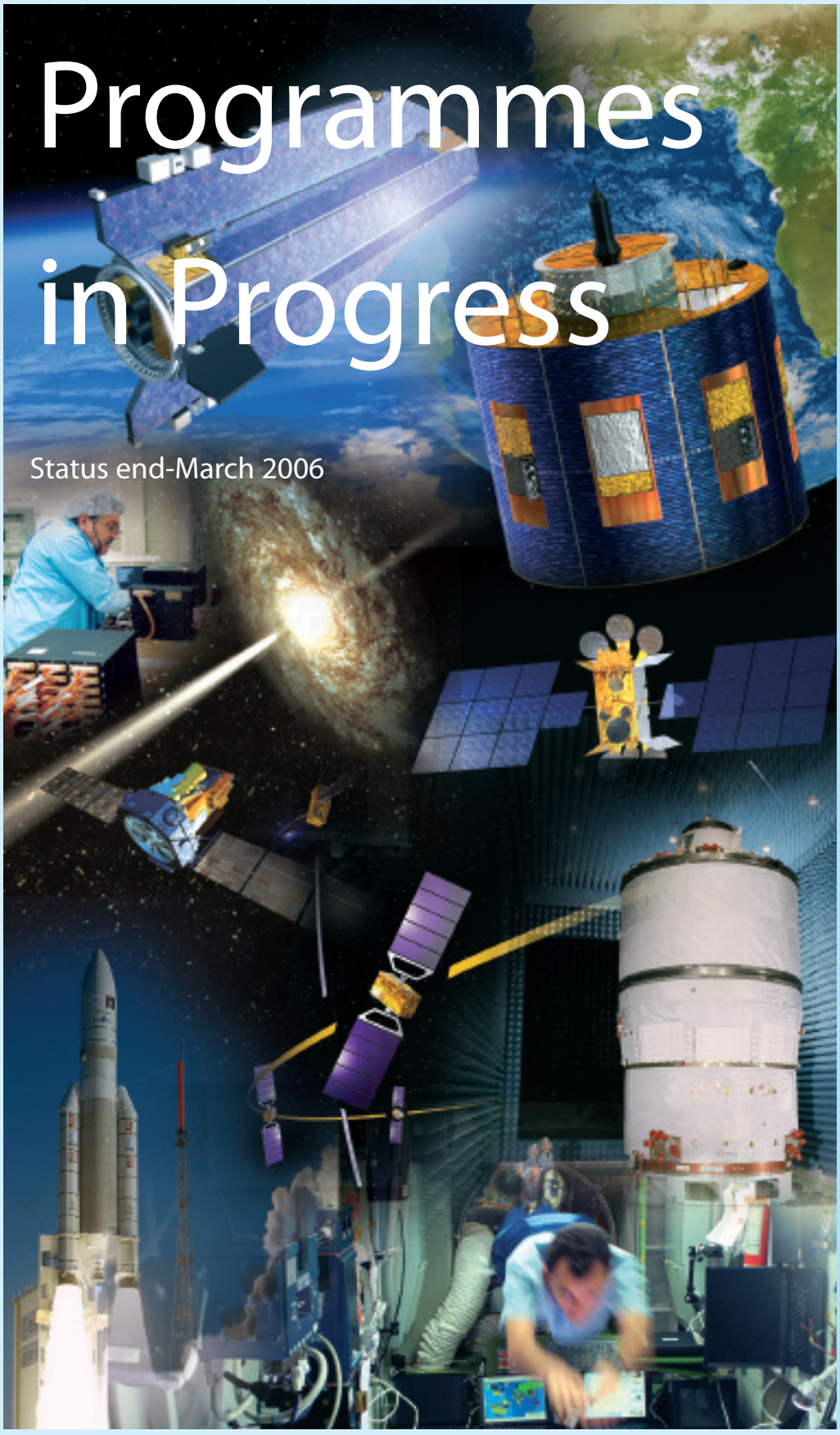
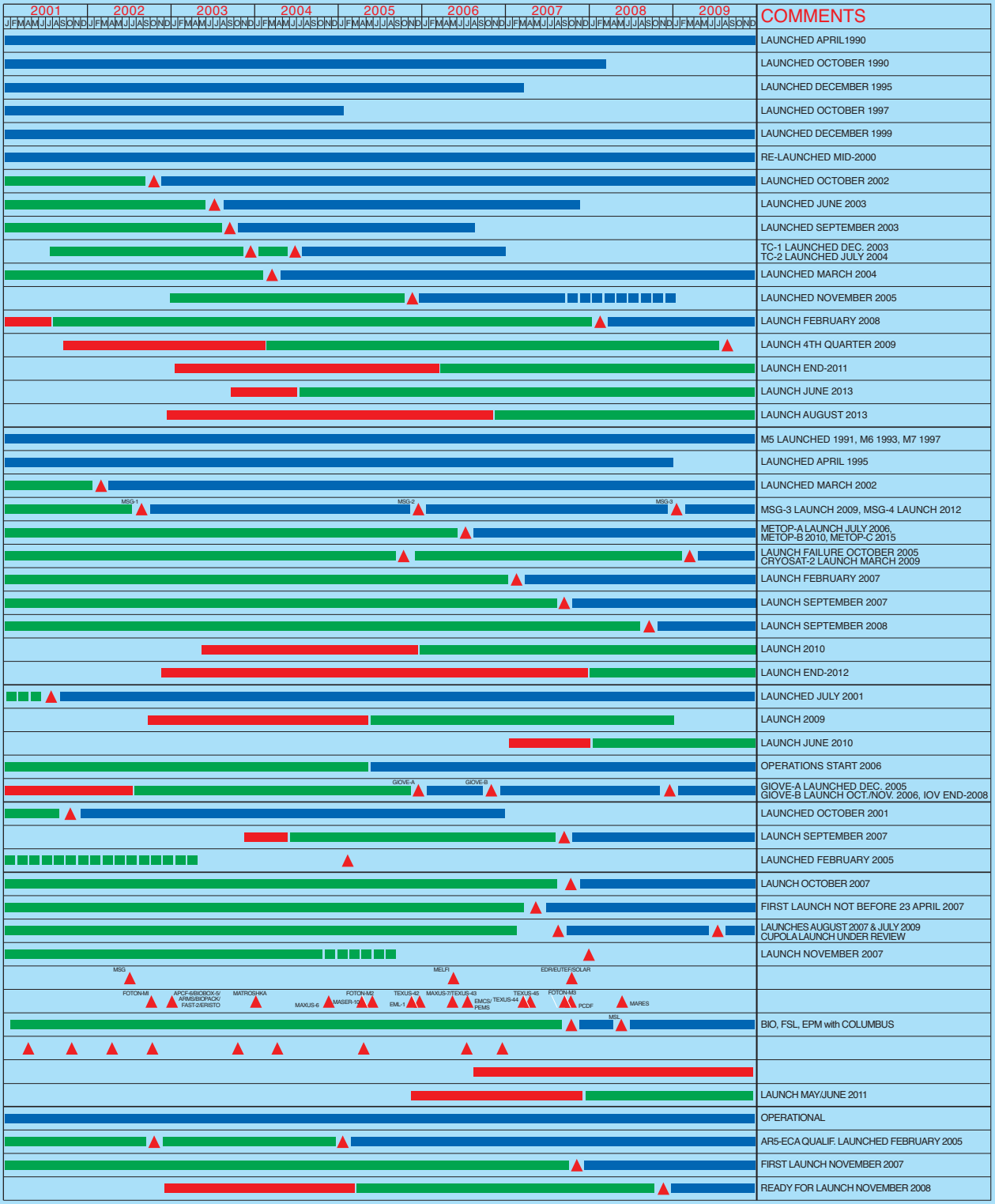
Programmes in Progress

Status end-March 2006



	PROJECT
SCIENTIFIC PROGRAMME	SPACE TELESCOPE
	ULYSSES
	SOHO
	HUYGENS
	XMM-NEWTON
	CLUSTER
	INTEGRAL
	MARS EXPRESS
	SMART-1
	DOUBLE STAR
	ROSETTA
	VENUS EXPRESS
	HERSCHEL/PLANCK
	LISA PATHFINDER
	GAIA
	JWST
	BEPICOLOMBO
EARTH OBSERVATION PROGRAMME	METEOSAT-5/6/7
	ERS-2
	ENVISAT
	MSG
	METOP
	CRYOSAT
	GOCE
	SMOS
	ADM-AEOLUS
	SWARM
	EARTHCARE
COMMS./NAV. PROGRAMME	ARTEMIS
	ALPHABUS
	SMALL GEO SAT.
	GNSS-1/EGNOS
	GALILEOSAT
TECHNOL. PROG.	PROBA-1
	PROBA-2
	SLOSHSAT
HUMAN SPACEFLIGHT, MICROGRAVITY & EXPLORATION PROGRAMME	COLUMBUS
	ATV
	NODE-2 & -3 & CUPOLA
	ERA
	ISS SUPPORT & UTIL.
	EMIR/ELIPS
	MFC
	ASTRONAUT FLT.
	AURORA CORE
	EXOMARS
LAUNCHER PROG.	ARIANE-5 DEVELOP.
	ARIANE-5 PLUS
	VEGA
	SOYUZ AT CSG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COMMENTS
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LAUNCHED OCTOBER 1997
LAUNCHED DECEMBER 1999
RE-LAUNCHED MID-2000
LAUNCHED OCTOBER 2002
LAUNCHED JUNE 2003
LAUNCHED SEPTEMBER 2003
TC-1 LAUNCHED DEC. 2003
TC-2 LAUNCHED JULY 2004
LAUNCHED MARCH 2004
LAUNCHED NOVEMBER 2005
LAUNCH FEBRUARY 2008
LAUNCH 4TH QUARTER 2009
LAUNCH END-2011
LAUNCH JUNE 2013
LAUNCH AUGUST 2013
M5 LAUNCHED 1991, M6 1993, M7 1997
LAUNCHED APRIL 1995
LAUNCHED MARCH 2002
MSG-1
MSG-2
MSG-3
MSG-3 LAUNCH 2009, MSG-4 LAUNCH 2012
METOP-A LAUNCH JULY 2006,
METOP-B 2010, METOP-C 2015
LAUNCH FAILURE OCTOBER 2005
CRYOSAT-2 LAUNCH MARCH 2009
LAUNCH FEBRUARY 2007
LAUNCH SEPTEMBER 2007
LAUNCH SEPTEMBER 2008
LAUNCH 2010
LAUNCH END-2012
LAUNCHED JULY 2001
LAUNCH 2009
LAUNCH JUNE 2010
OPERATIONS START 2006
GIOVE-A
GIOVE-B
GIOVE-A LAUNCHED DEC. 2005
GIOVE-B LAUNCH OCT./NOV. 2006, IOV END-2008
LAUNCHED OCTOBER 2001
LAUNCH SEPTEMBER 2007
LAUNCHED FEBRUARY 2005
LAUNCH OCTOBER 2007
FIRST LAUNCH NOT BEFORE 23 APRIL 2007
LAUNCHES AUGUST 2007 & JULY 2009
CUPOLA LAUNCH UNDER REVIEW
LAUNCH NOVEMBER 2007
MSG
MELFI
EDR/EUTEF/SOLAR
FOTON-MI
APCF-6/BIOBOX-5/
ARMS/BIOPACK/
FAST-2/ERISTO
MATROSHKA
FOTON-M2
TEXUS-43
MAXUS-7/TEXUS-43
TEXUS-45
FOTON-M3
MAXUS-6
MASER-10
EML-1
EMCS/
PEMS
TEXUS-44
PCDF
MARES
MSL
BIO, FSL, EPM with COLUMBUS
LAUNCH MAY/JUNE 2011
OPERATIONAL
AR5-ECA QUALIF. LAUNCHED FEBRUARY 2005
FIRST LAUNCH NOVEMBER 2007
READY FOR LAUNCH NOVEMBER 2008
DEFINITION PHASE
MAIN DEVELOPMENT PHASE
STORAGE
LAUNCH/READY FOR LAUNCH
OPERATIONS
ADDITIONAL LIFE POSSIBLE

HST

The Hubble Space Telescope has produced images of dense knots of dust and gas in our Galaxy. This cosmic dust is a concentration of elements that are responsible for the formation of stars in our Galaxy and throughout the Universe. These opaque, dark knots of gas and dust are called 'Bok globules' after astronomer Bart Bok, who proposed their existence in the 1940s. They are absorbing light in the centre of the nearby emission nebula and star-forming region, NGC 281.

Bok hypothesised that giant molecular clouds, on the order of hundreds of light-years in size, can become perturbed and form small pockets where the dust and gas are highly concentrated. These small pockets become gravitationally bound and accumulate dust and gas from the surrounding area. If they capture enough mass, they have the potential to create stars in their cores. However, not all Bok globules will form stars; some will dissipate before they can collapse to form stars. That may be what is happening to the globules seen here in NGC 281.

Near the globules are bright blue stars, members of the young open cluster IC 1590. The cluster is made up of a few hundred stars. The cluster's core, off the image towards the top, is a tight grouping of extremely hot, massive stars with an immense stellar wind. The stars emit visible and UV light that energises the surrounding hydrogen gas in NGC 281. This gas then becomes superheated via ionisation; it glows pink in the image.

Bok globules in NGC 281

The Bok globules in NGC 281 are located very close to the centre of the IC 1590 cluster. The exquisite resolution of these Hubble observations shows the jagged structure of the dust clouds as if they are being stripped apart from the outside. The heavy fracturing of the globules may appear beautifully serene but is in fact evidence of the harsh, violent environment created by the nearby massive stars.

The Bok globules in NGC 281 are visually striking. They are silhouetted against the luminous pink hydrogen gas of the emission nebula, creating a stark visual contrast. The dust knots are opaque in visible light. Conversely, the nebulous gas surrounding the globules is transparent and allows light from background stars and even background galaxies to shine through.

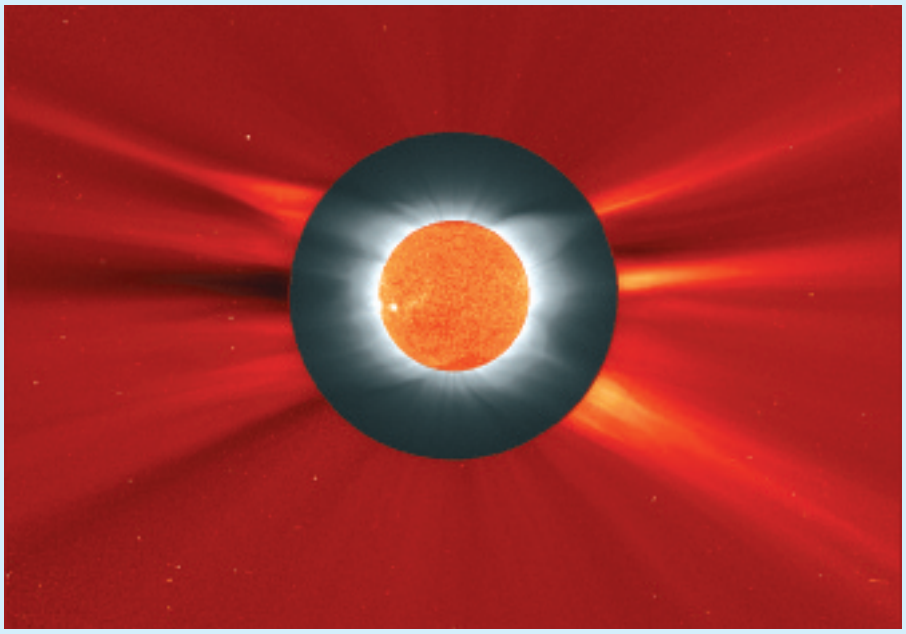
These images were taken with Hubble's Advanced Camera for Surveys in October 2005. The hydrogen-emission image that clearly shows the outline of the dark globules was combined with images taken in red, blue and green light in order to establish the true colour of the stars in the field. NGC 281 is located nearly 9500 light-years away in the direction of the constellation Cassiopeia.

Ulysses

The outcome of the NASA Sun-Solar System Connections 2005 Senior Review held on 14-15 November was positive for Ulysses. The panel recommended continuation of the mission until March 2008, as proposed. This is reflected in the NASA budget allocation for the project. All spacecraft subsystems are operating nominally.

All science operations during the reporting period have been nominal. The spacecraft team has performed a thorough review of the onboard power and thermal situation, taking particular account of recent experience when platform temperatures reached their lowest values during the mission to date. Based on this, it has been decided to modify the current payload power-sharing plan. As a result, instruments that are not part of the 'core payload' (and are presently turned off) will be switched on again for short periods this year, sooner than anticipated.

After a journey of 12.5 years and more than two complete orbits of the Sun, Ulysses is once again fully immersed in the fast solar wind from the coronal hole that covers the Sun's southern polar cap around solar minimum. This time around, the spacecraft had to climb higher in latitude, to almost 50°S, before leaving the slower, more variable wind behind. In mid-1993, the transition occurred nearer to 35°S. The explanation is related to the fact that the Sun's magnetic equator is still more highly inclined with respect to the rotational equator, even though the solar activity cycle is closer to its minimum, compared with the previous occasion. (At solar minimum, the Sun's rotational and magnetic axes are most closely aligned). Since the slower, more variable solar wind is mainly confined to the magnetic equator, this in turn means that, until recently, Ulysses continued to encounter slow wind once per solar rotation. Observations from the solar wind instrument on Ulysses over the past year showed regular excursions from slow (~400 km/s) to fast (~700 km/s) wind every rotation. At the start of the year, however, the speed profile began to show a systematic increase in the minimum speed encountered with each subsequent solar rotation, and since early March, the speed has remained high. Given the fickle behaviour of the Sun, with large outbursts of activity occurring relatively late in the declining phase of the present cycle, it will be interesting to see whether Ulysses remains in the fast wind until its trajectory brings it to lower latitudes again after traversing the southern pole in February 2007.



A composite of SOHO and ground-based images of the total solar eclipse of 29 March 2006

On 1 June 2006, Ulysses will be at a radial distance of 3.85 AU from the Sun, and heliographic latitude 50° south of the solar equator.

SOHO

With a unique view from the first Lagrangian point, outside the disturbing influence of Earth's atmosphere, SOHO's Large Angle Spectrometric Coronagraph (LASCO) produces its own eclipse all the time by simply blocking direct light from the solar disc. Other instruments onboard SOHO look directly at the Sun, with the same advantage of an uninterrupted view – there are no nights for SOHO, and the Moon never gets in the way.

So, when a total solar eclipse happens to be observable from Earth, SOHO is the primary source of information about what lies in wait for the eager observers in possibly remote locations. This was the case on 29 March 2006, when several eclipse expeditions went to Niger, Libya, Egypt, Greece and Turkey to catch the magic moment. Several groups collaborated with SOHO, requesting special observations that will be used for comparisons with the ground-based data.

The figure above is a composite of SOHO images and one taken at Kastellorizo, Greece, by the Williams College Eclipse Expedition. The central image from SOHO shows the Sun's disc at temperatures around 60 000–80 000K. The outer image from SOHO shows gas at a million degrees, typical of the Sun's corona. Combining the eclipse image with images from SOHO allows scientists to trace features in the corona from their bases on the Sun's surface up until the gas escapes into interplanetary space; some of this gas ends up hitting Earth's upper atmosphere.

XMM-Newton

XMM-Newton operations are continuing smoothly, with the spacecraft, instruments and ground segment all performing nominally. The completion status of the observing programme is:

– AO-3 programme: 99.7%
– AO-4 programme: 89.5% (A & B priority)
– AO-4 programme: 14.4% (C priority)

Completion of the above programmes is expected by April 2006, in line with the planned start of AO-5 observations. The Principal Investigators of AO-5 proposals have been informed of the Observation Time Allocation Committee decisions and observation of AO-5 targets will start on 1 May 2006.

A scientific workshop at ESAC (E) with the title *Variable and Broad Iron Lines around Black Holes* is planned by the XMM-Newton Science Operations Centre for 26–28 June 2006.

In January 2006, XMM-Newton celebrated its 1000th refereed paper with an ESA science and technology news release. In total, 1070 papers – either completely or partly based on XMM-Newton observations – had been published in the refereed literature. Of these, 286 were published in 2005; and 65 so far in 2006.

Cluster

The four spacecraft are in a tetrahedral configuration of 10 000 km to observe the polar cusp and the bow shock regions at large scales. All four spacecraft and instruments are operating nominally and the short eclipse season has just finished. Although a few anomalies have been observed due to the ageing of the batteries, it has been confirmed that the spacecraft can successfully endure short eclipses with minimum power from the batteries, which is providing experience for the coming long eclipses of September 2006.

JSOC and ESOC operations are continuing nominally. The data return from mid-November 2005 to mid-March 2006 was on average 99.5%. The Perth station has been used nominally since 1 January 2006, together with the Maspalomas station.

The Cluster Active Archive (CAA) opened as planned on 1 February 2006. A total of 136 users were registered at the end of February and more than 5 Gbytes of high-resolution data were downloaded. The CAA also delivers

all raw data to the Cluster PIs and Co-Is; a total of 97 Gbytes was downloaded during the last four weeks.

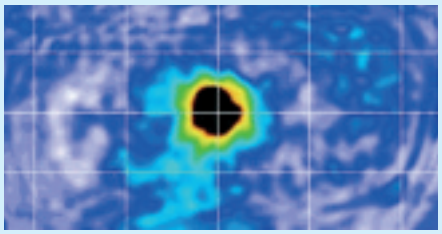
Fundamental 3-D properties of magnetic turbulence observed in the shocked solar wind were published in February 2006 in *Physical Review Letters*. These properties are of prime importance to model magnetic turbulence in the shocked solar wind, which plays a key role in the dynamical coupling between the solar wind and the magneto-sphere. These results were obtained by combining the magnetic measurements on all four spacecraft using a method known as 'k-filtering'. The magnetic turbulence is a fundamental process that also occurs in astrophysical and laboratory plasmas.

Integral

Cosmic space is filled with continuous, diffuse high-energy radiation. To find out how this energy is produced, the scientists behind the Integral gamma-ray observatory have tried an unusual method: observing the Earth from space. During a four-phase observation campaign lasting from 24 January to 9 February, Integral looked at Earth. Needing complex control operations from the ground, the satellite was kept in a fixed orientation in space, while waiting for the Earth to drift through its field of view.

Unusually, the main objective of these observations is not the Earth itself, but what can be seen in the background when the Earth moves in front of the satellite. This is the origin of the diffuse high-energy radiation known as the cosmic X-ray background. So far with Integral, this was never studied simultaneously with such a broad band of energy coverage since the 1970s, and certainly not with such advanced instruments. A preliminary analysis of the Integral results shows that the gamma-ray background intensity is about 20% higher than measured earlier.

Astronomers believe that the cosmic X-ray background is produced by numerous massive accreting black holes, distributed



The 25–50 keV image of the Earth obtained with Integral's SPI spectrometer. The Earth stands out as a dark 'hole' in the middle of the image. (J.-P. Roques, CESR, Toulouse)

throughout deep space. Their powerful gravitational fields attract matter, which is then accelerated to high energies, thus producing the observed gamma- and X-rays.

Mars Express

Final commissioning operations for the MARSIS instrument – primarily the commissioning and calibration of the monopole antenna – are being completed. Following these activities, the MARSIS radar will be fully operational.

Good progress is being made by ESOC and industry in identifying additional power margin required for the autumn 2006 eclipse season. The overall power budget for this period, however, still has a margin comparable to the known daily variation. More elaborate savings scenarios are being examined to create a better power margin.

Some problems in operating the ASPERA scanner and the PFS instrument are currently being investigated.

Science operations are proceeding well, albeit that the MARSIS commissioning operations placed a heavy burden on the Mars Express flight control team. Planning of future observations is progressing smoothly, although the limited power and ground station availability for the period currently being planned necessitates choosing between different kinds of science observations.

Further instrument data deliveries were recently made to the mission's data archive, and a new level of HRSC data products (map projected data) has been added.

The dedicated Mars Express session (*Mars Express: Probing the Depths*) opening the 37th Lunar and Planetary Science Conference in Houston, Texas, USA on 13 March was a great success; attendance broke all records. Participation from the HRSC, OMEGA and MARSIS teams was higher than before. In particular, the MARSIS team is hard at work processing their data and interpreting the results. After initial analysis of the northern plains, where buried tectonic structures and impact craters were discovered, analysis is focusing on the southern polar cap, revealing a very fine layering and confirming the presence of pure water-ice layers (initially mapped by OMEGA). The penetration depth of the radar is well in excess of 5 km. The other instruments also continue to provide valuable science.

Double Star

The two spacecraft (TC-1 and TC-2) and the instruments are operating nominally. The Chinese proposed to extend the lifetime of TC-2 to end-2006, the same as the current lifetime of TC-1. This was due to the better-than-expected thermal behaviour of the spacecraft.

The European Payload Operation System (EPOS) coordinates the operations for the seven European instruments on TC-1 and TC-2, and is running smoothly. Data are acquired using the VILSPA 2 ground station and the Chinese stations in Shanghai and Beijing.

A study on surface waves in the magnetotail was published in the special issue of *Annales Geophysicae* on Double Star on 8 November 2005. The study used five spacecraft: Double Star TC-1 and the four Clusters. Cluster demonstrated that they were surface waves and fully characterised them, while Double Star, 30 000 km away, showed that these waves extended over a large region of the magnetotail.

ISO

The ISO Active Archive Phase activities continue with a new release of the ISO Data Archive, featuring automatic querying facilities to other archives, interoperability with the XMM-Newton and Integral archives and Virtual Observatory tools. Two new Highly Processed Data Sets have been ingested as default products. A first version of the ISO Astrophysical Spectroscopic Database has been released. It contains extensive information gathered from the literature for a number of spectral lines.

ISO continues to have a significant presence in the literature, with over 1330 refereed papers published to date. Recent highlights include the discovery of two very cold and massive molecular cloud cores suggested to represent initial conditions for the formation of monstrous stars, shining 100 000 times more brightly than the Sun. This result, based on the 170-micron ISOPHOT Serendipity Survey (ISOSS) was obtained from follow-up sub-mm continuum and molecular line measurement. The first core is at 16.5K and contains 75 times the mass of the Sun and shows signs of gravitational collapse. The second one is around 12K and contains 280 solar masses. The conditions necessary to form high-mass stars are difficult to deduce because such stellar monsters form far away and are shrouded behind curtains of dust. Only long wavelengths of infrared radiation can escape from these obscuring cocoons and reveal the low-temperature dust cores that mark the sites of star formation. The discovery allows astronomers to begin investigating why only some regions of space promote the growth of these massive stars.

Akari (Astro-F)

ESA contributes to the JAXA Astro-F infrared sky survey mission via provision of tracking support and assistance with the survey data reduction, in return for 10% of the observing opportunities during the non-survey and post-helium parts of the mission, to be made

The launch of Akari (JAXA)

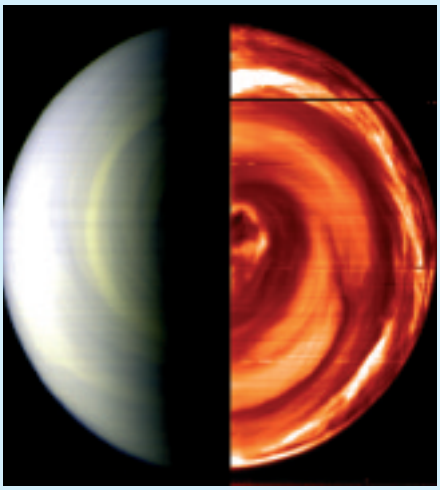
available to European astronomers via a Call for Proposals.

Astro-F was successfully launched on 21 February 2006 at 21:28 UT from the Uchinoura Space Centre by JAXA's M-V-8 rocket and renamed Akari ('red faint light'). The ESA Kiruna antenna has successfully tracked Akari for a number of passes. The telescope aperture lid was ejected on 13 April and the satellite declared ready for observations. The pointing reconstruction software, developed at ESAC, was used in an initial calibration of the spacecraft attitude.

The European Call for Observing Proposals was released by ESAC on 20 September 2005 and resulted in 50 proposals from 42 different Principal Investigators from 32 institutes in nine European countries plus ESO and ESA. The oversubscription factor was 7. The proposals were peer-reviewed by an ESA appointed Time Allocation Committee in December and merged with those resulting from the parallel Japanese call (48 proposals) in January.

Venus Express

The Venus Express spacecraft performed all of its cruise phase tests flawlessly, as well as the critical Venus Orbit Insertion. It successfully entered orbit around the target planet on 11 April 2006 and performed initial



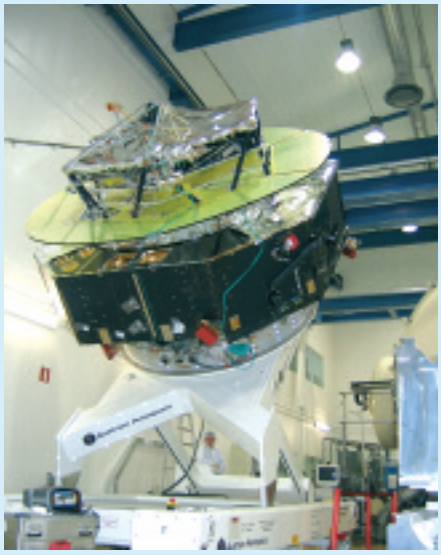
The dark vortex seen over the south pole of Venus by the Visible & Infrared Thermal Imaging Spectrometer (VIRTIS) of Venus Express from a distance of more than 200 000 km the day after Venus Orbit Insertion

observations with the instruments while in the highly eccentric capture orbit. The capture orbit had a period of about 9 days, which took the spacecraft out to an apocentre altitude of the order 350 000 km. This was an ideal opportunity for the instruments to view the full Venus disc over a wide range of altitudes before settling into the 24-hour operational orbit expected to be reached by 7 May.

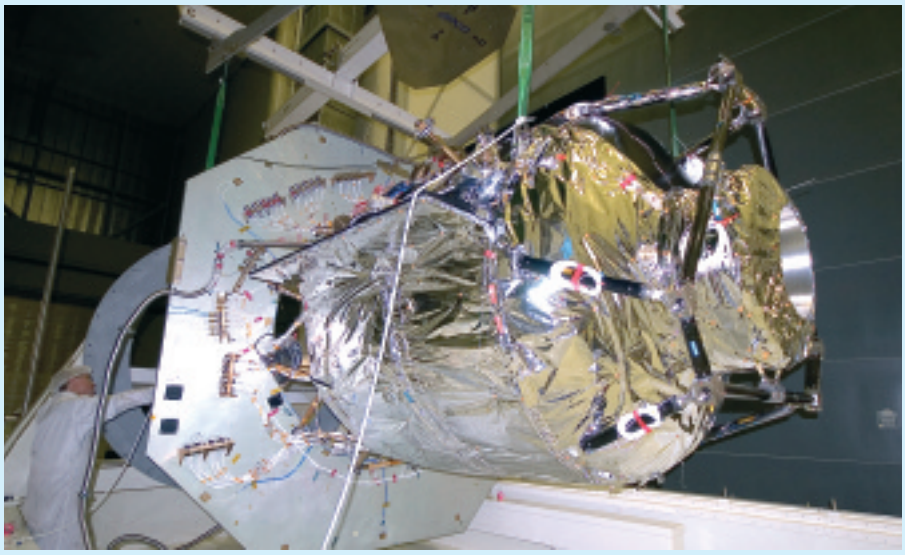
To reach its final orbit, the spacecraft has to perform a series of manoeuvres to reduce its apocentre altitude down to the desired operational orbit of about 66 000 km, and its pericentre down to 250 km. It requires two additional main engine firings and a number of finer adjustments using the reaction control thrusters. Once the operational orbit is achieved, the final parts of the instrument commissioning will take place, leading to routine science operations status in June.

Herschel/Planck

Major progress has been made in the satellite development programmes at industry in the past months. For Herschel, the satellite-level mechanical testing with the cryostat at launch conditions, i.e. filled with liquid helium, has been completed successfully. The satellite has been demated



The Planck flight model (without its top payload) ready for transport to CSL and cryogenic testing



The Herschel cryostat during loading into its satellite transport container, in preparation for a complicated 5-day transport through Europe back to Friedrichshafen (D)

and the cryostat returned to Astrium. The cryostat will be warmed up and opened for refurbishment. A further cryogenic test has been included in the flight model test sequence to validate the success of these activities. This will include the use of the SPIRE and HIFI instrument qualification model units.

The flight model of the Planck spacecraft has completed the first thermal vacuum test of the flight satellite at CSL in Liège (B). This included the operational testing of one of the two flight models of the hydrogen sorption coolers as well as the overall thermal testing of the Planck Service Module.

The flight model integration of the Herschel Service Module has been completed and the module acceptance testing is ongoing.

The acceptance testing of the scientific instrument flight model units continue at full swing, with a delivery to satellite integration later this year. Necessary actions have been put in place to stabilise the instrument deliveries. The instrument flight model deliveries and the optimised test sequences of the spacecraft flight models lead to the launch date of end-February 2008.

The final cryogenic optical testing of the Herschel telescope is close to completion and the telescope can be delivered to the satellite integration planned later this year.

On Planck, the flight model reflectors have completed their optical verification programme and are to be integrated with the telescope structure, with the final cryo-optical test coming up.

LISA Pathfinder

The SMART-2/LISA Pathfinder Implementation Phase contract is well in progress, with all activities proceeding according to schedule. The main system activity in the reporting period has been the preparation and the successful accomplishment of the Mission System Preliminary Design Review, whose Board met in February 2006.

In parallel, Industry and ESA have prepared and issued the majority of the Invitations to Tender for the spacecraft subsystems and equipment. At the time of writing, 22 ITTs have already been issued. Thirteen subsystem/equipment have been selected. Eight proposals are at various stages of evaluation. The remaining two ITTs will be issued as required during 2006. The proposal for the procurement of the micropropulsion subsystem, which requires a parallel phase 1 development of the two candidate technologies, is under evaluation and will be kicked-off in mid-May 2006. The spacecraft schedule has been continuously reworked to take into account the LISA Technology Package (LTP) delivery dates and the incurred delays in the micropropulsion development.

For the LTP, the subsystem PDRs have raised important technological and programmatic issues, which have been discussed with the parties concerned. Some have entailed extra cost. However, good progress is being made, despite the many technical challenges. Some subsystems are particularly critical, e.g. the inertial sensor vacuum enclosure, the electro-static suspension front-end electronics and the caging mechanism. The project is aware that the activities leading to a timely delivery of the LTP remain very challenging and require the full commitment of all parties involved.

The NASA-descoped Disturbance Reduction System (DRS) contribution to the LISA Pathfinder mission was analysed, reviewed and confirmed in an ESA-NASA review in mid-January 2006; the review was declared successful. The detailed implementation of the new configuration is ongoing.

The launch is expected to take place in the last quarter of 2009.

Microscope

The Microscope spacecraft Preliminary Design Review at CNES has been concluded. The project has reached a satisfactory level of maturity after Phase-B. However, there are two main concerns before starting Phase-C: one related to the electric propulsion system (discussed below), and the other to the ONERA accelerometer, which is on the critical path of the schedule.

CNES has been informed of the reorganisation of the Field Emission Electric Propulsion (FEEP) activities in coordination with LISA Pathfinder and in particular of the parallel phase 1 in LISA Pathfinder with both FEEP technologies. CNES will evaluate in the coming months if Microscope can also be made compatible with the alternative FEEP technology (lower thrust delivered and more power needed).

The Alta FEEP development activities will be carried out within the LISA Pathfinder parallel phase 1. The decision concerning the continuation of the Microscope FEEP development activities will be taken at the end of this phase 1.

Gaia

Following approval of the contract proposal for the implementation phase of Gaia by the Industrial Policy Committee in late January and approval of the overall project cost by the Science Programme Committe in February 2006, the project held a kick-off meeting with Astrium SAS, Toulouse, on 17 February. The big challenge ahead is now to place 78 subcontracts competitively within about a year from contract signature. The related process is already planned in detail and the first four Invitations to Tender have been released on time.

Some of the technology activities are still ongoing and constitute a good source of lessons learned for the flight model productions. As requested by the scientific community, the project is actively pursuing the option of implementing L3CCDs in the Radial Velocity Spectrometer instrument. A technical and financial proposal is expected from the single-source supplier in order to place the required technology development activity.

Meetings of the Gaia Science Team take place at regular intervals. During their last meeting, on 20/21 February, the newly selected Prime Contractor presented for the first time the detailed design of the spacecraft.

JWST

NASA has successfully completed the System Definition Review (SDR), which is typically held midway between the System Requirement Review and the Preliminary Design Review (PDR). The SDR demonstrated a solid system design and that all the critical developments are well advanced in terms of design and verification approach.

Specific system-level problems related to stray light suppression and long-term stability of the main telescope are under resolution with involvement of ESA.

NASA budget allocation for 2006 and budget request for 2007 for JWST are in line with a launch date of mid-2013. The JWST Memorandum of Understanding (MoU) is in the final review cycle between ESA and NASA HQs.

NIRSpec has successfully passed the instrument-level PDR. The subassembly PDR campaign has been started with all the involved subcontractors. Two more subcontracts have been placed: the Calibration Assembly and the Mechanical Ground Support Equipment. The remaining nine procurements are under preparation. The manufacturing of the first ceramics mirrors is ongoing.

The MIRI subsystem Critical Design Review (CDR) campaign is ongoing with seven reviews completed and seven still to go. This leads to the instrument-level CDR in September, giving sufficient time to clarify the issues and concerns raised at the lower level CDRs. Parts and subassemblies for the instrument Verification Model are under manufacturing and testing. The need for design improvements has been identified in a few cases.

BepiColombo

BepiColombo is an interdisciplinary mission to the planet Mercury selected as the fifth cornerstone in the Cosmic Vision programme. Owing to the high scientific potential related to the planet and its environment, the mission will open a new frontier in the study of the Solar System. BepiColombo is a collaboration between ESA and the Japan Aerospace Exploration Agency (JAXA). It consists of two scientific orbiters: the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO), which will study the origin and evolution of the planet, Mercury's interior dynamics and the origin of the magnetic field. The launch configuration consists of a stack of the two spacecraft and the chemical and electrical propulsion modules.

The consolidated BepiColombo mission scenario foresees a Soyuz-Fregat launch in August 2013 and arrival at Mercury in August 2019 for a nominal 1-year scientific mission. The 6-year cruise phase is achieved with a combination of 6 flybys (Moon, Earth, 2 Venus, 2 Mercury) and electric propulsion. The spacecraft design employs lightweight technologies and materials that are compatible with the aggressive thermal environment at Mercury.

ESA is responsible for the overall project, including the mission design, the MPO, the electrical and chemical propulsion modules, the launch, the cruise operations up to delivery of the two spacecraft in their respective Mercury orbits, and the MPO mission and science operations. JAXA is responsible for the procurement of the MMO and for its mission and science operation at

Mercury. The mission definition has been completed and the scientific payload of both spacecrafts has been selected.

Following confirmation of the mission by the SPC in early February 2006, the Invitation To Tender for the Implementation Phase of BepiColombo was issued by the Agency on 15 February 2006. The proposals from Industry are expected by 17 May 2006. After this date, the Tender Evaluation Board, supported by expert panels, will perform a detailed assessment of the proposals. The recommendations of the Tender Evaluation Board will then be submitted to ESA's advisory structure for final approval.

LISA

The LISA Mission Formulation Study led by Astrium GmbH and started in January 2005 is producing very good results. Many system- and payload-level trade-offs have been completed and the overall mission design was consolidated in the Mission Architecture Review (MAR) in October 2005. Since then, the detailed design of the payload and of the rest of the system has progressed, especially in the areas of the scientific performances assessment, of the Interferometric Metrology System and of the Disturbance Reduction System design. In April 2006, the Mid-Term Review will take place: the coherence of the system design performed since the MAR will be checked before entering the phase of the subsystems requirements definition.

The cooperation with NASA is progressing well. The management tools established to ensure design coordination – the Technical Interchange Meetings and the Quarterly Progress Meetings – and the effort spent in coordinating the activities are effective. All the architecture design elements firmed up so far, such as strap-down, arm locking, end-to-end data flow and optical architecture, have been agreed by the two agencies to be part of the new baseline architecture design.

A joint technology plan has been finalised between ESA and NASA. This ensures that, even with the limited resources available, all the critical technologies needed for a successful LISA design will be covered either by NASA or ESA.

GOCE

Work is continuing to integrate, test and finally accept the flight models (FMs) of the Accelerometer Sensor Heads (ASHs) for the Gradiometer instrument. Significant effort continues to be made at all levels to recover from the technical setbacks encountered during the initial phases of the ASH acceptance testing. The second part of the functional testing involving the FM Gradiometer Accelerometer Interface Electronics Unit, three Front-End Electronic Units and the Gradiometer Thermal Control Unit is progressing nominally.

The integration of the Proto-Flight Model of the Platform is nearly complete. Following the integration of the ion propulsion electronics, the remaining units to be integrated are only the ion thrusters and the associated xenon gas-feed system. Functional closed-loop testing of the Drag-Free and Attitude Control System is continuing on the Platform Engineering Model Test Bench.

The Flight Operations Segment development activities have continued nominally at ESOC. In particular, a System Validation Test has been conducted, where the telemetry and telecommand interfaces with the satellite have been tested using the Platform Engineering Model Test Bench. Work is also progressing nominally on the Payload Data Segment side. Version 2 of the system is under final coding and testing, and will be installed in ESRIN before summer. System tests of the ground segment elements located in ESRIN are also progressing according to schedule.

SMOS

Delivery of subsystem units for the payload protoflight model continues. All LICEF

Integration of the SMOS protoflight model arm at EADS Casa Espacio

receivers have been delivered, and are being used to populate the arm segments of the structural model to undergo the 'on farm' antenna pattern characterisation at the antenna measurement facility of the Technical University of Denmark. All three arm measurements have been successfully completed; still to be measured is the central hub structure with one adjacent segment of each arm. Once all the antenna characterisation activities are completed, the LICEF receivers will be transferred to the flight model arm segments that are under integration with electrical, RF and optical harness, thermal control hardware, and other subsystems such as the noise sources of the calibration subsystem.

Platform integration of the recurrent Proteus platform has progressed significantly at the Alcatel Alenia Space, Cannes (F) facilities. It is now interrupted owing to the resumption of the Calypso launch campaign.

Rockot launcher interfaces have been reviewed in the Preliminary Mission Analysis Meeting involving ESA, CNES, Alcatel, Eurockot and Khrunichev. The final Board Meeting for this review is scheduled for second half of April.

For the overall SMOS Ground Segment, the Preliminary Design Review has been completed. While the elements of the flight operations ground segment, both on the CNES and the ESA side, were found to be in an adequate development state, the payload data ground segment, including the data processors for level-1 and -2 data products,

were judged to be rather schedule-critical. Backup solutions were suggested by the Board for investigation and eventual implementation by the project.

The building refurbishment and preparations for the X-band receive antenna are progressing nominally for installing the ESA-part of the ground segment at ESAC (E).

ADM-Aeolus

The Flight Model (FM) propulsion system, including tanks and pipework, has been fitted to the FM Platform at EADS-Astrium, Stevenage (UK). A version of the flight software that includes all the data-handling functions is working on the Real-time Test Bed in EADS Astrium, Friedrichshafen (D). This allows the Electrical Ground Support Equipment (EGSE) to be used to send commands to the software, to execute them on the onboard computer, and to observe the result on the EGSE. Operationally, the satellite therefore now exists.

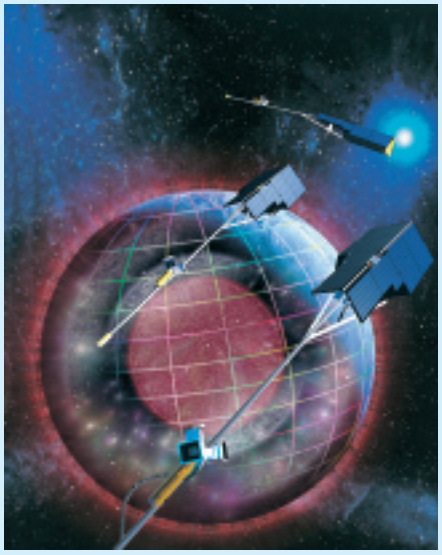
The coatings of the FM mirrors are excellent. They have been delivered to EADS Astrium, Toulouse (F) where they are being assembled with the FM Structure. The first step is to assemble the telescope.

There have been some difficulties preparing the Qualification Model of the laser for testing. Some minor design improvements have been identified as a result. The first 2 weeks of vacuum testing have therefore been somewhat postponed.

Launch of the satellite remains scheduled for September 2008.

Swarm

Swarm is the fifth ESA Earth Explorer Mission. The Swarm concept involves placing a constellation of three satellites in three different near-polar orbits at altitudes of 450 km to 530 km to provide high-precision and high-resolution measurements of



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

strength and direction of Earth's magnetic field.

Phase-B of the satellite activities with EADS Astrium, Friedrichshafen (D) is under way, with a consolidation at system level of the Phase-A trade-off, satellite conceptual design and performances. This consolidation takes into account the new elements to be considered since the completion of Phase-A. In particular, a new orbit scenario, instruments in a pre-development phase with performances and interfaces under definition, breadboard results and satellite-to-launcher interfaces are being closely examined and consolidated.

Phase-B1 of the Electrical Field Instrument (C-EFI) is completed. A preliminary instrument concept and design has been defined based on the heritage from sounding rocket instruments (GEODESIC). Following the successful Phase-B1 final meeting, Phase-B2 has been kicked off with Comdev (CND) as prime for this instrument, associated with the University of Calgary for the SII, the University of Uppsala (S) for the Langmuir probe and CAEN (I) for the high-voltage power supply.

The Absolute Scalar Magnetometer (ASM) Phase-B is under way with LETI, Grenoble under the leadership of CNES. A qualification programme is ongoing on two technologies: the optical bench for the laser and a piezo-electric motor for the polariser of the magnetic probe.

The Preliminary Design Review is planned in January 2007.

MetOp

The MetOp launch campaign at the Baikonur Cosmodrome started on 11 April 2006 with the arrival of the first of the three Antonov-124 transportation aircraft carrying the extensive MetOp equipment. The Satellite Payload and Service modules (PLM and SVM) arrived a week later with the second Antonov plane on 18 April; after a 5-hour train transfer, the satellite was transported safely into the MIK 112 integration area.

During the period preceding the launch campaign, the activities at EADS Astrium, Toulouse (F) concentrated on the reactivation of the satellite following a 6-month storage period, the closure of some open anomalies and the demonstration of the flight-worthiness of the thruster flow-control valves. During the final testing, a problem with the NOAA AMSU-A1 instrument necessitated its replacement just before the departure of the satellite.

In parallel, the first part of the (Eumetsat) Launch and Operations Readiness Review (LORR) was held in mid-February, followed by a successful satellite system verification test in March. The second part of the LORR confirmed a launch date of 17 July, with the delay from the nominal 30 June launch date being mainly due to ground segment readiness issues.

The Qualification Process for the new elements of the Soyuz-ST/Fregat launch vehicle is continuing as planned. The activities necessary to validate the modified launcher infrastructure at the Cosmodrome have been successfully performed in February by a dry-run, with the launcher and its extended ST fairing being rolled out and erected at the launch tower, during a period with extremely low

Unloading MetOp-A from the Antonov

MetOp-A on the train from Yubileiny Airport to the Baikonur Cosmodrome

temperatures ranging between –25°C and –38°C. The pre-shipment of the Fregat was successfully performed at NPO-L in March.

System and operations activities are intensifying, shared between ESOC for Launch & Early Orbit Operations (LEOP) and Eumetsat for Satellite In-Orbit Verification (SIOV) and routine operations preparation. ESOC is close to delivering the last flight control procedures, and the ESOC Ground Segment development is progressing on schedule. Rehearsals for LEOP and SIOV will take place during the last 3 months before launch, with the goal of training the operations and project support teams.

Two major Satellite System Validation Tests (SSVTs) have been successfully performed in March. These tests have fully validated critical operations procedures, and give good confidence in the robustness of the respective Mission Control Systems.

MSG

MSG-1

After an anomaly on the SSPA in October 2002, it was decided, although the satellite was designed with a 4/3 SSPA redundancy, to end its use. With MSG-2 also in orbit, it was decided to activate the Data Collection Platform (DCP) link again through SSPA-D. This reactivation was successful and shows nominal performance. The instrument performance remains of excellent quality.

MSG-2

The MSG-2 spacecraft, successfully launched in December 2005, is undergoing its commissioning phase, which is planned to last until the end of June 2006. Performance of the main instrument, the SEVIRI imaging radiometer, is of similar high quality to that on MSG-1.

MSG-3

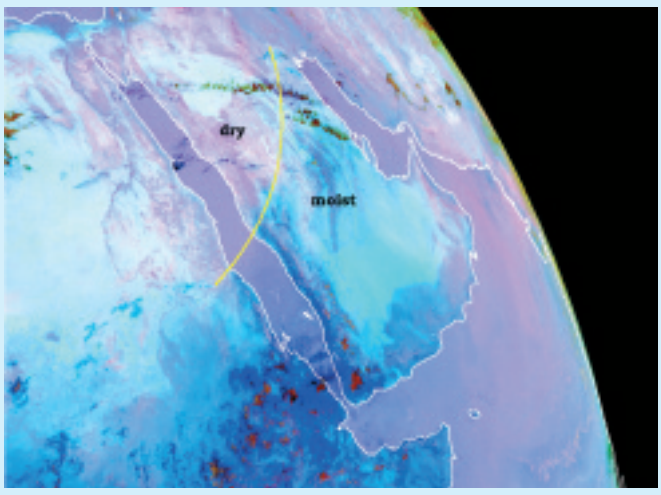
During this reporting period, some open work on MSG-3 has been performed. It is planned to put MSG-3 in long-term storage by the end of the year, awaiting its own launch, currently foreseen for early 2011.

MSG-4

The Mission Communication Package (MCP) platform has been delivered to Cannes (F) for system integration. The electrical integration on SEVIRI has been performed. The Unified Propulsion System (UPS) hardware has been integrated, and baffle and cooler covers have been installed. Preparation for the MSG-4 thermal vacuum test has started with the vacuum GSE preparation and thermocouple installation.

GIOVE

After its launch on 28 December 2005, followed by its platform commissioning, GIOVE-A began transmitting navigation signals on 12 January 2006. The quality of these first Galileo signals was then checked by several facilities, including the Navigation Laboratory at ESTEC (NL), the ESA ground



Composite red-green-blue images from MSG, besides monitoring dust storms and tracking thin, high-level clouds, can also be used to detect low-level moisture boundaries. This MSG-1/Meteosat-8 image shows a mostly cloud-free Arabian Peninsula; the southern part of the Peninsula appears with a strong blue colour while the northern part is a pale blue to cyan. The colour difference can be attributed mostly to an airmass/moisture boundary (yellow line) crossing the Peninsula from south-west to north-east (Eumetsat)

station at Redu (B), and the Rutherford Appleton Laboratory Chilbolton Observatory (UK). GIOVE-A achieved the first goal of its mission: satisfying the licence for the frequencies allocated to Galileo by the International Telecommunication Union (ITU).

The conformity of the GIOVE-A signals to the Galileo system's design specification was demonstrated. The quality of the signals transmitted by GIOVE-A have an important influence on the accuracy of the positioning information that will be provided by the user receivers on the ground, so a detailed check of the signal was mandatory. The quality can be affected by the environment of the satellite in its orbit and by the propagation path of the signals travelling from space to ground. Additionally, the signals must not interfere with services operating in adjacent frequency bands; this is also being checked. Several measurements were performed on the transmitted signal power, centre frequency, bandwidth and the format of the navigation messages generated onboard. This allowed the analysis of the satellite transmissions in the three frequency bands that are reserved for it; it confimed that GIOVE-A is transmitting as designed.

The GIOVE-A mission also provides an opportunity for testing a key element of the future Galileo system: the user receivers. The first experimental Galileo receivers, manufactured by Septentrio (B), were installed at the Redu and Chilbolton In-Orbit Test Stations and at the Guildford (UK) premises of Surrey Satellite Technology Limited (SSTL), the manufacturer of the satellite and now in charge of its control in orbit.

The mission of GIOVE-A now is to check the new critical technologies designed for the Galileo system, such as the rubidium clock and signal generator.

The perfect results registered so far for GIOVE-A provide confidence that Galileo can offer the value-added services that fundamentally depend on the quality of the signals.

Human Spaceflight, Microgravity & Exploration

Highlights

Following a series of meetings involving the Space Station Control Board and the Multilateral Control Board, a Heads of Agency meeting took place at the Kennedy Space Center (KSC) on 2 March. The partners endorsed a revised ISS configuration and an assembly sequence for the ISS that includes 16 Shuttle flights as well as two Shuttle-equivalent flights for logistics. Columbus is advanced in the sequence to the 7th Shuttle flight which, with the current planning, could result in its launch, complete with its two external payloads and five payload rack facilities, in late 2007. The associated transportation strategy was also agreed, which includes the use of a combination of transportation systems provided by Europe, Japan, Russia and the US in order to complete ISS assembly and to ensure full utilisation of the ISS. Furthermore, the partners agreed to implement 6-person crew operations in 2009.

Following approval of amendments to the Iran Non-proliferation Act, which now allows NASA to procure goods and services from Russia for the ISS until 2012, NASA and Roskosmos have reached agreement on the transportation by the Russians of crew and some cargo, during 2006, and negotiations for future years' services are under way. NASA announced 1-19 July 2006 as the new launch planning window for Shuttle mission STS-121. The window gives the agency time to replace the External Tank fuel sensors and to perform additional engineering work and analysis to ensure a safe flight for *Discovery* and its crew, which will include ESA astronaut Thomas Reiter.

Space infrastructure development

Columbus activities are proceeding to plan. A final end-to-end system validation test involving the User Support and Operations Centres has been performed. The Final Acceptance Review (FAR1) is planned for April/May and shipment to KSC for end-May 2006. The module itself has achieved its Certificate of Qualification from ESA.

On ATV Jules Verne, hardware problems identified in summer 2005 have now been rectified. All latch valves have been refurbished and the new designs of the camera target and solar array drive have been requalified. The spacecraft is now being prepared for the acoustic test in May 2006 and subsequent thermal-vacuum and end-to-end control loop tests prior to being reviewed for readiness to ship to the Kourou launch site by the end of 2006. Significant progress has been made on the functional testing, with most hardware/software chains now successfully validated. The formal functional qualification testing is now scheduled from end-May to November 2006. Detailed technical discussions on the launch strategy are taking place with the launch authority, which should lead to a launch readiness in spring 2007.

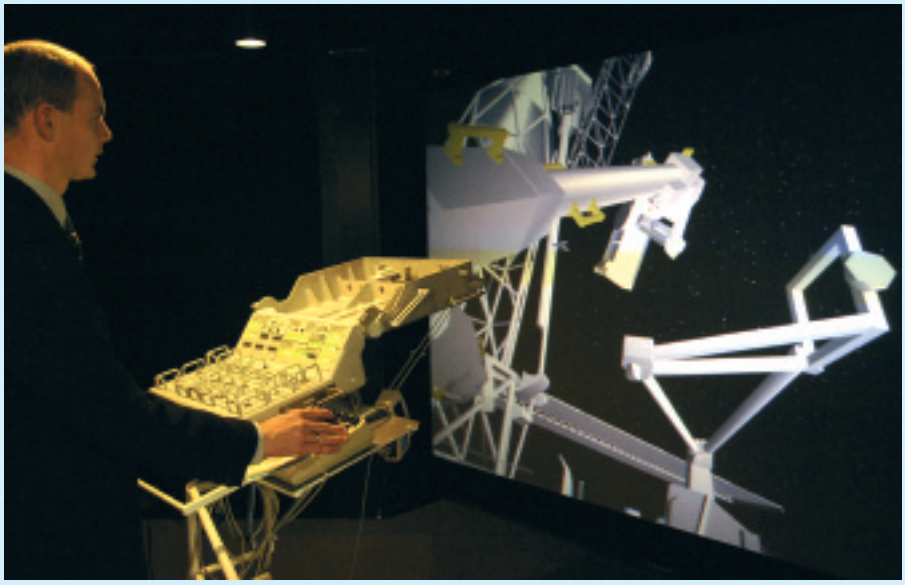
The European Robotic Arm (ERA) Mission Preparation & Training Equipment was shipped to Russia in February, and activities are under way in preparation of the shipment of the ERA flight unit early this summer. Node-3 integration has been completed and initial testing activities have started.

ISS operations and related ground segments

Work on the Mission Operations Implementation Plan for Increment-13 and the Astrolab Long-Duration Mission has been carried out. ESA's human physiology research programme on the ISS is ongoing, with four experiments supported by the Russian Expedition-12 cosmonaut V. Tokarev. Additionally, a protein crystallisation experiment was performed using PromISS in the Microgravity Science Glovebox in the Destiny laboratory. The passive Matroshka (human phantom) radiation dosimeters have been installed in the Russian ISS segment and Phase-IIA of the experiment is under way.

The Columbus Control Centre (COL-CC) Qualification and Acceptance Review Part 2

ERA displayed during the media day at Dutch Space in Leiden (NL) on 5 April 2006



The ERA training simulator at ESTEC. Cosmonauts will be able to operate the arm from a console fixed to the end of one of ERA's limbs

(Q&AR#2) plan is being prepared. The System Validation Test (SVT) Post-Test Review, between the Columbus Flight Segment and COL-CC has been carried out and some open actions have been identified. The planning for SVTs 4.2 and 4.3 activities is under discussion.

An ATV Control Centre (ATV-CC) operations preparation and qualification schedule has been defined to be compatible with a Jules Verne launch in Spring 2007. In order to introduce robustness into the schedule, ESA and CNES will investigate introducing an extra Flight Control Team.

Utilisation planning, payload developments and preparatory missions

Preliminary results from the second WISE (Women's International Space Simulation for Exploration) bedrest study, which was completed at the end of November 2005, indicate that the tested countermeasures (exercise and nutritional countermeasures) had beneficial effects on the health of the volunteers. The scientific teams are now processing the raw data, and the first publications are expected in the second half of 2006.

An information day on ESA's proposal to use the ISS as a research infrastructure (the 'SURE' project), attracting some 60 participants, was held in Prague as part of a promotion campaign.

The 42nd parabolic flight campaign was performed mid-March and 13 experiments were carried out. The 43rd campaign was performed 2 weeks later and 14 experiments in physical sciences, life sciences and technology, as well as two student-proposed experiments, were performed.

New payload developments and refurbishment activities for Foton-M3 are under way; launch is planned for September 2007.

The –80°C Freezer (MELFI) and the European Modular Cultivation System (EMCS) have been reintegrated in the Multi-Purpose Logistics Module (MPLM) for launch on ULF-1.1; refurbishment has been accomplished. The Columbus payload rack facilities (Biolab, Fluid Science Laboratory, European Physiology Module, and European Drawer Rack including the Protein Crystallisation Diagnostics Facility) have concluded their integrated testing and end-to-end System Verification Testing (SVT-2) successfully. Open work on these facilities is continuing in Bremen, Germany, and is expected to be completed in April. The Portable Glove Box is needed for experiments in autumn 2006 and its preparation for Progress-22P is under way. The External Payloads (SOLAR and EuTEF) have also been successfully tested with Columbus and have been returned to the developers for final closeout activities before their separate shipment to KSC. Activities on the Atomic Clock Ensemble in Space (ACES) ground segment definition have started; the ACES Mission-PDR is now scheduled for September 2006.

ISS education

The Dutch Ministry of Education has offered to sponsor and widen the distribution of ISS Primary Education Kits to all 7500 primary schools in the Netherlands.

The opening ceremony of EuMAS (European Master in Aeronautics and Space) took place on 19 January; the programme is supported by the European Commission/Erasmus Mundus, and the Universities of Pisa, Toulouse SupAero, Munich, Madrid and Cranfield are participating.

The preparation of AstroLab Mission Education Experiments is under way. The Exploration Kit for Primary Schools project was started in March.

Commercial activities

The annual review of the Commercial Agent was completed with the review of the

strategy plan for 2006. An agreement was reached on a more market-focused organisation for the Commercial Agent.

Various commercial proposals for the Astrolab Long-Duration Mission have been received and are being evaluated. The SURE Promotion campaign was performed in nine East European capitals, always with e xcellent support from local authorities. Each event was attended by 30-70 people. The campaign was mirrored by a stream of information via the Commercial Project Office website. A total of 37 notifications of interests were collected, including five from industry.

Preparation for participation in the Biosquare exhibition in Geneve (CH) is under way.

Astronaut activities

Thomas Reiter and his backup Leopold Eyharts are completing their training for the Astrolab Long-Duration Mission. They have trained at the Johnson Space Center (JSC) and at the Gagarin Cosmonaut Training Centre, accumulating 1600 hours on the US and Russian orbital segments, Soyuz and payloads. They will be at JSC for final training during the 6 weeks before launch on Shuttle mission STS-121/ULF-1.1.

Payload rack simulators for Biolab, the European Drawer Rack and the Fluid Science Laboratory have been delivered to the Euopean Astronaut Centre and are being integrated into the Columbus simulator.

Exploration

At the Ministerial Council in Berlin, in December 2005, subscriptions to the Aurora Space Exploration Programme were decided, amounting to €73.2 million for the Core Programme (2006-2009) and €650.8 million for the ExoMars mission (2006-2013); this latter amount exceeded the proposed envelope by almost 10%. The ongoing ExoMars Phase-B1 contract is being extended in scope and duration to accommodate the decisions taken at the Ministerial Council, in particular with respect to the study of mission configuration options and the conduct of an Implementation Review. A work plan for the Core Programme component of the Exploration Programme is being established; a series of discussions with participating states will be initiated in order to optimise activities.

Roskosmos has been informed that the Clipper programme has not yet been subscribed; the Russian agency has agreed to leave the possibility open for a few months for European participation in the programme. To avoid missing out on the opportunity to participate, a small internal ESA budget is being made available so that the Agency can work with the Russians until June 2006 to refine the proposal on Clipper so that Member States can take a positive decision on participation in the summer.

Soyuz at CSG

The complementary Preliminary Design Review for flight-safety took place in Guiana in February: the location of the 'launch centre' (CDL) has now been fixed.

Earthworks at the future Soyuz Launch Site have advanced at a rapid pace. This has translated to completion of works ahead of schedule; the only zone not completely finished at the end of March is 'zone 13', which represents the 'surrounding areas' around the 12 platforms.

Excavation of the flame chute (carneau) has proceeded as planned. The next step will involve explosives to penetrate the layer of granite that surfaced as a result of the 5 m-deep excavation, in early April.

On the contractual side, an open competitive tender for the industrial activities in the areas of fluids and low-currents has been issued. In addition, small contracts for modification of the launch base necessary for operating the Soyuz launcher from CSG were negotiated and finally signed with several European companies.

As far as the Industrial Design Reviews are concerned, the programme witnessed two major events: the Industrial Preliminary Design Review for the civil, electrical and mechanical installation that took place in Toulouse, and the Industrial Critical Design Review for the first lot of Russian equipment that took place in Moscow. A number of actions were launched to move to the next phase.

Finally, a management committee ('Consultative Committee') was assembled to look at the progress of the programme. ESA, CNES and Arianespace meet on a monthly basis, while Russian partners are invited on an *ad hoc* basis. Its aim is to identify and resolve any critical programmatic issue that goes beyond the normal programme and contractual thresholds.

Excavation of the flame chute for the Soyuz Launch Site