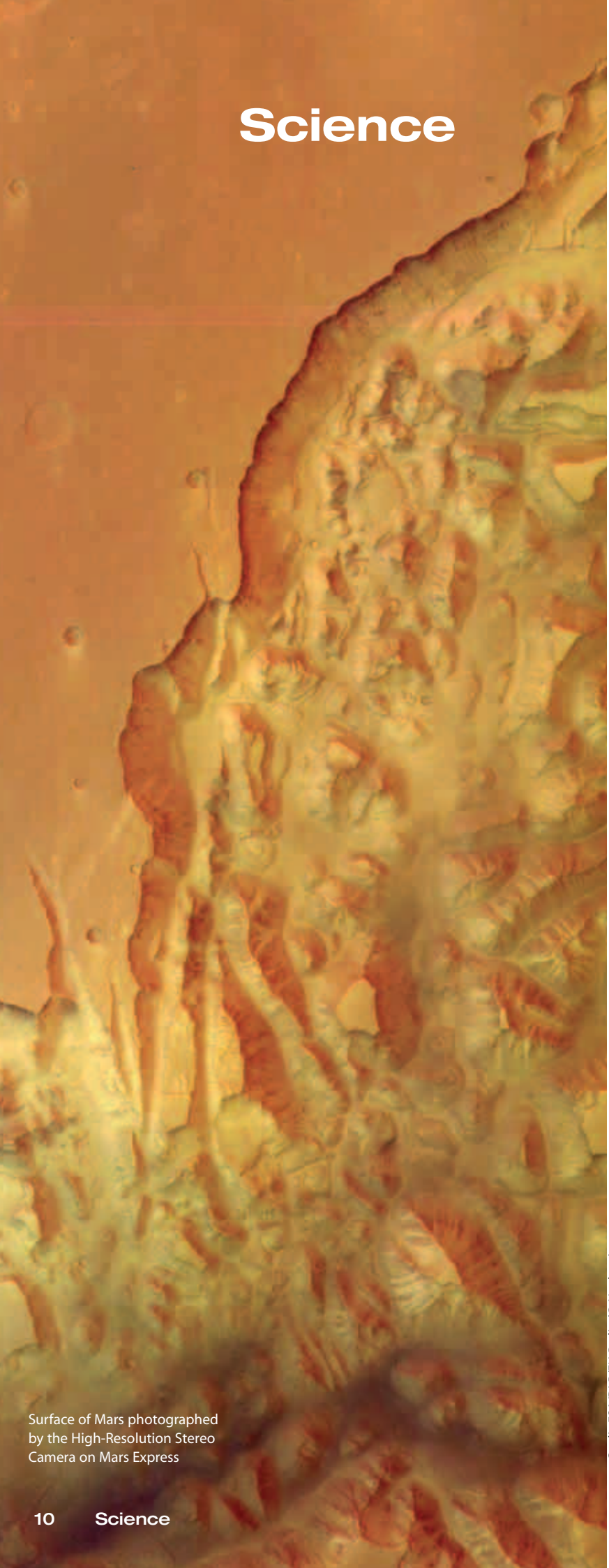
Science



Surface of Mars photographed by the High-Resolution Stereo Camera on Mars Express

Credit: ESA/DLR/FU Berlin (G. Neukum)

2003 will be written into the history of the Science Programme as possibly the most exciting year so far. In just 16 months the Programme has seen: the launch of Integral (17 October 2002), the biggest gamma-ray observatory in history; the launch of the first ESA mission to Mars (Mars Express on 2 June 2003); the launch of the first ESA mission to the Moon (SMART-1 on 27 September); the attempted landing of the first European probe on a celestial body far from the Earth (Beagle 2 on Christmas Day); and the realisation of the first ESA joint space mission with China (first Double Star launch, on 29 December). This impressive list will be augmented in February 2004 by the launch of the third Cornerstone mission (Rosetta). Not only has the ESA Science Programme never achieved so many significant milestones in such a short period, but it is hard to identify elsewhere anywhere near comparable performance with a comparable budget.

Nonetheless 2003 was a difficult year. Keeping within budget has led to much criticism and heartache within the European science community. For the first time, the Science Programme Committee (SPC) cancelled a planned mission, Eddington, in its approval of the revised 'Cosmic Vision' implementation plan, as well as drastically reducing the scope of the BepiColombo mission to Mercury, which was to have been the fifth Cornerstone mission.

In fact two financial problems constrained the future plans of the Science Programme, one short-term, one long-term. The root of the short-term problem was the decision in January not to launch Rosetta, and for all Ariane rockets to be grounded. The immediate impact on the Science Programme was thirteen months of delay for Rosetta, and six months for SMART-1.

Two other financial issues for the short term emerged at the peak of the Ariane crisis, in February and March. Both were associated with the present severe situation in some of our Member States' funding abilities and the crisis in the commercial space market. Both effects were causing anomalous demands on our expenditure, one to support Member State

Mars Express ready for launch from Baikonur Cosmodrome in Kazakhstan

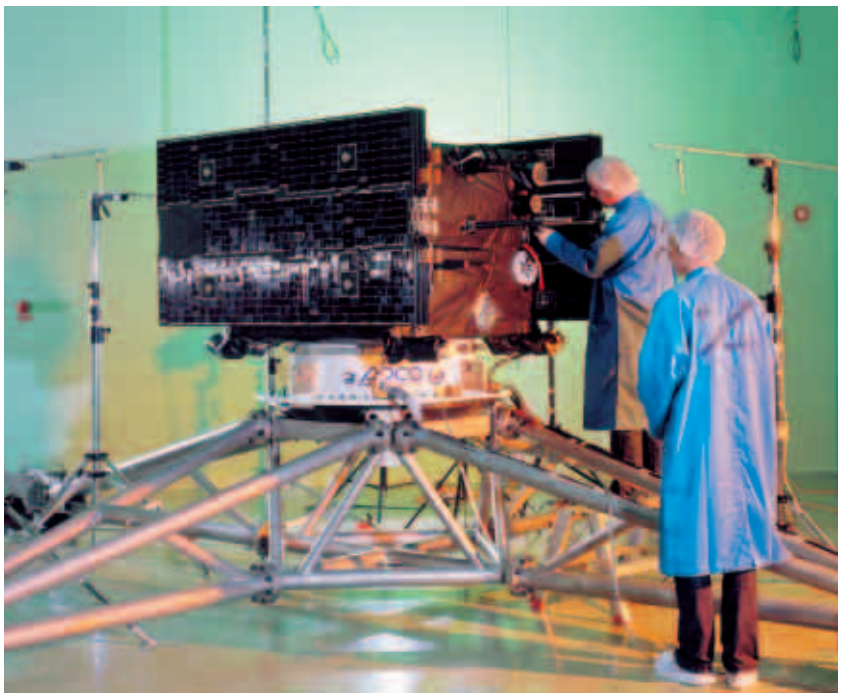
provision of payloads, and the other to maintain adequate cash flow in industry, an issue already drawn to the attention of our Member States by ESA's Director General in 2002. By April, with the immediate problems scoped, it became clear to the Director General and the Executive that special financial measures should be sought at Council level to move funds between years, whilst staying within the present five-year Level of Resources. Following action by the Directorate of Administration, in particular the Finance Department, and the Administrative and Finance Committee (AFC), the Council agreed unanimously in June to a re-phasing of the Science budget through a loan of 100 MEuro, to be paid back in 2005-2006.

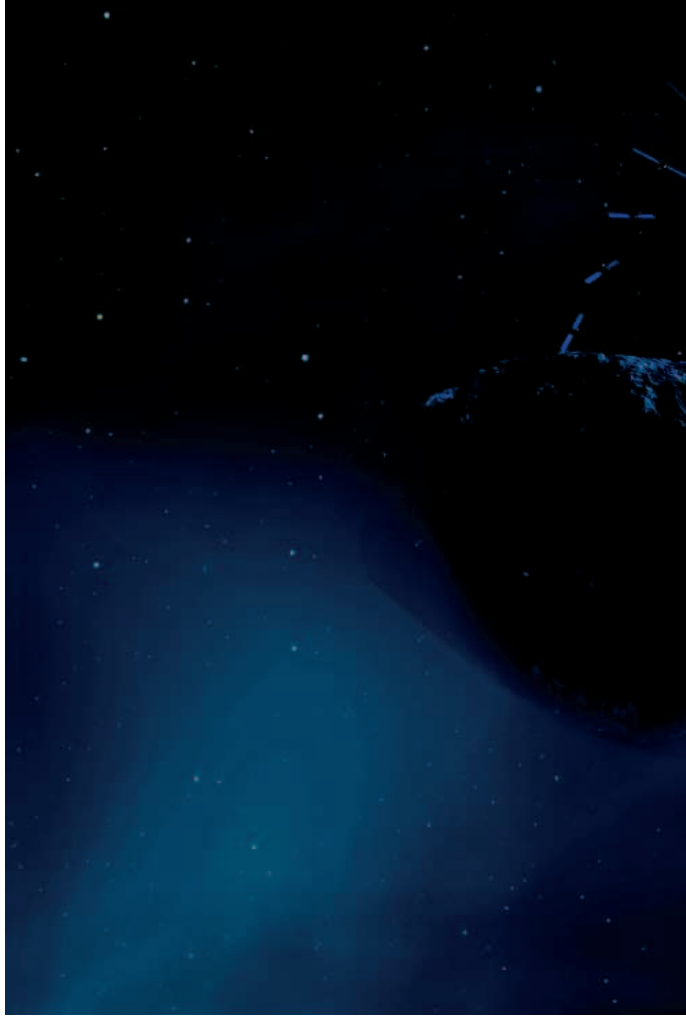
That brings us to the long-term problems. As reported in the Annual Report for 2002, following the outcome for Science of the 2001 Ministerial Council in Edinburgh, an ambitious new Programme was nonetheless agreed with the SPC in 2002 in Andenes (Norway), which squeezed in two more missions than expected, namely Eddington and Venus Express. Key elements for a successful implementation were timely execution and the efficient and on-time provision of payloads by our Member States. These two conditions have been violated by the exigencies of 2003.

The Science Programme endeavours to be highly user-driven, and so the ESA science advisory structure has been fully involved in the Programme's restructuring. In solving the longer-term planning problems (2003-2013), plans needed to match the highest scientific aspirations to the current slowly declining funding.

At its October meeting, the Space Science Advisory Committee (SSAC) formulated its recommendations to the SPC. Taking into account the scientific merit of the missions, and keeping in mind the need to have a balanced

The SMART-1 spacecraft during acoustic testing





Artist's impression of the Rosetta spacecraft orbiting comet Churyumov-Gerasimenko

Programme, the SSAC recommended to the SPC the missions to be implemented within the constraints imposed by the present financial situation. It was a sorry task, and a painful meeting.

The immediate choice was between Eddington and LISA Pathfinder, and was a stark one because delay was not an option. Eddington (being slipstreamed behind Herschel-Planck) would cost much more if it were delayed. LISA Pathfinder is part of a major collaboration between NASA and ESA and commitments have been made against a fairly tight timetable. Furthermore, there are the other missions waiting downstream.

At its meeting in November, therefore, the SPC was forced to make crucial decisions concerning the implementation of the Cosmic Vision Programme: it cancelled Eddington and rescoped the BepiColombo mission.

The Long-Term Programme

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

SMART-2/LISA PathFinder, in 2007

This is a technology-driven mission, which is ESA-led and has a payload contribution from NASA. It will prepare the way for LISA.

LISA, in 2012

This is a deep-space observatory to measure gravitational radiation from the cosmos. The radiation predicted by Einstein has yet to be detected on the ground, and so the observatory may also achieve the first detection of gravitational radiation.

GAIA, not later than 2012

This is a unique mission in astrometry to measure the position and movement of a billion stars in our Galaxy. It will examine the anatomy of the Milky Way and probe the nature of the matter that we cannot see.

BepiColombo, in 2012

This is a dual-spacecraft mission to Mercury, led by ESA but conducted in cooperation with Japan. It marks the first such cooperation and will make the most complete survey of Mercury, its environment, and its interaction with the Sun.

These missions join those already approved and currently under implementation, namely Rosetta (launch 2004), Venus Express (2005), Herschel (2007), Planck (2007) and JWST (2011).

Rosetta

This is the ultimate mission to a comet. It will both orbit the comet and drop a small lander onto its surface. Comets are relics of the primitive material from which the planets are believed to have formed. Thus Rosetta is designed to decode the origins of the Solar System.

Venus Express

This mission marks a return to the Earth's nearest planetary neighbour. Suffering a fiery death from the runaway greenhouse effect, Venus cannot harbour life, but the planetary atmosphere and its history have relevance to those of our own more hospitable planet.

Herschel

This is an observatory for infrared and even longer wavelength light. It follows on from the previous pioneering ISO (Infrared Space

planning window that the SSAC had set itself. This means that Solar Orbiter will not be put in competition in the context of possible future Announcements of Opportunity. Solar Orbiter is a follow-up to the magnificent SOHO mission, going as close to the Sun as the orbit of Mercury and also probing beyond the ecliptic plane.

Artist's impression of the James Webb Space Telescope

Observatory) mission and looks at the cold parts of our Universe, where stars, planets or even galaxies form.

Planck

This mission, which shares a launcher with Herschel, is designed to measure the ripples in the cosmic microwave background, the hiss that pervades the Universe as an echo of the original 'Big Bang'. It will probe into how matter first formed into the clumps that led eventually to the Universe we know today. At the same time, it may also call into doubt the very physical laws that underpin our current ideas of the early Universe.

JWST (James Webb Space Telescope)

This is a grand cooperation with NASA to build a next-generation astronomical observatory to replace the Hubble Space Telescope. 2003 saw the project moving steadily into the implementation phase, with Europe deeply involved in the provision of major focal-plane instruments as well as an Ariane-5 launch.

The SPC decided to keep Solar Orbiter in the Programme although, given the present financial projections, it cannot be launched before 2014, and is therefore outside the

The loss of the BepiColombo lander is a hard blow scientifically, but the longer-term Programme is now much better scoped. Nonetheless, the chance for Europe to be the first to land on at least one Solar System planet has probably been lost. However, to land on a planet so near the Sun is no easy matter, and the project might well have been too ambitious with the present financial outlook.

There are also other, smaller elements in the Cosmic Vision plan. The Science Programme is helping to sustain nationally-led missions such as Corot (in astronomy) and Microscope (in fundamental physics), both of which are led by the French space agency, CNES. Furthermore, the Programme is seeking to expand international cooperation with nations who have space experience, but who are new to space science. The second Double Star launch with China will take place in mid-2004, and opportunities are being sought to enhance cooperation with India in lunar science and astronomy.

The nature of cooperation with traditional partners is evolving also. For example, long-term but relatively low-level European cooperation with NASA in solar-terrestrial science is being coordinated through the International Living With a Star (ILWS) programme. The manner in which ESA Member States have formed a partnership through formal agreements to build the critical elements for the American JWST Mid-InfraRed Instrument (MIRI) is also new, and may be a useful precedent for the future.

Yet, despite the painful descoping of the Programme, everybody can still experience the excitements of the recent scientific outcome of Mars Express, with the most breathtaking images ever taken of the Martian surface; salute the performance of the flawless cruise of SMART-1 to the Moon; enjoy the successful collaboration with China as the first Double Star spacecraft teams up with the Cluster quartet; look forward to the Rosetta launch to Comet Churyumov-Gerasimenko in February 2004; and anticipate the long-awaited arrival at Saturn in July 2004 of ESA's Titan lander, Huygens, onboard the US Cassini mothercraft.

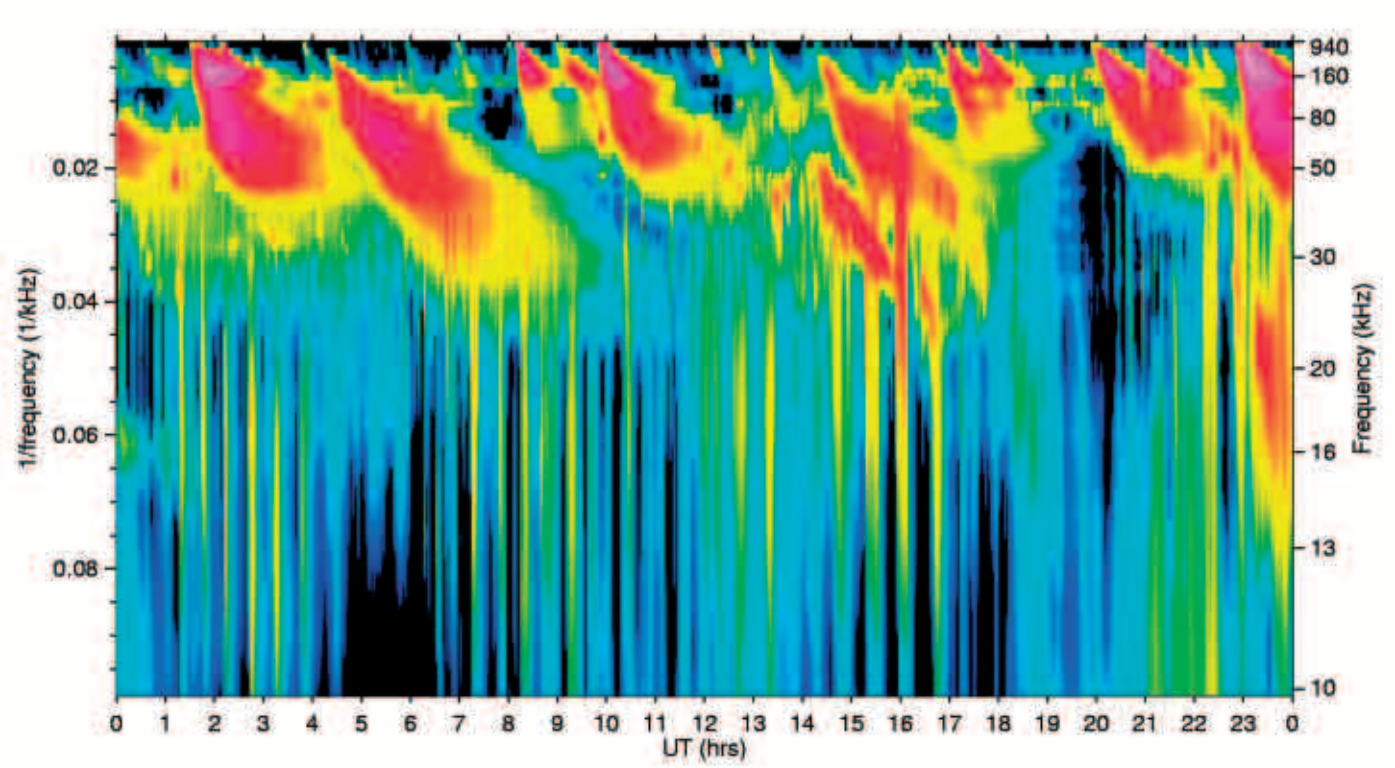
The grand aims of the Programme - its 'cosmic vision' - are the understanding not only of the Universe and its evolution, but also of how man, life itself, the Earth and the Solar System came out of that Universe. By pursuing this work, we are not only decoding our cosmic origins, but also throwing light on what can happen in the future. The work is not accomplished by one mission, or by building just one telescope, or by exploring a single planet - clues drawn from myriad sources need to be put together.

Losing Eddington, a mission to seek Earth-like planets is a step in the wrong direction, but not the end of the road. Our recent successes in reaching Mars and detecting water and sediments, and in launching the Integral gamma-ray observatory looking at the formation of the nuclear building bricks of matter far off in the Universe, are both part of the story, a story that should catch the interest and enthusiasm of everyone.

Evidence that the Science Programme can grab the public's imagination can be found in the media reporting of its activities during the year. The cancellation of the Rosetta launch in January generated enormous public interest, but it is important to recognise that the coverage was almost entirely sympathetic and the fact that the media felt the need to report on it reflects the perceived public interest in the subject. The launch of Mars Express was the big story in June and was followed up by steady coverage during the summer whilst Mars was at its closest to Earth in 60 000 years. September brought the launch to the Moon of SMART-1, with its ion drive, optical communications and miniaturised payload. Public interest and media coverage were exceptional. The end of the year saw the, sadly unsuccessful, landing of Beagle 2 on Christmas Day, followed a few weeks later by the release of the first images from the Mars Express orbiter and confirmation of the first detection of water ice on the south polar cap. These events captured the headlines across the world, unprecedented for an ESA space mission.

The source for most communications material are the scientists themselves within the projects, but extraction of the right messages for communications purposes and their diffusion to the world's media is the responsibility of a small dedicated group (4 staff) in the Science Directorate, who provide material to the corporate communications service. This year has required an extraordinary effort on both sides, happily rewarded with an extraordinary response from the media.

The past, recent and future events to come show that these days are not Science's finest hours, rather we are at present in Science's finest years, the fruit of long hard work, rigorous management and much past investment - and also tough decisions. But a question is now open for the decision makers to answer: in 2003 the Science Programme produced results worthy of Europe's ambitions. Unless positive decisions are taken urgently, there will be no more such years in the foreseeable future. Is this going to be the swan song of European space science? Is this what Europe wants?



An example of quasi-periodic (~40 minute period) radio bursts from Jupiter, detected by Ulysses' URAP experiment in October 2003 (Courtesy of R.J. MacDowall)

Missions in Operation

Ulysses

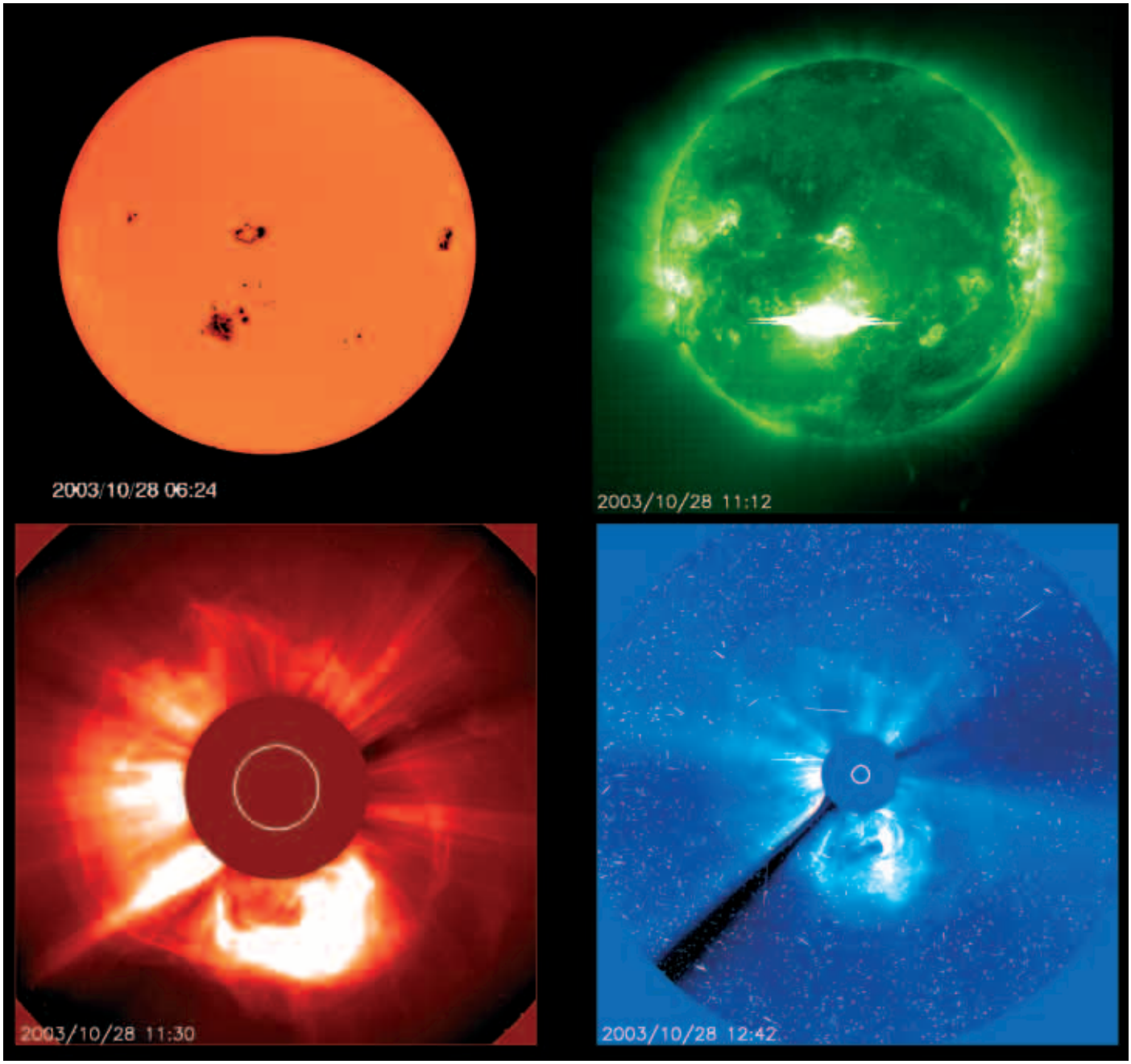
The Ulysses spacecraft, launched in 1990, has continued its groundbreaking exploration of the Sun's environment from the unique perspective of a solar polar orbit. The important role played by Ulysses in the study of the heliosphere (the bubble of magnetic field and particles surrounding the Sun) was underlined once again during the year when ESA's Solar System Working Group expressed support for a proposal to continue mission operations until March 2008. NASA's Sun-Earth Connections Senior Review panel made a similar recommendation at its meeting in mid-2003. If approved, such an extension would allow Ulysses to track the evolution of the heliosphere in three dimensions over the majority of the 22-year solar magnetic cycle.

Hubble Space Telescope

The Hubble Space Telescope (HST), launched in 1990, continues to provide excellent scientific data. The astronomy community in Europe has constantly succeeded, within a highly competitive process, in securing observing time significantly above the formally agreed 15%. The most requested instrument on-board HST in

The closing of HST

The Columbia tragedy has called for the early retirement of HST, in the sense that no further manned servicing missions (and therefore substitutions of instruments) are foreseen. This decision, made known in early January 2004, is based on astronaut safety considerations. No doubt, it is a severe blow to the hopes of scientists, but it must be respected as taken by the only authority responsible for the safety of the Shuttles, i.e. NASA. The Space Science Advisory Committee of ESA interpreted the feelings of the European scientific community, in asking the Executive to explore inventive ways in which they could offer support to NASA so that the potential offered by the new instrument complement now no longer able to fly on HST would not be lost for European scientists, while saluting the skill and bravery of the Space Shuttle crews who have made the HST mission a reality.



The Sun unleashed a spectacular show on 28 October, which was captured by SOHO's instruments. From top left: the giant sunspot regions 10484, 10486 and 10488 seen by MDI in white light; a solar flare as seen by EIT in Fe XII 195 Ångstrom emission; and a fast-moving coronal mass ejection seen by the LASCO C2 and C3 coronagraphs, with the particle shower visible as 'snow' in the image. The fast-moving cloud hit the Earth's magnetosphere with record speed, just 19 hours later

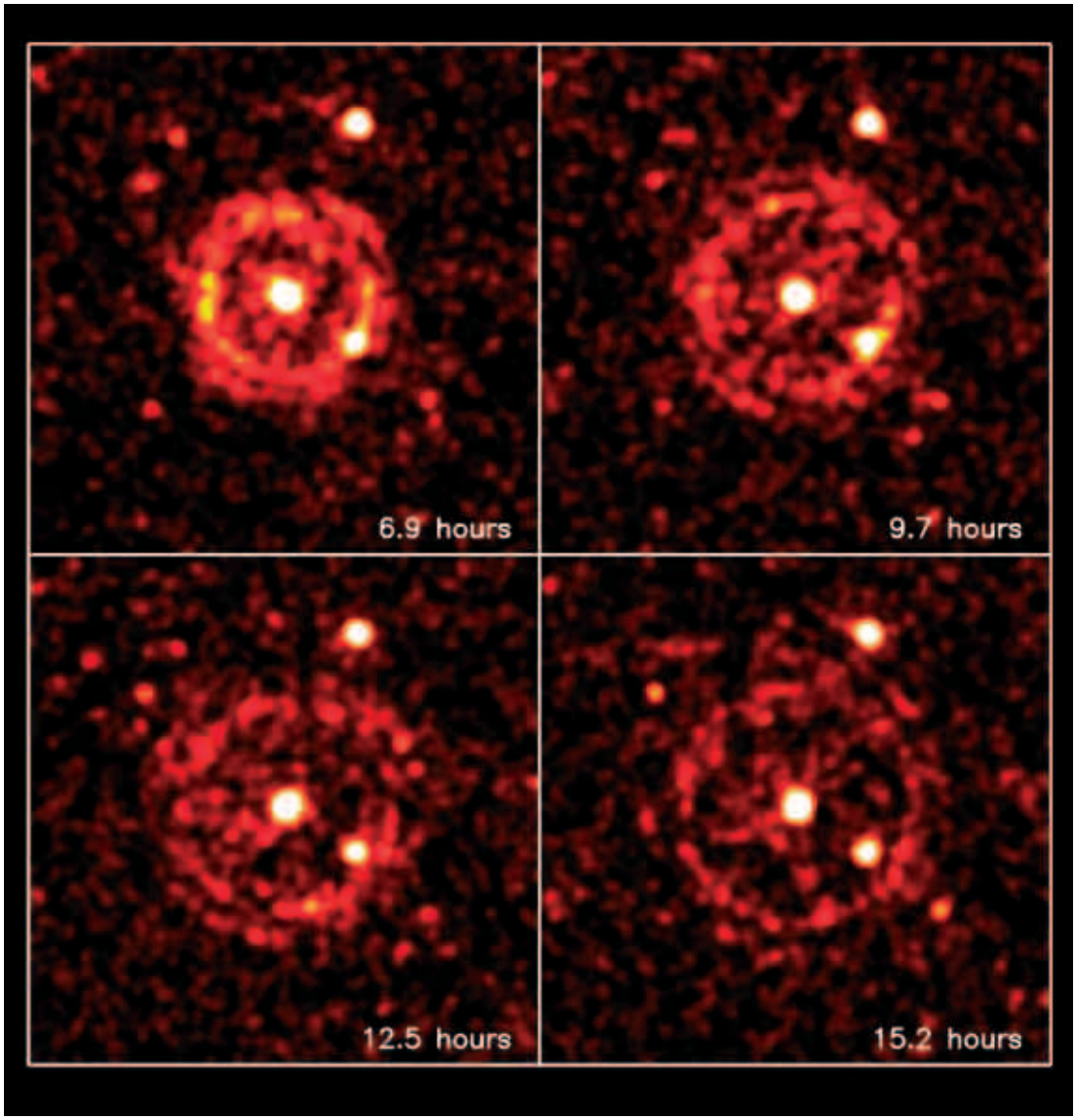
2003 was, not surprisingly, the Advanced Camera for Surveys (ACS) installed during the Shuttle's last servicing mission in 2002. Of particular interest is the use of the ACS to obtain spectra of supernovae leading to redshift measurements and fundamental cosmology studies. A spectacular example is provided by the observation of the supernova with the highest redshift recorded to date.

ISO

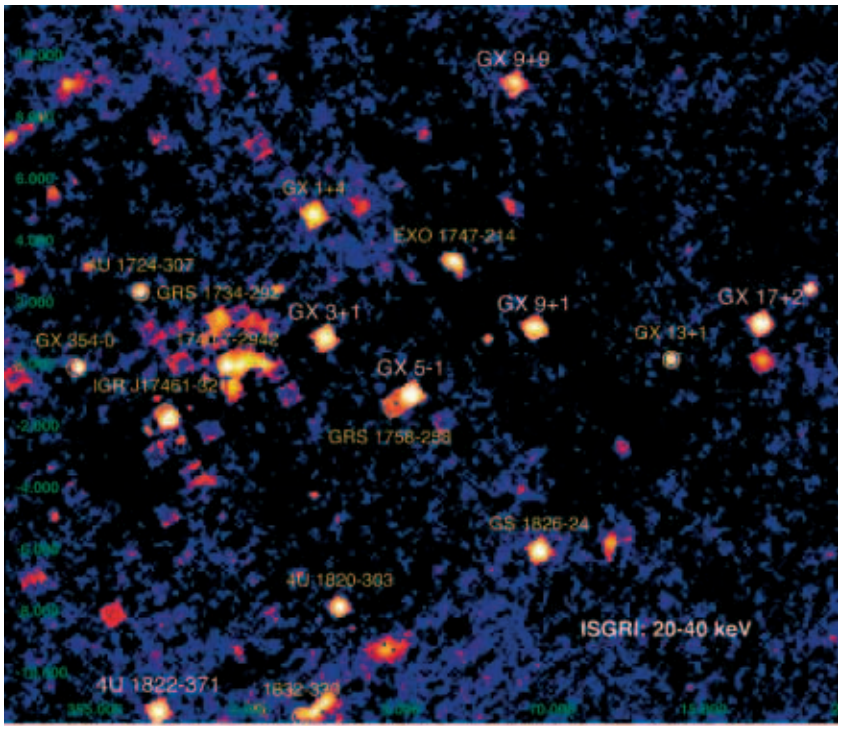
Activities have remained focused on maximising the scientific value and usage of the ISO data archive and on supporting the worldwide astronomical community in its exploitation of ISO's extensive data sets. In November, a new interoperability system was introduced, complying fully with the new standards defined by the Virtual Observatories. ISO continues to deliver ground-breaking results in all fields of astronomy. The 'milestone' of 1000 papers published in the refereed literature was reached in May, and the rate continues to be more than 120 papers a year.

SOHO

As SOHO celebrated its 8th Anniversary in space on 2 December, an eventful year for the mission was coming to a close. It had faced new technical challenges as the spacecraft's High Gain Antenna showed signs of sticking. SOHO had observed the biggest sunspot region of the solar cycle, record-breaking X-ray flares and coronal mass ejections that caught the world's



The four panels show the slowly expanding rings around the (fading) Gamma-Ray Burst GRB 031203, captured by XMM-Newton. The panels are labeled with the elapsed times after the original explosion (Courtesy of S. Vaughan, Univ. of Leicester, UK)



An Integral Imager view of a 24 x 30 degree region around the centre of our Galaxy, for the energy range 20-40 keV (Courtesy of Paizis et al.)

attention, the amazing comet NEAT, as well as a transit of Mercury across the solar disk. The SOHO team had also been presented with the prestigious Laurels for Team Achievement Award by the International Academy of Astronautics (IAA).

XMM-Newton

Scientifically, 2003 was an excellent year, with over 250 publications in, or submitted to, the refereed literature. The next round of observations to be conducted by the observatory was selected in record time, and several cross-mission initiatives, involving among others Integral and Mars Express, were executed. In March, the first catalogue of XMM-Newton-detected X-ray sources was issued, containing over 30 000 hitherto unknown sources, and this was achieved based on only 40% of the currently available data.

Cassini-Huygens

The Cassini/Huygens spacecraft is now in view of Saturn and performing very well. Continuous distant observations of the planet are planned to start on 10 January 2004. The Orbiter software was upgraded to its final configuration in early 2003 to make it ready for the main mission phase. Separation of the Huygens Probe is planned for 25 December 2004, and its landing in early 2005.

Cluster

The Cluster spacecraft have now completed their third year in space, and operations are funded until end-2005. Major advances in our knowledge of the physics of the magnetosphere (the magnetic bubble that surrounds the Earth) are being provided by Cluster's investigation of magnetic reconnection, or how the magnetic fields rearrange themselves, with the subsequent creation of currents and acceleration of particles. This process is observed for astronomical objects, but also on the Sun and in the Earth's magnetosphere. With Cluster, we are able to observe this phenomenon in-situ for the first time, and from four different vantage points, and thereby characterise it as never before.

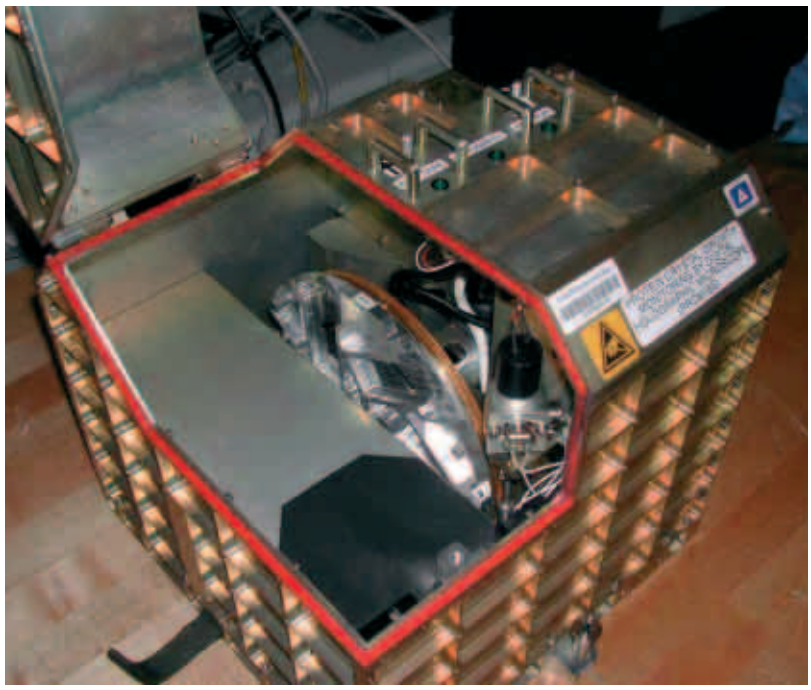
Integral

Integral was launched from Baikonur Cosmodrome on 17 October 2002. After successful performance and verification phases, the observing programme began in earnest at the beginning of 2003. The early scientific results, together with mission descriptions, are reported in 73 papers in a special Integral edition of *Astronomy & Astrophysics* (Volume 411, November 2003).

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 observations, etc.). The Agency provides both administrative and financial management know-how as well as technical support. The countries currently participating in PRODEX are: Austria, Belgium, Czech Republic, Denmark, Hungary, Ireland, Norway and Switzerland. The projects being developed range from small Earth-observation data-analysis programmes to fully-fledged instruments for scientific payloads.

As a follow-on to the Odissea Mission in October 2002, in which the ESA astronaut Frank De Winne took part, PRODEX contributed substantially in 2003 to the Spanish 'Cervantes' mission to the



The PROMISS experiment: protein crystal-growth monitoring using a digital holographic microscope (Courtesy of ULB, Brussels)

Experiments and Subsystems Developed within PRODEX/PECS in 2003

Cervantes Mission		
• MESSAGE	M. Mergeay	Mol (B)
• Cardioscience Rhythm	A. Aubert	Leuven (B)
• Cogniscience Neurocog	G. Chéron	Brussels (B)
• PROMISS 2	L. Wyns / F. Dubois	Brussels (B)
• NANOSLAB	J. Martens	Leuven (B)
SCISAT-1		
• ACE	R. Colin	Brussels(B)
SMART-1		
• Star tracker	J. Jørgensen	Copenhagen (DK)
DoubleStar		
• Contribution to NUADU	S. McKenna-Lawlor	Maynooth (IRL)
Hubble Space Telescope		
• Intercalibration of photometric software packages for the reduction of HST observations	G. Tammann	Basle (CH)
Maxus-5		
• Crystallisation of silicalite-1	J. Martens	Leuven (B)
Mars Express		
• SPICAM Light	D. Fonteyn	Brussels (B)
• ASPERA-3	P. Wurz	Berne (CH)
34th Parabolic Flight Campaign		
• Grip-load force coordination	J.-L. Thonnard	Brussels (B)
• Acute cardiovascular response	A. Aubert	Leuven (B)
35th Parabolic Flight Campaign		
• Eye-hand coordination	J.-L. Thonnard	Brussels (B)
• Bone fractures in microgravity	M. Hinsenkamp	Brussels (B)
• Bubble growth in microgravity	J.-C. Legros	Brussels (B)
STS-107 Mission		
• 4 biology experiments		
• 1 human-physiology experiment		
• 2 material-science experiments		
• 1 space-science experiment		

International Space station (ISS), involving ESA astronaut Pedro Duque, by supporting six Belgian life- and material-science experiments.

The experiments and experiment subsystems listed in the accompanying panel were completed during the year.

In addition, 170 scientists in the ESA Member States participating in PRODEX received support within 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 Co-operating States (PECS). In April, Hungary became the first country to sign an ECS Agreement with ESA. The corresponding PECS Charter was signed on 5 November, making Hungary the first PECS Participant. On 24 November, the Czech Republic followed Hungary's lead by signing an ECS Agreement.