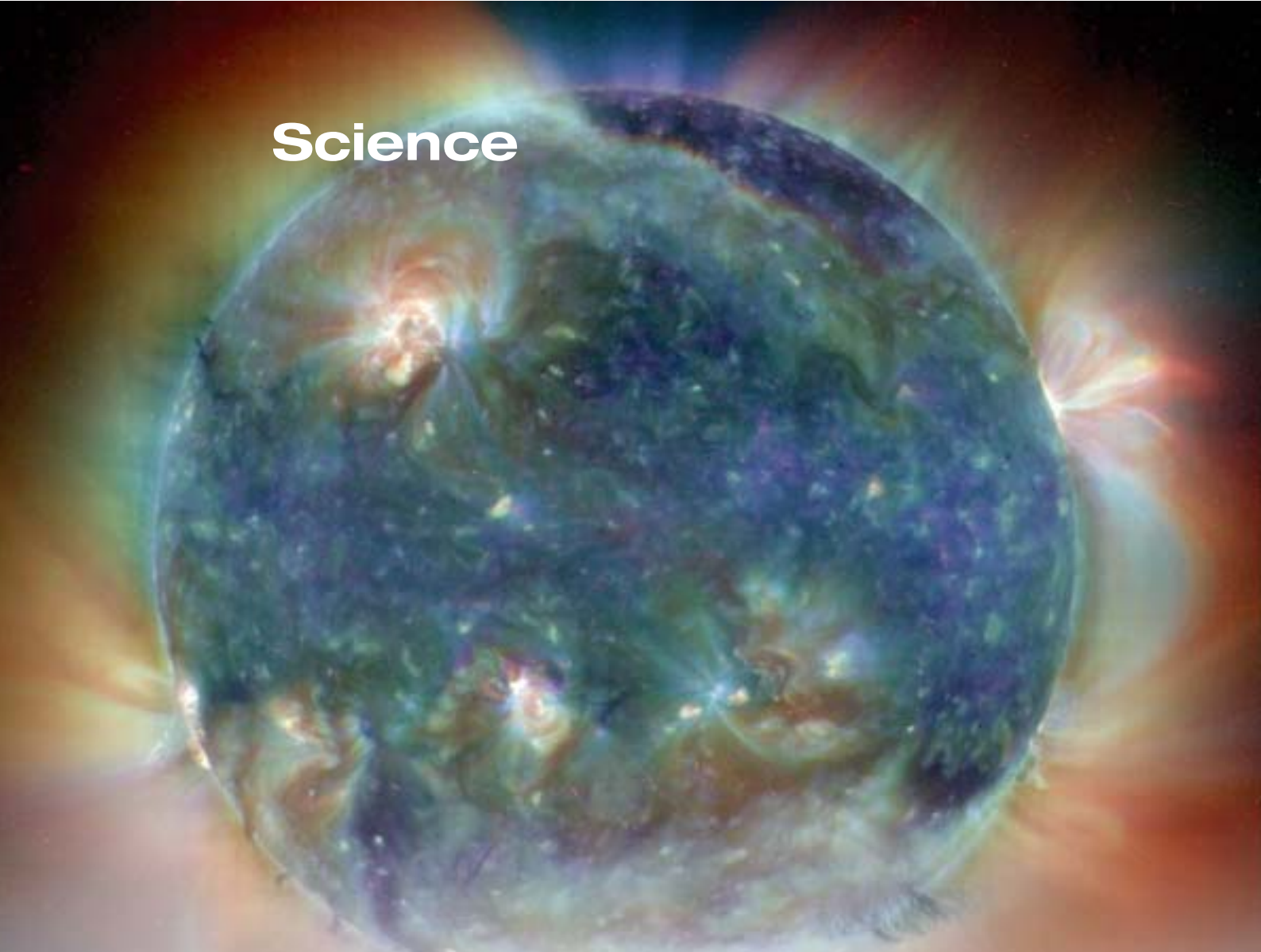
Science



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.

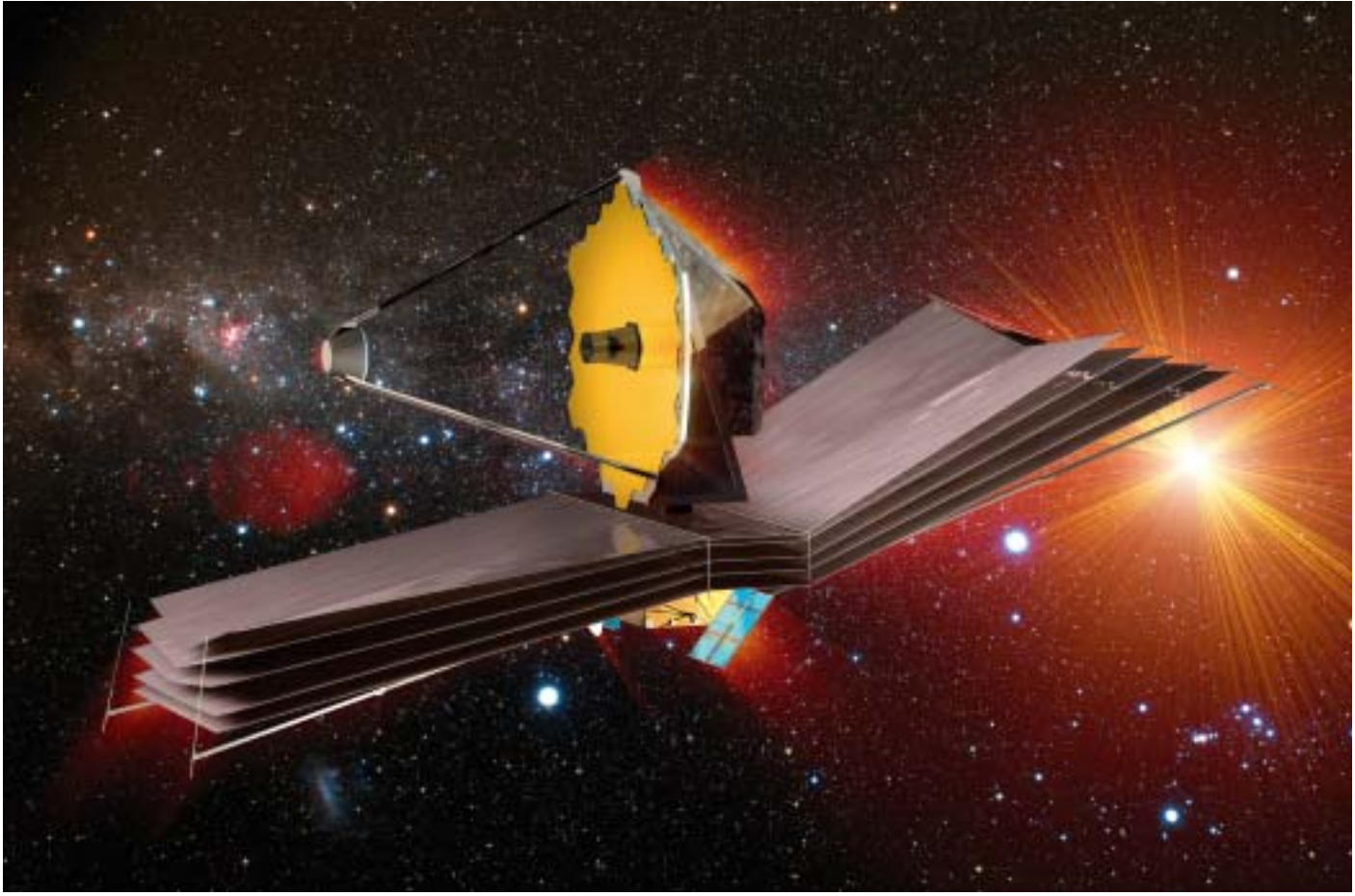
The ground-system development at ESOC progressed very well and the construction of the new ground station at Cebreros in Spain, which will become the primary station for Venus Express, advanced to the point where the 35-metre dish has been installed and the supporting equipment is now being integrated.

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

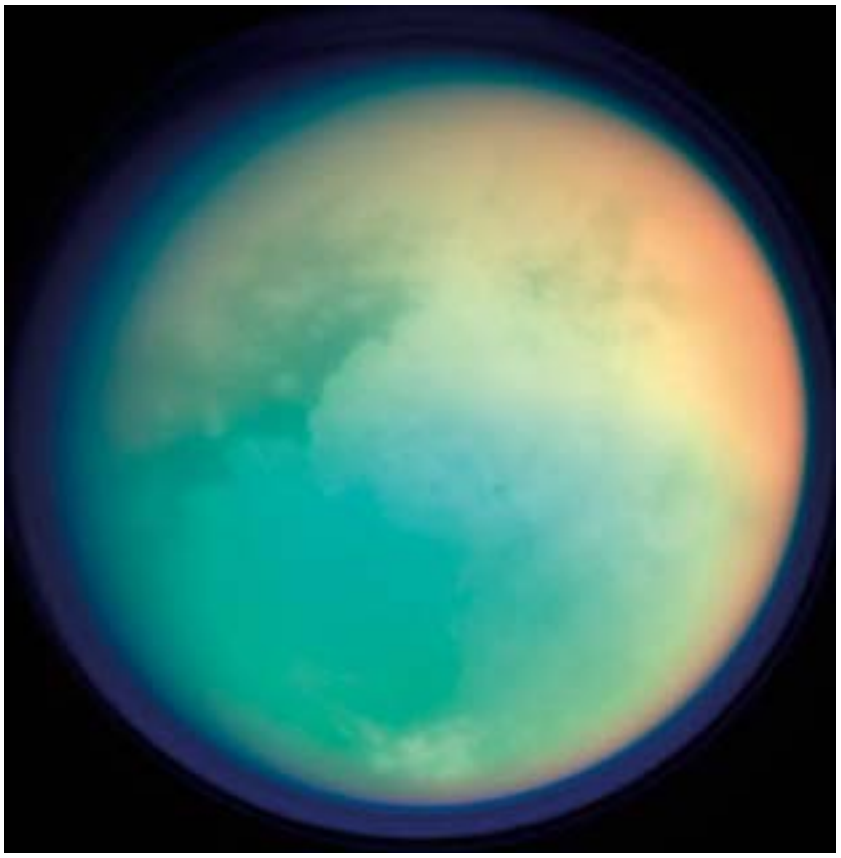
The Hubble spacecraft is operating nominally, with the exception of the Space Telescope Imaging Spectrograph (STIS), one of the five on-board science instruments, which failed on 3 August. Amongst its many scientific achievements, HST has obtained the deepest view yet of the remote Universe (ACS Ultra 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)

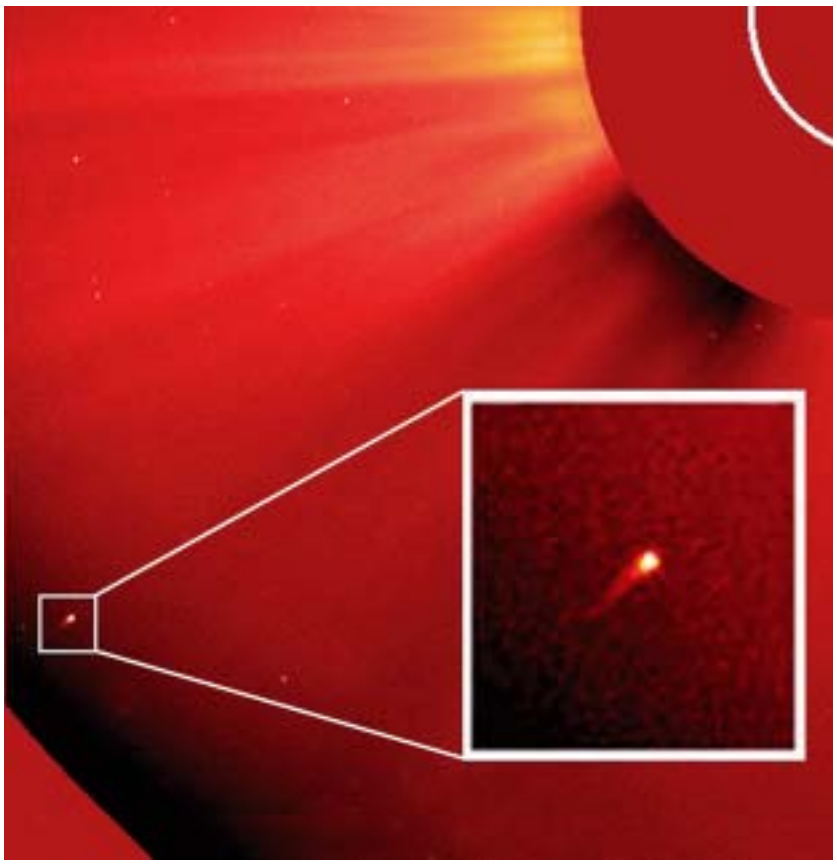
The ISO Data Centre Active Archive Phase activities continue to run smoothly. The mid-term Review was held in June and the Board, composed of external data providers and users, was impressed with the achievements of the past two and a half years. A major new version of the ISO Data Archive was released 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

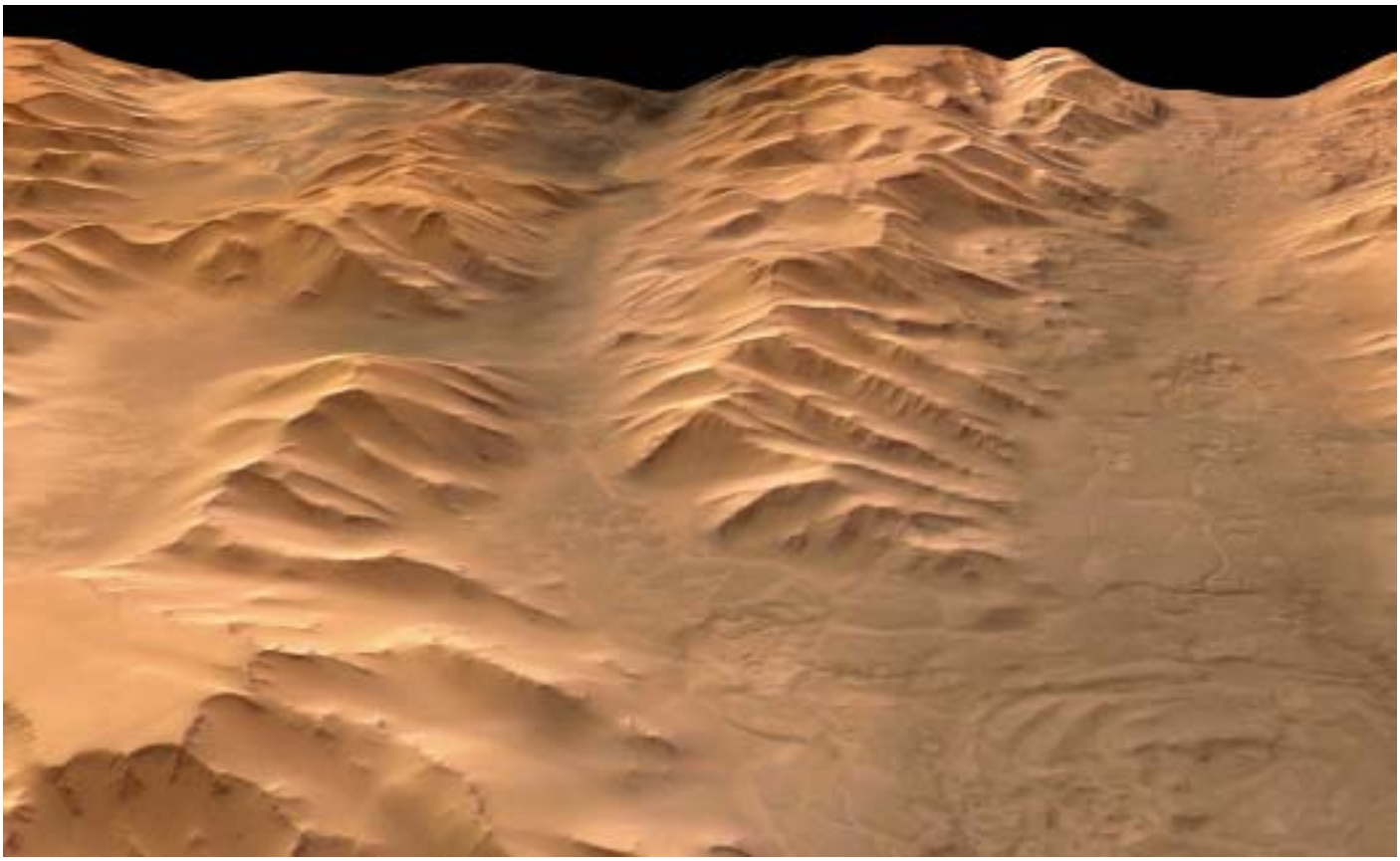
(ISDC) continues to routinely dispatch scientific data products to observers within 6-8 weeks of their observations. The on-line ISDC public archive includes data and science products from the first year of operations. By the end of 2004, a total of 69 refereed papers based on Integral data had appeared. 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



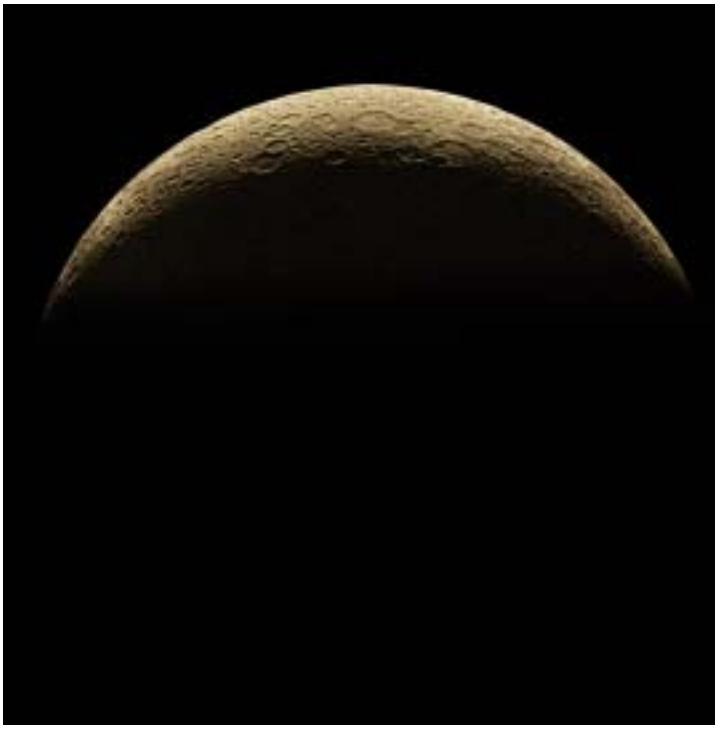
The Titonium Chasma canyon on Mars, part of a canyon system that is the result of a variety of geological processes. Tectonic rifting, water and wind action, volcanism and glacial activity have probably all played major roles in its formation and evolution

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



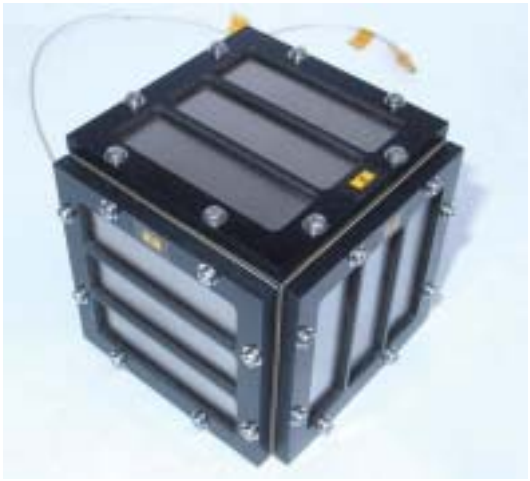
PRODEX / PECS

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.