage from Envisat's MERIS instrument



The Earthnet Programme

The Earthnet Programme ensures access to EO data from other space agencies and mission operators – the so-called 'Third Party Missions' – both in Member States and worldwide. Such missions currently include Landsat, Spot, NOAA, Terra/Aqua, OrbView/Seawifs, QSCAT and Proba. The list will be further extended in 2005 to include Bird, Scisat, Coriolis, DMC, IRS-P6, KOMPSAT, SAC-C, CBERS and Rocsat-2, making a total of more than twenty Third-Party missions covered by Earthnet. It also makes available historical archives of the JERS-1, Nimbus-7, IRS-P3 and Landsat missions, built up over the last 25 years.

New EO missions will be regularly scrutinised and added to the list if they satisfy a number of criteria, such as the value to Europe of the mission's data for both scientific and operational purposes, its accessibility and cost in terms of ground-segment facilities, and finally its relevance to ESA's EO strategy and objectives.

International cooperation projects were set up during 2004 with Russia, China and African countries, through the Bear, Dragon and Tiger programmes, respectively. A contingency-operation agreement with the Canadian Space Agency and Radarsat is being negotiated to increase user confidence in EO data access.

Ground-Segment Harmonisation

A European harmonisation effort was further pursued in 2004, under the supervision of a Ground Segment Coordination Body. Today, unlike a few years ago, users and projects are requesting coherent access to a multitude of EO data. User services continue to increase and handle a growing number of missions, as do the ground-segment facilities through a multi-mission design concept, in cooperation with national facilities and industry. The degree of cooperation with other mission operators has progressively increased, and is particularly successful for activities in the context of the International Charter on Space and Major Disasters.

Ground-segment harmonisation has become even more important with the preparation of the GMES programme and the need for coherent access to EO data.

The ESA EO sites have been complemented by an EO Portal, providing well-structured access to information about many ESA and non-ESA missions.

Missions under Development

Earth Explorer Missions

CryoSat

CryoSat has been designed to measure variations in the thickness of the polar ice sheets and the thickness of floating sea ice. Its data are intended to be used to study the mass balances of the Antarctic and Greenland ice sheets, to investigate the influence of the cryosphere on global sea-level rise, and to provide important observations of sea-ice thickness for use in Arctic and global climate studies.

Flight model of CryoSat at IABG (D) for environmental testing

The project is now well-advanced: integration of the proto-flight model was completed by EADS Astrium (D) and the spacecraft transported at the end of July to IABG (D) for environmental testing. These tests also confirmed the compatibility of CryoSat with its Rockot launcher. Development of the

Artist's impression of the ADM-Aeolus mission

ground segment is complete, including the processing facility for the SIRAL radar-altimeter data. Launch is due to take place from Plesetsk at the end of September 2005.

GOCE

The Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) core mission is designed to provide unique models of the Earth's gravity field and the geoid, on a global scale and with unprecedented accuracy and spatial resolution.

Following detailed consolidation of the design the year before, 2004 was devoted mainly to manufacturing and testing the various development models. Ground-segment development progressed according to plan, with the Design Review being successfully completed in November. The predicted launch date remains August 2006.

SMOS

The Soil Moisture and Ocean Salinity (SMOS) mission will demonstrate the observation of two key Earth-system variables from space: namely the soil moisture content over land surfaces, and the amount of salt dissolved in the oceans. Both parameters are key to understanding our climate and its changes, but have not so far been measured.

The SMOS payload, consisting of the Microwave Interferometric Radiometer with Aperture Synthesis (MIRAS) instrument plus supporting elements, moved into its full development phase (Phase-C/D) during the year. The satellite's Proteus platform, contributed by CNES, is currently in the design phase (Phase-B).

The procurement process for the Eurockot (Bremen, D) vehicle for SMOS's launch, currently planned in 2007, was initiated at the end of the year.

ADM-Aeolus

The Atmospheric Dynamics Earth Explorer (ADM-Aeolus) core mission, to be launched in 2008, will provide the first ever measurements of wind profiles from space. As the only such mission under development in the World, it will provide measurements far into the stratosphere where there have historically been almost none, and is therefore expected to enable significant advances in numerical weather prediction, especially in terms of predicting extreme weather events.

The main development phase (Phase-C/D) of the satellite procurement contract is well underway, and the ground segment also made good progress.

The payload data segment will consist of X-band reception from Svalbard (N), processing for engineering correction at Tromsø (N), and the derivation of wind products at the European Centre for Medium Range Weather Forecasts (ECMWF) in Reading (UK). Command and control will be conducted from ESOC in Darmstadt (D) using the Kiruna (S) ground station.

MSG-2 in flight configuration and MSG-3 in pre-integrated form in Alcatel Space's clean room in Cannes (F)
(Courtesy of Alcatel Space)

Earth Watch Missions

Meteosat Second Generation

MSG-1, renamed Meteosat-8 once in orbit, has completed its first year of routine operations, to the full satisfaction of the user community, with the optical performance of the Spinning Enhanced Visible and Infrared Imager (SEVIRI) and the Geostationary Earth Radiation Budget (GERB) instrument being of excellent quality.

The MSG-2 spacecraft has completed environmental testing and is now ready for shipment to Kourou in French Guiana, where it will be prepared for an Ariane-5 launch in November 2005.

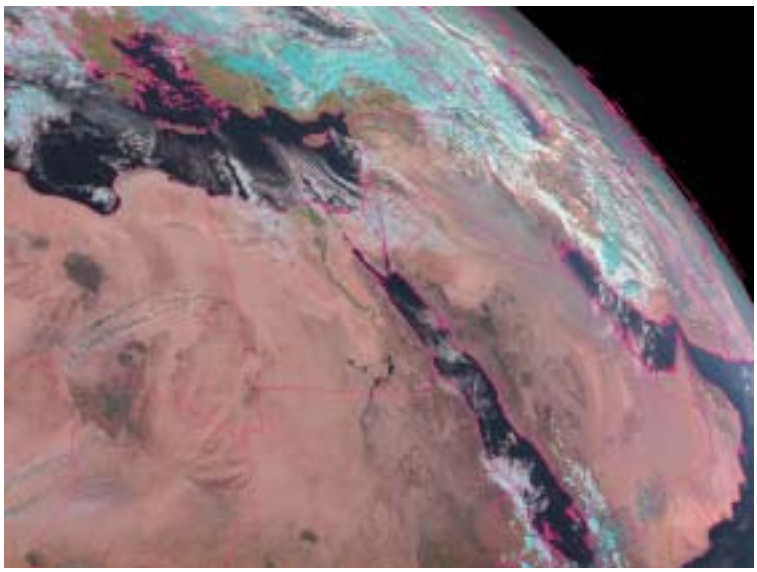
Environmental testing on the MSG-3 spacecraft has also been completed and, after the MSG-2 launch campaign, it will be put into long-term storage until its own launch, currently foreseen in 2009.

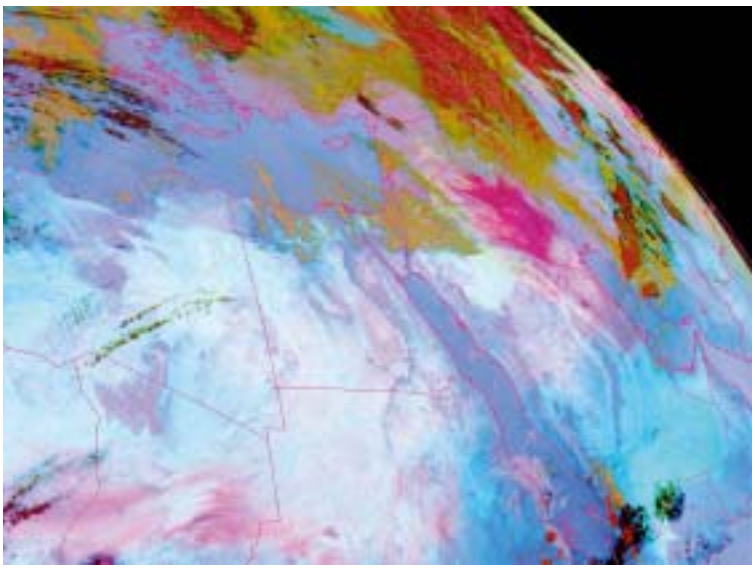
MSG-4 procurement activities progressed according to plan, with most subsystems having already been delivered and some pre-integration activities at system level already started. Full integration will start after the MSG-2 launch.

MetOp

Some very important milestones were achieved within the MetOp programme in 2004:

During the night of 23-24 November 2004, a dust storm (and cold air) moved into Saudi Arabia. The Meteosat-8 high-resolution visible image (left) shows the dust cloud as a bright, featureless area when compared with the well-structured desert surface. The dust storm can also be seen in the infrared image (right) where it appears as a relatively cold area compared to the hot desert surface
(Courtesy of Eumetsat)





- The MetOp-1 spacecraft was successfully completed and the first part of the Flight Acceptance Review held with positive results. The spacecraft is now in storage, where it will remain until its reactivation for launch in the 2010 time frame.

- Integration of the first MetOp spacecraft to be launched, MetOp-2, is now well underway, with the major electromagnetic-compatibility and mechanical-environment test campaigns being successfully completed by the end of the year. Launch is planned for April 2006.

- Links with the wider meteorological community were strengthened through a variety of activities.

InfoTerra/TerraSAR

The main objective of the TerraSAR mission is to provide geo-information services to commercial users exploiting joint data products from TerraSAR-L and TerraSAR-X (being developed concurrently as a German national programme). The TerraSAR-L system will provide ESA with its most powerful radar-imaging programme to date, key mission characteristics being a 5-year mission lifetime, global coverage from a 14-day repeat, 640-km altitude orbit, and 20 minutes of data acquisition per orbit.

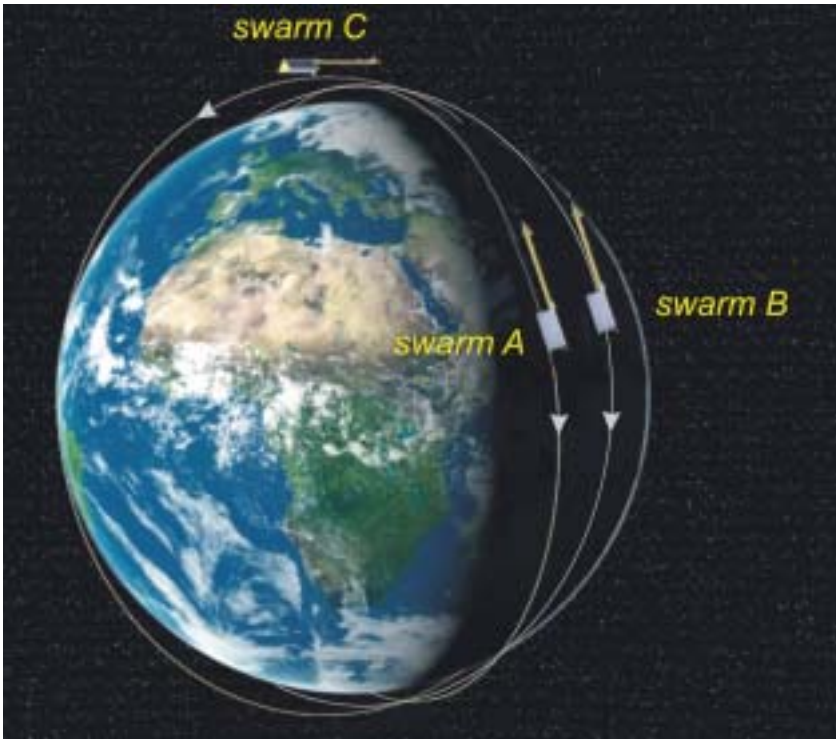
The principal payload is an L-band SAR instrument based on an 11 m x 2.9 m, active-phase-array antenna with 160 transmit/receive modules. More than 600 Gbit of data can be stored onboard and downloaded to a network of ground stations via a 300 Mbit/s link. The spacecraft platform, based on the novel 'Snapdragon' configuration, has a total launch mass of 2.4 t, to be accommodated on the Soyuz Fregat ST launcher. The solar array supplies 5 kW of power.

Fuegosat

The first step of the Fuegosat Consolidation Element has been completed. By prototyping and demonstrating services with the users

in their operational environment, the understanding of their needs and the capabilities of the space system have been consolidated. The architecture has been defined for a mission that should help to fight fire as a source of disaster that causes millions of hectares of forest to be lost every year. Such an architecture could consist of non-dedicated operational assets such as the GMES Sentinels, and dedicated sensors operating in the mid- and thermal-infrared for enhanced fire detection and monitoring.

Most of the Earth's magnetic field originates from a 'dynamo' operating in its outer core. There are, however, other contributions that the accurate observations of the Swarm fleet will help to disentangle



Preparation of Future Missions

These activities address future Earth Explorer and Earth Watch missions designed to improve our knowledge of the Earth system and to deploy space-based solutions in such critical areas as climate-change detection, environmental monitoring, sustainable development,

risk management and other areas of relevance to the GMES initiative, in addition to well-established areas such as operational meteorology.

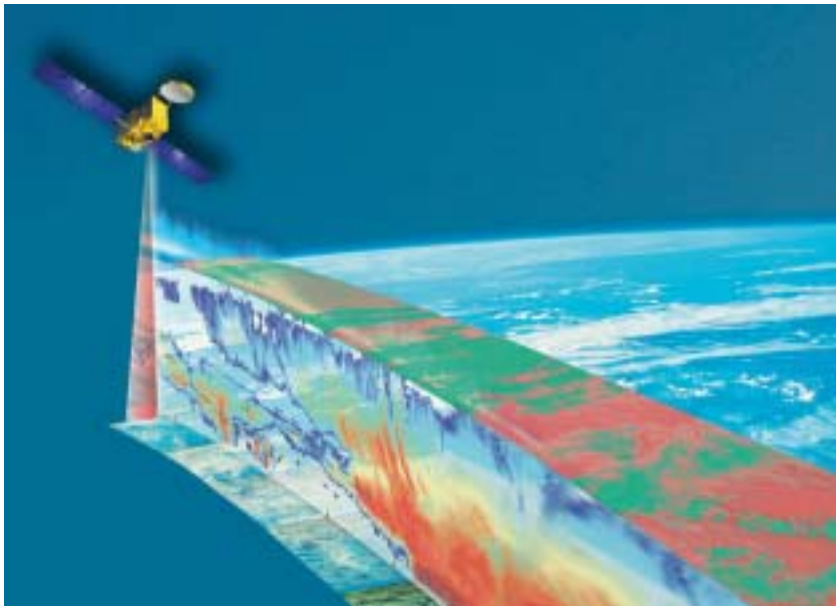
Earth Explorer Missions

The results of studies on the feasibility of six mission candidates – EarthCARE, SPECTRA, WALES, ACE+, EGPM and Swarm – were presented at a meeting at ESRIN (I) in April attended by 300 representatives from the scientific community and industry. Based on advice from the scientific community, Swarm and EarthCARE were selected for implementation, and both will fly around the end of the decade.

This brings the total number of Earth Explorer missions to six. They address a wide range of scientific issues, increasing our knowledge about how the Earth system works, how it changes, and how human activities impact upon the system.

Swarm, the fifth Earth Explorer mission, will monitor the magnetic and electric environment surrounding the Earth. By using a unique constellation of three small satellites, variations in the measured fields can be attributed to the dynamical behaviour of the solid Earth and to interactions with the incoming radiation from the Sun. Together with measurements from another Earth Explorer mission, GOCE, which will measure the Earth's gravity field, Swarm will provide new knowledge about the dynamics of the Earth's surface and improve our ability to understand the mechanisms of earthquakes, which pose an increasing threat to a growing population. Planned for launch in 2009, Swarm will be the culmination of a sustained European effort that started with the Danish Ørsted, and continued with the German CHAMP mission.

EarthCARE, which is a cooperative mission with Japan planned for launch in 2012, will be the sixth Earth Explorer mission. It will address the role of clouds and aerosols in the climate system, and will accurately measure the Earth's radiation balance. Clouds represent one of the most complex and important elements in our planet's climate system. Aerosols can have both a cooling and a heating effect, depending on the nature of particles, and human activities are strongly affecting the atmosphere's aerosol composition. EarthCARE will improve our knowledge of the factors influencing global change and the role that human activities are playing in the global warming that is currently being observed.



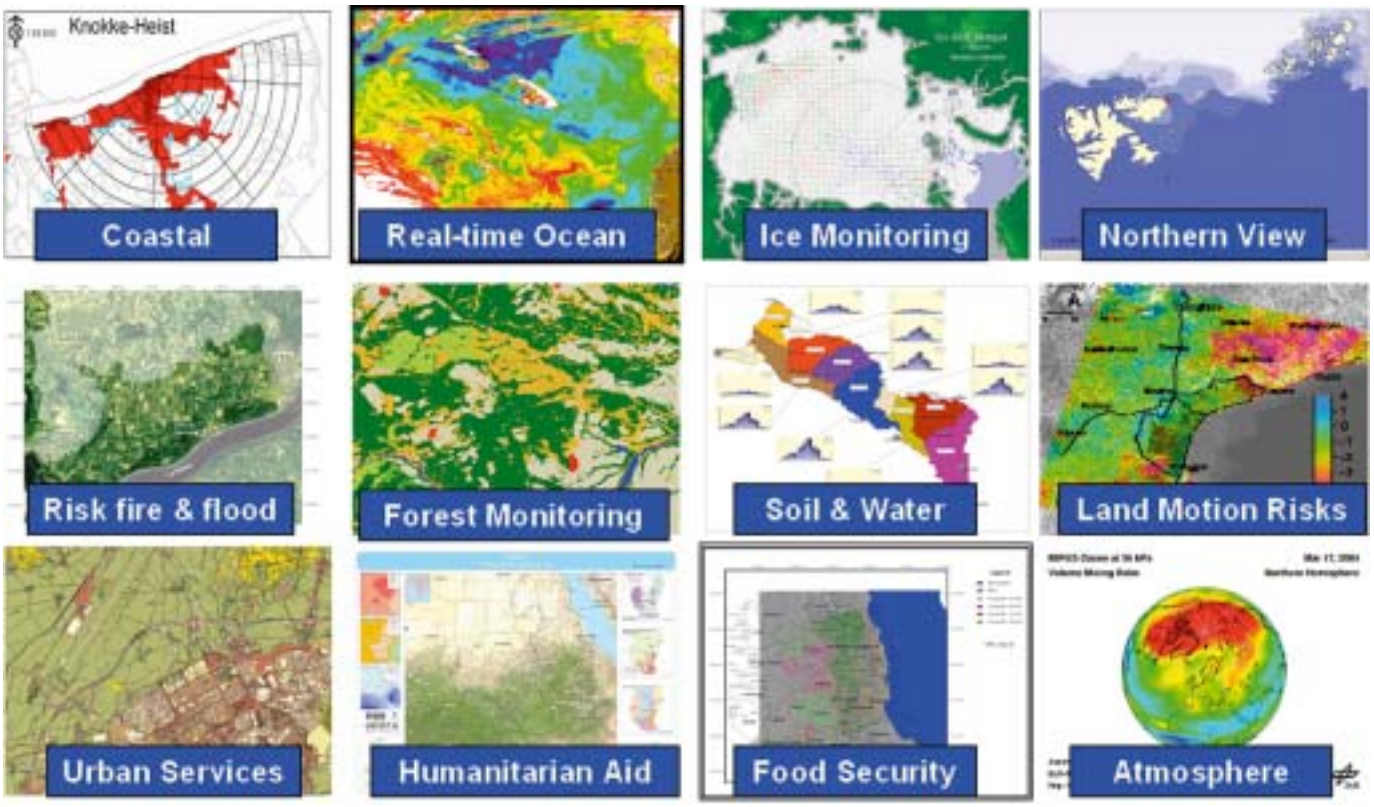
The EarthCARE mission will provide essential input data for numerical modelling and for global studies of the divergence of radiated energy, the aerosol-cloud-radiation interaction, the vertical distribution of water and ice and their transport by clouds, the vertical cloud-field overlap and cloud-precipitation interactions, among other major burning scientific issues

In the ten years since the birth of the Earth Explorer concept in 1994, nearly 70 mission proposals have been scrutinised, and six have been selected. They are currently in different stages of development, with the first, CryoSat, due for launch in 2005, and the last so-far selected, EarthCARE, in 2012.

Earth Watch GMES Missions

Analysis of mission requirements derived from user and service needs has led to the establishment of concepts for the first dedicated Global Monitoring for Environment and Security (GMES) space missions, the so-called 'Sentinels'.

A set of preparatory activities has been defined for execution in 2005, including socioeconomic-benefit studies and studies of implementation scenarios and architectures, encompassing all components but with emphasis on the Earth Observation component. The preparatory activities also include definition studies for Sentinel-1, a C-band SAR mission providing continuity with ERS, Envisat and Radarsat SAR data, Sentinel-2, a super-spectral optical-



imaging mission providing enhanced continuity with Spot and Landsat, and Sentinel-3, a mission devoted to monitoring of the oceans and land/vegetation on a global scale by means of an optical imager in the visible and thermal infrared and an advanced altimeter. Initial studies have also been planned for Sentinel-4 and Sentinel-5, devoted to monitoring atmospheric composition from geostationary and low Earth orbits, respectively.

Development of Services, and Applications

DUP-DUE

Many new projects were started within the Data User Programme (DUP) and Data User Element (DUE), leading to the establishment of global datasets, such as mapping of aerosols, coastlines, sea ice, deserts, acquifers and land cover. These projects were carried out in close collaboration with the relevant user institutions such as humanitarian-aid organisations, river-basin authorities, environmental ministries and agencies, forestry and agriculture ministries, WHO, UNESCO, FAO and UNEP.

Global Monitoring for Environment and Security (GMES)

The 10 contracts consolidating GMES services were successfully completed in 2004, with a clear mandate from the user communities to expand the role of EO-based information as a response to their policy-driven requirements for information. This activity resulted in the provision of an unprecedented number of products and services, ranging from iceberg location maps to water-quality maps for European coastal waters, delivered to over 200 user organisations from all over Europe and Africa.

Two new consolidation activities were started in 2004 in the areas of atmospheric-pollution monitoring and decision-making support for humanitarian-aid operations, such as the tsunami in Southeast Asia and the humanitarian crisis in Darfur.

All GMES services activities have been coordinated with the European Commission through the GMES Programme Office. This included preparations for the Earth & Space

Week in Brussels in February 2005, and detailed planning for the scaling-up of service provision for the next three-year period of 2005 to 2007.

EOMD

Through ESA's EO Market Development (EOMD) programme, service providers continued to work closely with potential customers in the areas of civil engineering, mining, oil and gas exploration, production and transportation, aquaculture, sailing, marine transport and certification, renewable energy, and re-insurance. More than 30 specific service trials designed together with these potential customers are planned to take place throughout 2005.

Education

EO education activities focused on the enrichment of Eduspace, the ESA multilingual EO web site for secondary schools developed under the auspices of EURISY. A new module titled 'Africa from Space' and accompanying study cases were integrated into the operational version of the website. LEOWorks 2.0, the upgraded version of the Eduspace image-processing tool for teachers and students, became operational during the summer.

Teacher events and courses dedicated to trainers were supported within Europe and also beyond. Several international trainees and national fellows were hosted at ESRIN during 2004.

GRID

2004 saw the completion and transfer into operation of mature GRID-based applications, with in particular the integration of the Envisat MERIS dedicated data-processing tool (BEAM) into the so-called 'GRID on-Demand' environment to generate various Level-3 products used for promotion and mosaicking of the ASAR global mode over the Antarctic continent.

The GRID environment allows the accessing of large datasets at source, instead of delivering the data products from the acquisition/storage facilities to the user site. GRID provides the user community with quick accessibility to data, high-performance computing resources and therefore rapid results.

Telecommunications

AmerHis

Hispasat's Amazonas satellite was successfully launched from the Baikonur Cosmodrome in Kazakhstan at 00:32 (CEST) on 5 August. On board was the ESA-funded AmerHis payload – the first switchboard in space. Results from the completed AmerHis in-orbit tests show that the payload is operating very well. Pilot operations will begin earlier than previously expected, with the intention of providing pre-operational services in the first half of 2005.

AmerHis enables Hispasat to provide high-performance interactive multimedia services anywhere within its four Ku-band coverage zones: North America, South America, Brazil and Europe. The payload works like a switchboard in space managed by a Network Control Centre on the ground able to configure the payload, assign capacity and manage user traffic. Four Gateways have been developed to provide the access system to the terrestrial network and user terminals have been developed. These are completely directed to the commercial

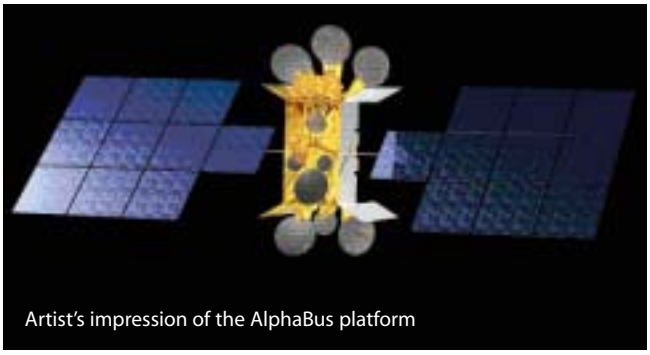
AmerHis

exploitation of new services, with the result that such services as high-speed Internet access, MPEG-based services, and video and radio on demand are available at a much lower cost.

The ambitious AmerHis project is the product of a collaboration between Alcatel Espacio, Mier Communicaciones and Indra Espacio of Spain, Alcatel Space of France, EMS Technology of Canada, and Nera ASA of Norway. It is funded by ESA and supported by the Spanish Centre of the Industrial and Technological Development (CDTI). In December, the General Management of the Instituto Nacional de Técnica Aeroespacial (INTA) presented Alcatel Espacio with the Aerospace Technology Award for the AmerHis project.

AlphaBus

In the race to market, Europe's first 12-18 kW telecommunications satellite platform, known as AlphaBus, has concluded its preparatory phase in 2004. It is slated to begin its main development phase (Phase-C/D) in 2005 with a newly created European consortium.



Artist's impression of the AlphaBus platform

The preparatory phase began in 2002 and included the initiation of over twenty projects. The results have been promising, with each project having been designed to push the technology limits. The consortium is led by an unprecedented alliance between the French companies Alcatel Space and EADS Astrium, and the equipment providers are spread throughout Europe. AlphaBus is Europe's answer to satisfying the growing demand in the commercial high-power satellite market for the coming 15 years. Although well represented in the small and medium-size satellite markets, the current European platforms, Alcatel's Spacebus and EADS Astrium's Eurostar satellite families, have been limited to 12 kW. This has meant that between 1998 and 2003 the 4 billion Euro global market for high-power satcoms has been left entirely to US manufacturers. The AlphaBus design surpasses the growth constraints of existing European platforms by providing up to 50% more payload power (up to 18 kW) and significantly increased payload-mass and accommodation capabilities.

Applications

2004 has been a very productive year for the Applications line of the ESA Telecommunications Programme. Distribution of digital media to public venues, utilisation of different satcom solutions in support of forest-fire and disaster relief, use of interactive advertisement applications on personal video recorders, use of satcom in support of tele-homecare, and broadband access for regional development are just some of the applications where tangible successes have been achieved. A further application success came in the form of one of the telemedicine projects providing tele-consultation support in areas affected by the tsunami disaster in December.

The Applications area continues to be a key innovation engine within the ESA Tele-

Telemedicine via satellite

communications Programme. New proposals for highly immersive interactive TV, telemedicine and medical education for travellers, tele-psychiatry, e-government for a public-administration regional service, Internet access on high-speed trains, and dissemination of information to cars using satellite and WiFi have been selected as key areas for innovation.

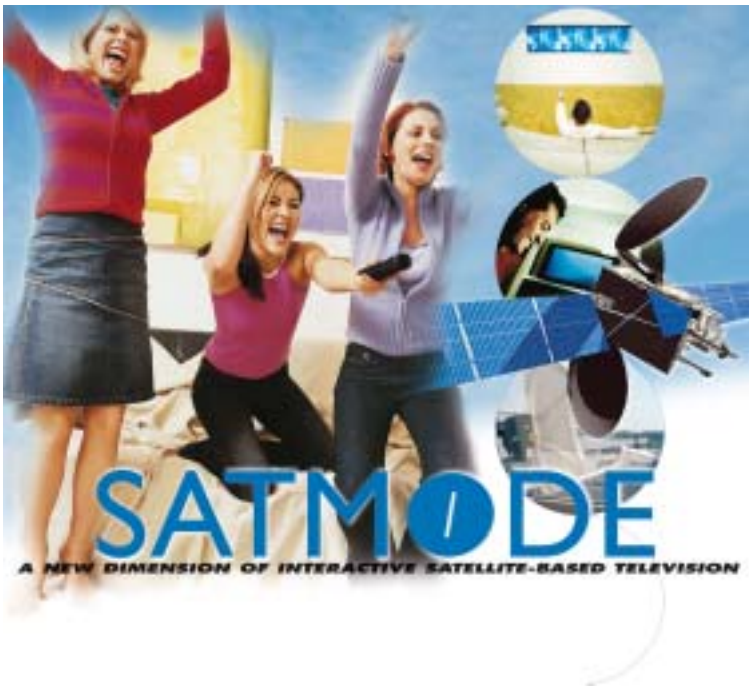
ESA is progressively addressing thematic areas that require specific actions to improve the uptake of commercially viable initiatives. These areas – so far Broadband Access to All, Interactive TV, Tele-Home Care, Security/Civil Protection, Broadband to Trains, Infopoverty/Capacity Building – will host mid-sized Pilot Projects in the next phase of the Telecommunications Programme.

Telemedicine

Health professionals need telemedicine via satellite for prevention, diagnosis, treatment and education. This is the conclusion of the ESA initiative that plans to propose space solutions that are well-adapted to users' needs. A Telemedicine Working Group was formed in 2004, composed mainly of users (health professionals and patients' representatives) and not the industry itself. The results from this Working Group and this new user-driven approach are now available and the content for the ESA Telemedicine Programme is being finalised.

SATMODE

SATMODE creates a two-way satellite communications link on top of the normal TV broadcast by simply upgrading commercial equipment. During 2004, the SATMODE consortium has developed all of the prototypes and the system required to support interactive TV via satellite. The modem specifications were made public and will soon become a standard, thereby favouring market penetration through the easy plug-and-play of interactive applications. The end-to-end system is currently undergoing final integration and validation and will soon be made available to application developers. SATMODE is being developed by a consortium led by SES Astra, including Newtec, Thomson, NDS, ST Microelectronics and Spacebridge.



User Support Office (USO)

The USO provides a user-friendly environment where established industrial teams and newcomers can find tools and information tailored to the typical needs of the Telecommunications projects. In 2004 two on-line training courses have been published, covering the tender procedures in the context of the Telecommunications Programme and a vast overview of satellite telecommunication systems and networks, respectively. The encouraging success of these courses stood alongside a peak in the utilisation of the ESA-provided satellite capacity, uplink stations and facilities to support the development and the field trials of the projects. The remarkable total of over 2600 hours of satellite transponder utilisation has prepared the ground for including a valuable new asset in 2005 that will allow two-way satellite Internet access via the Belgacom DVB-RCS based platform.

SatLabs Group

The SatLabs Group is proving instrumental in ensuring the commercial success of the DVB-RCS standard, an open standard for broadband communications via satellite. The Group is working to ensure that different products implementing the standard are mutually interoperable and that service-provision costs are minimised. During the year, the Group laid the foundations for the interoperability certification programme: independent test equipment was developed and an independent test laboratory selected. Using these elements, the SatLabs Group will verify that user terminals comply with the DVB-RCS standard and support interoperability.

Digital Divide Initiative

The 'digital divide' refers to the gap between individuals, households, businesses and geographical areas with regard to both their opportunities to access information and their ability to communicate effectively. In its White Paper on Space Policy, the European Commission has placed this issue – satellites contributing to bridging the digital divide – at the forefront of Europe's strategic priorities in the run-up to 2007.

Thus an EC/ESA Work Plan was set up to identify the problem, underwrite the technical dossier, and elaborate a sustainability model. The activities undertaken by ESA cover both the technical and the socio-economic aspects of the problem. On the technical side, a series of technology and system studies and pilot projects have demonstrated the possibility to deploy optimised systems aimed at drastically reducing the cost of the bandwidth. The socio-economic studies have demonstrated that, even if the great majority of the European population is covered by terrestrial means, the satellite solution is a key element for providing universal broadband connections.

Navigation

The Galileo concept (copyright ESA/J. Huart)

Galileo

System Test Bed Version-1

Following twelve months of successful ground-segment development operations for the Galileo programme, the Galileo System Test Bed Version-1 (GSTB-V1) routine operations were concluded on 22 December. The GSTB-V1 project supported investigation of the critical performances behind the services to be delivered to users by the final Galileo system. The results of the experiments conducted will be fed into the development-phase activities necessary for in-orbit validation of the system.

GSTB-V1 consisted of a worldwide network of sensor stations collecting high-quality GPS observables at 1 Hz, an Experimental Precision Timing Station, located at the Istituto Elettronico Nazionale (IEN) Time Laboratory, providing the reference time scale steered to universal time and international atomic time (UTC/TAI), and a Processing Centre located at the ESA/ESTEC in The Netherlands, which was used for the generation of navigation and integrity core products based on Galileo-like algorithms.

The experimentation results have made it possible to assess, in a realistic environment, the feasibility of some of the most important assumptions and performance objectives for the final Galileo system, including:

- experimental Galileo system time and steering to UTC/TAI
- orbit determination and time synchronisation, and signal-in-space accuracy
- integrity computation.

The GSTB-V1 has also mitigated the risks inherent in the development of the operational processing facilities for the Galileo ground segment, bringing added value in terms of confidence, design consolidation and accelerated schedule, by ensuring:

- actual measurements and comparison of alternative algorithms in a realistic environment
- an appropriate Galileo timing-infrastructure setup
- calibration over an extended period of time
- early verification and tuning of simulators, and the build-up of adequate analysis tools
- consolidation of the operational concept.

The next step will be a second Test Bed, GSTB-V2, geared to the launch of the first experimental satellite by end-2005, which will allow experimentation on the signal-in-space and the navigation payload, including onboard-clock characterisation.

In-Orbit Validation Contract

Following the signing of the first contract in July 2003 for two test satellites, known as GSTB-V2, the Galileo programme took a further step

forward on 21 December 2004 with the signature of a second contract concerning the In-Orbit Validation (IOV) phase. ESA and Galileo Industries signed a 150 MEuro contract, as a first step towards signing an approximately 950 MEuro contract covering the overall IOV phase.

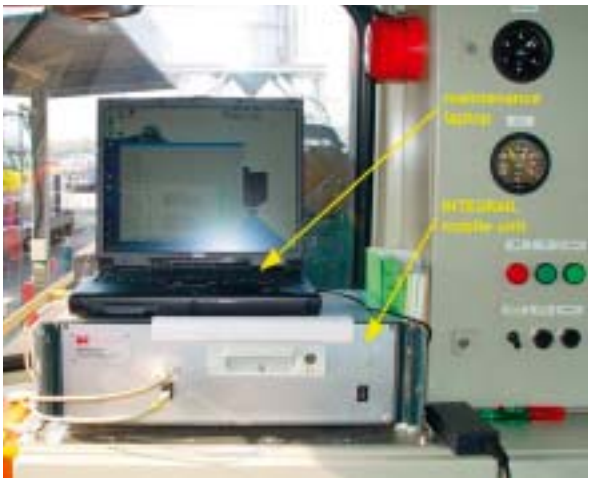
The contract provides the basis and the technical activities necessary for in-orbit validation of the Galileo system. It gives preliminary authorisation to proceed with the whole of this work, over a six-month period. It concerns the management of the programme and the choice of engineering systems and technical support required to maintain the overall credibility of the scheduling and to ensure system coherence.

IOV involves the delivery of the first four satellites in the Galileo constellation of 30, along with a number of ground stations. Subsequently, the programme will enter its deployment phase, which will cover the entire ground infrastructure network and the launch of the remaining 26 satellites, which will complete the constellation.

EGNOS

Several demonstrations were carried out in 2004, based on the European Geostationary Navigation Overlay Service (EGNOS), Europe's first step into satellite navigation, a service that provides superior positioning information by correcting the signals delivered by the American Global Positioning System (GPS) and the Russian GLONASS system. By offering better accuracy with integrity information and greater continuity of service, EGNOS can enhance the safety, reliability and efficiency of transport operations everywhere, from inland waterways to urban environments or railway networks.

Demonstration projects on the River Danube in Austria, and on the Yangtze River in China, showed the practical value of adapting satellite-navigation technology to the needs of inland-waterway transportation, improving safety and offering value-added services. Another demonstration project, still on the water but this time off the Greek coast near Athens, showed how EGNOS can enhance the management of a fleet of sailing boats, including a more efficient response to calls for assistance. Further demonstrations in the Athens Olympic environment proved how useful EGNOS can be in the management of a security company by offering appropriate tools to the patrol cars and guards on duty.



A prototype EGNOS-based train-locating unit, which forms part of a system known as INTEGRAIL, installed in a locomotive for test purposes (Courtesy of Bombardier GmbH)

Although first designed for aeronautical applications, EGNOS can also be used for railways, as was shown by trials in Belgium with train positioning via satellite, providing both safe and cost-effective solutions.

Lance Armstrong crossing the finishing line of the Alpe d'Huez stage of the 2004 Tour de France, tracked from the local EGNOS Control Centre (left)

Another remarkable EGNOS demonstration in 2004 was the real-time tracking of cyclists during the Tour de France. It was possible to pinpoint certain riders, calculate their positions and speeds, and measure the gaps between them. This represents a potential revolution not only for cycling events, but also for other large sporting events where one wants to follow the competitors' progress.

These EGNOS demonstration projects in 2004 clearly proved that, whatever the application, be it on land, on water or in the air, satellite navigation can surely make a difference!

Launchers

The year was characterised by the implementation of the decisions taken by Ministers at the ESA Council at Ministerial Level in May 2003. The reorganisation of the Ariane launcher sector, the consolidation of the Recovery Plan activities and the carrying out of the EGAS Ariane programme constituted the major highlights for the Ariane Programme.

The landscape for the European launcher sector for the 2010 time frame has also progressed on two fronts. Firsly, the Soyuz at CSG programme, covering the construction of the launch facilities and the adaptation of the launcher to the conditions for its exploitation from Kourou, has been started as an Optional Programme within the ESA framework. Secondly, the Future Launcher Preparatory Programme (FLPP) has been drawn up to develop Europe's technological capabilities and enhance the long-term competitiveness of European launchers, whilst also permitting the progressive restructuring of the industrial organisation for the next-generation launcher. These endeavours in establishing a longer term perspective encompass the recognition of the Russian Federation as a prime partner in the long-term cooperation on access to space. Crucial cornerstones for its success have been successfully laid, leading to the successful negotiation and consequent signature (in early 2005) of the 'Agreement between ESA and the Russian Federal Space Agency on Long-Term Cooperation and Partnership in the Field of the Development, Implementation and Use of Launchers'.

The launch of Rosetta on 2 March on an Ariane-5 G+

Ariane

The year was an important one for the Ariane launcher with consolidation of the activities covered by the Recovery Plan - endorsed by the 2003 Council at Ministerial Level - and the ongoing qualification of the four new versions of Ariane-5:

- Ariane-5 ECA 'heavy-lift'
- Ariane-5 G+
- Ariane-5 GS (backup for the ECA version)
- Ariane-5 ES-ATV (for launching the Automated Transfer Vehicle).

All three Ariane-5 G+ launches in 2004 were successful, and the Ariane Research and Technology Accompaniment Programme (ARTA) wrapped up the year with the flawless test-firing of a modified Ariane-5 booster in November.

At management level, the implementation of the new launcher industrial structure has been initiated, and the EGAS (European Guaranteed Access to Space) Ariane Contract was signed in March.

Ariane-5 launch campaigns

The three successful launches of Ariane-5 G+ were the last for this particular configuration of the vehicle. The first of them took place on 2 March, when flight L518 successfully lifted Rosetta into its interplanetary orbit. This required delayed ignition of the EPS upper stage, which marked an important milestone in the qualification of the re-ignition capability required for the future ATV launches. The second flight, L519 on 17 July, put Anik-F2, the heaviest commercial telecommunications satellite ever launched, into geostationary transfer orbit. By the end of the year, the race was on to see whether an Ariane-5 ECA or G+ would close 2004 with a successful launch. As some last verifications were still required on the ECA version, it was decided to go with the G+ version, which on 18 December inserted Helios-2A very precisely into its intended Sun-synchronous orbit position, as well as successfully releasing a set of six small satellites built by universities and research institutes.

Ariane-5 ECA

Implementation of the Recovery Plan and consolidation of the qualification activities continued, with major effort devoted to the successful closure of open qualification items, considerably reducing the number of open dossiers. Among the most prominent technical issues worked on at industry level and monitored through Qualification Reviews were:

The launch of Helios-2A on 18 December by an Ariane-5 G+ vehicle

- the reworking of the Vulcain-2 engine, particularly the nozzle extension, and the related qualification testing
- the qualification status of the ESC-A upper stage and HM7 engine
- investigations at system level, including the main-stage POGO effect
- the structural margins of the Vehicle Equipment Bay
- the risk of icing of the ESC-A upper-stage engine
- statistical evaluation of side loads during ignition of the Vulcain-2 engine.

Roll out of Ariane-5 ECA for the wet dress-rehearsal on 7 October

These activities progressed well and the qualification activities were successively completed. A wet dress-rehearsal with L521 on 7 October demonstrated correct launch-vehicle performance, but highlighted some anomalies at operations level. Further in-depth inspection of the launcher was decided upon and as a consequence the Ariane-5 ECA L521 qualification launch was moved to 11 February 2005.

Vulcain-2

Rework activities and related qualification of the Vulcain-2 engine constituted a major element of the Ariane-5 ECA Recovery Plan. Analyses were accompanied by extensive testing on the P5 (DLR, Lampoldshausen) and P50 (SNECMA, Vernon) test stands. Another important test using the P5's new Load Simulation Device reproduced both near-real-flight conditions (reduced pressure profile during ascent, down to 200 mbar) and the ovalisation loads on the nozzle. Qualification of the re-worked Vulcain-2 nozzle was completed and the related Qualification Reviews were successfully performed in July after extensive qualification testing. A complementary Qualification Review took place in September to finally pronounce qualification of the re-worked Vulcain-2.

Ariane-5 GS

The Ariane-5 GS launcher represents the return to production of the Ariane-5 Generic version. It has been introduced after the L517 flight failure, to guarantee Ariane-5 launch continuity by taking advantage of the experience and successes achieved with that version. It is built around existing hardware available from the Ariane-5 G+ and Evolution (E) versions, and the return to production of the Vulcain-1B engine. The EPC stage taken from the Ariane-5 E has to be modified to cope with the use of the Vulcain-1 engine instead of the Vulcain-2.

Vulcain-2 in the Load Simulation Device (LSD) at DLR in Lampoldshausen, Germany

Baseline missions for the Ariane-5 GS are double launches to GTO (Geostationary Transfer Orbit) and deliveries to SSO (Sun-Synchronous Orbit). The first launch foreseen in March 2005 is a double launch to GTO, and the second launch is scheduled for July 2005.

Ariane-5 ES-ATV

This launcher was confirmed in 2003 as the baseline version for carrying the ATV. Its development activities were therefore resumed at the end of that year with a very tight schedule. A launch strategy involving three EPS upper-stage ignitions has been chosen to reach the 260 km circular orbit with 51.6 deg inclination. Further Aestus upper-stage engine tests, lasting until summer 2005, are foreseen at DLR in Lampoldshausen to qualify the engine's re-start capability.

Ariane Adaptation for Launching Galileo Constellation

The Galileo satellites have no apogee engine, which means the launcher must put them directly into their circular MEOs (Medium Earth Orbits) at 23 616 km altitude, and thus must have an upper-stage re-ignition capability. ESA therefore foresees using an adaptation of the Ariane-5 ECA, with a launch dispenser on top of the upper stage. Technical investigations have confirmed the feasibility of this approach.

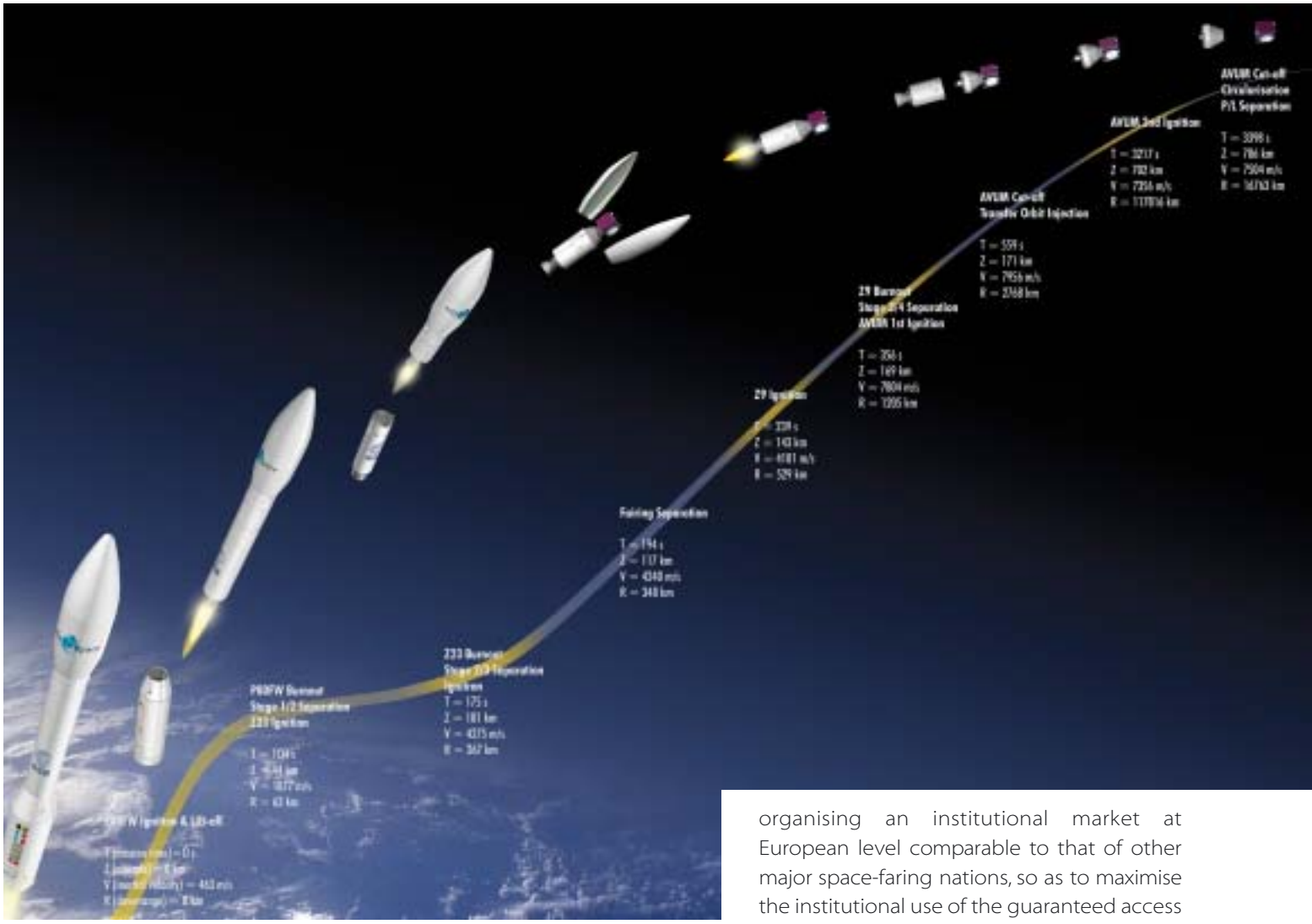
Ariane-5 ESC-B and Vinci

In line with the Recovery Plan, the span of these activities has been reduced as efforts concentrated on the Ariane-5 ECA launcher's qualification. Given the nature of the new technologies involved in the Vinci engine, which has been designed using the more efficient 'expander cycle', it was decided to advance its development through the integration of the first M-1 development motor and the performance of a short series of hot firing tests in the newly established P4.1 DLR test-facilities in Lampoldshausen, accumulating some 60 seconds of firing time in 2004.

Ariane-5 ARTA

It was a busy year for the ARTA programme, with the qualification efforts for restarting Ariane-5 GS production, qualification of the Vulcain-1 GS nozzle modifications, the ARTA-3 booster firing test, anomaly resolution, and the qualification of production transfer. A major achievement was the successful test-firing of the MPS ARTA-3 booster on 9 November. This test was of particular importance for the next batch of Ariane-5 launchers in PA configuration to fly in 2006, which includes cost-reduction and performance-improvement modifications.

The successful ARTA-3 booster firing test at CSG on 9 November



The Vega launch sequence

EGAS Ariane Programme

Following the Resolution on the Restructuring of the Ariane Launcher Sector adopted by the Ministerial Council on 27 May 2003, on 4 February 2004 the Potential Participants finalised the EGAS Ariane Programme Declaration and Implementing Rules. The latter were adopted by the ESA Council on the same day.

The main objective of the EGAS Ariane Programme is twofold:

- *to provide Europe with guaranteed access to space,* by securing the capability of providing reliable launch services for at least six launches per year, over a reference period of five years starting from completion of the current batch of P2.1 launches;
- *to foster the creation of a European institutional market for the Ariane launcher,* pending the setting-up of a legal framework organising an institutional market at European level comparable to that of other major space-faring nations, so as to maximise the institutional use of the guaranteed access to space.

The EGAS Ariane contract between ESA and Arianespace was signed on 9 March. In line with the terms of the EGAS Ariane Programme Declaration, audit actions have been initiated with a view to automatically determining the initial contribution scale that will be used in the course of the programme. A final automatic adjustment of contributions will be performed upon completion of PA-batch production.

Vega and P80

The Launcher System Design Review, which took place from May to July, involved the participation of independent reviewers from ESA, CNES and other European organisations. It identified a number of important points for remedial action and agreed the way forward on all of them. A check on the status of all of these actions was held in December.

By the end of 2004, all but one of the main launcher development subcontracts had been finalised by ELV, the Vega prime contractor. All of the subsystem Preliminary Design Reviews had been held, and some items had already reached the Critical Design Review stage. The year also saw the manufacture and testing of the filament-wound cases for all of Vega's solid-propellant motors, including a first P80 technological model. The lessons learned with these prototypes have been introduced into the next models, manufacture of which started before the end of the year.

The P80 Inert Loading Model verification took place at CSG, with casting and compatibility tests with the Ariane SRM firing test-stand (BEAP). During the year, this test stand was modified (in synergy with other modifications necessary for the ARTA programme) to interface with the Vega first stage in time for its two planned firing tests.

The ground segment reached an important milestone with a contract proposal discussed at the ESA Industrial Policy Committee in June. The development contract for the Vega ground segment was awarded to Vitrociset (I) as prime contractor, leading a consortium of European companies responsible for the four main work packages for the new facility (covering civil engineering, mechanical engineering, fluids and general means, and the control bench). In July, the consortium was awarded an Authorisation to Proceed, and on 20 October the work site was opened at CSG. By the end of 2004, the first Industrial Preliminary Design Review had started.

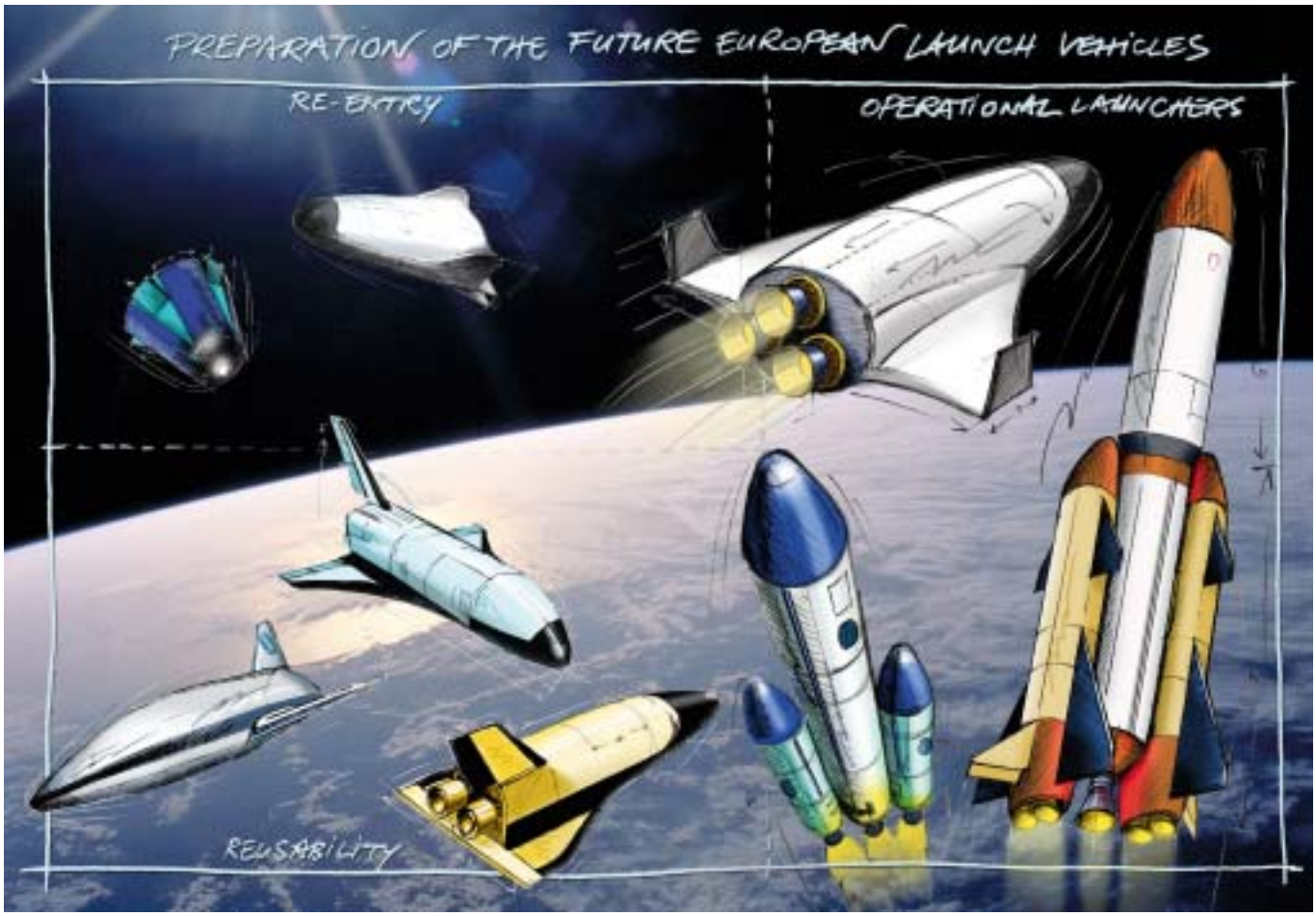
Soyuz at Europe's Spaceport

The Declaration on the Soyuz at CSG Programme was drawn up by the Participating States on 4 February, and negotiations during the year on the Launcher Agreement between ESA and the Russian Federal Space Agency further paved the way for the exploitation of the Soyuz launcher from Europe's spaceport.

The Participating ESA Member States have committed to contribute to this project and Arianespace has accepted to provide a contribution of the order of one-third of the overall programme costs, via a loan from the European Investment Bank guaranteed by the French Government. In compensation, ESA has granted Arianespace exclusive exploitation rights for ten years to the infrastructure to be constructed within the scope of the programme. Further steps were made towards obtaining complementary funding from the European Union equivalent to 10% of the ESA programme's financial envelope, as preliminarily envisaged.

Artist's impression of a Soyuz launch from Kourou (D. Ducros)

Excavation work was initiated in April, taking advantage of a weak rainy season in French Guiana in order to avoid stretching the already tight schedule. During the second quarter, agreement was reached on the final configuration of the launch zone between the different parties involved (ESA, CNES, Arianespace and Roskosmos). Following the



Artist's impression of some current FLPP concepts

concerns expressed by the Russian partners regarding the launcher acoustic environment and optimisation of the facility's exploitation by Arianespace, a new configuration with a mobile gantry was finally selected, thereby harmonising the upper-composite integration methods at the different launch pads (Ariane, Soyuz and Vega). The 53 m-high mobile gantry, weighing an estimated 1200 tons, will be moved back 60 m from the launch pad prior to the actual lift-off.

Due to the complexities inherent in the programme, ESA had to delay any contractual commitment until both the financial and overall programmatic situations had reached a satisfactory level of consolidation. This stage was reached at the beginning of December, and the ESA Council gave the Programme the necessary approval to proceed at its December meeting.

The Future Launchers Preparatory Programme

The Future Launchers Preparatory Programme (FLPP) was agreed upon and subscribed to in February, with the aim of preparing the development of the Next Generation Launcher (NGL), to be operational from around 2020 onwards. The major objective for the coming two years will be the assessment of the value of reusability from the standpoints of launcher affordability and robustness.

Activities in 2004 focused mainly on the initiation of industrial activities and the necessary internal pre-conditions. Preliminary contractual coverage of the industrial prime contractor for system studies and the preparation of the in-flight experimentation was in place before the end of the year. The prime contractor for all NGL activities will be a new company, NGL Co., set up jointly by EADS and Finmeccanica and based in Turin, Italy.

At the inception of the FLPP programme, a number of cooperative activities in the RLV (Reusable Launch Vehicle) field have been identified, especially with Russia. The negotiation during 2004 and subsequent signature of the Launcher Agreement between ESA and the Russian Federal Space Agency enables this novel type of cooperation in joint developments in the field of future launchers

and related preparatory activities to be embarked upon. Negotiation of the Implementing Arrangement between ESA and the Russian Space Agency on cooperation in research and technology for future launchers is nearing completion. This Arrangement encompasses the first phase of cooperative preparatory activities to be carried out, without exchange of funds, in the field of reusable liquid engines, reusable liquid stages, and experimental vehicles.

Guiana Space Centre (CSG) - Europe's Spaceport

The anticipated downturn in the launcher market regulated the pace of launch operations at CSG in 2004. The three successful Ariane-5 G+ launches, carrying Rosetta to its Earth-escape trajectory, Anik-F2 to GTO, and Helios-2A to Sun-synchronous orbit, were different in nature but all equally important.

Work on the Vega launch site, formerly occupied by Ariane-1, was officially started on 20 October, paving the way for the first flight of Europe's new small launcher currently scheduled for 2007.

After adoption of the Soyuz at CSG programme in February, activities focussed on the pre-excavation works of deforestation, opening up of stone pits, opening up of access ways and safety studies. Confirmation of programme funding at the end of the year allowed the main excavation work on 35 hectares of land to start.

The internal reorganisation of the CSG structure continued throughout the year. This was a concerted exercise, led by a project team composed of key staff from ESA, CNES/CSG, Arianespace and EADS-ST, in full consultation with their industrial counterparts.

Europe's spaceport in Kourou, French Guiana

Human Spaceflight, Microgravity and Exploration

At year's end, the International Space Station (ISS) was in good shape with a permanent crew of two, and there were no critical hardware or consumables issues. The European elements delivered so far, namely the Data Management System for the Russian Segment (DMS-R) and the Microgravity Science Glovebox, were also performing well. Preparation of the European-provided Automated Transfer Vehicle (ATV-1), of Node 3 and of the ground segment is on schedule, while the development of other elements such as Columbus, the Cupola and the European Robotic Arm (ERA) has been successfully completed.

A total of six flights were made to the ISS during the year, four of which were logistics flights with unmanned Russian Progress vehicles, and two were Soyuz flights used for crew rotation. The first of the Soyuz flights also hosted the 11-day 'DELTA' Dutch Soyuz mission with ESA astronaut André Kuipers (left), who successfully performed experiments in the fields of life sciences, physical sciences, Earth observation, technology and education.

As the US Space Shuttle is the key transportation element for completing ISS assembly, its grounding following the Columbia accident on 1 February 2003 continued to have a major impact on the European part of the ISS programme during 2004. Currently, the Shuttle's return to flight is planned by NASA for May/June 2005.

Furthermore, 2004 was marked by US President George W. Bush's announcement in January of the New US Space Exploration Vision/Policy, several aspects of which are relevant to the ISS programme:

- confirmation that the completion of ISS assembly by 2010 is the first goal, and that the United States will meet its obligations to International Partners
- the plan to retire the Shuttle when ISS assembly has been completed
- provision of commercial cargo transportation
- cancellation of the development of the Orbital Space Plane, which was foreseen as a crew transport vehicle for the ISS, in

favour of the development of a new Crew Exploration Vehicle, planned to be operational in 2014.

In providing an insight into the new Policy, NASA reiterated that the US is fully committed to: meeting the International Partners' ISS utilisation requirements and US crew-rescue obligations, increasing the ISS crew size beyond three as soon as technically possible, completing the ISS assembly and operating the ISS subsequent to assembly completion, and implementing already agreed cooperative research projects. In view of NASA's decision to cancel the Orbital Space Plane, the International Partners agreed to use a second Russian Soyuz capsule, as soon as technically possible, to increase the size of the permanent crew (a crew of six as of January 2009). Final endorsement of the approved ISS technical configuration, and formal endorsement of the advancement in the assembly sequence of the launch of the European laboratory Columbus such that it immediately follows the launch of Node 2, was later obtained at a meeting of the Heads of Agencies in January 2005.

The delays to ISS elements due to the Shuttle's grounding necessitated some re-planning of European development activities to take into account the delayed launches. The ESA utilisation-related activities for the period 2004-2006 have also been adapted and complemented by a package of Interim Utilisation Activities, which are essential for the user community to bridge the gap until the start of Columbus utilisation. Columbus payload development extension activities were also defined and their contractual implementation is in progress. The Columbus payload racks have been returned to their developers until autumn 2005 for further flight-readiness completion, including further enhancement of technical robustness and implementation of upgrades/modifications to satisfy the latest scientific user requirements. The industrial teams will be maintained until Columbus is launched, and in the meantime studies related to the post-Shuttle-retirement era will be performed.

Biolab, the European Physiology Module, the Fluid Science Laboratory and the European Drawer Rack integrated into Columbus

In preparation for the arrival at the ISS next year of the first ATV, named 'Jules Verne', the ISS Expedition-9 Crew successfully performed two 'space walks' to install some associated equipment on the Russian module 'Zvezda'.

Preparations are well underway for an Italian Soyuz Mission known as 'ENEIDE', to be launched on 15 April 2005 with ESA astronaut Roberto Vittori aboard. A long-duration ISS mission for an ESA astronaut is planned for later in 2005.

Space Infrastructure Development

Testing of Columbus has shown that the audible noise level is well below the requirement threshold, making it the ISS's quietest module. The Integrated System Test (of the Columbus module together with its integrated active payload racks: Biolab, European Physiology Modules, Fluid Science Laboratory and European Drawer Rack) was successfully performed during the year, as were the System Validation Tests 1 (Columbus Control Centre and Columbus engineering model), and 2 (Columbus flight model, payload racks, Control Centre, and User Support and Operations Centres). Testing of the first NASA payload rack installed in Columbus, the Human Resource Facility, was completed in October, and the Columbus Qualification Review 2 was successfully concluded in November.

The flight model of the first Automated Transfer Vehicle (ATV-1) being prepared for environmental testing in the ESTEC Test Facilities

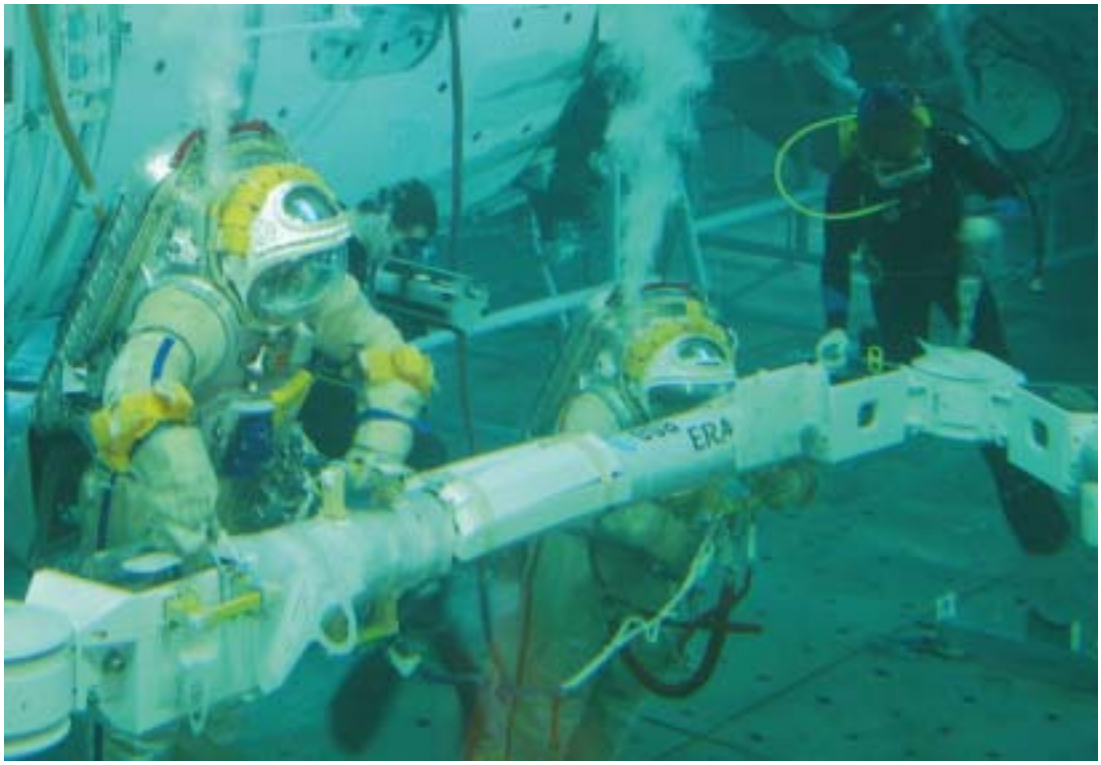
The flight model of the Cupola, which was delivered to NASA/KSC

The ATV-1 Spacecraft Structure Qualification Review and System Validation Tests involving the ATV flight and ground segments and using the Data Relay Satellite System, were also successfully performed. In mid-July, the flight model was delivered to ESTEC in Noordwijk (NL) for extensive environmental testing prior to shipment to Europe's Spaceport in French Guiana for launch. The first mating of the flight model and the first part of the environmental test campaign were successfully completed, and functional testing continues. Development of the very complex Flight Application Software and the adaptation of Ariane-5 necessary to launch the ATV are ongoing.

During the year the management of the Nodes programme, which had previously been delegated to ASI (I), was transferred to ESA by mutual agreement. An updated technical baseline, an updated schedule (for delivery in late 2006), and a joint ESA/NASA management approach for the future implementation of the remainder of the Nodes 2/3 project was established with NASA and industry. In the meantime, the external structure of Node 3 has been completed and the post-proof Non-Destructive Inspection successfully performed. The overall integrated leak test on Node 2 was successfully performed in the vacuum chamber at NASA's Kennedy Space Center (KSC).

Development of the Cupola was completed in September, and the flight unit was delivered to KSC, where the post-shipment incoming inspection was successfully performed.

A new mission scenario for the European Robotic Arm (ERA) has been established, whereby it will be launched in late-2007 by a Russian Proton rocket together with the Russian Multipurpose Laboratory Module, which will act as its 'home base'. The ERA development activities were completed and its ownership transferred to ESA in November; some design adaptations and re-qualifications will be needed, as well as modifications to the



An underwater test on the ERA Weightless Environmental Test Model, in progress at the Gagarin Cosmonaut Training Centre near Moscow

operations planning and training scenarios, to fit with the new plan.

Operations, and Related Ground Segments

The highly successful DELTA mission was launched, with ESA astronaut André Kuipers serving as flight engineer, on 19 April from the Baikonur Cosmodrome in Kazakhstan. It concluded with a successful landing on 30 April near the town of Arkalyk, also in Kazakhstan. The 11-day mission, which included nine days on the ISS, achieved all of the major objectives set for it: the intense experiment programme was successfully carried out, the ISS Expedition-8 crew was exchanged, and the Soyuz spacecraft, which had served for six months as the crew lifeboat, was replaced.

During the DELTA mission, Kuipers carried out one of the most extensive experiment programmes ever undertaken by a European astronaut onboard the ISS, conducting a total of 21 experiments in the fields of human physiology, biology, microbiology, physical science, Earth observation, education and technology. There were also numerous contacts with the media in The Netherlands and other countries during his stay onboard.

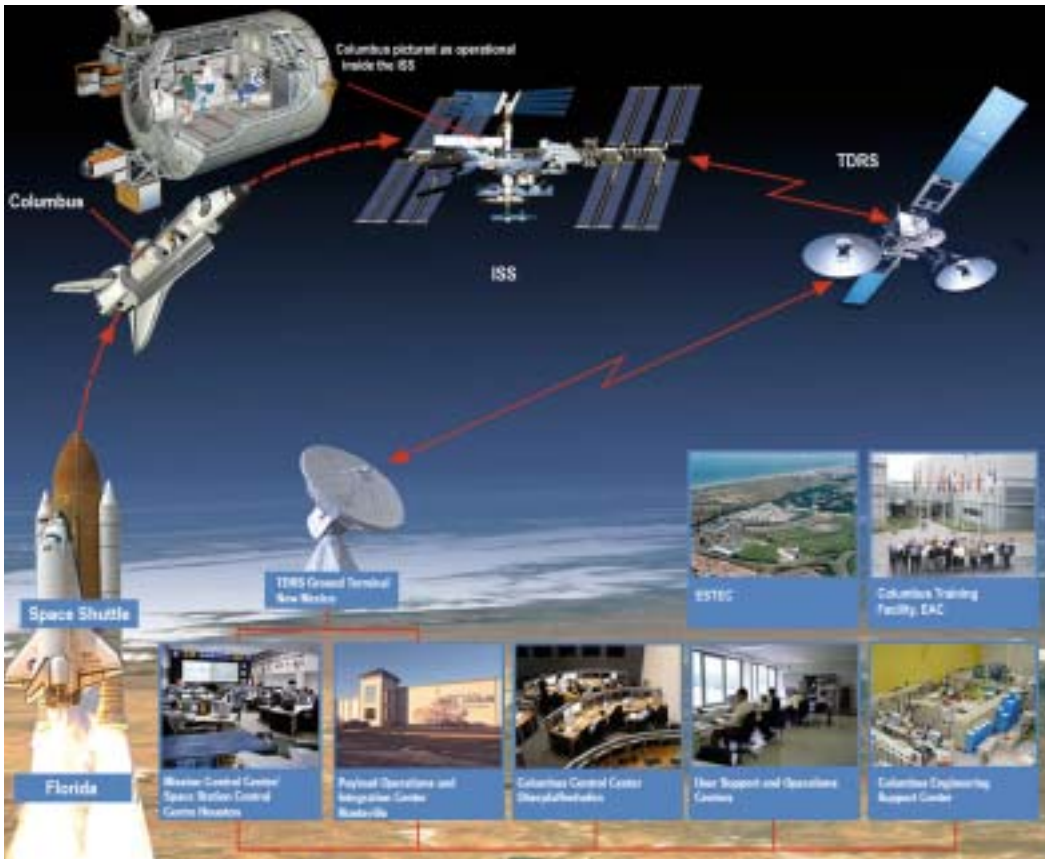
Real-time operations during the Dutch Soyuz mission were coordinated from the DELTA Payload Operations Centre at ESTEC in Noordwijk (NL), which acted as an interface

The Automated Transfer Vehicle Control Centre in Toulouse (F) during a System Validation Test

between Kuipers, the Dutch Investigator Support Room and the Control Centres in Moscow, Houston and Huntsville. The European Astronaut Centre (EAC) near Cologne (D) was responsible for the ESA astronaut's medical support and crew safety.

The human upper-body radiation phantom 'Matroshka', mounted on the Russian Service Module during an EVA at the end of February, is performing as expected with on-orbit science operations proceeding satisfactorily.

System Validation Tests, including end-to-end tests with the NASA Tracking and Data Relay Satellite System, and involving the ATV Control Centre (ATV-CC) in Toulouse (F), were successfully performed. The ATV-CC infrastructure is currently nearing completion and the operations products are in preparation. The ATV Flight Operations Readiness Review was successfully held in September. The first



The Columbus mission scenario

Experimenters at work during the 37th Parabolic Flight Campaign in June

interface tests between the ATV-CC and the Houston Mission Control Centre, and between the ATV-CC and the Russian Service Module Simulator, have been conducted successfully.

The Columbus Control Centre (COL-CC) was inaugurated on 19 October, signifying its readiness to support mission preparation. During the year, significant progress was made in preparing the COL-CC to support the Interim Utilisation Activities, the 'Jules Verne' ATV mission, and the Italian Soyuz mission. The COL-CC will in fact control and command the European science experiments during the ENEIDE mission.

Work on preparing the User Support and Operations Centres is progressing well, with all USOCs being outfitted with ESA-furnished communications, data-processing, archiving, voice and video equipment.

Signature of the Initial Exploitation Contract, involving a total of around one billion Euros and covering the production of six ATVs, logistics and sustaining engineering, ATV crew training and operations-preparation activities, took place on 13 July.

Utilisation Planning, Payload Development and Preparatory Missions

Additional experiment drops have been performed within the Interim Utilisation activities. December saw the inauguration of a new catapult system at the ZARM Drop Tower in Germany, which allows vertical rise-and-fall trajectories to be performed, thereby almost doubling the free-fall time.

During the 36th, 37th and 38th ESA Parabolic Flight Campaigns, which took place in March, June and October, respectively, a total of 36 experiments were performed. 30 experiments were also conducted during the 7th ESA Student Parabolic-Flight Campaign in July.

Development was completed of the 400 kg payload complement (15 facilities and 38 experiments in the fields of physics, biology, technology and education) for the unmanned Foton-M2 capsule flight scheduled for 30 May 2005. The 315 kg ESA scientific-payload complement for Foton-M3 (14 facilities and 35 experiments), scheduled for launch at the end of 2006, was approved in early November and the necessary development work has already started.

The Maxus-6 sounding-rocket launch from Esrange (S) on 22 November

The Maxus-6 sounding-rocket mission was successfully launched on 22 November from Esrange in Sweden. Carrying eight scientific experiments in biology, fluid physics and materials science, the rocket reached an altitude of 706 km before falling back to Earth, providing 12.5 minutes of microgravity for its scientific payload.

The Pulmonary Function System and the Percutaneous Electrical Muscle Stimulator, to be integrated into NASA's Human Resource Facility-2, have been delivered to NASA and are ready for launch in 2005 on LF-1.

Following a successful Flight Acceptance Review, the flight model of the European Modular Cultivation System (EMCS) was shipped to KSC, where final testing will be completed by March 2005, prior to its launch in an EXPRESS rack on the ULF-1.1 mission to the ISS.

The Portable GloveBox's development (for biology-experiment handling in orbit) is progressing towards its launch with ATV-1, and training- and flight-model deliveries are on schedule.

Testing of the -80°C Freezer MELFI Flight Unit 1 and 2 at KSC was successfully concluded. MELFI FU-1 will also be launched on ULF-1.1.

The European Transport Carrier Final Acceptance Review 1 was completed in December.

All Columbus rack payloads (Biolab, EPM, FSL, EDR) have successfully passed their interface verification tests and have been returned to the developers for verification closeout, further science-driven upgrades, and robustness testing. Biolab, EPM, and FSL have also passed their Flight Acceptance Reviews.

The preliminary acceptance of the engineering model of the Protein Crystallisation Diagnostics Facility took place in December, and the Acceptance Review for the flight model began in November.

Post-shipment activities for the engineering models of the Materials Science Laboratory (MSL) and the Low Gradient Furnace were completed at NASA's Marshall Spaceflight Center.

The first three experiments for EuTEF (an external payload providing accommodation for

Interface testing of the first three experiments to be integrated on the EuTEF flight model

up to nine technology experiments) were integrated on the flight model, and interface testing with Columbus was successfully completed in November.

The acceptance of the three SOLAR (Solar Monitoring Observatory Facility) flight-model instruments is in progress, and interface testing of the SOLAR engineering model with Columbus was successfully completed in December.

The Payload Preliminary Design Review for the Atomic Clock Ensemble in Space (ACES) was successfully closed out and the payload development continued. The Status Evaluation for the Space Hydrogen Maser (SHM) is in progress, and agreement has been reached on the development of the other instrument, PHARAO (laser-controlled atomic clock), up to completion of the engineering model in December 2006.

The Muscle Atrophy Research and Exercise System (MARES) completed its Critical Design Review and the full functionality of its interface with the Percutaneous Electrical Muscle Stimulator was verified.

The first 60-day campaign of Long-Term Bed-Rest Studies on females, being conducted in cooperation with NASA and CNES, is scheduled to start on 22 February 2005.

Dutch and Belgian children who won the 'Zeg Het ISS' competition putting their questions during the live ARISS link with André Kuipers on the ISS

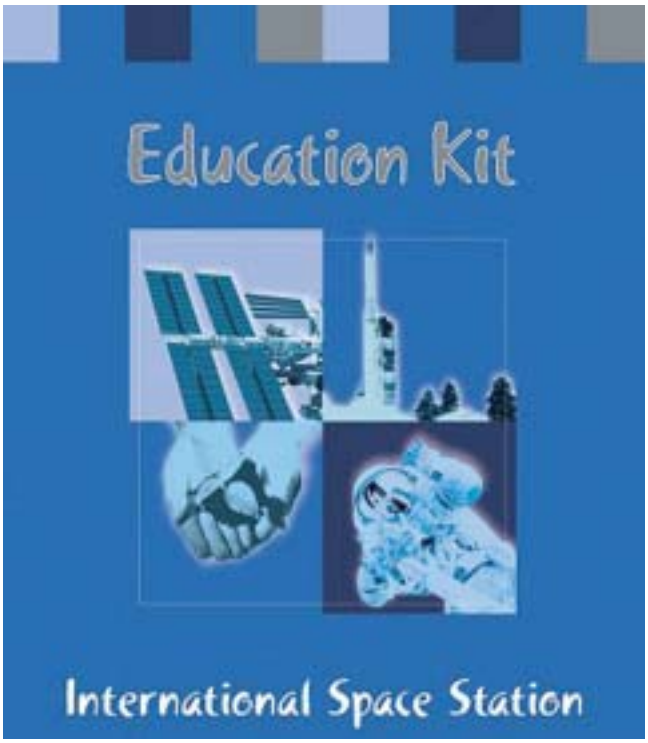
32 Microgravity Application Promotion (MAP) projects are continuing into Phase-2.

In response to the International Life Science Research Announcement (ILSRA2004), around 70 proposals were received, of which 15 have been selected for definition studies; ESA's AO 2004 elicited some 150 proposals, 120 of which have been selected for definition studies..

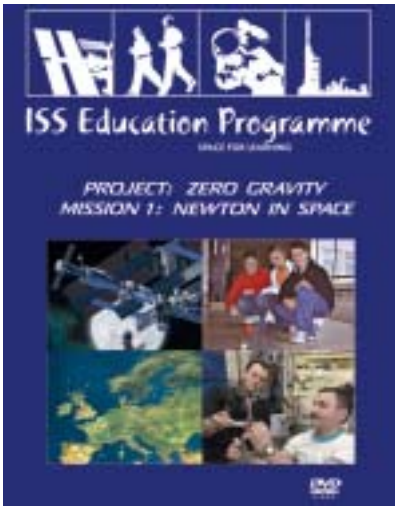
2004 also marked the start of important utilisation projects involving the European Commission (EC). ESA, the World Health Organization, the International Telecommunication Union, and the EC Directorate of Information Society Technologies Programme signed a contract for the TM Alliance Telemedicine project, which officially started on 1 August. The second phase of the project, TeleMedicine Alliance-Bridge, has also been approved by the EC and is proceeding smoothly towards the next phase. 1 November marked the official start of the 41 MEuro IMPRESS Integrated Project, which will investigate the materials processing, structure and properties of new higher-performance inter-metallic alloys for industrial applications.

ISS Education

An education programme including experiments and activities for the full formal school cycle was implemented during the Dutch Soyuz mission. The Dutch and Belgian children who won the 'Zeg Het ISS' competition (project for primary schools) were rewarded with the opportunity to put questions to André Kuipers during an Amateur Radio on the ISS (ARISS) live link. Two such links were set up during the mission. Two university biology experiments were performed, as well as the 'Seeds in Space' experiment, in which 70 000 Dutch pupils took part. An educational demonstration of human physiology, made by filming four basic physiology experiments onboard the ISS, is currently being used, together with experiments shot on the ground at schools in Denmark, France, The Netherlands and Belgium, to prepare a DVD titled 'The Human Body in Space', to be released in 2005.



The secondary-level ISS Education Kit, now available in 11 languages



The educational DVD 'Newton in Space' distributed in September

In September, the EC project 'Life in Space 2004', undertaken in the framework of the ERASMUS/SOCRATES Programme, concluded with a two-week Workshop in Banyuls-sur-Mer (F). The 35 life-sciences students who took part, from five European universities, were introduced to the latest European research in space biology.

In 2004, eight new funding members joined the ISS Education Fund, which continues to support the development of new educational products. Meanwhile, the existing education material, such as the DVD 'Newton in Space' and the secondary-level ISS Education Kit, which is now available in 11 languages, are in great demand.

The didactic content of the new ISS Education Kit for primary schools was assessed by a group of teachers from five ESA Member States at a Workshop in Glasgow (UK). In another Workshop at ESTEC, teachers validated the 'Space Team' web site.

Starting in 2005 for a period of three years, 15 Dutch primary schools will be able to qualify for the title of DELTA Researcher School by developing a lesson plan using human spaceflight to attract pupils aged 10-12 into science and technology. The initiative forms part of the five-year Dutch Space Action Plan, and is a cooperative venture between ESA, NASA and the Dutch Ministry of Education, Culture and Science, as a follow-up to their collaboration in the DELTA Soyuz mission education programme.

The third edition of the SUCCESS contest for university-student experiments to be performed onboard the ISS was launched on 1 December.

Commercial Activities

The MEDIET (Mediterranean Diet) experiment, sponsored by the COOP supermarket chain and conducted onboard the ISS during the Dutch Soyuz mission, attracted extensive media coverage.

The European Health Care Network, aimed at exploiting ESA's expertise, technology, access to research facilities and high-tech image commercially in the healthcare and well-being sectors, was launched in May. Products integrating ESA technologies and know-how, and developed with the support of the Network, will be branded using the new ESA Space Solutions trademark.

Contracts for commercial 'ESA Space Training' and for appointing a Commercial Agent to market the use of the European facilities and resources onboard the ISS, were signed in September. Meanwhile, the ISS Business Club continues to acquire new members.

Exploration

As part of an Agency internal reorganisation, from 1 November activities related to Exploration have been integrated into the newly created Directorate of Human Spaceflight, Microgravity and Exploration.

In line with the goals expressed by ESA's Director General, and renewed interest in exploration worldwide, the Agency has introduced Space Exploration as an inspirational element of the European Space Programme, continuing the activities carried out since 2001 within the Aurora Programme. In late 2004, the Participating States approved a significant increase in the financial envelope for Aurora, with emphasis being placed on conducting a Phase-B1 study of the ExoMars mission, and associated instrument and technology studies, and the development of a European long-term scenario for space exploration. Sweden has joined this optional programme, and the EC has Observer status in accordance with the Framework Agreement.

Following President Bush's announcement of the New US Space Exploration Vision/Policy in January, ESA staff had a number of meetings with their NASA counterparts to understand fully the content of the US programme, to analyse its potential interest to Europe, and to evaluate possible cooperation scenarios.

Whilst Mars remains the long-term goal for the ESA human-exploration activities, lunar-exploration scenarios are also being evaluated as an important intermediate step, and their integration into the overall European roadmap for exploration is in progress. To that end, the industrial mission-study initiatives in the framework of the Aurora Programme – Phase-A of ExoMars, Entry Vehicle Demonstrator feasibility, and Mars Sample-Return mission definition – were completed in 2004, and will be followed up in greater detail in 2005.

A study on Human Lunar Exploration was also performed in the ESA Concurrent Design Facility, which examined mission architectures and common elements for different lunar-exploration objectives, such as Mars technology demonstration and lunar exploration.

Technical and Quality Management

The main tasks in a very busy year included:

- A review of the laboratories, the investment plan, and updating the positioning of and strategy for of the different laboratories and the ESTEC Test Centre, both internally and vis-a-vis industry.
- Defining a strategy for the evolution of concurrent engineering.
- Analysis and redefinition of technology programmes and processes in the Agency.
- Improvement of the Directorate's internal reporting on activities, both on-going and planned.
- Significant achievements in the many technology activities in the various disciplines, some of which are mentioned below.
- Commencement of the Proba-2 project dedicated to in-orbit technology demonstration and the scientific solar-science experiment.
- Renewal of framework contracts for contractor support.
- A review of workforce and recruitment management.
- Re-organisation of the Directorate teams and the creation of a Systems Engineering Support Department.

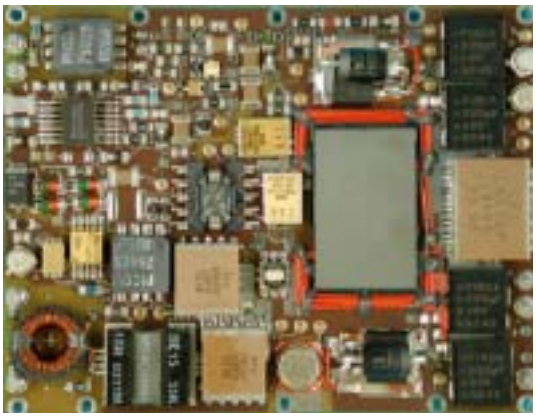
Electrical Engineering

Power Systems

The development of high-efficiency European solar cells has achieved the important milestone of 28% efficiency for 150 micron-thick triple-junction cells, comparable to the worldwide state of the art. In parallel, the development has begun of thinner, 100 micron germanium epi-ready wafers, which are used as substrates for multi-junction solar cells. Their reduced thickness will allow mass savings of the order of 30%.

A 100 micron germanium epi-ready wafer (Courtesy of Umicore)

The number of spacecraft flying European lithium-ion batteries, both small-cell (AEA Technology) and large-cell (SAFT), has continued to increase. ESA's Proba-1 spacecraft has completed three years of operation with such batteries, and the first two Eurostar-platform-based commercial telecommunications missions in the World to use this technology were launched.



Top view of the engineering-model low-voltage converter board (Courtesy of Austrian Aerospace)

Advances in digital payloads require lower voltages (reducing firstly from 5 V to 3.3 V, and later to 1.8 V) for logic circuits to increase their speed. The average load current is also rising sharply, in step with more demanding dynamic requirements. Achieving high efficiency at very low voltages is quite a challenge, and the development of an optimal concept for a standard very-low-voltage converter was pursued for ESA by Austrian Aerospace in 2004. Having selected two promising concepts for prototyping, the best-performing topology was subsequently manufactured as an engineering-model printed- circuit board. Its conversion efficiency of better than 87% in the 18 to 30 W range surpasses the original design objective and the board's thin profile and small area (less than 100 cm^2) make for easier integration.

Development and qualification of a failure-tolerant Power Conditioning Unit (PCU) for Field-Emission Electrical Propulsion (FEEP) with a 0.1 to 150 microNewton thrust range was completed by Galileo Avionica (I) during the year.

Data Systems

Much work was done on streamlining the design and implementation of onboard data systems, following a top-down approach. Particular attention was devoted to reducing onboard cabling through the standardisation of existing interfaces, complementary developments for SpaceWire onboard networks, and the potential integration of optical and RF wireless interconnect solutions.

After a long development phase, the LEON2FT 32-bit processor reached the point of prototype manufacture and will be tested on the Proba-2 satellite in 2006. The LEON2FT (AT697 from Atmel (F)) can handle 100 million instructions per second, while still maintaining compatibility with its ERC32 and ERC32SC predecessors (limited to typically 25 MIPS). Flight components will be produced with support from the European Space Components Initiative.

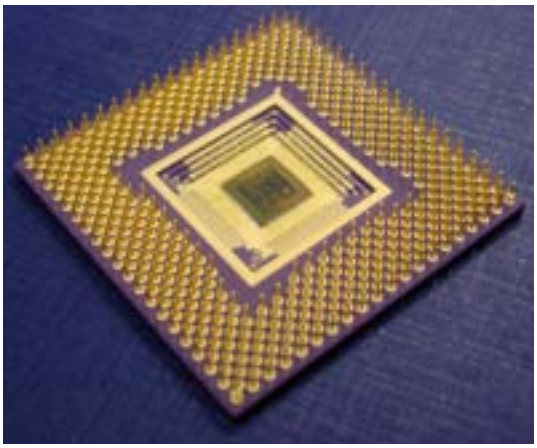
The FEEP Power Conditioning Unit
(Courtesy of Galileo Avionica)

Control Systems

Significant milestones were achieved in the development and validation of cutting-edge guidance, navigation and control (GNC) system technologies to support future ESA missions. They include the breadboarding of an autonomous vision-based camera for planetary soft landing, hardware-in-the-loop testing of a control-moment gyro-based attitude-control system for future agile Earth-observation satellites (e.g. Spectra), in-flight validation of autonomous onboard navigation algorithms for interplanetary missions (SMART-1), and environmental testing of a high-performance inertial sensor to be flown on LISA Pathfinder.

Three new integrated-circuit technologies for space applications, all promoted and co-funded by ESA, became available in 2004. The first Application-Specific Integrated Circuit (ASIC) prototypes developed under the new ESA - Atmel Space Multiproject Wafer Programme were manufactured using the new 0.18 micron radiation-hardened Atmel technology. In addition, the first large telecommunications ASIC manufactured using the new Design Against Radiation Effects (DARE) technology proved to be fully functional and to have excellent radiation hardness. Last but not least, the first European radiation-hard, reprogrammable Field Programmable Gate Array (AT40KEL040 from Atmel) was brought to market.

AOCS sensor technology developments in support of a variety of Science, Earth Observation and Telecommunications missions also made good progress. The miniature 1.5 kg star-tracker unit developed for BepiColombo will be flight-tested on Proba-2 in 2006. Pre-developments have confirmed Active Pixel Sensors (APS) as a promising technology also for future geostationary platforms, cutting costs by at least by 30% compared with CCD-based star trackers. Digital Sun sensors are ready for test flights on GOCE and Proba-2. A novel European magnetometer (Anisotropic Magneto-Resistive technology) is also being manufactured and will flown on ADM-Aeolus in 2007.



The first large (750 kgates, 438 pins @ 105 MHz) telecom ASIC developed using the new DARE technology by Alcatel Space (F) and IMEC (B). The package is just 40 mm x 40 mm

APS-based star tracker (centre) for the Bepi-Colombo mission, shown between a precursor Cassini Stellar Reference Unit (right) and Rosetta's CCD-based Autonomous Star Tracker

Control-moment gyroscope for high-agility Earth Observation satellites

Radio Navigation

Performance assessment for Europe's Galileo navigation system was a major task in 2004. The GSTB-V1 and GSSF tools were deployed in the European Navigation Laboratory at ESTEC, where joint ESA-Industry teams worked closely together to determine the system's end-to-end performance, validate the integrity-computation algorithms, and evaluate the orbit-determination models. Successful completion of these tasks by year's end was instrumental in the preparations and negotiations for Phases-C/D/E1 of the Galileo In-Orbit Validation (IOV) activities kicked-off at the end of December.

The pre-development of Galileo receivers was initiated to help prepare European industry for the technical challenges associated with their development and the fierce competition expected.

2004 also saw the system validation, ground infrastructure deployment and demonstration outside Europe (China, South Africa) of the European Geostationary Navigation Overlay Service (EGNOS). In collaboration with the European Commission, ESA is actively contributing to the development of EGNOS and Galileo applications in the road, rail, maritime and aeronautical sectors.

Communications

During the year ESA completed the acceptance of a comprehensive mobile testbed that allows faithful laboratory emulation of a complete third-generation satellite system based on adaptation of the terrestrial 3G Universal Mobile Telecommunication System (UMTS) standard. Multi-beam satellite constellations, traffic interference and mobile fading channels can be realistically emulated in real time. It also allows over-the-air experimentation and demonstration of S-UMTS services using Artemis's L-band payload. Specific 3G applications, such as location-based services and reliable digital multimedia multicasting, have also been developed, in addition to other interactive applications. The public-service demonstrations that took place in 2004 were supported by ESA's advanced multimedia van.

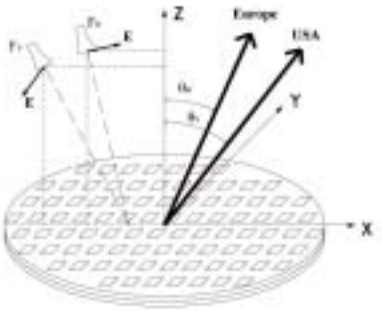
Telemetry, Tracking and Command

Development of the Galileo TT&C transponder is progressing well. It is a key element of the Programme as it will provide secure satellite commanding and control, as well as satellite time synchronisation. Its unique features include multi-mode operation and in-orbit reconfigurability.

The Ka-band Transponder Experiment (KaTE) on SMART-1 in 2004 was the first in-flight demonstration of deep-space telemetry transmission at 32 GHz. Its success means that KaTE is paving the way for future deep-space science missions, the first being BepiColombo.

Electromagnetics and Antennas

As part of the Technological Research Programme (TRP), a three-layer printed 'reflectarray' dual-polarisation antenna, providing different coverages for each polarisation, has been designed, manufactured and tested by Universidad Politécnica de Madrid (E), Lehrstuhl für Leichtbau, TU Munich (D), KRP-Mechatec Engineering, Munich (D) and Alcatel Space, Toulouse (F). The reflectarray can replace a dual-grid-shaped reflector on a telecommunications satellite to generate a



Geometrical features of the patented reflectarray antenna, and its breadboard model. The dimensions of the rectangular printed patches can be adjusted to achieve the required phase shift for each beam at several frequencies in the operating band

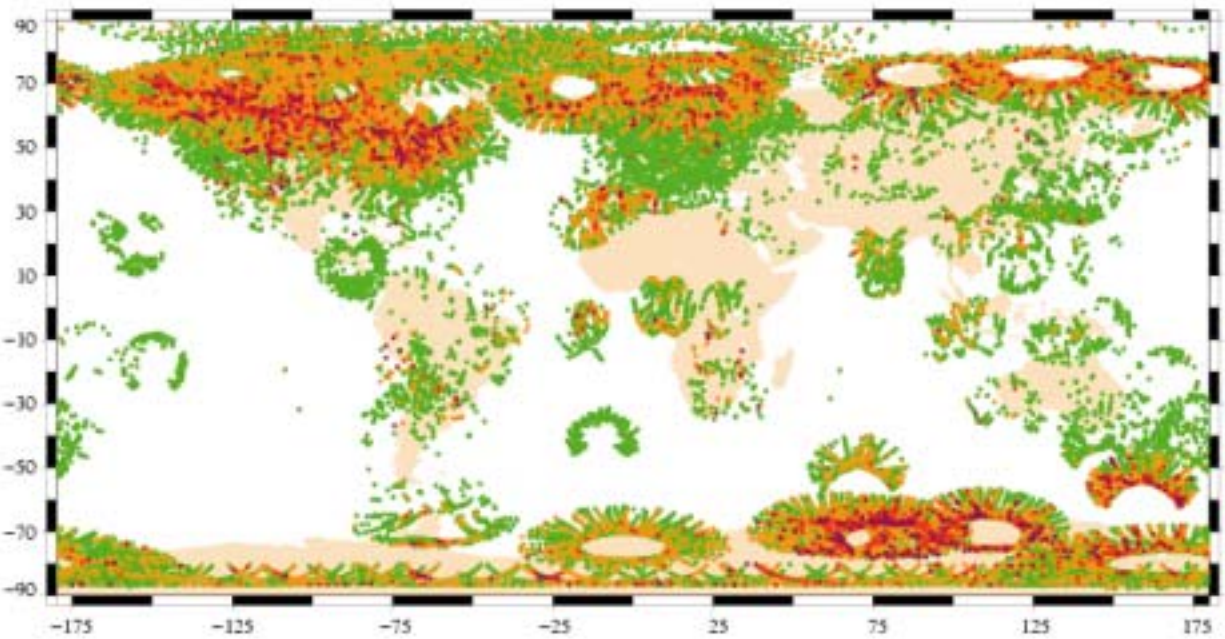
contoured Ku-band beam for Europe in H-polarisation and a pencil beam for the US East Coast in V-polarisation. It also occupies less volume due to its flatness and is some 20% lighter.

Space-Environment Effects

A European network of space-weather services is being developed through the Space Weather Applications Pilot Project, and will be used to assess the benefits of a possible future space-weather programme for Europe. Other European and International space-weather activities in which ESA is collaborating include the COST Action 724 'Developing the Scientific Basis for Monitoring, Modelling and Predicting Space Weather' (EU), the E-STAR Eurocores Programme (ESF), the International Living with a Star End-Users Task Group, and the International Space Environment Service. They came together in 2004 for the first 'European Space-Weather Week', a workshop covering a broad range of science and applications topics and attended by 200 scientists, engineers and industry representatives.

Software Systems

As the coordinator of 29 partners from 11 countries in Europe, ESA was awarded the ASSERT Project (Automated proof-based System and Software Engineering for Real-Time applications) in the context of the European Commission's 6th Framework Programme. A 15 million Euro project in the area of 'embedded systems', ASSERT brings together academic and industrial expertise in Europe to establish a new process for building design-proven computer systems.



Space Weather Applications Pilot Project estimation of the scintillation index for a given day, which allows prediction of the effects of space-weather-induced changes to the Earth's external magnetic field on, for example, GPS signal quality

The latest version of the Simulator Handling Module, SHAM6

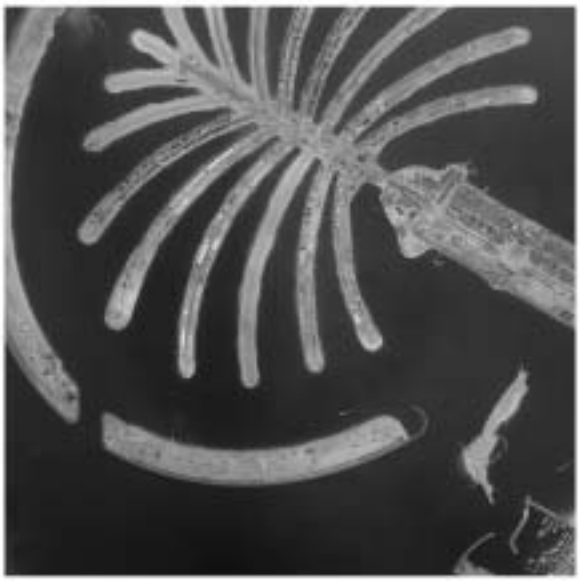
Low-cost Software Validation Facilities (SVF) containing a hardware-in-the loop emulator have been developed to support the validation of onboard software for the microprocessors used on ESA spacecraft. The latest in the series, the SHAM6, is a revolutionary and compact design that allows the processor emulator to be installed in a standard workstation.

In-Orbit Technology Projects

The Proba-1 mission has completed three years in orbit with all subsystems still in good health. All of the mission's technology-demonstration activities have been successfully completed, including the demonstration of Earth-observation manoeuvres using only the attitude provided by the star tracker. The imaging success rate proved that it was a viable solution in terms of both performance (rates up to 1 deg/s) and availability (no specific area where the number of stars would be insufficient). Also, Proba-1's lithium-ion battery, which is based on commercially available cells, has now achieved 17 000 cycles without significant degradation in performance. The Earth Environment instruments – SREM and MRM for radiation measurements and DEBIE for debris monitoring – have also been working extremely well. With the dedicated ground segment at ESA's Redu (B) station also performing nominally, the mission has been extended for another year.

The follow-on Proba-2 micro-satellite mission, to be launched at the end of 2006, entered its main development phase (Phase-C/D) in 2004. It will demonstrate new propulsion, battery, star- and Sun-sensor technologies, and its payload complement also includes plasma measurement instruments, a UV Sun imager and a radiometer.

Two images of Dubai taken by the Proba-1 imaging spectrometer with motion compensation (colour image) and the miniature telescope (black and white) with point-and-stare manoeuvring

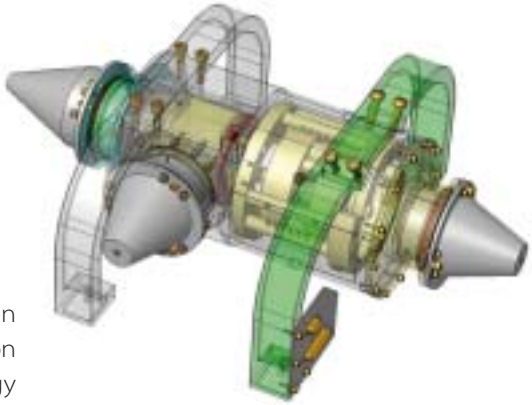


Mechanical Engineering

Mechatronics and Optics

Engineering expertise in these areas was again in high demand to support advanced mission studies, ongoing projects, technology developments and external customers. Intense optical-engineering effort was directed towards the scientific missions, with the testing of the Planck reflectors at cryogenic temperatures and infrared wavelengths, the evaluation of sintered ceramic mirror materials for the James-Webb Space Telescope, and the assessment of ultra-stable optical benches for Gaia and LISA. Accompanying technology developments included the realisation of a monolithic ultra-stable glass interferometer for the LISA Pathfinder mission, the development of a tunable, high-resolution optical filter for advanced Lidar instruments, and the fabrication of single-mode optical fibres for mid-infrared light guides for Darwin, which represented a 'World first' technology breakthrough.

Many external customers called upon ESA's optical communication expertise for help, in particular Germany's DLR and Japan's JAXA for their TerraSAR-X and OICETS laser-communications projects, respectively. Early studies were also initiated on security-relevant space technologies, such as dual-use optical communication systems and quantum-optical encryption for secure communications.

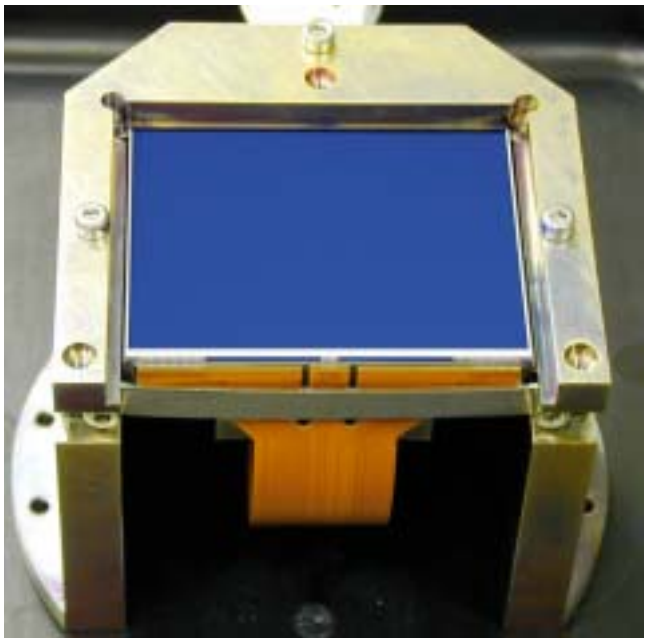


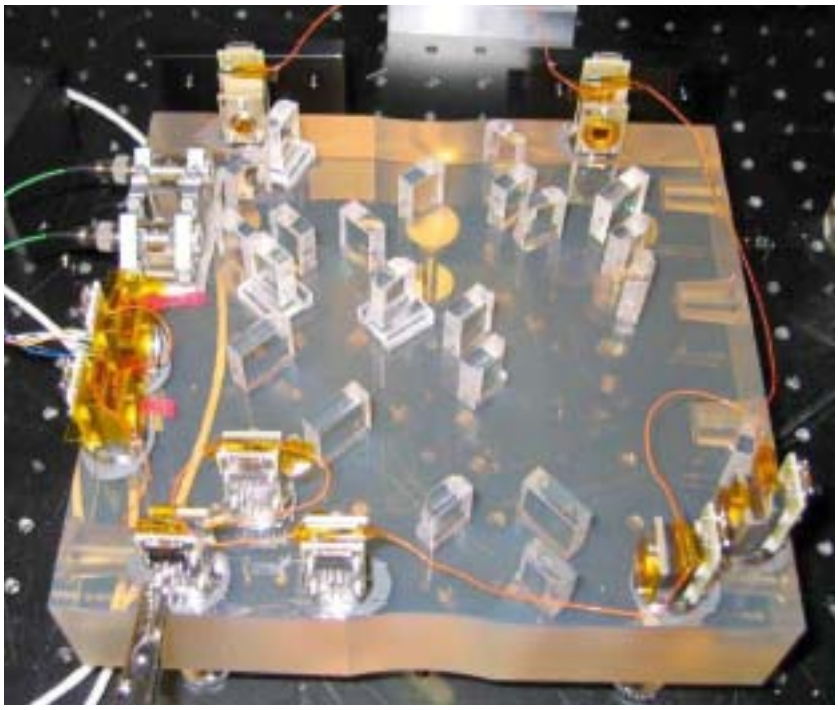
High-resolution optical filter for narrow-bandwidth filtering of light in Lidar applications, based on a capacitance-stabilised Fabry-Pérot etalon

Related efforts in the opto-electronics area included the realisation of a full-size, back-illuminated Charged-Coupled Detector (CCD) demonstrator for the demanding Gaia mission, which requires maximum efficiency to detect faint stars whilst still being able to handle very bright objects.

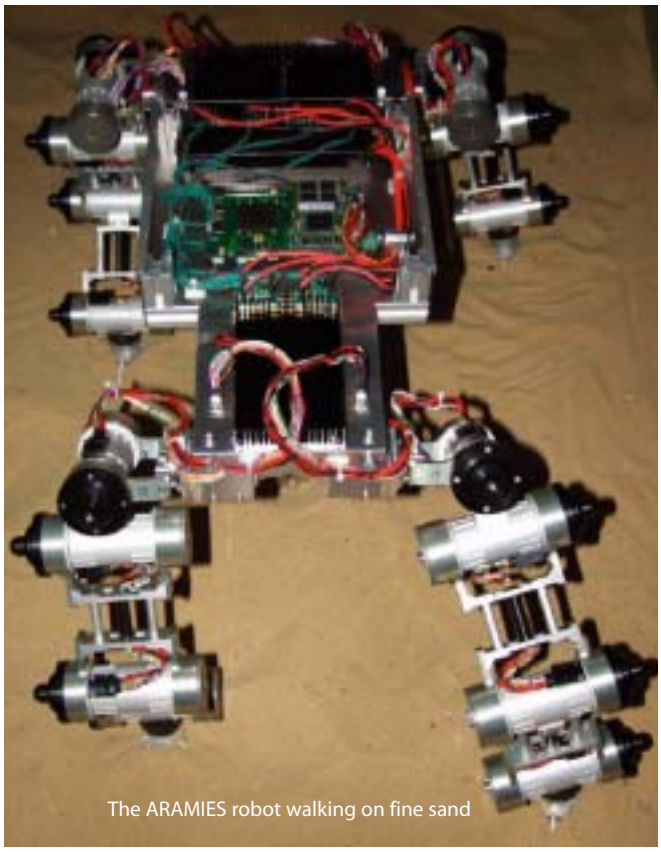
Activities in the robotics field concentrated on advanced elements for future science and exploration missions, including navigation systems for aerobots, advanced locomotion systems for Mars, and micro-probes for Venus. Development of a rover terra-mechanics tool kit was initiated to allow the performances of the ExoMars prototype rovers to be assessed for terrains with different soil conditions and inclinations.

Engineering model of Gaia's ASTRO thinned and back-illuminated CCD

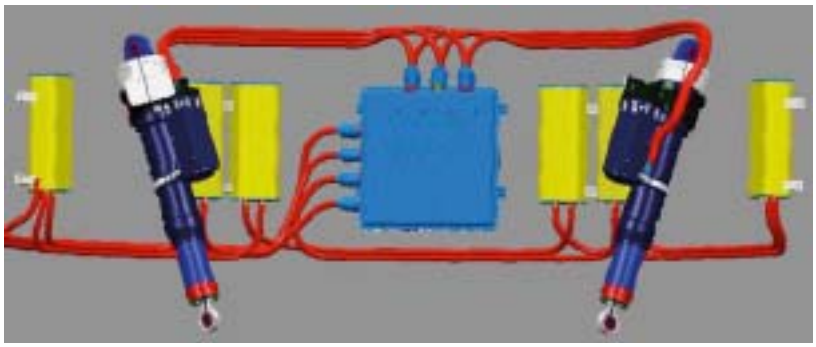




Monolithic, ultra-stable glass interferometer for the LISA Pathfinder mission



The ARAMIES robot walking on fine sand



The multi-purpose integrated motor controller (HBRISC 2) for launcher thrust-vector control

Breadboard model of the SONOS scanning-probe microscope

New activities were initiated in the payload-automation field in support of the Foton-M3 mission, to enable the scientists to interact with their payloads during flight.

Major development efforts in the space-mechanisms domain focused on strategic European products such as solar-array drives, control momentum gyroscopes, antenna-pointing mechanisms and launcher mechanisms. The HBRISC 2 multipurpose integrated motor controller, for example, will be a key component in realising the fully electrical – as opposed to hydraulic – thrust-vector control systems needed for future-generation launchers, including Vega.

The development of a family of analytical tools was further extended with the completion of the SONOS system, a scanning-probe microscope for applications down to the nano-technology scale, with early application potential in the ISS environment and good prospects for use in extraterrestrial invest-igations.

Thermal and Environmental Control

Structures and Pyrotechnics

New technology-demonstrator activities were initiated to support the development of large flexible structures, such as solar arrays, antennas and shields. The feasibility of using piezo-patches to control the alignment, stability and shape of structures was demonstrated, paving the way for their application in future spacecraft instruments.

A lightweight equipment housing made from composites rather than aluminium has been developed and will be used for the first time in Proba-2's data- and power-management system. It provides significant mass savings whilst still meeting the mechanical, thermal, radiation and EMC requirements.

Thermal Control and Life Support

Cryo-cooler R&D activities were initiated in line with the Technology Harmonisation roadmap, and a new vibration-free cooler design for missions such as Darwin has been finalised. An in-orbit demonstration experiment, called

Composite equipment box breadboarded by Verhaert (B), Helsinki University of Technology and Componeering (SF)

The ANITA air-quality monitoring instrument destined for the ISS

'MiniTherm', consisting of miniature two-phase heat transport devices was developed in cooperation with CNES for flight on Foton M2 in 2005.

Cryogenic nitrogen slush has been successfully produced in a test phase, as a first step towards producing hydrogen slush for future launchers.

In the life-support area, due to the very strong interest expressed by NASA's ISS Human Factors Office, ESA's planned 10-day in-orbit technology demonstration of ANITA (Analysing Interferometer for Ambient Air) has been extended to a six-month experimental validation in support of atmosphere monitoring inside the ISS. ANITA will be uploaded to the ISS with the first ATV flight.

Thermal Analysis and Verification

A thermal-analysis model-exchange facility (TASverter) that converts ESARAD and THERMICA thermal models through the open STEP-TAS standard developed by ESA/ESTEC was released and is already being used successfully by industry. ESA co-organised the 6th NASA-ESA Workshop on Product Data Exchange with EADS/Astrium GmbH, and continued its role as Aerospace Industry Coordinator (together with EADS/Airbus) in the EU Thematic Network 'FENET' on the dissemination of engineering-analysis technology. This activity is facilitating the exchange of analysis and modeling knowhow between 110 European engineering entities.

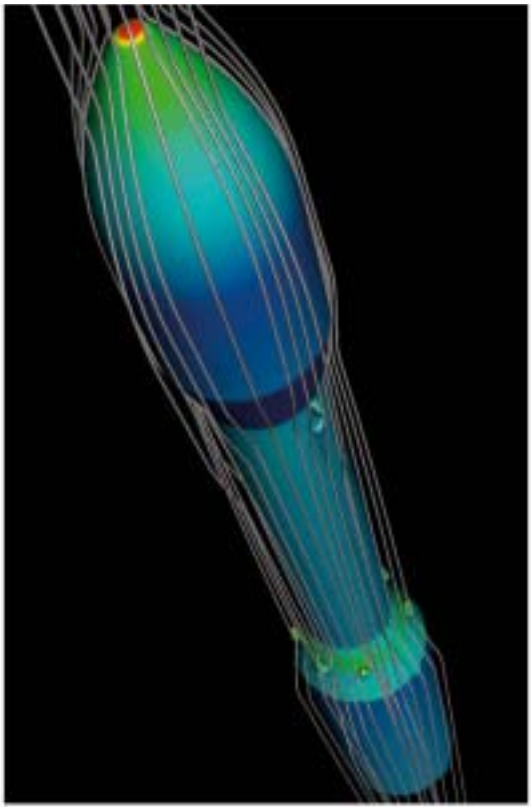
A new cryogenic-cycling facility providing a minimum temperature of less than 10 K was developed by the Mechanical System Laboratory for testing materials for the Planck satellite. The performance of the Multi-Layer Insulation (MLI) for the Venus Express mission was measured at 250°C, and a new MLI test setup was designed to cover the BepiColombo requirement of 350°C. The accreditation of five test methods under ISO 17025 was also successfully completed.

Propulsion and Aerothermodynamics

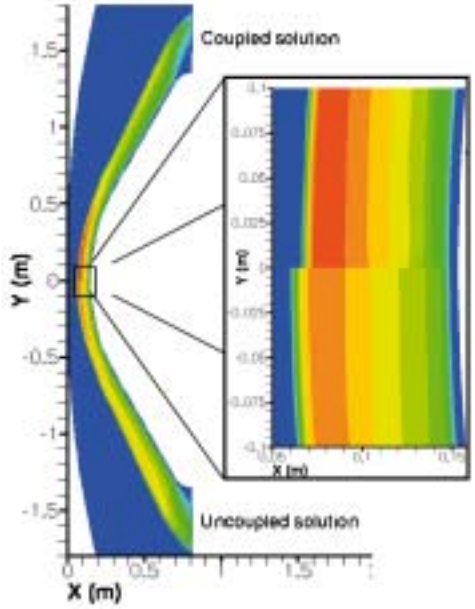
The development and qualification of European ITAR-free chemical-propulsion components and advanced materials progressed. The AlphaBus system development effort addresses the need for higher-performance chemical propulsion for the next generation of telecommunications platforms, whilst also enabling further improvements at component level. Investigation of the replacement of the classical highly toxic liquid propellants with non-toxic 'green' propellants is another ongoing ESA initiative.

The arrival of SMART-1 in lunar orbit at the end of 2004 clearly demonstrated electric propulsion's ability to serve as the primary propulsion system for future interplanetary missions. At Industry's request, a Working Group was formed to exploit SMART-1 experience in terms of performance evaluation, lifetime estimation and assessment of spacecraft/propulsion-system interactions, for future telecommunications missions.

The 5000-hour ion-engine qualification test for the GOCE mission was successfully completed. The AlphaBus project has selected electric-propulsion systems for station-keeping (NSSK) on its telecommunications platforms. ESA is also providing the FEEP (Field Emission Electric Propulsion) micro-thrusters for CNES's Microscope mission, and ESA's LISA-Pathfinder



Simulation of Vega launcher flight at Mach 2: streamlines and surface-pressure modelling computations used to assess the effect of the attitude control system, wiring channel, and retro-motor firings on the vehicle's aerodynamics



Predicted radiative flux emission around the Huygens Probe during its entry into Titan's atmosphere

project is closely monitoring this technology for its own use.

Turning to aerothermodynamics, support for Ariane-5 focused on numerical and experimental modelling of the first-stage engine's interaction with the ambient base flow. Support for Vega concentrated on the prediction of external pressure loadings for a variety of flight conditions, including the effect of the attitude control system, wiring channel, and retro-motor firings on the launch vehicle's aerodynamics.

The effects of engine and thruster plume impingement were also analysed numerically for the Aeolus, CryoSat and SMART-1 spacecraft.

In the re-entry domain, the aerothermal environment of the Huygens Probe was assessed to support the final phase of the mission during its entry into Titan's atmosphere. Such evaluations are benefitting from recent advances at ESTEC and other European laboratories in the study of non-equilibrium plasma radiation.

Development of flight experiments is being pursued with two vehicles, the Inflatable Reentry and Descent Technology Demonstrator (IRDT) and the European Exerimental Re-entry Testbed (EXPERT). The IRDT is a probe protected by an inflatable shield during re-entry. EXPERT is an Earth re-entry capsule being developed to gather flight data on critical aerothermodynamic phenomena by means of several scientific payloads onboard.

Concurrent Engineering

Concurrent Engineering (CE) methods and tools were applied to an even wider range of applications in 2004 in support of various Directorates. Efficiency measurements on the Concurrent Design Facility's (CDF) conceptual studies indicated savings of at least 75% in time and 50% in cost compared to other approaches.

The CDF provided effective multidisciplinary support to many Programmes, including Aurora, Science, Human Spaceflight, Microgravity, General Studies and Launchers. Several potential future missions were also studied and designed at conceptual level: Lunar Exploration, Mars Demo Lander, Solar Orbiter, X-Ray Evolving Universe Spectrometer (XEUS), and Near-Earth Objects. The CDF also hosted several reviews of industrial design work and preparations for the next industrial phases of such projects as ExoMars, Mars Sample Return, and Human Missions to Mars.

The models and tools developed and used by

the CDF are being shared with ESA's institutional partners, and activities initiated to encourage their wider application. The Concurrent Engineering Team also helped several other organizations during the year, including CNES and ASI, to implement similar design facilities of their own. The CDF also played an active role in ESA's Education and Technology-Transfer initiatives by hosting several studies and reviews, presentations and workshops.

A CDF Study Report on the definition and design of a Low Resource Radar for a mission to Jupiter's moon Europa (ELRR)

More than one hundred participants from space agencies, industry and academia attended the first 'Concurrent Engineering for Space' Workshop held at ESTEC. The two-day programme contributed to the sharing of CE experience and know-how with other European and international partners. The Workshop highlighted the wide interest in the CE approach and confirmed the CDF as a centre of excellence in Europe.

Product Assurance and Safety

European Component Initiative

Global trends in the Electrical, Electronic and Electromechanical (EEE) components industry over the past decade have resulted in critical dependence of the European space user community on non-European component manufacturers and products, which are often the subject of export controls. A dedicated programme known as the 'European Component Initiative (ECI)' has therefore been put in place to ensure the timely and unrestricted availability of enabling, space-qualified components for European projects, and to improve the global competitive position of the European space industry. Supported by national space agencies, in its first phase ECI will provide new European manufacturing capabilities for a range of radiation-hardened, space-qualified components such as power MOSFETs (Metal Oxide Semiconductor Field-Effect Transistors), low-power digital devices, FPGAs (Field-Programmable Gate Arrays), memories and high-performance micro-processors.

Russian and ESA engineers working in the CDF on 'Human Missions to Mars'

EEE Components

The Components Division supported the ESA projects and the European space community in the areas of EEE component evaluation and qualification, and the resolution of reliability and application problems experienced in the field. Tantalum capacitors, for example, may constitute a reliability hazard under certain conditions, and are the subject both of a systematic test evaluation activity and an ESA Alert prescribing corrective actions. Working closely with the national agencies, industry and academia, component and technology needs were updated to reflect changing requirements and industrial conditions to ensure their timely availability for inclusion in the next generation of European equipment and missions. The focus remained on mission-critical technology and component developments such as the radiation-hardened submicron and deep-submicron silicon technologies, wide-band-gap semiconductors, Micro-Electro-Mechanical Systems (MEMS) and nano technologies, as well as three-dimensional packaging concepts.

Particular efforts were also directed at the continued provision and enhancement of ESCIES, the European space-component community's on-line information system (https://escies.org). Now in its fourth year of

operation, it has become the major European space-component data repository.

Materials and Processes

The growing number of activities carried out in the Materials and Processes Laboratory confirmed the importance of having a fast-reaction capability to support ESA's Programmes as well as European industry. The laboratory supported several failure investigations during the year, not least for the future scientific missions. Venus Express posed one of the major challenges due to its short development schedule, and imminent launch in October 2005.

In addition to the qualification to ECSS Standards of printed-circuit-board manufacturers as in previous years, the qualification of surface-mount-technology lines was also pursued. Two of the Standards published in 2004 are already highly valued by industry: ECSS-Q-70-71 on 'Data for selection of space materials and processes', and ECSS-Q-70B on 'Materials, mechanical parts and processes'.

Some 300 material-analysis and technical-assessment reports were published in 2004, on subjects ranging from outgassing and contamination analyses, thermo-mechanical characterisation, inspection of small surface-mount devices, to large cold plates for the Columbus laboratory.

A growing part of the Materials and Processes Division's workload results from so-called 'third-party activities' in support of ESA's industrial partners. Twenty-six contracts were placed by industry with ESA for such services as dynamic outgassing tests, environmental exposure to ultraviolet radiation or atomic oxygen, thermal-cycle testing, and examinations using the laboratory's C-mode scanning acoustic microscope. The laboratory also cooperated with industrial and research facilities in the development and performance characterisation of advanced materials and processes in such high-potential areas as nano-structured, self-healing and hybrid materials, and new joining and manufacturing processes.

European Cooperation for Space Standardization (ECSS)

The ECSS recognises that industry needs to deliver quality products and services to its customers in an efficient and cost-effective manner. This requires stable, qualified processes that can be operated with the minimum of variation to meet all customer requirements. ECSS Standards are therefore developed according to strict rules to ensure that they are both transparent and fair.

The good progress of ECSS Standards and the growing awareness of them in the project teams had led to a sharp increase in their use. This was reinforced by the publication in March of a new Administrative Instruction titled 'Application of ESA Approved Standards', to clarify the Agency's implementation of the ECSS and other ESA approved standards. It stipulates that the related documents shall serve as a common reference for formulating contractually binding requirements on suppliers, together with the programme/project-specific requirements.

Altogether work has progressed on 142 standards (not including revisions and document requirements definitions), which are either already published, under review or in the drafting stage (see table).

In addition, 46 ECSS standards were approved as European Standards (ENs) and three as International (ISO) Standards.

	Engineering (ECSS-E Series)	Management (ECSS-M Series)	Product Assurance (ECSS-Q Series)
Published	27	11	42
Under review	14	1	13
Drafting	36	3	10
TOTAL	77	15	65

Technology

The Technology Programme Themes: translating a vision into technology activities

Basic Technology Research Programme (TRP)

The release of the ESA strategic document 'Agenda 2007' in October 2003, shortly before completion of the TRP and GSTP preparation cycle, triggered the need to assess its impact on the activities selected, and eventually align the plans accordingly. The challenge consisted of ensuring fulfilment of the long-term strategic needs without disrupting the vital stream of continuous R&D funding to industry and research laboratories. That led to an approach that succeeded in producing a yearly work plan for 2004, which was presented at the January meeting of ESA's Industrial Policy Committee (IPC).

A next stage would arise with the presentation to the June ESA Council of the Director General's proposal for new initiatives: three new optional development programmes for Earth observation (GMES), space telecommunications (Digital Divide) and space exploration (Aurora). These programmes entailed the urgent development of enabling technologies, and the TRP was therefore directed to participate in the funding.

General Support Technology Programme (GSTP)

The General Support Technology Programme (GSTP) saw further consolidation in 2004 of its role as a key element in ESA's day-to-day work. The GSTP indeed supports not only the pre-development and qualification of space technologies required by ESA missions, but also the competitiveness of European Industry. The Programme's attractiveness is clearly demonstrated by its financial standing, with the funding envelope for the third phase (GSTP-3) reaching 231 MEuro by the end of 2004, and the first contributions to the next phase (GSTP-4) already amounting to 32 MEuro.

GSTP-4 was successfully initiated in 2004, with a preliminary selection of activities for the period 2004-2006 being drafted in April, in close co-operation with the ESA Technical and Applications Directorates as well as with the national Delegations. Based on this preliminary selection, a GSTP-4 work plan was approved by the IPC in June. Coupled with the programme's Declaration and Implementing Rule updates, the work plan's approval marked the formal launch of the fourth phase of the GSTP.

The European Space Technology Master Plan and the European Space Technology Requirements Document

Technology Harmonisation and Strategy

European Space Technology Requirements Document (Dossier 0)

Dossier 0 is the starting point and a key element of the European space-technology strategy that has been developed by the Agency. It is a valuable instrument for the generation of all space-technology R&D plans, providing the European space community with a complete Europe-wide view of:

- all envisaged missions/activities and their associated top-level technology requirements - 'User Pull'
- the technology requirements related to 'Technology Push'.

The most recent updating of the document in 2004 resulted in a bound version of the Dossier 0 introductory document, and an update to the Dossier 0 Web Application (D0WA) electronic database, accessible via the Internet (http://dossier0.esa.int). The latter contains 176 missions and 1436 technology requirements, approximately 30% of which were amended with the 2004 update.

European Space Technology Master Plan

Endorsed by the Ministerial Council in 2001, the third edition of the European Space Technology Master Plan (ESTMP) was issued in June. Developed in 2002 as an instrument for providing all European stakeholders with a synthesis, overview and analysis of planned European institutional technology activities, the ESTMP has gradually matured into a true Master Plan for space-technology development in Europe. Today, the ESTMP not only provides an overview of technology activities in Europe, it also reflects the results of the harmonisation process, presenting roadmaps harmonised at European level with ESA Member States, the European Commission and Industry. The 2004 edition reflects changes in the political environment, summarises what has been done in terms of technology coordination to comply with the priorities set out in both 'Agenda 2007' and the EC's White Paper on Space, and sets the stage for actions leading to an enlarged coordination, including the definition of the technology component of the European Space Programme.

European Space Technology Harmonisation

The European Space Technology Harmonisation effort, endorsed by the ESA Ministerial Council, was developed to achieve better-coordinated space R&D in Europe, enhancing synergies and reducing technology gaps, to establish a strong technology base as a key to the worldwide competitiveness of European Industry and the success of future space missions. This activity involves all ESA Member States, the European Commission, European Space Industry, and the Agency's Technical and Programme Directorates. Following a pilot phase in 2000 and 2001, the Technology Harmonisation process has now reached maturity, based on two cycles per year, each articulated around mapping and road-map meetings. By the end of 2004, more than 30 technologies had been harmonised, with the participation of more than 700 professionals from 165 European space companies.

The harmonisation process has already produced results. Its advantages in terms of co-ordination at European level, efficiency gains, a focus on strategic and critical technologies, added value for Member States, better understanding of national and industry issues, and a contribution to the restructuring of European Industry are already widely recognised. Today, technology harmonisation is a successful European tool, involving all space players, providing visibility, coordinated planning and concrete actions for technology development. It is strongly supported by all stakeholders and recognised by the EC White Paper as a key instrument for space technology in Europe. The ESA Council, at its 17 June meeting, unanimously approved the recommendations from the FINPOL Council Working Group asking for reinforcement of the technology-harmonisation process and that *"…the recommendations stemming from this process are implemented in ESA programmes and promoted and duly considered by Member States and their industry for introduction into national and commercial programmes".*

Artist's impression of a solar-sail mission

Cooperation with the European Commission on Space Technology

Following the efforts of the EC/ESA Joint Task Force (JTF) Working Group on Technology during 2003, the EC White Paper on Space recognises the role of research and technology development in space, and recommends increasing investments in harmonised and multiple-use space technology according to the European Space Technology Master Plan. With the entry into force in May of the Framework Agreement on cooperation, ESA has been working with the EC on the definition of the European Space Programme. Proposals are being made for an EC contribution to the development of strategic technologies through the definition of an upcoming 7th Framework Programme. They foresee actions on critical technologies to pursue European non-dependence and improved synergies between space and non-space research, with particular emphasis on upstream and multiple-use technologies.

Innovation Triangle Initiative (ITI)

One of ESA's roles is to support the introduction of breakthrough innovations and technologies in the space environment, through the Innovation Triangle Initiative. It is a specific ITI goal to explore technologies or services for space applications *that are not currently being used or exploited in the context of space* and have the potential of being the seeds for significant innovation. Following a successful pilot phase and the IPC's endorsement in 2003, the ITI operational phase was started in 2004 with 1.5 MEuros of funding and the publication of the Announcement of Opportunity (AO) on 16 March (on EMITS). The ITI Web Application was put online the same day at: http://iti.esa.int/. By November, 138 proposals had been received in response to the AO. The 82 proposals evaluated by year's end resulted in 18 approved activities. By the end of the year, the ITI Web Application had 396 registered users, 321 of whom were proposal submitters. The results achieved in the first year of operation, in terms of the number of proposals received, their innovative content, and the quick turnaround, are above initial expectations and have fully validated the Initiative's basic principles.

Solar-Sailing Missions

Solar-sail missions are based on low-thrust photonic propulsion and must therefore make use of technologies developed for large and lightweight structures. The missions will typically be of a scientific nature, either to explore the Sun at high latitudes or to reach the

Running on liquefied petroleum gas (LPG), one of the least polluting fuels, and lubricated with sunflower oil, the IdéeVerte racing car is protected against fire hazards by TTP-sourced space materials

outer planets of the Solar System and beyond. The scientific interest in such missions is growing worldwide and is being reflected through activities also in USA and Japan. ESA has also been following this route since 1999, when the first ground demonstration of a large sail was mastered in cooperation with DLR. 2004 saw the completion of an industrial Phase-B study that laid the foundation for the logical and essential next step: the development, manufacture and in-orbit operation of a deployment demonstrator.

Technology Transfer Programme (TTP)

Since ESA set up its Technology Transfer Programme (TTP) in 1990, it has had considerable success in transferring space technologies to the non-space sectors throughout Europe and Canada, using an international network of technology brokers. The TTP effort involves European governments, industrial companies, SMEs, universities, entrepreneurs and venture capitalists, as well as the European Commission.

The TTP opens new markets for space technologies, provides new possibilities for collaboration, creates new companies and jobs, and offers new sources of income and opportunities for investment. It thus helps to maximise the return on investment in space activities, while aiming at improving the quality of life and well-being of Europe's citizens.

In 2004, the members of the ESA's Technology Transfer Network (TTN) achieved 11 new space spin-offs, with a total value of more than 18 million Euros. The transfer assistance provided induced public funding sources to contribute more than 8.5 million Euros and private investors more than 3 million Euros. Moreover, 29 start-ups and/or entrepreneurs were identified and assessed regarding their potential suitability for being 'incubated'.

European Space Incubator

The European Space Incubator (ESI), established at ESTEC in 2003, gives small start-up companies the means and opportunity to develop technologies and products based on space-developed expertise, in a secure environment

German athlete Wojtek Czyz winning gold in the 100 metres at the Paralympic Games in Athens on 21 September

and with limited risk, and turn them into viable businesses. It is an integral component of ESINET – a network of some 35 incubators throughout Europe with a strong space connection and supported by both ESA and the European Commission. In 2004, ESI received 80 proposals for new start-up companies, 19 of which successfully passed the selection criteria and evaluation boards. Five selection committees sat during the year, resulting in the creation of 15 start-ups.

ESA Health Care Network

The ESA Health Care Network was officially launched early in 2004. Relying on the expertise of the Technology Transfer and Promotion Office, the ISS Utilisation and Promotion and Commercialisation Divisions, and the European Astronaut Centre (EAC), the Network aims to add value to the wellness and healthcare industries in the form of technologies, know-how, access to research facilities and image association. Products developed with the support of the Network will be branded using the new ESA Space Solutions trademark. Five separate projects were initiated with Industry for further development in 2005, with more expected in the near future.

Some Recent Success Stories

The TTP continued its work on transferring space technologies to high-tech automobiles. A prototype racing car with space technologies onboard established a new World record (315 kph) using an engine running not on petrol, but on liquefied petroleum gas (LPG). The prototype draws upon the most innovative technologies, including Ariane thermal wrapping materials for insulating the LPG fuel tank and exhaust system and reducing the risk of gas leaks igniting. The fuel tank itself is made of lightweight titanium, and the driver is protected by automatic fire extinguishers originating from Russian rockets. The car's acceleration, speed and position were logged using EGNOS satellite navigation and tracking devices. Motor racing is one of the best ways of raising public awareness of alternative 'green' fuels that are both more efficient and pollute less. By participating in these activities, the TTP is demonstrating its commitment to sustainable development.

The low-weight, safety and reliability requirements for spacecraft are also being applied elsewhere within the automobile sector thanks to the TTP. Using lightweight carbon space composites for racing cars provides significant reductions in both weight and fuel consumption, and hence a gain in performance. Safety is improved by using thermal insulation for petrol tanks, exhaust pipes and cockpits. The friction and weight of the wheels have also been reduced by using high-performance space bearings originally developed for spacecraft gyroscopes and rocket-engine fuel pumps. Equipping their cars with space technologies in partnership with the TTP enabled Pescarolo Sport to finish fourth in the gruelling Le Mans 24 Hour endurance race. These technologies will ultimately find their way into our mass-produced cars.

At the Paralympic Games in Athens, leading German athlete Wojtek Czyz won three gold medals and set two new World records in the long jump and 200 metres, and a new Paralympic record in the 100 metres. He wore an artificial leg, parts of which were made from high-performance materials developed for space systems, making it both stronger and lighter and less prone to breaking. Two versions of the prosthesis were designed and developed in record time. The first, optimised for the long jump, used carbon-fibre-reinforced plastics to strengthen the weakest part of the prosthesis; the second, for running, used ultra-light, high-strength aluminium. His success illustrates how innovative space technologies can also improve the quality of life for disabled people in our society.

Operations and Infrastructure

The new Directorate of Operations and Infrastructure, established on 1 April, consists of two Departments from the former Directorate of Technical and Operational Support, namely Mission Operations and Ground Systems Engineering, and two from the former Directorate of Administration, namely Site Management and Information Systems. The new Directorate is thereby responsible for the Agency's flight operations and the complete life-cycle systems management of the corresponding ground-segment facilities, and for the Agency's infrastructure facilities.

By mid-2004, the overall process for strategically planning the ESA-wide infrastructure had been defined and the various Customer Advisory Boards could meet for the first time to prepare an Infrastructure Strategic Plan for the period 2005-2009.

Operationally speaking the year was also extremely busy, supporting the scientific operations of Mars-Express, the Rosetta launch, the capture of SMART-1 by the Moon, and the successful separation of the Huygens probe and Cassini spacecraft. An important step towards readiness to support the Venus-Express mission was the installation of the second ESA deep-space antenna at Cebreros in Spain.

The Network of Technical Centres initiative continued in 2004, culminating in a joint unsolicited offer to Galileo Industries for the operation of the In-Orbit Validation satellites.

Ongoing Missions

Rosetta

ESA's comet chaser Rosetta was launched on 2 March on an Ariane-5 vehicle from Kourou in French Guiana. Following a perfect injection onto its interplanetary trajectory, the ESOC Flight Control Team completed the Launch and Early Orbit Phase (LEOP) operations in a record time of 72 hours. Initial commissioning of the spacecraft and its payload was successfully completed on 6 June, including a first deep-space manoeuvre on 10 May that was executed with very high accuracy (within 0.05%).

The second part of the Rosetta Commissioning Phase was successfully completed on 16 October. The Mission Commissioning Results Review was concluded on 3 December with no major discrepancy identified. The first Earth fly-by will occur on 4 March 2005 at a distance of about 1900 km.

Ulysses

The Ulysses encounter with Jupiter in 1992 flipped the spacecraft into a unique out-of-ecliptic orbit over the poles of the Sun. Twelve years later, in February 2004, Ulysses flew past the giant planet again, this time at a much greater distance. The spacecraft continues to provide excellent scientific data, with real-time daily operations conducted by the ESA flight-control team located at the Jet Propulsion Laboratory in Pasadena (USA). The mission is expected to be extended until 2008.

Huygens

On 1 July, Cassini-Huygens was successfully inserted into orbit around Saturn. On 17 December, Cassini completed the probe targeting manoeuvre to put Huygens on course for its landing on Titan. On 25 December, Huygens separated from Cassini and shortly afterwards the latter completed the deflection manoeuvre needed to take it away from the impact trajectory with Titan. Everything was then set for Huygens' entry into Titan's atmosphere and the subsequent descent to its surface on 14 January.

XMM-Newton

On 10 December, XMM-Newton completed five years in orbit. The spacecraft remains in excellent condition and all operations have been problem-free. All spacecraft subsystems are working nominally and all instruments performing well, providing high-quality scientific data. The mission has been extended until March 2008, but there are still sufficient onboard consumables (solar-array power and hydrazine) for operations well beyond that date.

Integral

Integral completed its baseline mission at the end of 2004. Efficient management of spacecraft resources since launch meant that an extension of the mission could be agreed. The overall performance of the ground and space segments has always been significantly above the system performance requirements.

Cluster II

During the second year of the mission-extension phase, all spacecraft subsystems and the vast majority of the 44 instruments were still in excellent condition. All four spacecraft continued to return scientific data on the interaction between solar wind and the Earth's magnetic field and, after 56 manoeuvres, the Cluster inter-spacecraft separation was increased from 200 to 1300 km to focus on phenomena occurring within this range.

The Main Control Room at ESOC

Mars-Express

Mars-Express completed its first year in orbit around the planet in 2004. Mission commissioning combined with early science operations lasted from January to May, and the routine phase commenced in June. About 1000 targets have been observed on Mars, in its atmosphere and on its moon Phobos. 50 Gbytes of science data have been returned through daily use of the New Norcia and NASA Deep Space Network ground stations.

SMART-1

Launched in September 2003, SMART-1 was first injected into a Geostationary Transfer Orbit, out of which it spiralled over a 14-month period before being captured by the Moon on 17 November 2004. This was the first time ever that a spacecraft has been captured by the Moon after three gravitational resonances using low-thrust electrical propulsion. At year's end, the spacecraft was about to commence its scientific lunar mission, with all instruments fully operational.

ERS-2

November 2004 saw ERS-2 complete its fifty thousandth orbit around the Earth. Since the loss of both tape recorders in 2003, the mission's real-time data acquisition network has been progressively expanded to compensate, and the data-transmission periods have been correspondingly increased to nearly 50% per orbit. There is ample fuel available and the power situation, though degrading slowly, could allow many more years of operation.

Envisat

The Envisat mission celebrated its third anniversary in 2004, with both the satellite and its ground facilities at ESOC, Kiruna and Svalbard performing nominally in terms of mission control throughout the year. The scientific data return was significantly increased compared to the beginning of mission by using the Artemis data-relay satellite. A specific series of orbit manoeuvres was carried out by ESOC to support special radar-interferometry operations over the Iranian city of Bam, which had been devastated by an earthquake on 26 December 2003. This novel data provided greater insight into the tectonic-plate movements at the root of the disaster.

Proba-1

This mission, developed to demonstrate autonomous onboard spacecraft operations, continues to be operated from ESA's Redu station, supporting the Earth Observation Programme.

Missions in Preparation

CryoSat

The year saw significant progress in the CryoSat launch preparations, with the ESOC team supporting the preparation and execution of the first three System Validation Tests with the satellite hardware (SVT0, 1a & 1b) and the first AOCS Closed Loop Testbed test. A number of Mission Control System deliveries took place, which means all of the functionality required to support the launch and routine operations is now available.

The Configuration and Integration tests of the Ground Segment Overall Validation were performed, verifying all of the interfaces between the Flight Operations System (FOS) and the external facilities. The first end-to-end tests with the LEOP stations were also performed.

GOCE

An important milestone was achieved with the successful completion of the Ground Segment Design Review. The FOS design is now considered stable. Other important FOS milestones during the year were the installation and testing at ESOC of the first versions of the Mission Control System and Simulator. Specific support is in place for the mission-analysis-related aspects, which are considered particularly tricky due to the extremely low altitude of the satellite's orbit. Preparations for system testing activities were started towards the end of the year.

ADM-Aeolus

The successful completion of the Ground Segment Requirements Review marked an important milestone. Thanks largely to its strong heritage from other Earth-observation missions (CryoSat and GOCE), the Aeolus FOS design was found by the Board to be complete, consistent and realistic. Other important FOS milestones

during the year included the agreement and signature of the FOS Mission Implementation Requirements Document and associated FOS Mission Implementation Plan.

Venus Express

The ground-segment and mission-operations preparation activities could be implemented with very high efficiency and minimum lead time thanks to the heritage from the Rosetta and Mars-Express missions. Two System Validation Tests were successfully completed with the spacecraft flight hardware. The Ground Segment Implementation Review was successfully held on 28 September. An agreement with NASA was obtained for the provision of delta DOR support during the Venus-orbit-insertion phase, and a European delta DOR capability, compatible with DSN, is in preparation and expected to become available by late-2005.

BepiColombo/Solo

Activities at ESOC focussed mainly on the provision of mission-analysis and cost-tradeoff support to the projects.

Herschel / Planck

The operations-preparation activities for Herschel/Planck proceeded according to plan. The Mission Operations Centre Ground Segment Design Review was completed successfully. The On-board Software Management Subsystem was delivered to the Principal-Investigator teams for use during the integration and testing activities. The major industrial procurements for the Mission Control System and the Herschel and Planck Simulator were kicked-off.

LISA Pathfinder

The primary activities were in the field of mission definition based on the use of a 'low-cost' launcher, and compatibility with the use of a 15 metre ground-support antenna during all mission phases. The main ground-segment elements needed to support the mission have been identified and the technical specifications are progressing in parallel with main onboard subsystems technical definition.

Flight Dynamics

The year saw the culmination of several highly critical and complex activities. Firstly, Mars-Express's orbit around the red planet had to be shaped very precisely in accordance with the scientific requirements. Next came the Rosetta launch and the subsequent orbital manoeuvres needed to ensure that the planned gravity-assist manoeuvre (swingby) at the Earth in early 2005 can be achieved with both high precision and minimum fuel consumption. Then there was the first-ever orbit insertion around a Solar System body – the Moon – using only low-thrust solar-electric propulsion. The final critical manoeuvre for SMART-1, lasting about four days, was completed in mid-October, two months earlier than initially planned, once again demonstrating the excellence of the ESOC flight-dynamics team and the performance of the ORATOS (Orbit and Attitude Operations System) infrastructure.

ORATOS simulation of SMART-1 in lunar orbit during the transfer manoeuvre from the initial insertion to the final operational orbit

Space Debris

ESA has continued to make measurements of previously unknown debris populations near the geostationary ring. Operational screening of high-risk conjunctions of the ERS-2 and Envisat orbits with the trackable space-object population resulted in three avoidance

manoeuvres in 2004: one for ERS-2 on 28 March, and two for Envisat on 2 September and 22 October. A feasibility study for a 'European Space Surveillance System' was completed. It outlines concepts and cost frames for an independent system able to detect, track and characterise up to 99% of the space-debris population currently accessible in the US Catalogue. ESA was also actively involved during the year in international committees working on debris-mitigation guidelines and standards.

Ground Systems Engineering

Ground-infrastructure construction and the upgrading of the ESA Tracking Network (ESTRACK) continued, along with the development of specialised communication equipment. One of the highlights was the lifting of the 110 ton, 35 m-diameter antenna reflector structure onto its pedestal at ESA's new deep-space ground station at Cebreros in Spain at the end of November.

ESA's first communication antenna operating in the Ka-band (32 GHz) was completed at the Villafranca ground station. This 12 m antenna is being used together with the Agency's SMART-1 satellite to explore communication behaviour at this very high frequency.

Upgrading of the 15 m LEOP antennas in the ESTRACK network continued, with 2004 being the turn the X-band transmit/receive (8 GHz) antenna in Perth (Australia). The upgrading programme is important because the standard S-band (2 GHz) communication will gradually have to be phased out.

The new experimental Ka-band antenna system at the Villafranca ground station

Substantial effort was put into supporting the European Technology Harmonisation initiative in terms of ground-segment software. The EGOS concept (ESA Ground Operation System) continues to attract attention from other centres and European Industry. It encompasses a general architecture for all ground-segment data subsystems in order to achieve greater synergy and better interoperability between products. The policy of making all ground data systems Unix/Linux-based will ensure ESA a vendor-independent position.

ESOC's operational software includes an open licence policy and support for Member State Industry on product lines such as SCOS-2000, SIMSAT, PSS, TMTCS, etc. DLR, Radarsat, Eutelsat, ASI's Cosmos SkyMed, ESA's Vega Programme and Galileo GSTB V2 are integrating and validating their new control centres based on SCOS-2000. More than 65 SCOS-2000 licences have already been granted within Europe. The use of SCOS-2000 as satellite/instrument EGSE by Herschel/Planck is also demonstrating its ability as a common EGSE and Mission Control System.

Third-Party Support

ESOC continues to market spare capacity in terms of operations facilities and expertise to external customers. Major activities of this sort in 2004 included preparation of the LEOP support for Eumetsat's MSG-2 and MetOp-1 missions. Other third-party projects included development of the GRAS ground-support network for Eumetsat; telemetry, telecommand and ranging services and in-orbit testing from Redu for Eutelsat; hosting of a back-up control centre at Redu for NewSkies (NL); a precise orbit and clock service to Fugro (N); provision of GPS data to Galileo Industries (B) for GSTB-V1; provision of ground-station support to the Helios-2A LEOP for CNES (F); preparations for ground-station support to the TerraSAR-X LEOP for DLR (D); and antenna hosting at Redu for Vitrociset (I).

Network of Centres Initiative

The qualification phase for the Flight Operations Network of Technical Centres was completed in 2002 and there were a number of important achievements in 2004. Early in the year, the panel of financial experts was able to certify that the cost data provided by a number of Technical Centres (BNSC-RAL, BNSC-QinetiQ, CDTI-INTA, CNES-Toulouse-Ops, DLR-GSOC and ESA-ESOC) compared well for the 'calibration case' under consideration, and that the procedures defined for transforming cost data from each of the centres into a common format were validated.

Secondly, rather than proceeding with academic reviews of possible scenarios for Network of Centres involvement in future ESA, EU and national programmes, attention was focussed on the practical involvement of a network of Flight Operations Centres in the Galileo IOV programme. To this end, ESA/ESOC initiated and coordinated a process principally involving CNES-Toulouse-Ops, DLR-GSOC and Telespazio, as well as SSC and NSC-KSAT, related to the preparation and implementation of the Galileo IOV flight operations.

Although it was not possible to involve all of the original members of the Flight Operations Network of Technical Centres, ESA/ESOC can be commended for creating an environment of openness, trust and cooperation, culminating in the submission of an unsolicited comprehensive offer to Galileo Industries for the Galileo IOV Operations Segment.

ESA Site Management

It was a year of change for the Site Management Department, taking up its new position within the new Directorate of Operations and Infrastructure. The immediate impact of this was the relocation of the Head of Department and his managerial staff from Paris to Darmstadt.

The budget reductions in previous years combined with the critical budget situation of 2004 significantly reduced the Department's ability to complete all planned activities. This led, for example, to the cancellation of urgent measures to improve accommodation at Head Office.

These not inconsiderable organisational changes and budget limitations came at a time when the operational demands on the service continued to increase, in an environment of annual rises in the numbers of on-site contractors and visitors, and of mounting external pressure for actions to comply with applicable national health, safety, workplace and environmental legislation.

Nevertheless, 2004 did see the completion of a number of infrastructure projects throughout the Agency, including the:

- 'Modular Building' at ESTEC and continuation of the asbestos removal programme
- Navigation Facility, Rotunda Modification and Child Care Centre at ESOC
- acquisition of temporary rented office accommodation in Avenue Suffren and the new Entrance Hall for Head Office
- new Computer Centre and the Child Care and Sports Centre at ESRIN.

Notwithstanding the above, the drive for improvements, as defined in the 2004 Site Management Action Plan, proceeded to address:

- compliance with national health, safety and environmental regulations, and the formulation of a new ESA-wide Health and Safety Policy
- introduction of a new process for strategic Site Infrastructure planning involving the

The restyled ESOC Rotunda

The corporate IT Service Desk at ESRIN

ESA customers, as input to the budget preparation exercise
- analysis of Crisis Management within the Directorate, the definition of 'Site Security Command Centres', and the strengthening of on-site protection through the installation of badge-operated entrance systems at Head Office, ESOC and ESRIN
- introduction of tools for workplace and facility management.

In the drive to increase internal synergies within the Directorate, responsibility for all ESAC site-related activities was also transferred to the Site Management Department in 2004.

ESA Corporate Information Technology

The volume of IT users increased beyond expectations in 2004, with the office-automation services growing to include 4000 users, mostly at the four main sites in Europe,

Activity on the ESA web site on the night of 14/15 January following the landing of the Huygens Probe on Titan

but also including small ESA sites ranging from Washington to Beijing, as well as many travelling users exploiting mobile connections. A typical ESA day now involves more that 500 000 messages being transmitted and delivered, corresponding to 10 Gbytes of information.

Major launch and mission events during the year meant that services to external users also had to be upgraded, with dedicated server systems for web casting of major events being put in place to avoid saturation problems. This allowed events like SMART-1's lunar capture and the Huygens landing on Titan to reach out to the public on an unprecedented scale, with information and images delivered to typically 200 million citizens, at a rate of close to 3000 downloads per second.

The IT services for corporate management also made major steps forward during the year, including modernisation of the Human Resources and payroll systems and the continued updating of finance and contract-management systems. Electronic processing of contracts, invoices and other administrative activities is replacing more and more of the paper flow, allowing several legacy systems to be closed and leading to major savings in running costs.

IT security is a major development needed to enable the execution of ESA new programmes involving sensitive information. This requires upgrading and certification of the Agency's IT infrastructure and during the year detailed plans were put in place, and closer collaboration with the national security agencies for implementing such measures was initiated. This is in addition to the existing protection against virus and hacker attacks provided by 'ESACERT', which received formal accreditation by the appropriate international bodies in 2004.

The Agency's IT activities are managed from ESRIN in Frascati (I), where the Service Desk and main corporate management servers are also located. Since ESRIN is also the distribution centre for Earth-observation data, the resulting synergy facilitated a joint project to connect it to the main European research data networks. As a result, all the ESA technical sites now have access to these high-speed networks, with capacities of several Gbits/sec at each node. In addition to providing highly effective data distribution, this also opens up new possibilities for collaboration and new ways of tele-working across Europe.

International Relations

Mrs Erna Hennicot-Schoepges, Luxembourg's Minister for Culture, Higher Education and Research, and Mr Jean-Jacques Dordain, ESA's Director General, signing the Agreement on Luxembourg's accession to the ESA Convention, in Paris on 6 May

Mr Dimitris Sioufas (right), Greece's Minister for Development, and Mr Jean-Jacques Dordain, ESA's Director General, after signing the Agreement on Greece's accession to the ESA Convention, in Paris on 19 July

Two New Member States for ESA

Luxembourg and Greece signed the Accession Agreement to the ESA Convention on 6 May and 19 July 2004, respectively. They then become ESA Member States as soon as their internal procedures of ratification have been completed.

For each country, a Joint Task Force (ESA/Luxembourg and ESA/Greece) will be created and remain active for six years starting from the date of accession. The Task Force's mandate will be to advise the Director General on the implementation of the special transitional measures concerning industrial policy that are defined in the Accession Agreement.

Relations with the 10 new EU Member States

On 24 November, the Czech Republic became the second European Cooperating State of ESA, after Hungary on 5 November 2003. Within the framework of the Plan for European Cooperating States (PECS), the two countries are now able to take part indirectly in the Agency's programmes. Romania has recently expressed its wish to enter into negotiation with a view to joining PECS, and Poland will certainly soon follow this scheme.

Relations with Space-Faring Countries

Canada

The 25th anniversary of the cooperation between ESA and the Canadian Space Agency (CSA) was celebrated during the IAF Congress in Vancouver in October. In July, Telesat Canada's Anik F2 satellite, equipped with a Ka-band transmitter financed by CSA, was launched by an Ariane-5.

The Chinese Prime Minister Wen Jiaobao receiving a small gift from ESA Director General Jean-Jacques Dordain, in the company of ESA astronauts Frank De Winne (far left) and André Kuipers, during the Chinese Delegation's visit to ESTEC in Noordwijk (NL)

United States

Further to President Bush's 'Vision for Space Exploration', the NASA Exploration Systems Mission Directorate hosted an 'International Workshop on Creating New and Sustainable Space Exploration' in Washington in November, bringing together some 19 space agencies from around the World. The main objectives were to provide a forum for NASA and other space agencies to exchange information on their individual plans and capabilities for the human and robotic exploration of space, and to begin discussions on interests and mechanisms for potential cooperation on exploration systems.

After more than four years of intensive talks, the European Union and the United States concluded an agreement on Galileo and GPS regarding the promotion, provision and use of the two satellite-based navigation systems and related applications, thus providing a framework for the interoperability of the two systems.

The great success of the NASA/ESA/ASI Cassini-Huygens mission highlighted the importance of international cooperation and strengthened the existing links between the two agencies.

Russian Federation

The Agreement between ESA and the Government of the Russian Federation on Cooperation and Partnership in the Exploration and Use of Outer Space for Peaceful Purposes entered into force on 15 October. In the framework of this general agreement, ESA's Director General Jean-Jacques Dordain and the Head of the Russian Federal Space Agency Anatoly Perminov subsequently signed an Agreement for Long-term Cooperation and Partnership in the Development, Implementation and Use of Launchers. This Agreement paves the way for cooperation between ESA and the Russian Federation based on two pillars: the exploitation of the Russian Soyuz launcher from Europe's Spaceport in French Guiana, and cooperation, without exchange of funds, on research and development in preparation for future launchers.

Japan

The 29th ESA/Japan Annual meeting, which took place at ESA Headquarters in Paris on 26/27 October, provided an opportunity to review the overall ESA/Japan cooperation. During the year, ESA and JAXA pursued their collaboration on the JAXA ASTRO-F mission, after reaching an agreement on the legal instruments to cover the cooperation. In addition, ESA and JAXA concluded a Letter of Agreement to formalise cooperation on the BepiColombo mission.

China

On 9 December, on the occasion of the European Union - China Summit in The Hague (NL), Chinese Prime Minister Wen Jiaobao visited ESTEC in Noordwijk. He was accompanied by the Chinese Minister of Foreign Affairs, the Minister of Science and Technology, the Minister of Commerce and the Minister of Agriculture. Two days beforehand, on 7 December, Mr Sun Laiyan, recently appointed Administrator of the Chinese National Space Administration (CNSA), visited ESA Headquarters in Paris to discuss further possibilities for cooperation between China and ESA.

Both of the Double Star satellites have now been launched. The DRAGON Earth-observation programme is successfully moving forward. Together with the Chinese Ministry of Science and Technology, ESA organised a DRAGON Symposium on Envisat data in Xiamen on 26 - 29 April, which brought together more than 150 European and Chinese scientists.

An Agreement was signed in 2004 between the Galileo Joint Undertaking and the Chinese National Remote Sensing Centre regarding cooperation on the Galileo Programme.

India

ESA and ISRO are discussing the possibility of European institutes participating in the Indian Chandrayaan-1 mission.

The Chairman of ISRO, Mr Madhavan Nair, visited ESA's Director General Jean-Jacques Dordain in June.

Relations with Emerging Space Powers/Countries

Latin America

On 19 May, the Government of the Federative Republic of Brazil notified ESA of its acceptance of the prorogation, from October 2004 until October 2012, of the Cooperation Agreement pertaining to the use of the Natal tracking station, which is a key station for the tracking of Ariane-5.

Asia and Oceania (excluding Japan, China and India)

Together with the United Nations and the Governments of Switzerland and Austria, ESA organized a Workshop in Kathmandu, Nepal, on space technology for sustainable development in mountain areas, hosted by the International Centre for Integrated Mountain Development (ICIMOD). As the first in a new series of activities dedicated to sustainable development in mountain areas, this Workshop provided the opportunity to present and discuss the usefulness of remote-sensing applications, satellite communications and global satellite-navigation systems for sustainable development in mountain areas.

First contacts have been established with representatives from the Korean Aerospace Research Institute in order to investigate potential areas of cooperation with ESA.

ESA has begun talks with the Government of New Zealand to obtain authorisation for the installation of a mobile telemetry station for tracking Ariane-5 during the launch of the first ATV, 'Jules Verne'.

Relations with the Mediterranean countries and Africa

On 15 July, Turkey signed a Framework Cooperation Agreement with ESA concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes. It will allow cooperation in such fields as space science, Earth observation research and applications, telecommunications, microgravity research and ground-segment engineering.

The European Commission and Israel finalised an Agreement regarding Israel's participation in the Galileo Programme.

A TIGER Announcement of Opportunity offering ERS and Envisat data at cost price to African water-related institutions was issued in mid-2004 and attracted some 100 proposals from across the whole continent. 65 of them were selected for further assessment and discussion at the annual TIGER Workshop held in Pretoria in November, in the presence of the New Partnership for Africa's Development (NEPAD) Secretariat.

Relations with International Organizations

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

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

UNOOSA (United Nations Office for Outer Space Affairs)

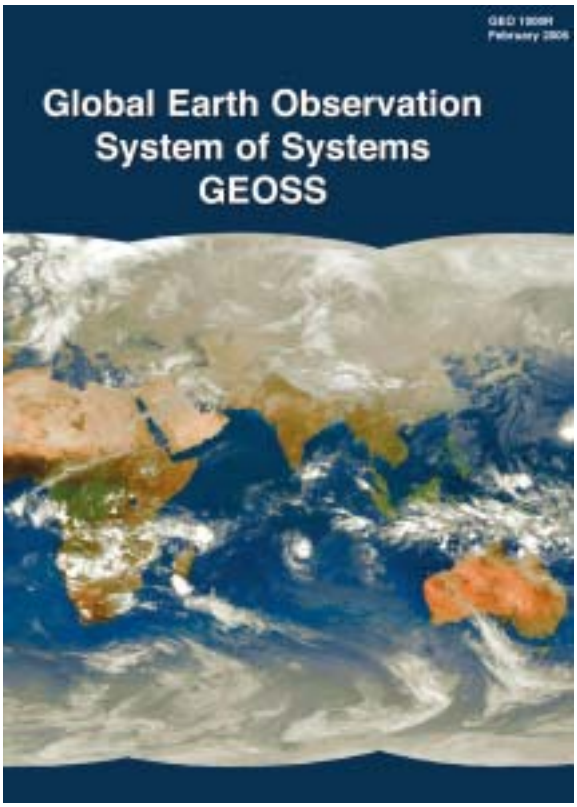
In 2004, the UN, through OOSA, officially associated itself with the activities carried out under the International Charter on Space and Major Disasters, and is now an authorised user of the Charter and can therefore request satellite imagery by this mechanism. During the year, the Charter was triggered nine times by UN organisations through OOSA.

UNESCO (United Nations Educational, Scientific and Cultural Organization)

ESA continued to support the Open Initiative on the Use of Space Technology for the Assessment of World Heritage Sites, under the World Heritage Convention. The Agency participated, for instance, in a UNESCO/ESA/Argentina/EURISY Expert Meeting for World Heritage Site Managers in Latin America, held in Cordoba, Argentina.

GEO (Group on Earth Observations)

The EO Summit at Ministerial Level held in Tokyo in April adopted the Framework Document defining the fundamental elements to be included in the 10-year Implementation Plan for what will henceforth be called a Global Earth Observation System of Systems (GEOSS). It also established an Implementation Plan Task Team of experts to finalise the plan in time for the next EO Ministerial Summit scheduled to take place in Brussels in February 2005.



The GEOSS 10-Year Implementation Plan Reference Document, produced by ESA Publications Division

CEOS (Committee on Earth Observation Satellites)

Under the chairmanship of China, ESA continued to support the CEOS efforts to optimise the benefits of global Earth-observation missions through cooperation.

Communications

The message 'Space as Part of our Daily Life' was at the heart of ESA's Communication Policy and the prime element of the corporate communication strategy in 2004, with space activities expected to increase our quality of life, contribute significantly to providing solutions to key problems in today's society, and enrich our lives by extending scientific knowledge. The reception given to ESA's science missions in 2004 was on an unprecedented scale, with a much increased level of interest being shown by an increasingly broad cross-section of the general public.

Communication Campaigns

In 2004 the ESA Communication Department conducted a variety of communication campaigns, many in close cooperation with Member State Delegations and the respective ESA Programme Directorates.

Mars Express

The loss of Beagle-2 attracted even more attention than usual and the Communication Department continued to promote the mission as a whole, underlining that Europe was actually extremely successful with its first visit to planet Mars. The presentation of the first 3D images on 23 January drew 100 journalists to the Press event at ESOC, and the next day the images and the story of Mars Express finding the first direct evidence of water on the Red Planet made the front pages of all major newspapers in Europe and many others around the World. These first images also resulted in an explosion of traffic on the ESA web portal.

Rosetta

Although it could have been overshadowed by Mars Express, the Rosetta launch was followed with great interest due to the presence of the lander onboard and the mission's search for the origins of life. The latter appealed particularly to the media and the general public, in addition to the scientific value of the cometary research.

DELTA mission

The communication campaign for the Dutch Soyuz mission (DELTA), which took Dutch ESA astronaut André Kuipers to the International Space Station, was a great success in the Netherlands, meeting its primary objective of increasing awareness of space activities within Dutch society. A continuous media-relations effort aimed particularly at broadcasters and a series of well-targeted events, combined with strong backing from the Dutch government, ensured high and sustained interest by both the media and the general public, in the months before the flight as well as during the 10-day mission itself.

The mission also provided the Communication Department with the opportunity to try new initiatives, including media partnerships, a 'science market' held several months before the launch, and an educational slant to mission communication.

Cassini-Huygens

With the joint ESA/NASA/ASI Cassini-Huygens mission entering its final phase, a Press trip was organised to NASA/JPL to coincide with the Saturn orbit-injection manoeuvre at the end of June, to stimulate media interest in the mission. It resulted in good coverage for the European probe.

CryoSat

Despite the postponement of the launch of ESA's first Earth Explorer mission by a few months to early 2005, the communication campaign planned around the original launch date was successfully initiated in close cooperation with the Member States, national agencies and Industry. Special information events and media briefings were arranged on the occasions of the ILA and Farnborough air shows, and a trip to IABG was organised for the Finnish Press.

Media Relations

The Media Relations Division handled more than 500 interviews and approximately 2200 requests for photographs, and issued more than 75 Press Releases and Information Notes. It also organised several Press trips and Press Conferences, and worked with some 300 journalists from ESA's Member States who regularly follow the Agency's activities. It participated directly in the promotion of the Agency's main missions and mission-related events, including Mars Express, Rosetta, Cassini-Huygens and the ISS DELTA mission.

The ESA TV Service produced more than 70 video programmes, which were distributed via satellite to TV channels across Europe. There are now 1607 subscribers to ESA TV mailings, representing a 39% increase in the last year. Almost all terrestrial TV networks in Europe are now in regular contact with ESA. The distribution of material on cassette has been reorganised to reduce costs, without impacting the ability to send out more than 1000 tapes per year. Live transmissions were set up for the key events, including web streaming, enabling Europe's space-interested citizens to follow space events as they unfolded.

In the first half of 2004, more than 1300 articles on ESA programmes were published, resulting in an OTR (Occasion To Read) for more than 215 million readers. Monitoring of the TV coverage of key ESA events showed similarly good results. The tone was generally positive and the events were mentioned in almost all news programmes on the day of occurrence.

Since 1 April, EuroNews has been contracted by ESA to produce a bi-weekly space magazine, which is also offered via the European Broadcasting Union (EBU) to all public broadcasters in Europe. Audiences for the programme on the EuroNews channel itself ranged from 947 000 to 1.4 million viewers. The space magazine has also led to better exposure for non-key-event stories by public broadcasters, who are often hesitant to use material not originating from a journalistic source, but will use material from EuroNews via the EBU Exchange mechanism.

The Media Relations Division was also responsible for updating the *All About ESA* newspaper and its publication in the main Member State languages, for distribution to the general public, and particularly at space exhibitions, events and Press Conferences.

Exhibitions and Events

ESA was present at the main space-related exhibitions in 2004, including ILA in Berlin (Germany), Farnborough International Airshow (United Kingdom), as well as the International Astronautical Congress (IAC) in Vancouver (Canada).

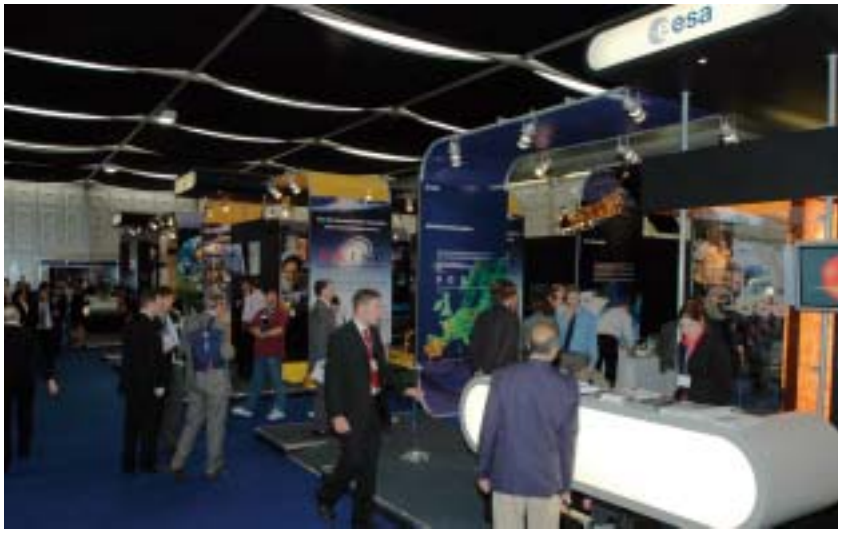
In Berlin, ESA participated in a joint space pavilion in cooperation with the German Space Agency (DLR) and industry (BDLI), with the

The 'Space for Life, Europe in Space – Deutschland im Weltraum' pavilion at ILA in Berlin, and (inset) Chancellor Schroeder who attended the Opening Ceremony

theme 'Space for Life, Europe in Space – Deutschland im Weltraum'. The pavilion, opened by the German Chancellor Gerhard Schroeder, was visited by numerous high-ranking decision-makers and guests. During the public days, thousands of visitors were able to acquaint themselves with current and future European and national space programmes.

At the Farnborough Airshow, an International Space Pavilion and a Space Day were dedicated to future exploration for the first time, where ESA faced the challenge of presenting the future European programmes, in close cooperation with BNSC and British space industry (UKISC). This new initiative brought together key players from the space world and the pavilion was well attended by space professionals, the Press, dignitaries, industry and the general public.

The ESA exhibition at the IAC in Vancouver contributed to the celebration of 25 years of space cooperation with Canada. Numerous presentations allowed the new generation of delegates attending the congress to meet the ESA Directors and learn more about Europe's space programmes.



The ESA stand in the International Space Pavilion at Farnborough

ESA also cooperated during the year with various science and space museums and other

institutions organising exhibitions for the general public. One example was the 'Forum of Culture' in Barcelona, co-organised by UNESCO and the Spanish national and regional governments, which was held over several months (May-September) and visited by several million people. Similarly, ESA was present at the COSPAR Scientific Assembly in Paris, the Envisat Symposium in Salzburg, and the UN General Assembly in New York, as well as many other scientific and technical exhibitions (19 in total).

During the year, the ESA 'highlights collection' of 20 self-standing panels was used extensively throughout the Member States for various events in support of the Country Desks, and in non-Member States in support of International Relations activities.

Online Communication

The key events in 2004 were undoubtedly the release of the first Mars image and Mars Express's first direct evidence of water on the Red Planet in January, which caused web-portal traffic to rise to unprecedented levels: there were a total of 3.4 million external visitors during the month, with a peak of 310 000 on 20 January. Approximately half a million images of Mars were downloaded over the following three days. This was a milestone in the history of the Agency's communication activities, setting a record for the number of members of the public ever reached directly by ESA. Thanks to the use of very advanced technological solutions, the ESA web portal delivered information to all its users around the World continuously and with no delays, despite the extreme traffic levels.

The Cassini-Huygens orbit insertion and the subsequent release of high-quality colour images of Saturn's rings on 1 July showed that the web audience built up with the Mars Express online campaign had been retained and was actively looking for new, exciting information from ESA. The quantity of images downloaded was again enormous. A new visitor peak is expected for the descent of Huygens through Titan's atmosphere in January 2005.

When the ESA web portal was launched in October 2000, there were roughly 20 000 external visitors a month. The number had increased to 500 000 a month by 2002, and rocketed to a peak of 3 400 000 in January 2004 for the Mars events. Since then it regularly reaches 1 500 000 visitors a month. At the same time, the number of subscribers to the direct ESA news e-mail server has reached 30 000, following a steady increase over the years.

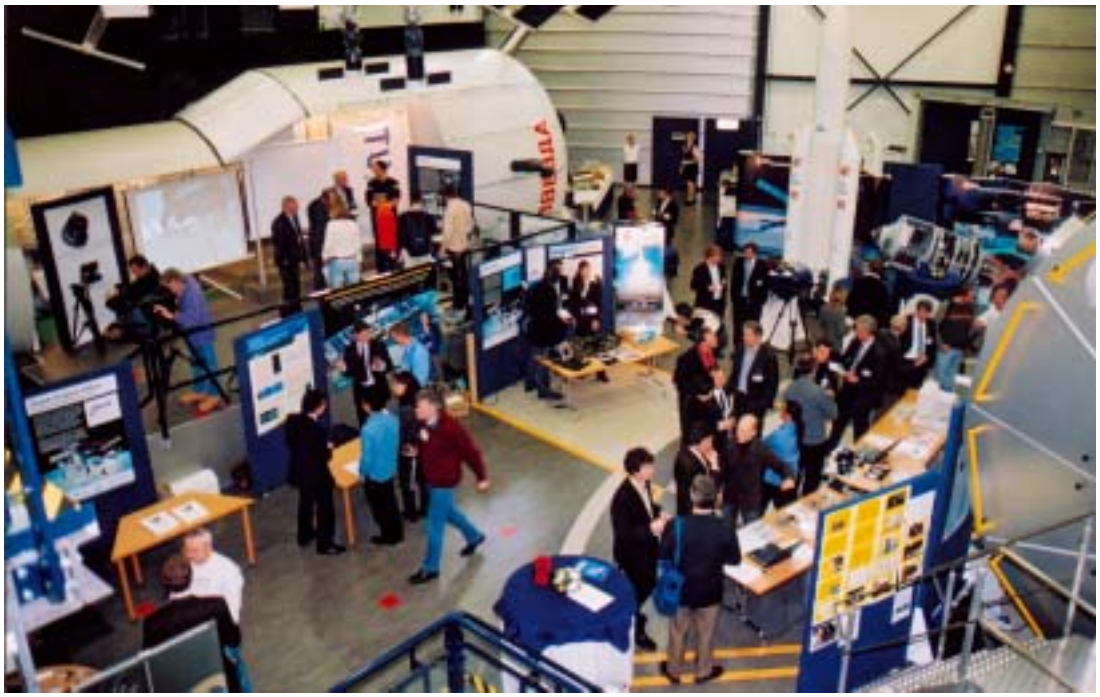
Moreover, ESA's web-portal stories are picked up by the online media community worldwide. For one recent story, research conducted only on online media sites in Latin alphabet languages showed that 124 media organisations from 30 countries took the story. This success is due to the web portal's online magazine approach, which has over time created confidence that ESA is a continuous and reliable source of European space information. In addition, the web portal chooses to publish stories on issues in which the general public has a keen interest, and the key stories are published in all ESA Member State languages.

Internal Communication

Communication addressing ESA staff members uses: two publications, the house journal *ESA Today* and *On the Move*, a publication created in 2004 on ESA staff movements produced by the Department of Human Resources; on-line communication in the form of 'Internal News' via Lotus Notes; and staff events organised around video transmissions of the main ESA missions and addresses to staff by the Director General. *ESA Today* was further improved during the year, with the enlargement of the network of correspondents and authors, and further efforts are being made to enable as many remote ESA sites and seconded ESA staff as possible to participate in the video transmissions.

Quality Management and Impact Monitoring

The management tools introduced in 2003 to improve quality control and impact monitoring allowed assessment of the value of particular



The DELTA pre-mission 'information market' at ESTEC in January

activities, and lessons to be learnt about the optimal organisation of initiatives for their target audiences. The media analysis service continued to provide detailed information on the quantity of coverage of ESA in the most important newspapers in the Member States and to give an indication of the quality of reports on ESA's programmes, as well as an analysis of coverage by the main terrestrial TV channels in six of the Member States. A survey was carried out in February to quantify the impact of the Mars Express communication campaign and the results were published in the second 'Quality Report' to be issued, along with the results of the more general survey on public opinion on space conducted in 2003.

ESTEC

The DELTA mission to the International Space Station carrying ESA's Dutch astronaut André Kuipers was one of the 'news highlights' of the year for ESTEC. It stirred strong public interest and was followed by hundreds of schools, by Ministers and by members of the Dutch Royal Family. It received highly positive media attention throughout, thanks also to the enthusiastic efforts of André Kuipers himself. The successful commercial spin-offs included a book and a DVD about the mission, available just three weeks after the flight.

In terms of media coverage for ESTEC, 490 interviews were initiated, 103 TV teams visited the site (four times more than the previous year), special TV programmes were triggered, and a weekly radio 'space diary' was aired during prime time. The media statistics showed 7.5 hours of TV coverage and some 700 articles published in the period January-May alone, with the number of Internet hits also dramatically increased.

Other highlights included the Rosetta launch, plus seven Nordic events under the ESTEC Country Desk's responsibility. The 10-day, 3000 km trip by the race-winning Nuna-2 solar car through Norway and Sweden, stopping at ten different points along the way for promotional/educational events, proved a very popular communications tool.

With the Netherlands holding the EU Presidency, many of their international guests were invited to ESTEC in the second half of the

Nuna-2's visit to Kiruna in Sweden in August

year, including EU Ambassadors, European Ministers and their partners, and the Russian Prime Minister, Mikhail Fradkov, who toured the Establishment in September. Other distinguished visitors in 2004 included Belgium's King Albert II in February, and the Chinese Prime Minister Jiabao Wen, accompanied by a large delegation of Ministers and media representatives, in December. Many of these guests were welcomed personally by ESA's Director General, Jean-Jacques Dordain.

In all, 740 VIP guests were welcomed at ESTEC, 55 university groups made education-related visits, and 17 communications events were arranged for or with staff. The Space Expo Visitor Centre also benefited from the 'Kuipers-effect', with 80 000 paying visitors, 11 500 of whom also took the space-train tour of the ESTEC facilities. In 2004, a total of 63 000 visitors were registered at the ESTEC gatehouse.

ESOC

ESA's Control Centre was the focus of historic missions and events in 2004. The year opened with the presentation of the first pictures from Mars Express and the confirmation of water on the Red Planet on 23 January. Following up the popular Mars Express in-orbit insertion event of 25 December 2003, the successful beginning for the Rosetta mission on 2 March drew enormous attention from the Press, helped by the long duration and daring nature of the mission.

The Mars Express Press Conference at ESOC on 23 January

Among the 41 events organised by the ESOC Communication Office during the year, the exhibition at the Automobil Forum in Berlin, which attracted more than 160 000 visitors between 17 June and 30 August, was certainly a high point. ESOC also cooperated with the magazine *STERN* for Germany's first 'Long Night of the Stars' on 18 September, with 3500 people visiting the Centre and listening to lectures during the night. The Press Conference on 2 September to publicise the event was opened by Mrs Edelgard Bulmahn, German Minister of Research and Science, and ESA Director General Jean-Jacques Dordain. The SMART-1 satellite's arrival in orbit around the Moon was announced during an international Press Conference on 16 November. The list of highlights would not be complete without a mention of the event organised on 1 July to witness the perfect insertion into orbit around Saturn of the Cassini-Huygens spacecraft, leading to the historic descent by Huygens onto the planet's surface on 14 January 2005.

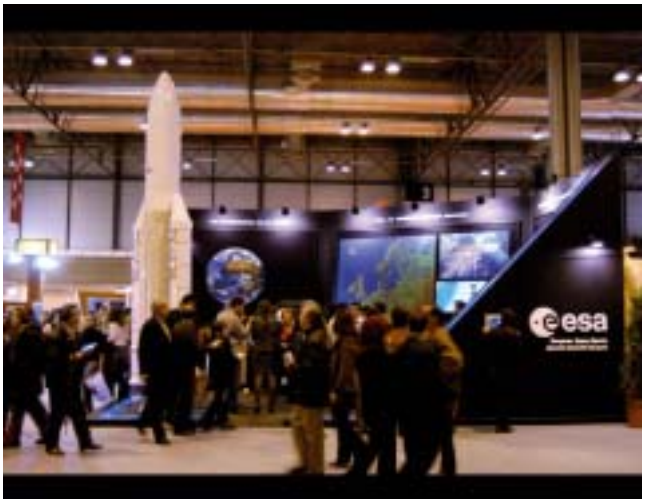
ESRIN

The communications activities handled from ESRIN for Italy, Spain and Portugal in 2004 included a number of events organised bilaterally with their national Delegations.

In Portugal, an Industry Forum was arranged in May to brief Portuguese industry and the Portuguese Minister for Science and Technology on ESA activities.

In Spain, ESA participated in the Barcelona Forum (May to September) with a contribution to the exhibition and speakers at the conference sessions dedicated to the Environment and Sustainable Development. ESA was present at the Madrid Fair in March, which included educational events for youngsters and attracted large numbers of visitors. ESA also actively contributed to the Spanish Science Week, and an Open Day was organised at ESAC in Villafranca to coincide with that initiative. A visit to ESAC was arranged for a European Parliamentary Space Conference Delegation in November., on the occasion of the VIth Interparliamentary Space Conference in Madrid.

The Rosetta launch event at ESOC on 2 March



The ESA stand at the Madrid Fair in March

In Italy too, ESA participated in several major scientific and outreach events with exhibits, media briefings and presentations. Together with the Tor Vergata University in Rome and research institutes from the Frascati area, it organised the 'Scienza Orienta' initiative to inform young people about space and career opportunities linked to research. ESA also participated in the Science Week in Genoa, and in the special exhibition in November at the IDIS museum in Naples devoted to Mars, with exhibits on education, space science and Earth observation. ESA was also present at the SATEXPO telecommunications fair in Vicenza in October with a stand, demonstrations on telemedicine and satellite-communications applications, and a conference on Galileo.

ESA joined with the Italian Space Agency (ASI) and Alenia at 'Futurshow' in Milan, to present its space science, International Space Station (ISS) and applications activities.

A special space exhibit was jointly organised by ESA, Aleniaspazio, Finmeccanica, the Lazio Region and Aeronautica Italiana in Rome in December to publicise the Soyuz mission of ESA astronaut Roberto Vittori to the ISS.

The ESA stand at the SATEXPO fair in Vicenza in October

EAC

There were 716 requests for public appearances by ESA's astronauts in 2004, including:

- more than 130 for André Kuipers as a result of the DELTA mission
- 114 for Pedro Duque due to his Cervantes mission
- 109 for Claude Nicollier
- 102 for Thomas Reiter
- 78 for Reinhold Ewald
- 71 for Frank De Winne
- 68 for Gerhard Thiele, and
- 65 for Jean-François Clervoy.

With only 20% of all such requests ultimately rejected during the vetting process, the ESA astronauts, supported by their EAC colleagues, clearly worked hard in coping with the growth in requests and serving as ambassadors in furthering the visibility and public awareness of ESA, EAC, and Human Spaceflight activities throughout Europe.

As the home base of the European Astronaut Corps, EAC is committed to organising human-spaceflight events related to specific astronaut missions. Several such events were organised in 2004, with audiences of typically 100 VIPs drawn from governments, embassies, private companies, schools and universities. The 'Night of the Astronauts', for example, attracted an audience of more than 5000, including 48 accredited media representatives. EAC welcomed a total of 7931 visitors during the year.

To further increase the visibility of ESA and EAC during all of these events, a considerable amount of photographic and video material was produced and distributed, including video footage shot during actual missions and mission training.

The 'German Space Days' attracted thousands of visitors to EAC in September

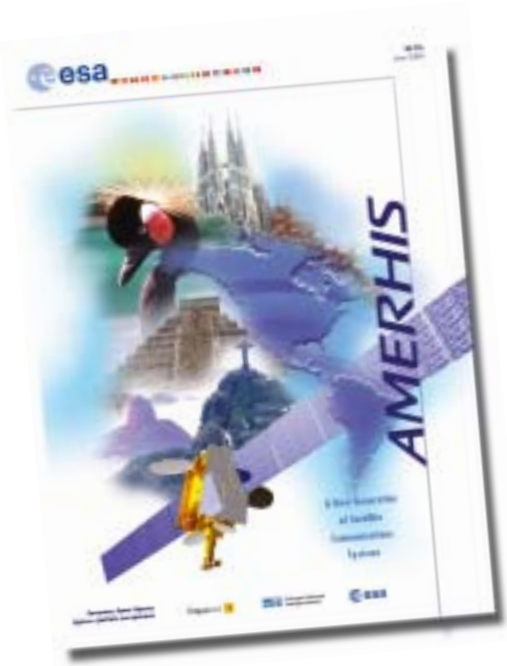
A second commercial ESA Space Training course was organised together with EADS and PRO-TOURA for eight businessmen.

Publications

In 2004 the Division produced the usual broad spectrum of publications, ranging from highly scientific and technical documents for the ESA projects to PR-oriented brochures and newsletters. More than 16 000 pages were published during the year in support of all ESA Directorates, including:

- The *ESA Annual Report* (English and French versions), the *ESA Bulletin* (four issues), and *The European Space Sector in a Global Context* (BR-222), for the Director General
- *ESA's Report to the 35th COSPAR Meeting* (SP-1276), *Cassini-Huygens – Unique Insights into a Ringed World* (BR-225), and *Mars Express – The Scientific Payload* (SP-1240), for the Directorate of Science
- *Artemis – Paving the Way for Europe's Future Data-Relay Land-Mobile and Navigation Services* (BR-220), *AmerHis – A New Generation of Satellite Communications Systems* (BR-226), and the *Connect* newsletter (two issues), for the Directorate of European Union and Industrial Programmes
- *The European Astronauts – A Case for Humans in Space* (BR-221), *Telemedicine 2010 – Visions for a Personal Medical Network* (BR-229), and the *On Station* newsletter (three issues), for the Directorate of Human Spaceflight, Microgravity and Exploration

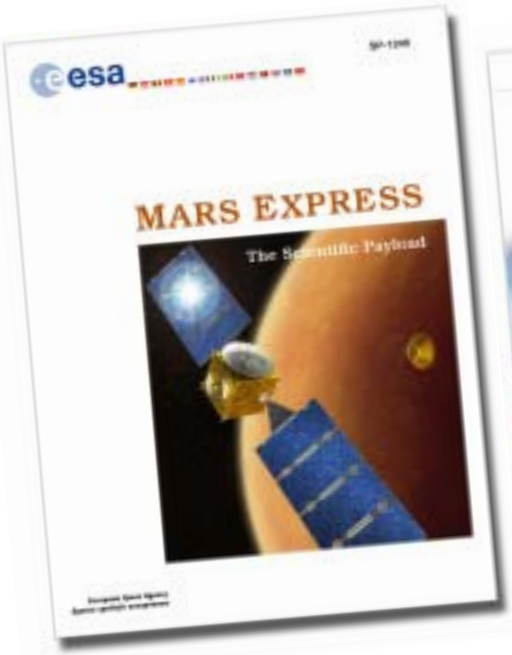
- *SMOS – ESA's Water Mission* (BR-224), and the *GEOSS 10-Year Implementation Plan Reference Document* (SP-1284), for the Directorate of Earth Observation
- *The Dutch Technology Transfer Programme – Knowledge from Space within Reach* (BR-231), *Space Project Management – Risk Management* (ECSS-M-00-03B), and *Space Product Assurance – Data for the Selection of Space Materials and Processes* (ECSS-Q-70-71A), for the Directorate of Technical and Quality Management.
- *VEGA – The European Small Launcher* (BR-233), for the Directorate of Launchers
- *Austria's History in Space* (HSR-34), and *Norwegian Space Activities – An Historical Overview* (HSR-35), for the ESA History Committee.



Publications support was also provided to 25 high-level ESA-sponsored Conferences and Symposia organised by the various Directorates, in addition to numerous Workshops and less formal meetings.

Support provided to ESA's sister organisations during the year included assistance to the International Space Science Institute (ISSI) for the production of its Annual Report, a brochure entitled *Understanding Space* and the monograph *The Solar System and Beyond – Ten Years of ISSI*, and to the new international Group on Earth Observations (GEO) in the preparation and publication of its *Ten Year Implementation Plan Reference Document*.

Substantial work was also undertaken on the ESA Publications website to enhance its completeness, searchability and user-friendliness.



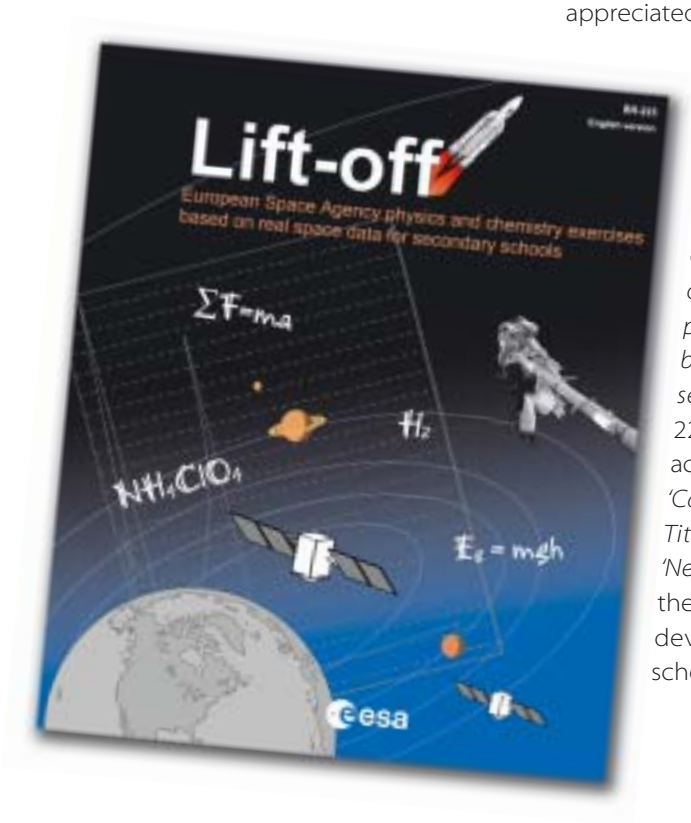
Education

Although education was included from the outset in the ESA Convention as one of the Agency's basic activities, it is only in recent years that a dedicated education effort has been undertaken both at Corporate level and within Directorates. With education having become one of the priorities listed in the Director General's 'Agenda 2007', a separate Education Department was created in 2004.

Focus on Teachers

In a continued effort to give teachers the relevant 'tools' to exploit space as a topic in the classroom, several workshops and training sessions were organised throughout Europe. These were also excellent occasions for obtaining first-hand feedback on the education resources proposed by the Agency.

Participation in the 2004 Congress of the European Council of International Schools (ECIS) allowed ESA Corporate and Programme Directorate education staff to further strengthen the already excellent and fruitful cooperation with the respective international schools. ESA is now fully recognised as a valuable partner for national and international schools, and its education tools are highly appreciated.



Also in cooperation with the Programme Directorates, emphasis was put on the development and dissemination of resources that teachers can use directly in the classroom, such as the brochure *'Lift-off: European Space Agency physics and chemistry exercises based on real space data for secondary schools'* (ESA BR-223), pedagogical sheets to accompany the comic book *'Cassini-Huygens: A Probe to Titan'* (ESA BR-228), the *'Newton in Space'* DVD, and the *'Heavens Above'* CD-ROM developed for primary-school use.

Meeting of the EDUspace Council of Teachers at ESA Head Office in Paris

In addition to the already operational Education web site (www.esa.int/education), the Education Department launched its multilingual site for younger children (http://kids.esa.int). The EDUspace web site, focussing on Earth Observation and with more than 1300 schools already having registered, was further developed. A Danish-language version financed by the Danish Ministry of Science, Technology and Innovation was put online.

ESA became a member, as the first of the international partners, of the newly created French 'Comité National pour l'Accompagnement en Sciences et Technologies à l'Ecole Primaire'. This committee has the task of advising the French Ministry of Education regarding possible partnerships with primary schools and the selection of partnership projects proposed to the Ministry by external partners.

Direct Contact with Youngsters

Knowing how important it is to complement teachers' efforts, the Agency seized many opportunities to address and involve pupils directly. The Ciencia Viva exhibition in Madrid, for example, gave hundreds of children the opportunity to play the space quiz, to attend presentations on space topics, and to learn more about the role of satellites and working aboard the International Space Station.

Student Projects

As in previous years, to continue motivating students ESA organised the highly successful 7th Student Parabolic-Flight Campaign. Through these Campaigns, over 700 students have now had the opportunity to experience zero-gravity and conduct experiments into basic physical and physiological phenomena.

140 students selected by the Education Department and from the Aurora Design contest participated in the International Astronautical Federation (IAF) Congress in Vancouver in October. All of them concurred in emphasising how important it is for their careers to experience such a unique opportunity to interact with space professionals and to present their very own ideas and projects.

Both of these initiatives generated significant media interest, with articles in several scientific magazines, both national and regional TV coverage, etc., all of which helps to encourage youngsters to take a greater interest in science and technology in general, and in space activities in particular.

Another significant educational activity is the Student Space Exploration and Technology Initiative (SSETI). This is a network of several hundred students spread throughout the major

European universities, who have joined forces over the past three years to design their own micro-satellite, with the help of ESA experts. Their hard work culminated in 2004 with the integration of the subsystems developed and built in the various European universities to construct the SSETI Express satellite. The drawing together of all of the different nationalities and cultures around the integration of a single spacecraft is proving a very enriching experience for all parties involved. But the most difficult part still lies ahead, namely the launch in June 2005 and subsequent operation of the micro-satellite and its three deployable nanosats.

In parallel, a second team of students was finalising the Critical Design Review documentation for the Young Engineers Satellite, YES 2. This 40 kg educational payload, composed of a tether system and a deployable capsule, is designed for inclusion in the Foton M3 mission, currently scheduled to be launched from Baikonur in autumn 2006.

The Education Department has also consolidated its IT tools, in order to optimise its interaction with the students, and in particular facilitate and simplify the application processes and the management of the student/professor contact database.

Cooperation with Other Organisations

Following the successful 'Physics on Stage 3' festival in 2003, ESA and its EIROforum partners have defined a four-year plan of activities, set to begin in 2005. These activities will involve many additional partners, such as ECSITE, the European Collaboration for Science, Industry and Technology Exhibitions, and European Schoolnet. A journal for European science educators will be launched and a new 'Science on Stage' programme will support national and international activities for science teachers.

The successes of the many projects continued or launched in 2004 are a great encouragement for the Education Department and demonstrate the explicit need for educational resources based on real space data.

The Ciencia Viva Exhibition in Madrid

History Project

Extended ESA History Project

Within the framework of the extended ESA History Project, two short histories of Austria and Norway, and two longer histories of Member-State space programmes, namely those of Finland and Germany, were published in 2004. The translations into English of the two longer histories are currently in progress and are due to be completed in 2005.

An overview of the ESA History Project, written by Karl-Egon Reuter (Chairman of the ESA History Advisory Committee) and Johann Oberlechner (Director General's Cabinet), was published in the August issue of the ESA Bulletin (No. 119, pages 48-54).

Published in 2004

Country	Title	Author	Publication
Austria	Austria's History in Space	Bruno Besser	HSR-34, January 2004
Finland	Suomalaisen Avaruustutkimuksen Historia	Ilkka Seppinen	Helsinki University Press 2004
Germany	Geschichte der deutschen Raumfahrtpolitik Konzepte, Einflußfaktoren und Interdependenzen 1923-2002	Niklas Reinke	R. Oldenbourg Verlag, München 2004
Norway	Norwegian Space Activities 1958-2003	John Peter Collett & Ole Anders Røberg	HSR-35, October 2004

ESTEC

The Automated Transfer Vehicle (ATV) in the new 'Maxwell' EMC chamber at ESTEC

Technical Infrastructure

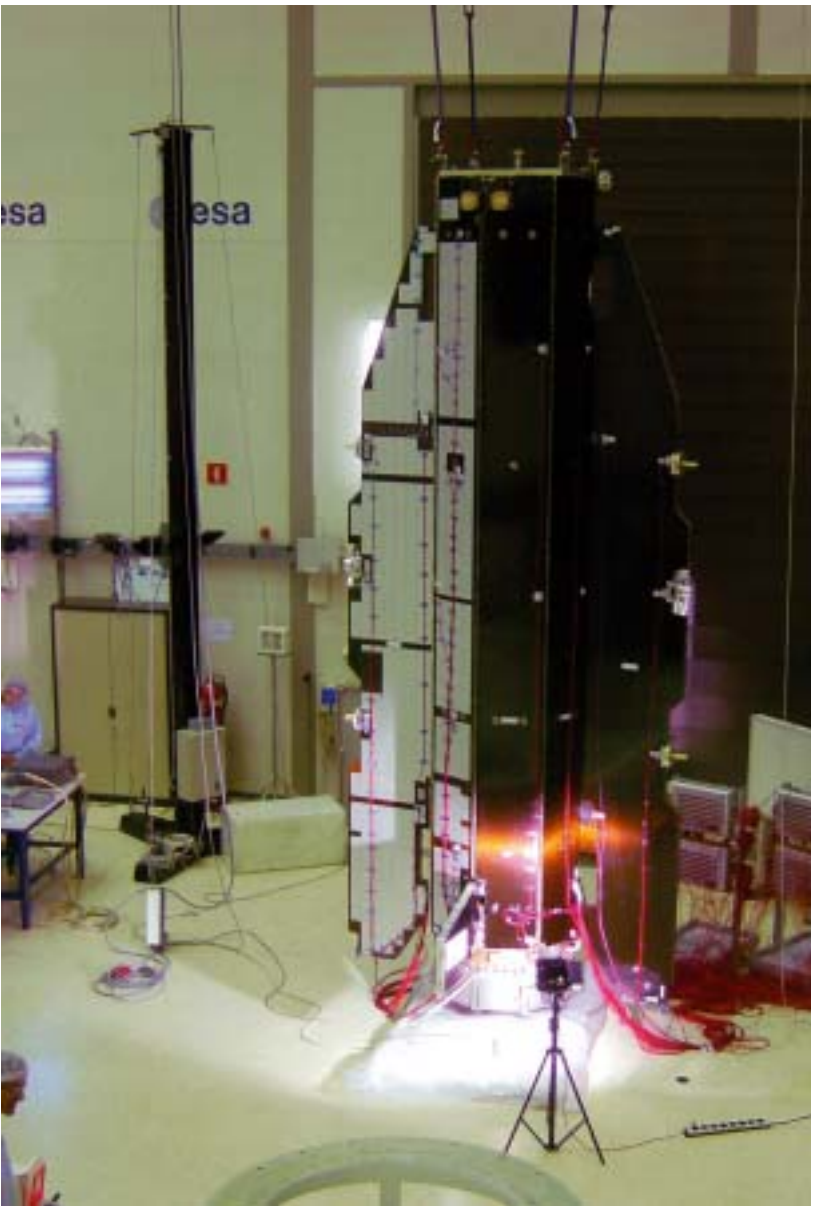
In accordance with Agenda 2007, ESTEC finalised an intensive, customer-focussed review of its Technical Facilities, namely the laboratories working in the mechanical, electrical, software and design domains, as well as the Test Centre and the Microgravity Laboratory, and defined its strategy and medium-term investment requirements. Both the internal customers from the ESA Programmes as well as external customers from Industry expressed their satisfaction with the services received and provided detailed information regarding their future needs. In implementing the results of the review, care will be taken to ensure funding of the competences needed to successfully support the various Programmes.

Test Centre

The ESTEC Test Centre played host to four spacecraft during the year: the second flight model of the MetOp Payload Module, the structural model of GOCE, the structural qualification model of Galileo GSTB V2A, and the proto-flight model of the Automated Transfer Vehicle (ATV). The EMC tests for the latter were performed in the newly completed Maxwell chamber, and the campaign is scheduled to last until mid-2005 with further tests in the acoustic chamber (LEAF) and the Large Space Simulator (LSS). The new large 'Maxwell' chamber provides an EMC facility of the same high standard as the other ESTEC Test Centre facilities.

In parallel, a number of smaller test campaigns were executed with satellite instruments, antennas and solar arrays primarily for the Scientific and the Human Spaceflight Directorates, but also for external customers. One of the latter was a novel test on the hydraulic shaker (HYDRA) in which Airbus 380 cargo containers were subjected to transient landing vibrations.

Upgrading of the force measurement device and the mass-property measurement facility was initiated for first use by the Herschel project. The replacement/updating of ageing equipment will be further pursued over the



The GOCE structural model on the Multishaker in the ESTEC Test Centre

The carbon-fibre-reinforced reflector for ESA's Planck spacecraft under test at the Centre Spatial de Liège (CSL)

Electrical Engineering Laboratories

The first version of the Galileo Signal Validation Facility (GSVF) was delivered to the European Navigation Laboratory. This unique facility can simulate in real-time the Galileo constellation signal-in-space, the propagation impairments, an advanced, multi-channel, multi-carrier receiver, and the navigation processing unit. It is currently being configured to support the most recent Galileo signal-in-space specifications.

coming years in order to continue offering the best possible service to the ESTEC Test Centre's customers.

European Coordinated Test Centres

ESA-related activities at the coordinated test centres included tests at Intespace (F) on the first and second flight models of MetOp. A large number of subsystem tests were performed at IABG (D) for ESA projects, including Planck, Herschel, Venus Express, ATV, MetOp and GOCE. Tests performed at CSL (B) included cryogenic vibration tests for the Herschel experiments, and a thermal-vacuum test on the Planck qualification-model reflector at cryogenic temperatures.

Mechanical Engineering Laboratories

Laboratory Accreditation to ISO/IEC 17025 by the Dutch RvA has been awarded to the Optics Mechanical Systems, Life Sciences Instrumentation, Propulsion, and Metrology Laboratories. This accreditation adds value in terms of system quality and technical authority at international level and extends the ISO 9001 certification already issued for the Propulsion Laboratory, the Automation and Robotics Laboratory, and the Engineering Services of the Mechanical Engineering Department.

The integration and optical alignment of the qualification model of the COROT baffle took place in the Metrology Laboratory.

The winning entry in the ESTEC No-smoking Poster competition, an intriguing interpretation of the ESTEC Site map by Ms Kaisa Hyryla, chosen by a jury led by the Technical Director Mr Michel Courtois and including the ESTEC Medical Officer Dr Elisabeth Kubbinga

The Establishment

ESTEC welcomed a record 64 000 visitors in 2004 as part of an ongoing trend, which was also influenced by the Dutch Presidency of the EU in the second half of the year. In addition to 76 conferences and major meetings, the Establishment also hosted visits from a number of World figures, including the King of Belgium and the Russian and Chinese Prime Ministers.

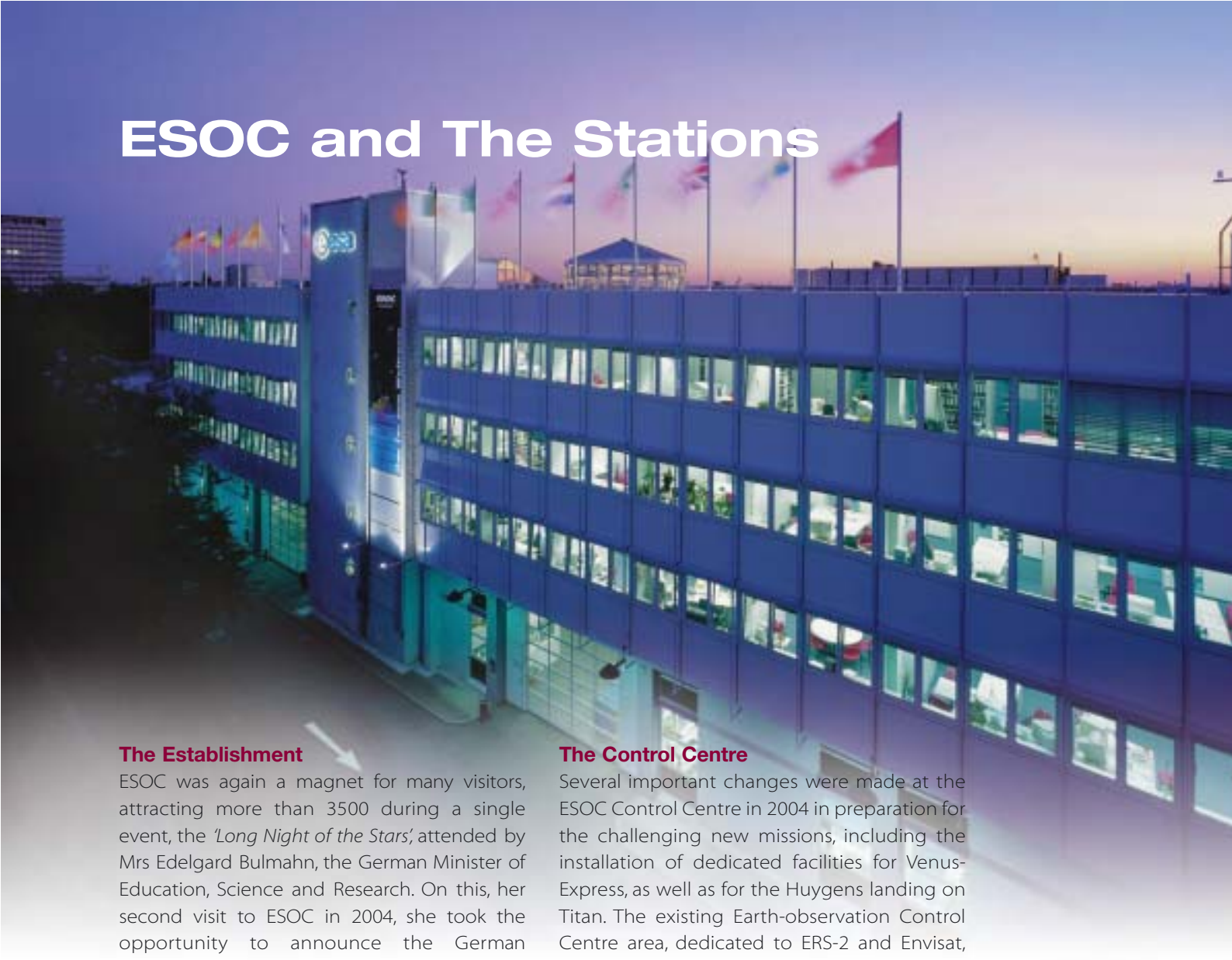
The continuing drive to consolidate ESTEC's security situation proved its worth during all of these events, and the year also saw the commencement of major works to upgrade control of access to the site, with the first phase due to be completed by mid-2005.

The main change to the ESTEC architectural landscape was the completion of a new office block adjacent to the Erasmus building. The new 'T Building', constructed in just six months using advanced modular techniques and state-of-the-art methods to minimise life-cycle costs, has also proved to be highly popular with its occupants. It has not only allowed all HME Directorate team members to be brought together, but it has also provided an impulse in the drive towards modern, high-standard accommodation for all those on site.

Work has continued on the design of a major new office and laboratory building; construction will begin in mid-2005 and will represent the next major step in the programme to eliminate asbestos on the site, which is due to be completed by the end of 2007. The year saw work in many other areas of the site as part of that programme.

ESTEC also moved progressively towards the goal of being a non-smoking work area by 1 January 2005. To back the effort, a large number of highly innovative posters were designed by staff members and their families.

ESOC and The Stations



The Establishment

ESOC was again a magnet for many visitors, attracting more than 3500 during a single event, the *'Long Night of the Stars'*, attended by Mrs Edelgard Bulmahn, the German Minister of Education, Science and Research. On this, her second visit to ESOC in 2004, she took the opportunity to announce the German Government's decision to purchase a plot of land in the immediate vicinity of the current site and make it available for an extension of ESOC, signalling strong political support for ESA and space activities in Germany.

The ESOC crèche was inaugurated at the end of September, representing an important milestone in the implementation of ESA's Policy on Equal Opportunities and Gender Diversity. Further building works completed during the year included an extension to the Operations Control Centre to accommodate a new Navigation Facility, and remodelling of the reception area in the building that houses the ESOC conference facilities.

Several important workshops took place at ESOC during the year, including an international TT&C workshop, an EGOS workshop, and a Galileo Information Day. The latter was an initiative of the Regional Government of Hesse as a means to promote the development of European navigation-system applications in this region of Germany.

The Control Centre

Several important changes were made at the ESOC Control Centre in 2004 in preparation for the challenging new missions, including the installation of dedicated facilities for Venus-Express, as well as for the Huygens landing on Titan. The existing Earth-observation Control Centre area, dedicated to ERS-2 and Envisat, has been considerably expanded in order to accommodate forthcoming missions such as CryoSat in 2005, GOCE in 2006 and ADM-Aeolus in 2007. A completely new facility, the Communications and Computer Centre (CCC) was also completed in 2004, allowing more efficient control of the operational IT infrastructure. Substantial efforts to improve the resilience of the control-centre systems and boost the capacity of the communications Local and Wide Area Networks are beginning to deliver results.

The new Navigation Facility infrastructure element that will support all current and future navigation activities consists of a control room with meeting and office space, and a computer infrastructure on ESOC's operational network. It will be used operationally for the first time in support of MetOp-1's GRAS experiment (GNSS Receiver for Atmospheric Sounding), and for other ESA and third-party projects, including high-precision orbit determination for Earth-observation mission science data exploitation

The ESOC Communications and Computer Centre (CCC)

(currently ERS-2 and Envisat) and GNSS-related activities. This new navigation facility therefore underwrites ESA's expertise in the field of Global Navigation Satellite Systems in support of a multitude of institutional and industrial users.

The Stations

The already high utilisation of the ESA worldwide network of stations in 2003 was surpassed in 2004, with more than 50 000 hours of tracking being provided to the various classes of missions using the ESOC facilities, including:

- Deep-space missions: Mars-Express and Rosetta through New Norcia
- Near-Earth missions: XMM-Newton, Clusters 1-4, Integral and SMART-1 through Kourou, Perth, Maspalomas and Villafranca
- LEO missions: ERS-2 and Envisat through Kiruna and Svalbard.

The upgrading of the station network continued with the addition of an X-band capability to the Perth station, and rapid progress in the construction of the Cebreros antenna at ESA's second deep-space facility. Substantial work was also completed at the Kiruna station, with the installation of a second 13 metre terminal and the redeployment of a modern multi-mission Monitoring and Control System. These upgrades ensure that the station network will be able to support the complete range of currently planned ESA missions fully independently.

Redu

Redu continued to serve as the prime TT&C (Telemetry, Tracking and Command) station for the Integral mission. In-orbit-testing activities continued for both ESA projects and third-party missions, complementing the TT&C services offered. In addition to providing Artemis data-relay mission control for Envisat and Spot-4, the station successfully supported several commercial Artemis L-band mobile payload users. It was also connected to the ATV Control Centre in Toulouse (F) to interface with the Artemis data-relay feeder link antenna. Redu also completed three years of successful operation of Proba-1, ESA's first microsatellite launched to demonstrate new technologies for future European spacecraft, during which it has provided images of the Earth for both the scientific and educational communities.

Villafranca

ESA's Villafranca site in Spain (VILSPA) became the European Space Astronomy Centre (ESAC) in April. The station has continued to provide primary or backup TT&C support to a large number of ESA missions (Cluster, XMM-Newton, Integral, Envisat, ERS-2). Support was also provided to SMART-1 using the recently refurbished 12 metre parabolic antenna, which has been converted from C-band to the X- and Ka-bands in order to operate the KaTE experiment. The Double Star mission (DSP1 and DSP2 spacecraft) of the Chinese Space Agency and the Centre for Space Science and Applied Research have also been regularly supported. The XMM-Newton Space Operations Centre (SOC) and the ISO Dedicated Centre, both located at ESAC, performed perfectly throughout the year and activities associated with the development of the ESA Planetary Archives continued.

European Deep-Space Network

The construction of ESA's second deep-space ground station at Cebreros made very good progress. A major milestone was achieved on 24 November when the 35 m-diameter antenna

The 15 m antenna at the Kiruna ground station in Sweden

reflector was lifted onto its pedestal. All RF components have been delivered and integrated, and are now being commissioned. The target for operational readiness is end-September 2005, in order to support the Venus-Express mission.

International Cooperation

International cooperation between ESA and the national space agencies (CNES, DLR) in Europe has continued in the area of mutual network cross-support, notably with support to the French Helios-2A satellite using the Perth station for its LEOP operations, as well as with the preparation of further network activities for Syracuse-IIIA (CNES) and TerraSAR-X (DLR-Astrium).

An ambitious test involving Envisat and the Japanese DRTS spacecraft aimed at demonstrating the compatibility of the two systems and their ability to communicate in space in the Ka band was initiated with JAXA (Japan).

Several contacts have been made with China, particularly with the Chinese National Space Agency, the Xi'an Satellite Control Centre and the Beijing Institute for Tracking and Telecommunications Technology. In addition, network support was provided to the two Chinese Double Star satellites using ESA's Villafranca station.

Last but not least, important Inter-Operability Advisory Group (IOAG) meetings took place between the World's major space agencies in 2004 to agree on the application of worldwide standards and the coordination of network evolution.

Lifting into position of the Cebreros 35 m antenna reflector on 24 November

ESRIN

ESA astronaut Paolo Nespoli at the ESRIN Open Day on 22 March

More than 30 000 people visited ESRIN in Frascati (I) in 2004 and participated in scientific international conferences, working meetings, launch retransmission events and VIP visits.

In March, ESRIN opened its doors to the general public for an 'Open Day' that attracted around 1000 people. This initiative was organised in the framework of the Italian Science Week, in conjunction with other research institutes based in the Frascati area.

Several major international scientific and user conferences took place at ESRIN during the year, such as the GMES Information Day in May, the Telemedicine Workshop in July, a Tele-communications Applications Workshop in November and a major Earth Observation User Consultation meeting. The 100th meeting of the ESA Earth-Observation Programme Board was held at ESRIN on 27 May.

The arrival of the new Director of Earth Observation Programmes and Head of ESRIN gave new impetus to ESRIN's activities, in particular its role as a focal point and reference centre in Europe for Earth-observation activities.

A major event for ESRIN was the organisation of the Envisat Symposium in Salzburg from 6 to 10 September. It attracted more than a thousand participants, most of whom were scientists, users and representatives of industry working with Envisat data.

ESRIN devoted considerable effort during the year to its ground-infrastructure activities and liaison activities with receiving stations worldwide. The User Helpdesk has a database of about 8000 users, as well as managing mission planning and operations requests from institutional entities and commercial users and supporting pilot projects. It also managed the distribution via Earthnet of data from 25 satellites operated by third-parties.

The ESRIN Satellite Multimedia Infrastructure responded to a number of requests for support from external institutional and commercial users in 2004, such as the French and Italian Civil Protection Authorities. A laboratory area was set up with appropriate uplink facilities to ensure good connections to the Internet and academic networks, to provide access to satellites and to serve as a showcase for ESA's telecommunications activities in the fields of telemedicine, tele-education, secure communications and other applications.

The Vega Management Team based at ESRIN was consolidated during the year and activities

The official opening of the Envisat Symposium in the Salzburg Congress Centre on 6 September

associated with the Vega ground segment in Kourou were initiated in October.

The ESA Web Portal, managed from ESRIN, experienced a considerable increase in visitor numbers in 2004 and implemented new measures targeting improved security and wide broadband access.

ESRIN supported various university and other educational activities in Europe during the year. It made arrangements with Italian universities, such as Rome's Sapienza University, to support Masters courses devoted to space-technology infrastructure and applications, as well as hosting numerous stagiaires of European and other nationalities.

The European Centre for Space Records (ECSR), established at ESRIN in 2002, further supplemented its technical and project-related documentation during the year. It now includes documentation on the ERS-1 and ERS-2, Envisat, SOHO, MOP, Silex and Hermes programmes.

A new Informatics Service Desk area was set up in the context of a rationalised approach to offering services across the whole Agency.

A Virtual Reality Theatre was installed, to serve both as a working environment for scientific meetings and to provide external visitors with 3D presentations on Earth-observation activities.

A new social centre with childcare facilities was inaugurated at ESRIN in December.

The Agreement with the Italian Space Agency (ASI) for hosting its Science Data Centre at ESRIN has been renewed for three years.

EAC

EAC trains all ISS crews on the European-contributed elements of the ISS programme

The Dutch Soyuz mission, 'DELTA' carrying ESA astronaut Andre Kuipers was launched on 19 April and concluded with a successful landing on 30 April. He conducted the most extensive experiment programme yet undertaken by a European astronaut on the International Space Station (ISS), performing a total of 21 experiments, as well as participating in several educational and communications activities. During the Soyuz flight to the ISS, he played an active part in piloting and docking the spacecraft, in his role as Flight Engineer. The European Astronaut Centre (EAC) was in charge of crew operations, medical support, and training coordination with Russia, and for the coordination and implementation of payload-related training activities. Although the prime responsibility for the ISS crew lies with the Mission Control Centre in Houston, the ESA Medical Operations team monitors the ISS systems and the health of the ESA astronauts in real time from its consoles at EAC.

The next mission involving ESA astronauts will be the 10-day Italian Soyuz mission 'ENEIDE', scheduled for launch on 15 April 2005 with ESA astronaut Roberto Vittori. He and his back-up Robert Thirsk (from the Canadian Space Agency) have been training at the Gagarin Cosmonaut Training Centre (GCTC) near Moscow, and preparations for the mission and the experimental programme are already well advanced.

Meanwhile, Thomas Reiter and Leopold Eyharts have been training both at Johnson Space Center and at GCTC for the first Long Duration Mission onboard the ISS of a European astronaut, planned for later in 2005. Christer Fuglesang, who is scheduled to fly on Shuttle STS-116 as a NASA Mission Specialist, has continued training, but at a reduced pace due to the delay induced by the grounding of the Shuttles

Significant progress was achieved during the year in the development of training material, with several new training facilities having been delivered to EAC. The Training Models of the Protein Crystallisation Diagnostics Facility, the European Physiology Modules (including Cardiolab and its sub-modules) and the European Transport Carrier were delivered, and

The ESA Medical Operations team at work from its consoles at EAC

The new ATV crew-training mock-up at EAC

Consequently, everything is now ready for the ATV training for the Expedition-13 primary and back-up crews, which is due to start in the second half of 2005. The content and flow of the ATV training has also been harmonised with the training programmes of the other ISS Partners.

the Acceptance Reviews for the Fluid-Science Laboratory and European Drawer Rack Training Models were successfully completed in February and July, respectively. In October, the Biolab Training Model was officially handed over to EAC and the Automated Transfer Vehicle (ATV) Onboard Crew Trainer was delivered. The Soyuz Simulator was installed in November, and the Final Acceptance Review for the ATV Mock-up was performed early in December.

During the year, EAC conducted about 18 weeks of training for astronaut crews, programme managers, and ESA and NASA flight controllers. In March and September, a class of six ISS astronauts (five from ESA and one from the Canadian Space Agency) received Columbus Science Payload and ATV Advanced Training. Three week-long sessions of Columbus System User Level Training were provided for payload engineers, Facility Responsible Centre personnel and Columbus flight controllers. Columbus System Advanced Training was provided to payload instructors and Payload Training Unit personnel. Three biomedical engineers completed Columbus System Training and internal training on ISS countermeasure devices. The Columbus Control Centre ground controllers were given ATV and Payload Advanced Training at EAC during October and November, and an ESA Training Academy course for about 25 ATV Control Centre staff was held in November. The first Human Behaviour and Performance Pilot Training with the Italian Army, which includes team-building, leadership and multi-cultural training, took place in the last quarter of the year.

In summer 2004, ATV courses and lessons, as well as the ATV facilities and the certification process for ATV instructors, were finalised. The first commercial 'ESA Space Training' course was held, with eight participants, at the end of November and that programme is now fully operational. Although any individual may purchase a ticket, the initiative mainly targets managers from non-space companies.

EAC received a significant number of visitors during the year. The German Space Days, held during the weekend of 18-19 September, and supported by EAC staff and most ESA astronauts, attracted some 100 000 visitors. The opening *Night of the Astronauts* gala in the Cologne Arena on 17 September was attended by about 5000 people. In view of the general public's strong interest, EAC, in association with the German Space Agency (DLR), will develop a 'Space Learning Centre' in Cologne, in the form of an educational park focussing on space and aeronautical activities. The Centre will provide information on space activities and their benefits for humankind, as well as education and training in aerospace subjects for students and teachers, and facilities for congresses.

Just some of the many thousands of visitors to EAC during the German Space Days

Finance

Income and Expenditure

The Agency's overall budget for 2004 (including appropriations carried forward from 2003) for the financing of its programmes and other activities was:

- 3172.8 MEuro in Contract Authority, and
- 2791.2 MEuro in Payment Appropriations.

The Agency's Mandatory Activities represented approximately 25% of the total expenditure (689.9 MEuro), whereas 70% was allocated to Optional Programmes (1949.2 MEuro) and 5% to Programmes for, and financed by, Third Parties (152.7 MEuro). A minor decrease in participation in Optional Programmes in favour of Mandatory Activities – approximately 2.5 percentage points of the Agency's 2004 budgets or almost 70 MEuro – seems to conform to the trend of recent years. On the other hand, the steady participation in Programmes financed by Third Parties during the same period confirms the Agency's enhanced management role in such activities, and represents an additional source of income for the future.

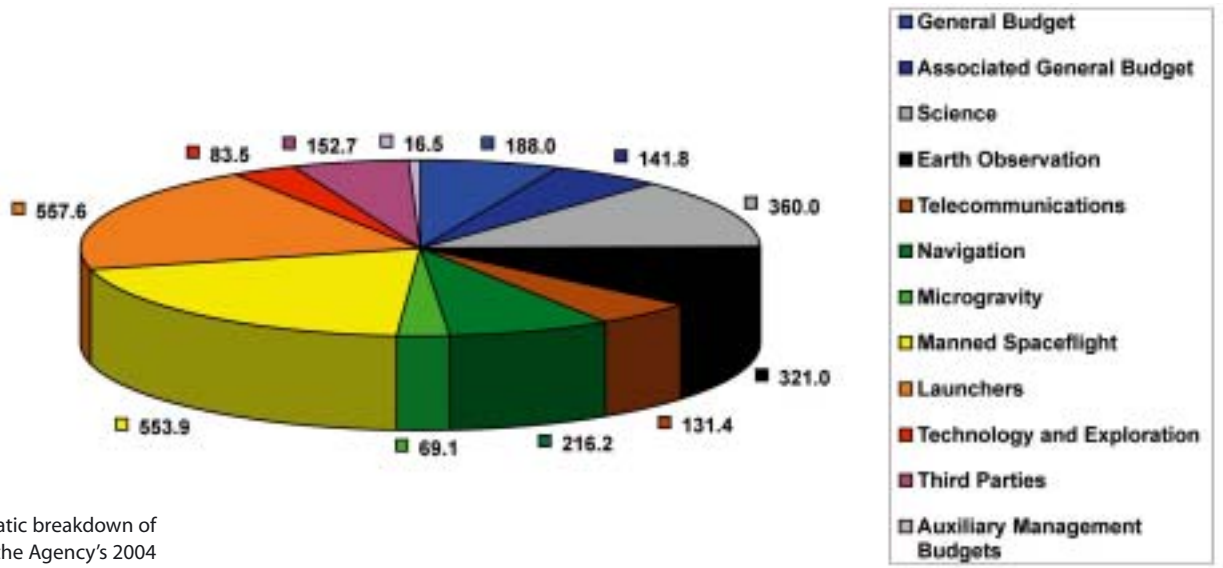
The core of the Agency's Mandatory Activities consists of the Science Programme, a Technological Research Programme, and the technical and managing infrastructure, which together enable ESA to fulfil its role as a scientific and technical organisation.

During 2004, the Science Programme's budget decreased by 22%, to the average 370 MEuro per annum of the Level of Resources in force. It had exceptionally been increased by 100 MEuro in 2003 following Council's approval of a bridging loan to finance the impact of additional costs due mainly to the unavailability of Ariane-5 to launch Rosetta and SMART-1, and knock-on effects on Mars Express and Venus Express, plus the Programme's extended support to ensure that payload elements were complete and delivered in time by Member States.

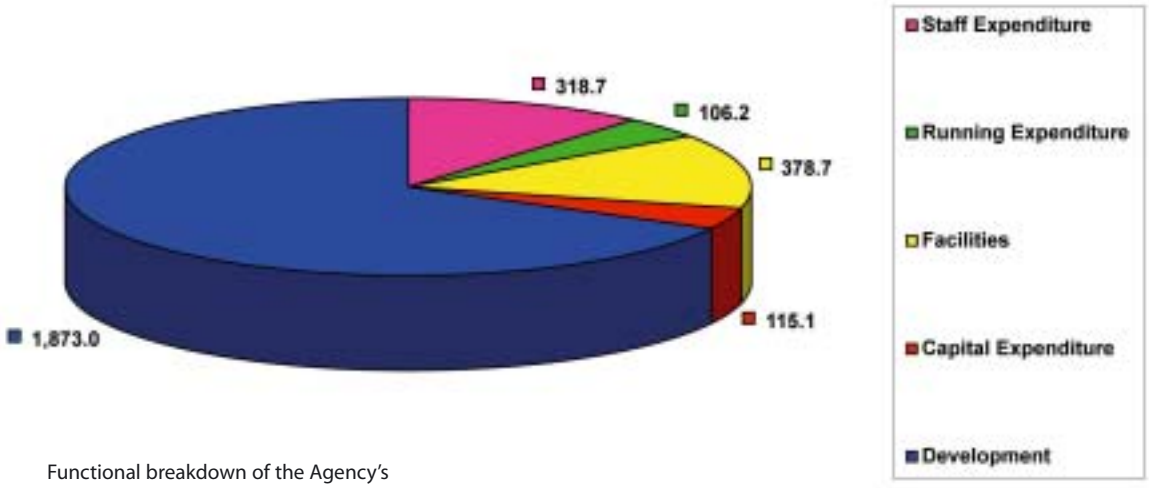
The funds for the development of applications are largely provided via the Agency's Optional Programmes, to which Participating States declare a voluntary subscription.

About 20% of the total ESA budget (557.6 MEuro) was allocated to the Launchers Programme. The successful qualification of the Ariane-5 Evolution ECA launcher was the result of the financial effort by Participating States in allowing for additional funding and the redeployment of available budgetary credits for on-going programmes. These decisions had been taken at the Ministerial Council in Paris in 2003. In addition, the starting of the Soyuz programme, including the construction of the Soyuz launch facilities (ELS) at CSG and the adaptation of the Soyuz launcher for exploitation by Arianespace, also confirmed the positive evolution of launcher activities.

A further 20% of the budget (553.9 MEuro) was devoted to the Human Spaceflight,



Programmatic breakdown of the Agency's 2004 expenditure, in MEuro



Functional breakdown of the Agency's 2004 expenditure, in MEuro

Microgravity and Exploration Programme, which was 4% more than in the previous year. The remaining part of the budgetary credits that had been blocked in Period 1 of the ISS Exploitation Programme at the 2001 Ministerial Council in Edinburgh, amounting to around 180 MEuro, was fully released and made available to the programme in 2004.

The Earth and Environment Monitoring from Space Programme represented 11% of the budget (320.9 MEuro). This programme's expenditure fell by 19% compared with 2003 due to the fact that the spacecraft development programmes of EOEP 1 have passed their point of maximum expenditure, and Envisat operations-related expenditure has been brought back to routine levels.

The Telecommunications Programme accounted for 5% of the Agency's expenditure in 2004 (131.4 MEuro). This represented an 18% decrease compared with 2003, after revising the Programme's annual work-plan for strategic reasons and the delay in starting the AlphaBus programme (ARTES 8).

The Navigation Programme represented 8% of the Agency's total expenditure (216.2 MEuro), an increase of 79% over its 2003 budget. The Galileo programme, which is co-funded with the European Union, saw a peak in development work in 2004 with the start of Phase-C0, the development of two GSTBV2 satellites, and the procurement of the launches for these two satellites.

During the year, approximately 85% of the Agency's budget was spent on contracts in the Member States for research or project-related activities, the running of technical or operational facilities, and the financing of capital expenditure and industrial development. The Member States also benefited at national level from the investment multipliers and the creation of jobs resulting from their industrial and scientific relationship with ESA.

Enhancing Efficiency

The Director General continued to pursue the rigorous efforts of his predecessor to implement an efficiency-oriented financial management plan providing Member States with greater value for money. The Agency's R&D and programme activities were preserved, with a year-end complement of 1908 staff. Staff costs in 2004 amounted to 11% of ESA's overall expenditure, while running costs represented 4%, making a total of 15% for internal expenditure.

A significant overhaul of the Agency's financial system has been almost completed in 2004 and only follow-up actions are to be expected in that area. After the entering into force of a new set of Financial Regulations in 2003, the Agency is gradually aligning its internal procedures with European best-practice, and in particular with International Public Sector Accounting Standards. In addition, improved management and reporting tools are constantly being reviewed and improved, providing a better medium-term planning base, greater consistency with long-term planning figures, and increased transparency of budgetary data. This helps to better match Programme needs

with Member States' annual contributions, without allowing transfer of funds between Member States.

The Budgetary Management System, designed to optimise the allocation of budgetary credits and Member State funding to the Optional Programmes, centrally managed budgetary risks of around 32%, or 891MEuro in 2004. The flexibility of this tool has both enabled the contribution profiles of Participating States to be reduced, and the efficient allocation of budgetary resources to the various Optional Programmes. These positive results are the consequence of improved control over budgetary risks.

ESA Financial and Invoicing System (EFIS)

EFIS is an Internet-based, integrated e-business tool designed for the administration of financially relevant processes and data over the full life cycle of an ESA obligation. It provides appropriate levels of visibility and access privileges for all parties involved, i.e. ESA staff and industrial suppliers. In 2004 most of ESA's industrial partners utilised this faster, more secure and fully traceable e-invoicing system, which makes paper invoices a thing of the past. Further enhancements to EFIS have been achieved, such as its integration with COSY-II, the Agency's corporate information procurement application, thus linking online up-stream to the commitment phase and down-stream to the payment of the invoice in the Agency's contractual process.

Calculation of the Contribution Scale for Mandatory Activities

The ESA Convention dictates that the Agency's Mandatory Programme be financed using a contribution scale based on the national incomes of the Member States over the last three years for which statistics are available.

In October 2002, the ESA Council adopted a new scale for the period 2003-2005, calculated on the basis of the revised method agreed at the March 1997 Ministerial Council. The calculations are based on national-income statistics expressed in national currencies and converted into Euros at average annual conversion rates. An equal weighting is applied to all three years of the statistical reference period (1998-2000).

The resulting total contributions from Member and Cooperating States for the three-year period 2003-2005 for the Agency's Mandatory Activities and for the Optional Programmes in 2004 are shown in the accompanying tables.

Contributions to Mandatory Activities (%)		Contributions to Optional Programmes* (%)	
AUSTRIA	2.30	AUSTRIA	1.09
BELGIUM	2.88	BELGIUM	8.27
DENMARK	1.85	DENMARK	0.78
FINLAND	1.40	FINLAND	0.56
FRANCE	15.90	FRANCE	32.24
GERMANY	23.82	GERMANY	21.46
IRLAND	0.96	IRELAND	0.29
ITALY	13.10	ITALY	11.56
NETHERLANDS	4.51	NETHERLANDS	2.99
NORWAY	1.73	NORWAY	1.13
PORTUGAL	1.22	PORTUGAL	0.25
SPAIN	6.99	SPAIN	5.90
SWEDEN	2.68	SWEDEN	2.34
SWITZERLAND	3.46	SWITZERLAND	4.20
UNITED KINGDOM	17.22	UNITED KINGDOM	5.70
TOTAL MEMBER STATES	100.00	TOTAL MEMBER STATES	98.76
CANADA	3.43	CANADA	1.00
CZECH REPUBLIC	-	CZECH REPUBLIC	0.06
HUNGARY	-	HUNGARY	0.01
LUXEMBOURG	-	LUXEMBOURG	0.08
GREECE	-	GREECE	0.08
TOTAL Cooperating States *	3.43	TOTAL Cooperating States (**)	1.24
TOTAL ESA	-	TOTAL ESA	100.0

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

Annual Accounts

The phased implementation of Accrual Accounting continued in 2004, to gradually improve compliance of the Agency's accounts with the accounting method adopted by a growing number of States and governmental bodies and supported by the OECD and the International Federation of Accountants (IFAC).

Since 2003, the accounting policy and procedures applied in the ESA Annual Accounts have been based on the International Public Sector Accounting Standards (IPSAS) issued by the IFAC, without yet achieving full compliance. The main departure concerns the treatment of fixed assets – described in IPSAS 17 – which, according to the Agency's existing accounting convention, are considered as fully depreciated in the year of acquisition and presented as 'memorandum account' items.

The implementation of full Accrual Accounting in compliance with the IPSAS is under review by the Agency. An in-depth analysis of all of the costs, benefits and implications of such a change is required before moving forward.

NOTES TO THE FINANCIAL STATEMENTS

The Annual Accounts of the Agency are summarised in four main financial statements presented herewith (in unaudited form at the time of this publication), including comparative information for year 2003.

Among the assets, the 346 MEuro balance under Cash and Banks does not include 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 745 MEuro, the not yet financed portion is shown as a receivable amount.

The main current asset represents 379 MEuro of advance payments to suppliers, made across the on-going programmes of the Agency. Until the relevant services are tested and accepted, these payments are considered as a claim towards the contractor companies.

The 20 MEuro Investment in Associates represents the interest taken 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 2004 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-end.

The net effect of provisions and accruals is reflected in the item 'Change of Accounting Method'. The 99 MEuro credit balance in 2004 can be considered as the net accumulated excess of assets over liabilities recognised in the accounts.

Provisions and accruals are included in the Statement of Assets and Liabilities in order to provide a comprehensive picture of all claims, entitlements and obligations of the Agency, but at this stage of the transition to Accrual Accounting they are not financed. Therefore, the net effect of reversed accruals of the previous year and new accruals is identified in a separate line of the Statement of Income and Expenditure, which adjusts the year's expenditure in order to show the total cost incurred. In 2004, this balance amounted to a 210 MEuro net increase in restated prior-year accruals.

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

The 2004 Surplus amounts to 54 MEuro, inclusive of 229 MEuro of underspending of the budget allocations, 35 MEuro of excess actual income over the budget, with other minor balances, and a 210 MEuro net increase in restated prior-year accruals.

FINANCIAL STATEMENTS 2004

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

	2004		2003		Increase/ Decrease
OPERATING INCOME					
Contributions	2,636,209		2,934,572		-298,363
Other Income	189,267		238,428		-49,161
		2,825,476		3,173,000	-347,524
Third Party Programmes Income	210,646		199,495		11,151
Plan for European Cooperating States	2,181		1,000		1,181
Management Outputs/Esrange Income	16,975		5,120		11,856
Internal Tax Income	102,950		96,162		6,788
		332,752		301,777	30,976
Total operating income		**3,158,228**		**3,474,777**	-316,549
OPERATING EXPENDITURE					
General Budget	188,010		184,112		3,898
Scientific Programme	360,038		465,830		-105,792
Earth Observation	320,963		396,713		-75,750
Telecom	131,393		163,623		-32,230
Navigation	216,197		121,052		95,145
Manned Spaceflight	553,940		532,635		21,305
Microgravity	69,118		69,828		-710
Launchers	557,596		668,112		-110,516
Technology	83,499		68,597		14,902
CSG Kourou and other activities	86,933		86,409		524
Pensions	54,900		48,840		6,060
Total financed by contributions		2,622,587		2,805,752	-183,165
Third Party Programmes	151,954		167,546		-15,592
Plan for European Cooperating States	533		0		533
Management Outputs Expenditure	16,494		-10,547		27,041
Esrange/Andøya special project	189		134		55
Internal Tax	102,950		96,162		6,788
Variation of accruals/provisions	220,012		-134,177		354,189
Restatement of expenditure to assets	-10,000		-10,000		0
		482,132		109,119	373,013
Total operating expenditure		**3,104,719**		**2,914,871**	189,848
NON-OPERATING CHARGES	0		0		0
Net Surplus for the Period		**53,509**		**559,907**	-506,397

REPRESENTED BY		
Bank and Cash	345,591	365,341
Other Assets	1,518,919	1,565,091
Prepaid Contributions, Other Liabilities	-1,673,681	-1,300,363
Loans on Outstanding contributions	-4,000	-66,059
Reserves	-133,320	-4,103
Net Surplus for the Period	**53,509**	**559,907**

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

	2004		2003		Increase/ Decrease
ASSETS					
Current assets :					
BANKS AND CASH	345,591		365,341		-19,750
AMOUNTS RECEIVABLE :					
Outstanding contributions	251,557		362,574		-111,017
Other customers (net)	54,230		2,738		51,492
Other amounts receivable	68,767		69,844		-1,077
PREPAYMENTS	379,365		392,936		-13,571
		1,099,510		**1,193,432**	**-93,922**
Non-current assets :					
Investments in associates	20,000		10,000		10,000
PENSION SCHEME to be financed	557,161		544,081		13,080
PENSION SCHEME Buffer Fund	187,839		182,919		4,920
		765,000		**737,000**	28,000
Total assets		**1,864,510**		**1,930,432**	**-65,922**
LIABILITIES					
Current liabilities:					
Prepaid Contributions and other payables to Member States	228,997		110,882		118,115
Regulation Fund	81,214		100,304		-19,090
LOANS IN LIEU OF CONTRIBUTIONS	4,000		66,059		-62,059
ACCRUED PAYABLES	571,782		320,936		250,846
OTHER AMOUNTS PAYABLE	7,061		6,864		197
UNTAKEN STAFF LEAVE	39,627		34,379		5,248
		932,681		**639,422**	**293,259**
Non-current liabilities:					
PENSION SCHEME	745,000		727,000		18,000
		745,000		**727,000**	18,000
Total liabilities		**1,677,681**		**1,366,422**	**311,259**
NET ASSETS		**186,829**		**564,010**	**-377,181**
NET ASSETS/ RESERVES					
RESERVES Telecom 3 bis, GNSS2, ARTES, PPF Envisat, Marecs, Exchange gains	34,333		49,293		-14,960
Change of accounting method	98,987		-45,189		144,177
SURPLUS	53,509		559,907		-506,397
		186,829		**564,010**	**-377,180**
MEMORANDUM ACCOUNTS					
Property, plant and equipment	2,597,453		2,567,011		30,442
Fixed Assets in progress	513,373		509,417		3,956
INVENTORY OF FIXED ASSETS		**3,110,826**		**3,076,428**	**34,398**

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

Note	CASH FLOWS FROM OPERATING ACTIVITIES		
	Receipts		
1	2004 Contributions received (net of loans)	1,687.3	
2	Contributions received for Regulation Fund	497.1	
3	Previous years contributions cashed in 2004	183.1	
4	Prepaid contributions cashed	81.3	
			2,448.8
5	Proceeds of Third Party Programmes	175.9	
6	Proceeds of Plan for European Cooperating States	1.1	
7	Other proceeds of ESA Programmes	155.8	
8	Net movements of other receivables	0.3	
9	Net movements of other reserves	12.6	
			345.7
			2,794.5
	Payments		
10	Payments for ESA Programmes	-2,539.8	
11	Payments for Third Party Programmes	-152.0	
12	Payments of Plan for European Cooperating States	-0.5	
13	Net movements of other amounts payable 2004/2003	0.2	
14	Reimbursement of contributions	-60.1	
			-2,752.2
	Net cash flow from operating activities		42.3
	CASH FLOWS FROM FINANCING ACTIVITIES		
15	Proceeds of loans taken in lieu of contributions	0.0	
15	Reimbursement of bank loans in lieu of contributions	-62.0	
	Net cash flow from financing activities		-62.0
	Net increase (decrease) in cash		-19.7
	CASH AND BANKS 31.12.2003		365.3
	CASH AND BANKS 31.12.2004		345.6

4. Changes in Net Assets/Equity for years 2003-2004 (in MEuro)

	SURPLUS	RESERVES	CHANGES IN ACCOUNTING POLICIES	TOTAL NET ASSETS
	(A)	(B)	(C)	(A+B+C)
Balance at 31 December 2003 ESA/AF(2004)1	559.9	49.3	-45.2	564.0
Allocation of Surplus 2003 to income 2004:				
- Programmes funded by contributions	-251.1			
- Plan for European Cooperating States	-1.1			
- Programmes funded by Third Parties	-31.8			
- Management and Suspense Outputs	-15.5			
Reimbursement to participants	-116.2			
Adjustments for accrued expenditure 2003	-144.2		144.2	144.2
Sub-total Allocation of Surplus 2003	-559.9			-559.9
Surplus 2004	53.5			53.5
Net movements in reserves		-15.0		-15.0
Balance 31 December 2004	**53.5**	**34.3**	**99.0**	**186.8**

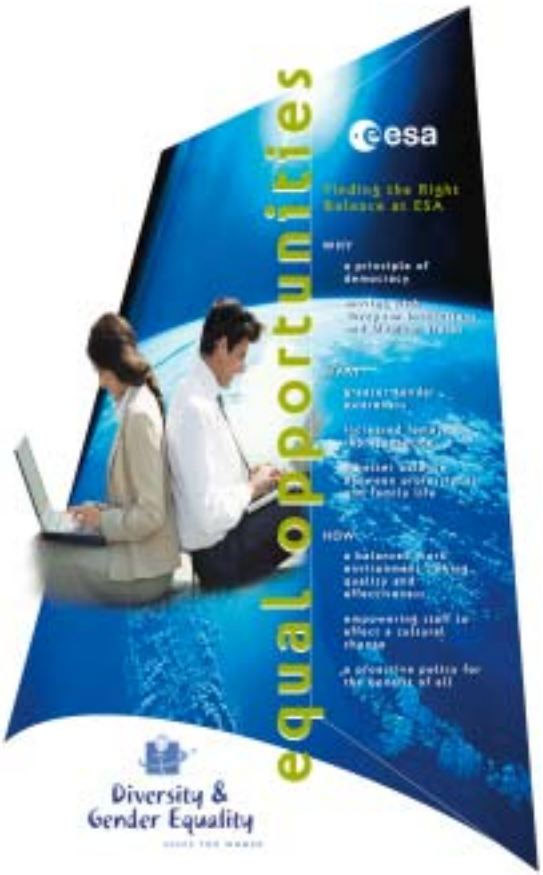
Human Resources

Human Resources Policy

The review of the HR Reform process was concluded in the summer with a report containing more than 20 recommendations. This document forms the basis for an implementation process due to begin in early 2005.

Meanwhile, the following major tasks were undertaken during the year:

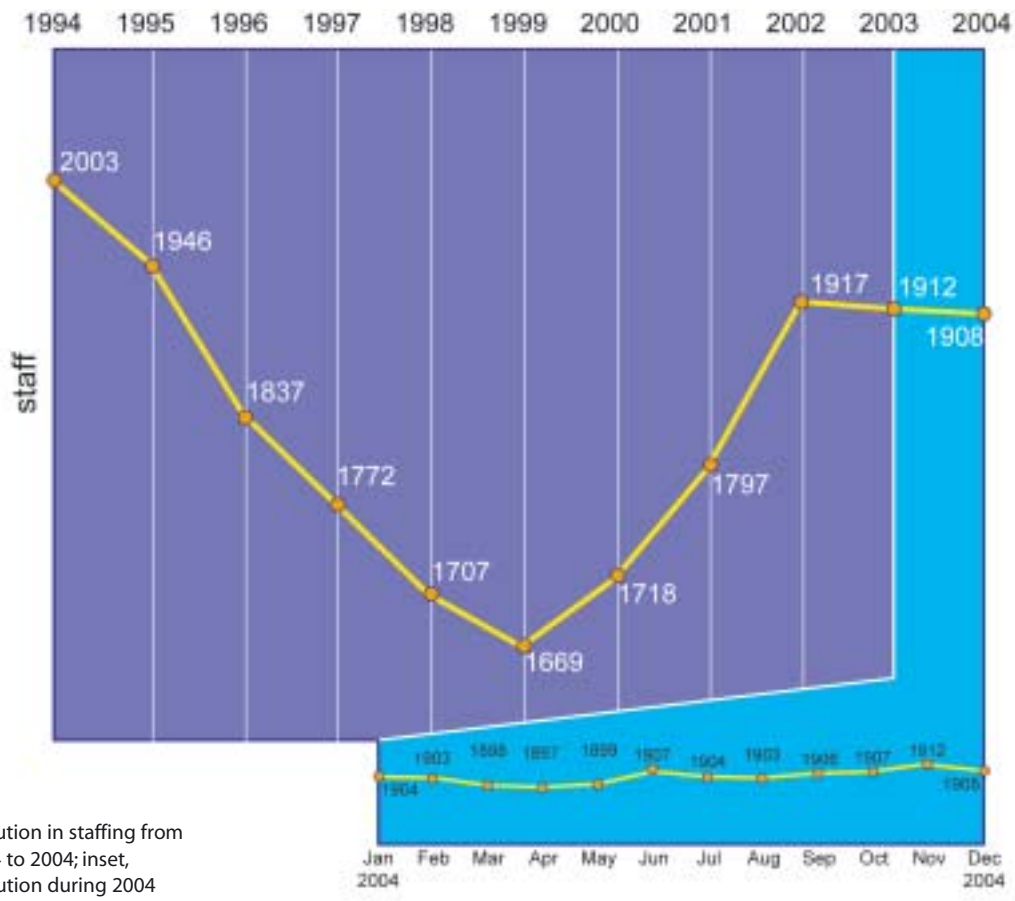
- The design of a teleworking scheme, aimed at creating a more flexible working environment for staff and allowing a better work/life balance.
- A survey of working-time arrangements was performed with a view to identifying the degree of satisfaction with the measures (part-time scheme, parental leave, etc.) introduced in 2001, and reflecting on possible improvements for the future.
- Some modules of the new Human Resources Management and Payroll System were validated and their deployment will start early in 2005, in particular with the new Payroll System.
- In order to foster mobility towards external institutions, as well as mobility between ESA places of work, a policy has been designed to cover cases of short- and medium-term mobility. In the frame of this policy and of the increased cooperation with the Europan institutions, opportunities for secondment were posted and the secondment of ESA staff members to EU institutions has started.
- The Agency launched internal information and support campaigns in order to become a non-smoking organisation.
- ESA participated in job fairs and other promotional events in several Member States in the context of special recruitment and promotional efforts to raise the number of job applicants from these countries.



Staff Training and Development

Concerned about staff maintaining and enhancing their professional and personal competences, the Agency has been offering a wide range of training opportunities at its various Establishments, covering the technical fields, but also management, communication, personal skills and information technology.

To better prepare ESA staff members for dealing with new increasingly diverse and complex challenges, steps have been undertaken to establish an Internal University specifically targeting the development of the specific competences required to support ESA's strategies and needs. In parallel with establishing a robust conceptual basis for such an Internal University, several existing corporate programmes have been re-designed to better respond to this imperative, and new ones introduced. Particular attention has been paid to improving the induction and orientation of new staff members in order to promote their alignment behind common corporate objectives. 'Introducing ESA', a 90-minute web-based learning application was launched providing an overview of the Agency, its purpose, its institutional and decision-making framework, its main areas of actitivity and its key internal processes, and a number of complementary seminars are under development for 2005. A 'Seminar on the European Union' was conducted at all Establishments to raise awareness about the EU, to provide basic knowledge about its institutions and decision-making processes, and to inform staff about the evolving relationship between



Evolution in staffing from 1994 to 2004; inset, evolution during 2004

ESA and the EU. Other programmes have focused on developing essential attributes such as leadership and negotiation skills.

More than 4300 man-days were devoted to staff training across ESA's Establishments in 2004, including the participation of 450 staff members in the corporate educational programmes.

External Training

Over 2300 applications for the 2004 Young Graduate Trainee (YGT) programme resulted in the successful recruitment of highly motivated young men and women, contributing to the total of 137 YGTs, compared with 101 in 2003. These YGTs gained valuable 'hands-on' work experience, preparing them for future employment in the space industry or research.

30 Internal Research Fellows (compared with 36 in 2003) were given the opportunity to carry out research in a variety of disciplines, mainly related to space science, space applications or space technology, under the supervision of ESA scientists and engineers.

20 External Fellows received ESA funding to carry out research at a university or research institute in 2004. 19 Spanish and 28 Portuguese graduates benefited by gaining practical experience at ESA in engineering and scientific disciplines related to space applications, within the framework of bilateral agreements with these two countries.

ESA also hosted 56 university students on internships during 2004.

Gender Equity

It was a year of action for equal opportunities, with the implementation of concrete measures supporting the Equal Opportunities and Diversity Policy introduced in 2002.

The emphasis continues to be on the long-term objective of increasing female representation in science and engineering and at managerial level. Meanwhile, career development for female staff in all categories is supported by a range of new tools including networking, mentoring and specific personal development and leadership training.

		Hors Class	A	L	B	C	Total Staff
Menber States	A	-	32	-	5	-	37
	B	1	72	-	13	-	86
	DK	-	25	-	3	-	28
	FIN	-	12	-	3	-	15
	F	3	325	10	100	11	449
	D	3	293	4	68	-	368
	IRL	-	11	-	8	-	19
	I	2	297	-	36	1	336
	NL	1	62	-	52	1	116
	N	-	21	-	2	-	23
	P	-	6	-	3	-	9
	E	-	129	-	9	-	138
	S	-	41	-	4	-	45
	CH	-	27	-	2	-	29
	UK	1	138	5	41	-	185
	Total	11	1491	19	349	13	1883
Non-Member States	CDN	-	22	-	3	-	25
Grand total		11	1513	19	352	13	1908

Staff distribution by nationality and category at the end of 2004

To help staff achieve a better balance between their professional and family lives, childcare facilities have been arranged at all Establishments, involving the building of new facilities that are already open or soon will be.

The Agency is linked into a wide range of equal-opportunity networks, in both the private and public sectors, for the exchange of best practices.

Coordination

The year was a turning point in the history of the Coordination system, with the adoption of the reform of its regulations by the six Coordinated Organisations and its progressive implementation by the members of the Coordination system. The Administrative and Finance Committee (AFC) adopted the Regulations concerning the reform of the Coordination system at its 213th meeting on 22 April. The reform is based on a number of recommendations made by a group of independent experts, and the changes concern, on the one hand, the introduction of a certain flexibility for the individual Organisations and, on the other, an amendment to the Coordination process to faciltate the reaching of consensus.

In its 160th Report, the Coordinating Committee on Remuneration recommended that Councils adopt a new procedure for calculating the daily rates of subsistence allowance. The Coordinating Committees also began a review of the system for the education allowance, which is still ongoing.

Staff

At the end of 2004, the Agency had 1908 staff in post, compared with 1912 at the end of 2003.

Pensions

At the end of 2004, the number of pension recipients stood at 909, compared with 856 at the end of 2003.

Procurement

Evolution of the Agency's Procurement and Industrial Policies

FINPOL: results and way forward

The so-called FINPOL Resolution (ESA/C/CLXXI/Res. 2 (Final)) approved unanimously by Council in June 2004 is meant to reform some aspects of the Agency's industrial and procurement policy, the details of which will be worked out by mid-2005.

- The future of the ***technology harmonisation process*** calls for the enforcement by the Director General of the recommendations regarding the process itself in ESA programmes, where he has direct power, and for increased promotion of the conclusions of the said process within Member States and industry for their programmes, where that process can only be implemented on a voluntary basis.

- Total convergence was achieved on the need for developing a ***strategic European procurement policy***, in order to ensure that strategic areas such as technologies, components and equipment remain under the control/leadership of European industry.

- The principle of the proposal to ***foster the participation of European industry in national programmes*** was supported by a large majority of Member States, with the understanding that it can only be implemented with the agreement of those States involved, since it impinges on national prerogatives, and on a reciprocity basis.

- Another profound change approved by Council is the ***hierarchy of return rules***. It foresees a pyramid-like approach, in which greater flexibility is allowed for the return rules of individual programmes and a narrower flexibility is set for the overall return, whilst maintaining the need to target the ideal return coefficient of one.

- The need for further ***mastering of risks*** for programmatic and procurement purposes has been recognised. Accordingly, adequate funding has to be assured by Member States within the programme envelopes for the preparatory activities and early phases of programmes, before embarking on the development phase. It will be necessary to prepare a ***development dossier*** before initiating development-phase procurement. An ***incremental approach to procurement*** when risks are deemed very high (e.g. in the case of interfaces not under the Agency's direct control) is also foreseen.

- The ***Code of Best Practices***, which dictates the rules to be followed by the Prime Contractor in a competitive environment vis-à-vis its subcontractors, will be revised and presented to the Industrial Policy Committee (IPC) for approval, to reinforce the Code's use as a general tool for fair competition. It will be complemented by the 'Make or Buy' Plan. Furthermore, the ***return requirements approach*** will become the basis for the achievement of competitive offers.

Procurement Rules and Procedures

The new Intellectual Property Rights regime approved by Council in October 2003 was put in place in 2004, and several implementation aspects had to be regulated. In particular, a new policy on fees due to ESA in the event of subsequent exploitation by the contractor of the contract results was adopted: henceforth, fees will be claimed only when a contractor grants a licence allowing production of articles to a third party established outside the ESA Member States.

The revision of the General Conditions of Tender (GCoT) was completed. As a result, two sets of GCoTs were produced, one addressing the characteristics of large contracts and including several explanations and examples, and a second, much smaller one tailored for smaller contracts. These new GCoTs are expected to enter into force in early 2005.

Industrial Cost-auditing Activities

These activities were reinforced during the year, the main reason being the auditing activity mandated by the Directorate of Launchers for the Ariane EGAS programme. This focussed

initially on the industrial-return data to be used for the calculation of the programme's initial contribution scales, and audit activities were carried out at all industries involved in the production activities (manufacturing, integration, and operational) for the Arianespace order placed in May covering the production of 30 Ariane-5 launchers.

The other main focus was on the dossier presented to the Council covering ESA's purchasing power and the potential consequences for the Agency of the costs incurred by European space industry for reorganisation and restructuring. Discussions and exchanges in a dedicated working group and within the Council resulted in a number of directives being implemented to ensure that the purchasing power of the ESA budget remains as high as possible.

Furthermore, the new policy is aimed at achieving multi-year labour/facility and overhead agreements with space industry, to provide the necessary stability in terms of planning figures for both the industries involved and ESA. It will be implemented in collaboration with the various national audit authorities, with whom cooperation and coordination has been intensified.

Facts and Figures

Procurement Activities

416 Invitations to Tender (ITTs) were sent to Industry in 2004:

- 165 in open competition
- 10 in restricted competition
- 241 in direct negotiation.

ESA also placed:

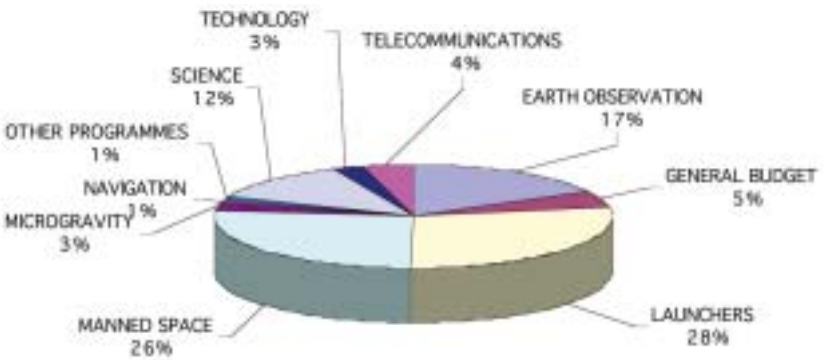
- 795 contracts
- 183 riders
- 219 work orders
- 2410 Contract Change Notices

with total released funding of 2822 MEuro.

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

- JWST Near-Infrared Spectrograph implementation phase
  69 MEuro
- Launch Services for Galileo GSTB V2
  75 MEuro
- Industrialisation of ISS Exploitation Programme
  128 MEuro
- Ariane-5 Development Programme Slice-9
  165 MEuro
- PATP for Galileo Phase-C/D/E1
  149 MEuro
- Ariane EGAS
  950 MEuro.

Value of commitments made to industry in 2004, per Programme



Total: 2650 MEuro

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

- 422 procurement proposals were submitted to the AC, of which 216 were presented to the IPC, and
- 42 contract proposals were submitted to the AC, of which 15 were submitted to the IPC.

The value of the contract proposals submitted to the AC was 2569 MEuro. Of these, contracts worth 257 MEuro were finalised at AC level, and the remainder, worth 2312 MEuro, were passed on to the IPC for a final decision.

Industrial Activity and Evolution of Industrial Return

Industrial activity was maintained at a sound level, with some 2650 MEuro of weighted commitments 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 22% of the total contract value. 28% was related to Launchers, 29% to the Human Spaceflight, Microgravity and Exploration Programme, and 12% to the Scientific Programme, with the remaining 9% being split between the General Budget and Technology.

About 249 MEuro committed with industry is not yet included in the above figures, pending finalisation of the relevant subcontracts (mostly underway).

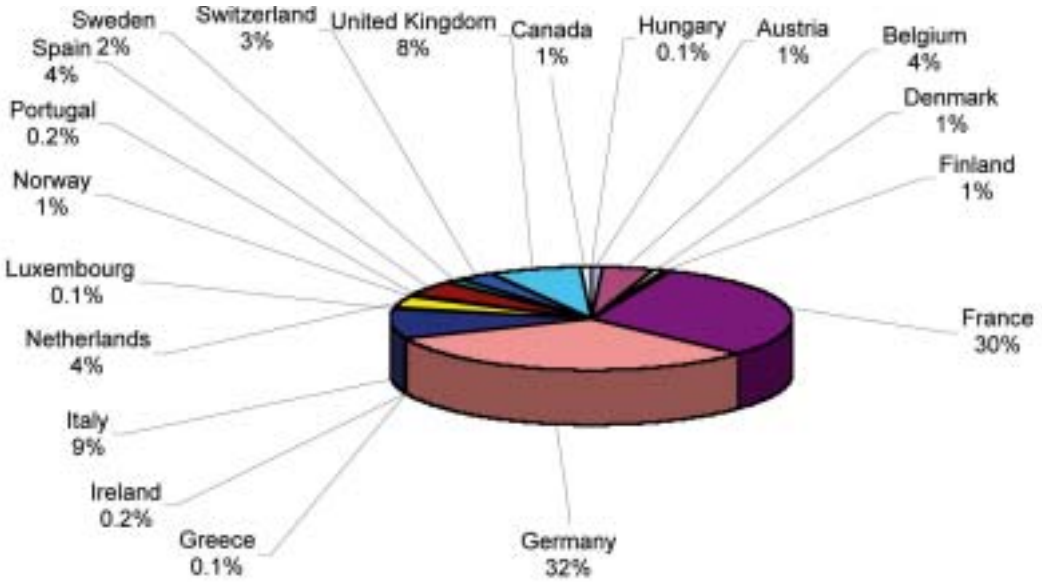
The return situation will be presented at the Formal Review of the geographical distribution of contracts for the period 2000-2004, to be conducted by the IPC in March 2005.

Third-party Activities

In 2004, six new third-party activities for the European Community were started, with a total contract value of 5 MEuro, and the resulting income during the year to ESA amounted to 1.5 MEuro. These new activities include the Community's support for the 'Soyuz at CSG' project.

ESA (through ESOC) submitted a total of 18 formal proposals in 2004, comprising 3 to other space agencies (CNES, DLR, Eumetsat) and 15 to European industrial entities: Astrium (F), Eutelsat (F), Fugro (N), GFZ Potsdam (D), KSAT (N), SES Astra (Lux), SSC (S), Telespazio (I), Vitrociset (I). They related to services in the areas of technical support, provision of infrastructure for hosting equipment, stations and network provision, LEOP and routine operations. As a result of these 18 proposals, 7 contracts were awarded to ESA and 7 proposals were still under

Value of commitments made to industry in 2004, per Member State



Total: 2650 MEuro

negotiation at the end of the year. The total value of the new contracts received in 2004 amounted to 3.2 MEuro, and the proposals still under negotiation at year's end were valued at 13 MEuro.

Cooperation agreements are in place with Swedish Space Corporation (S), the Norwegian Space Centre (N), Astrium GmbH (Dornier Space Systems) (D) and Merlin Communications International (UK). These are non-exclusive arrangements to facilitate mutual utilisation of facilities, whereby each activity is the subject of a separate contract.

A Frame Contract for the mutual exchange of TT&C services to be rendered by ESOC is in place with CNES (F). A similar contract is under discussion with DLR (D).

In addition, ESA (through ESTEC) has undertaken a considerable number of activities in the areas of general technical support, individual consultancies and testing.

The ESTEC External Customer desk handled 126 enquiries (of which 25 were carried forward from previous years, and 101 were new) in 2004 concerning services performed at the Establishment. This resulted in the receipt of 71 contracts with a total value of 3.8 MEuro (including subsidies for technical support for European Space Incubators).

In addition, ETS (NL) the contractor currently responsible for the management, marketing, sales, maintenance and operation of the ESTEC Test Facilities handled some 100 enquiries, 13 of which resulted in contracts.

Chairmen of Council, Programme Boards and Other Delegate Bodies

Council

Chairman	P. Tegnér (S)
Vice-Chairs	M. Wagner (B) P. Piffaretti (CH)

Programme Boards

Communication Satellites	B. Mathieu (F)
Satellite Navigation	E. Buergo (E)* J. López (E)
Earth Observation	S. Wilson (UK)
Launchers	F. Rossi (I)
Human Spaceflight, Research and Applications	G. Van der Wees (NL)

Other Delegate Bodies

Administrative and Finance Committee	K.-O. Pfeiffer (D)
Industrial Policy Committee	G. Hovmork (N)
Scientific Programme Committee	R. Pellinen (FIN)
International Relations Committee	K.-U. Schrogl (D)

Statutory Bodies

Appeals Board	J. Massot (F)
Audit Commission	P. Brügger (CH)
Staff Association Central Committee	B. Melton (UK)

* Until end-August 2004

National Delegates to Council

AUSTRIA
K. Pseiner
K. Schramek

BELGIUM
E. Beka
P. Simon
M. Wagner (Vice-Chair)

DENMARK
H. Grage
G. Petersen
B. Sode-Mogensen

FINLAND
A. Joensuu
E. Panula-Ontto
K. Tilli

FRANCE
L. Beau
P. Brudieu
Y. d'Escatha
S. Janichewski

GERMANY
L. Baumgarten
V. Liebig
S. Wittig

IRELAND
A.M. Grace
P. Hennessy
T. McDonald

ITALY
V. De Luca
G. Morsillo
S. Vetrella

NETHERLANDS
J.H. de Groene
R. van Akker
J. van Enst

NORWAY
N.C. Ihlen
M. Mathisen
R. Skår

PORTUGAL
V. Corrêa
J. Rosa Lã

SPAIN
J.C. Cortés
J.M. Leceta
M. Lucena

SWEDEN
L. Lübeck
S. Strömberg
P. Tegnér (Chair)

SWITZERLAND
D. Fürst
P. Piffaretti (Vice-Chair)
P. Vinard

UNITED KINGDOM
P. Freedman
C. Hicks
R. Sivalingam

CANADA
M. Garneau
M. Giroux
F. Guertin

Agreements Signed

Amendments to the Plan for European Cooperating States (PECS) Charter between the European Space Agency and the Republic of Hungary, made by an exchange of letters on 17 and 31 March 2004 signed by Mr Jean-Pol Poncelet, ESA's Director of External Relations, and Mr Elod Both, Director of the Hungarian Space Office.
(ESA/LEG/280, add.1)

Convention between the European Space Agency and Arianespace concerning the production phase of Ariane launchers, signed in Paris on 3 April 2004 by Mr Antonio Fabrizi, ESA's Director of Launchers, and Mr Jean-Yves Le Gall, Director General of Arianespace. It entered into force on the same day. This Convention cancels and supersedes the Convention signed on 8 February 2002.
(ESA/LEG/282 (R))

Rider 5.2 to the Convention between the European Space Agency and Arianespace on the Ariane-5 launcher production phase, signed in Paris on 3 April 2004 by Mr Antonio Fabrizi, ESA's Director of Launchers, and Mr Jean-Yves Le Gall, Director General of Arianespace. This Rider entered into force on the date of its signature. The duration is limited to that of the renewed Convention between the European Space Agency and Arianespace concerning the production phase of Ariane launchers, signed on the same day.
(ESA/LEG/283 (R))

Agreement between the European Space Agency and the Grand Duchy of Luxembourg concerning the accession of Luxembourg to the ESA Convention and related terms and conditions, signed in Paris on 6 May 2004 by Mr Jean-Jacques Dordain, ESA's Director General, and Ms Hennicot-Schoepges, Minister for Culture, Higher Education and Research of the Grand Duchy of Luxembourg. This Agreement will enter into force on the date of deposition by Luxembourg of its instrument of accession with the Government of France.
(ESA/LEG/284 (R))

Multilateral Agreement concerning the European contribution to the MIRI instrument, signed in Noordwijk (NL) on 8 June 2004 by Prof. David Southwood for ESA, Mr Richard Bonneville for CNES, Dr. Eigil Friis Christensen for DRSI, Dr. Thomas Galinski for DLR, Mr Manuel Serrano Arriza for MEC-PNE, Dr. Wilfried Boland for NOVA The University of Groningen, Prof. Richard Wade for PPARC, and Dr. Lennart Nordh for SNSB. It entered into force on the day of its signature by all Parties and shall remain in force until the end of the JWST (James Webb Space Telescope) mission.
(ESA/LEG/285)

Agreement between the European Space Agency and the Government of the Hellenic Republic concerning the accession of Greece to the ESA Convention and related terms and conditions, signed in Paris on 19 July 2004 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Dimitris Sioufas, Minister of Development of the Hellenic Republic. This Agreement will enter into force on the date of deposition by Greece of its instrument of accession with the Government of France.
(ESA/LEG/286 (R))

Agreement between the European Space Agency and the Government of Turkey concerning cooperation in the exploration and use of outer space for peaceful purposes, signed in Ankara (Turkey) on 15 July 2004 by Mr Jean-Pol Poncelet, ESA's Director of External Relations, and Prof. Dr. Nüket Yetis, Acting President of the Scientific and Technical Research Council of Turkey (TUBITAK). It shall, for the Government of Turkey, be subject to approval in accordance with the legal order of Turkey and will enter into force upon notification by the Government of Turkey of such approval. It will remain in force for a period of five years.
(ESA/LEG/287)

Agreement between the European Space Agency and Eumetsat concerning the Meteosat Second Generation (MSG) fourth satellite, signed in Paris on 2 November 2004 by Mr Jean-Jacques Dordain, ESA's Director General, and Dr. Lars Prahm, Director General of Eumetsat. It shall remain in force at least for the period until the delivery into storage of the MSG-4 satellite.
(ESA/LEG/288)

Agreement between the European Space Agency and the Centre National d'Etudes Spatiales (CNES) on cooperation for the implementation of the SMOS mission, signed in Paris on 19 November 2004 by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Yannick D'Escatha, President of CNES. The Agreement entered into force on the day of its signature and will remain into force until full completion of the activities described in it.
(ESA/LEG/289)

Plan for European Cooperating State (PECS) Charter between the European Space Agency and the Czech Republic, signed in Prague on 24 November 2004 by Mr Lars Fredén, ESA's Head of International Relations, and Ms Petra Buzkova, Minister of Education, Youth and Sports. It entered into force on the day of its signature.
(ESA/LEG/290)

Extension of the Agreement between the Deutsche Zentrum für Luft- und Raumfahrt e.V. (DLR) and the European Space Agency concerning the installation and utilisation of certain assets located at Lampoldshausen, made by an exchange of letters dated 13 and 22 December 2004, signed by Mr Jean-Jacques Dordain, ESA's Director General, and Mr Sigmar Wittig, for DLR. The duration of the Agreement has been extended until 31 December 2005.
(ESA/LEG/234 add. 1)

Patents

PAT 486 ELECTRONIC DEVICES COMPRISING MICRO-ELECTROMECHANICAL ADJUSTABLE CAPACITANCES

International Application	PCT/FR04/00358
Filing Date	17 February 2004
Applicant	European Space Agency
Inventors	F. Petz & M. Wittig
Other Applications	France

PAT 489 MINIATURISED OPTICAL HIGH-RESOLUTION SPECTROMETER

US Application	10/892,832
Filing Date	15 July 2004
Applicant	European Space Agency
Inventor	B. Harnisch
Other Applications	France

PAT 491 ARCHITECTURE FOR AN ITERATIVE DECODER

US Application	10/926,063
European Application	04 292102.3
Filing Dates	26 and 28 August 2004, respectively
Applicant	European Space Agency
Inventors	A. Martinez & M. Rovini
Other Applications	France

PAT 492 PROCESS FOR PROVIDING PHASE SYNCHRONIZATION OF A PILOT AIDED CARRIER

Norwegian Application	20043212 and 20043213
US Application	10/931,236 and 10/930,864
Canadian Application	2,475,895 and 2,475,899
Filing Dates	29 July, 1 September and 27 July 2004, respectively
Applicant	European Space Agency
Inventors	A. Ginesi, D. Fittipaldi, A. Bigi & R. De Gaudenzi
Other Applications	Europe

PAT 496 FRONT-END ARCHITECTURE FOR MULTI-BEAM FOCAL-ARRAY-FED REFLECTOR ANTENNAS WITH FAILURE COMPENSATION

US Application	10/958,465
Canadian Application	2,483,251
Filing Dates	4 October and 30 September 2004, respectively
Applicant	European Space Agency
Inventor	F. Coromina
Other Applications	France

PAT 497 ARC QUENCHING DEVICE FOR A SOLAR ARRAY

International Application	PCT/EP04/00612
Filing Date	26 January 2004
Applicant	European Space Agency
Inventor	J.E. Haines

PAT 498 PULSE-CODED REMOTE CALIBRATION OF AN ACTIVE PHASED-ARRAY SYSTEM

International Application	PCT/EP2004/002569
Filing Date	27 February 2004
Applicant	European Space Agency
Inventor	D. Bast

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

French Application	04 50278
Filing Date	16 February 2004
Applicant	European Space Agency
Inventors	M. Bavdaz & M. Beijersbergen

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

French Application	04 00419
Filing Date	16 January 2004
Applicant	European Space Agency
Inventor	P. Rueda Boldo

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

French Application	04 51985
Filed	8 September 2004
Applicant	European Space Agency
Inventor	J.-F. Clervoy

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

French Application	04 11296
Filing Date	22 October 2004
Applicant	European Space Agency
Inventor	M.-A. Vázquez Castro

GAL PAT 002 A METHOD AND DEVICE FOR DEMODULATING GALILEO ALTERNATE BINARY OFFSET CARRIER (ALTBOC) SIGNALS

International Application	PCT/EP04/009952
Filing Date	7 September 2004
Applicant	European Space Agency
Inventors	J.-M. Sleewaegen, W. De Wilde & G. Seco Granados

GAL PAT 003 SPREADING CODES FOR A SATELLITE NAVIGATION SYSTEM

International Application	PCT/EP04/014488
Filing Date	17 December 2004
Applicant	European Space Agency
Inventor	J.O. Winkel