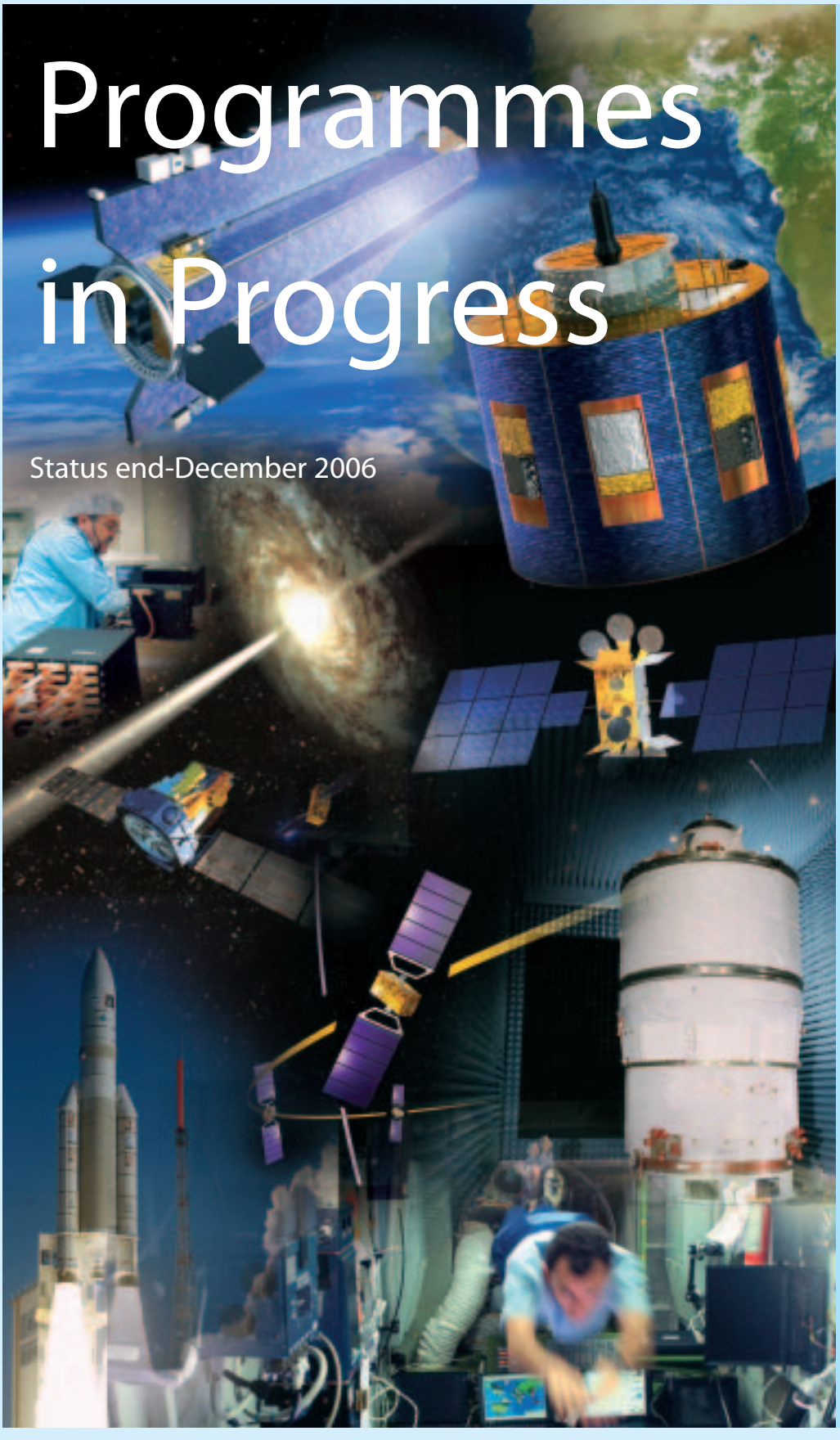
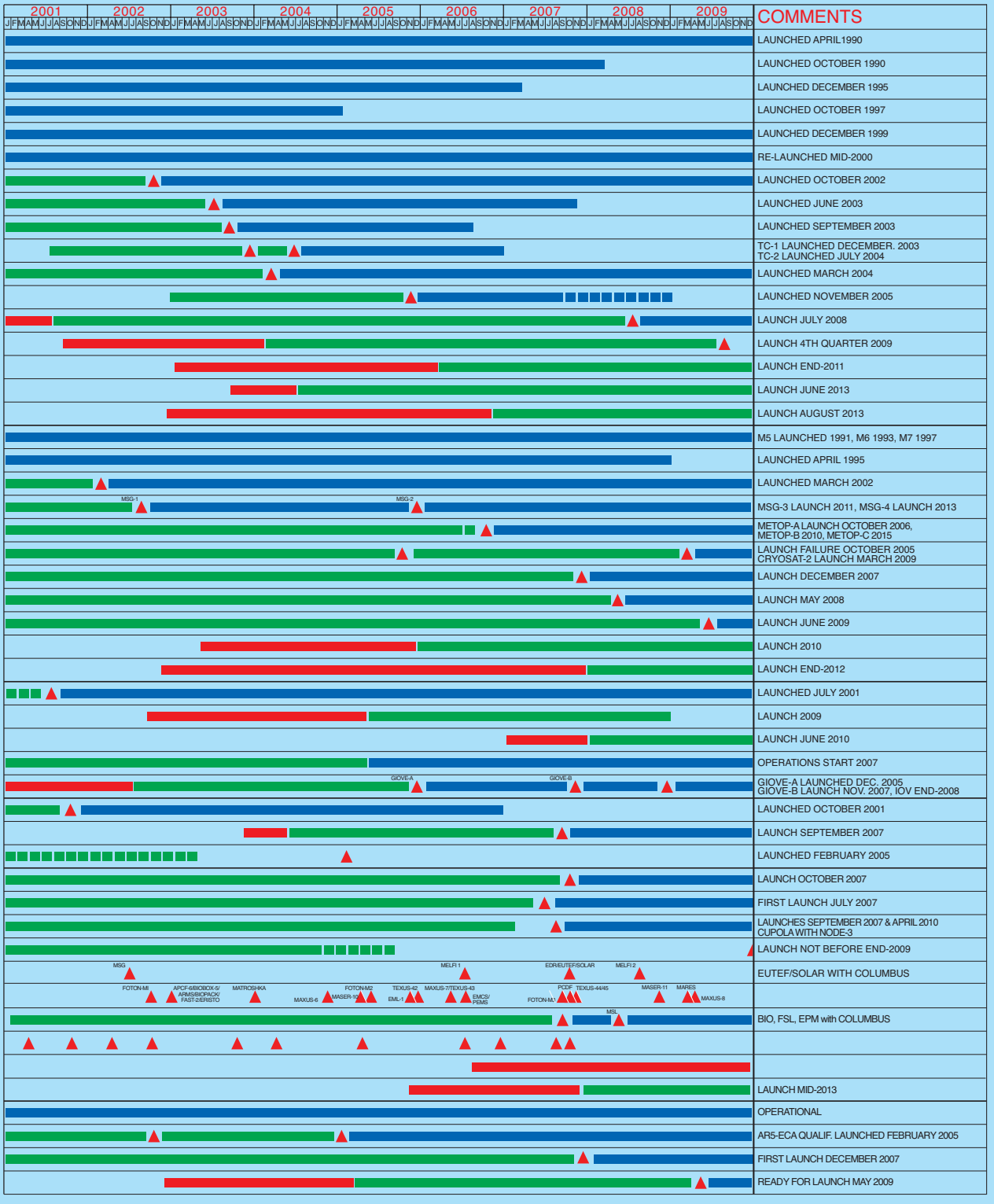
Programmes in Progress

Status end-December 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 BARTER & UTIL. PREP.
	EMIR/ELIPS
	MFC
	ASTRONAUT FLT.
	AURORA CORE
	EXOMARS
LAUNCHER PROG.	ARIANE-5 DEVELOP.
	ARIANE-5 PLUS
	VEGA
	SOYUZ AT CSG


2001
2002
2003
2004
2005
2006
2007
2008
2009
COMMENTS
LAUNCHED APRIL1990
LAUNCHED OCTOBER 1990
LAUNCHED DECEMBER 1995
LAUNCHED OCTOBER 1997
LAUNCHED DECEMBER 1999
RE-LAUNCHED MID-2000
LAUNCHED OCTOBER 2002
LAUNCHED JUNE 2003
LAUNCHED SEPTEMBER 2003
TC-1 LAUNCHED DECEMBER. 2003
TC-2 LAUNCHED JULY 2004
LAUNCHED MARCH 2004
LAUNCHED NOVEMBER 2005
LAUNCH JULY 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 LAUNCH 2011, MSG-4 LAUNCH 2013
METOP-A LAUNCH OCTOBER 2006,
METOP-B 2010, METOP-C 2015
LAUNCH FAILURE OCTOBER 2005
CRYOSAT-2 LAUNCH MARCH 2009
LAUNCH DECEMBER 2007
LAUNCH MAY 2008
LAUNCH JUNE 2009
LAUNCH 2010
LAUNCH END-2012
LAUNCHED JULY 2001
LAUNCH 2009
LAUNCH JUNE 2010
OPERATIONS START 2007
GIOVE-A
GIOVE-B
GIOVE-A LAUNCHED DEC. 2005
GIOVE-B LAUNCH NOV. 2007, IOV END-2008
LAUNCHED OCTOBER 2001
LAUNCH SEPTEMBER 2007
LAUNCHED FEBRUARY 2005
LAUNCH OCTOBER 2007
FIRST LAUNCH JULY 2007
LAUNCHES SEPTEMBER 2007 & APRIL 2010
CUPOLA WITH NODE-3
LAUNCH NOT BEFORE END-2009
MSG
MELFI-1
EDR/EUTEF/SOLAR
MELFI-2
EUTEF/SOLAR WITH COLUMBUS
FOTON-M0
APCF-6/BIOBOX-5/
AFMS/BIOPACK/
FAST-2/ERISTO
MATROSHKA
FOTON-M2
MASER-10
MAXUS-6
TEXUS-42
EML-1
MAXUS-7/TEXUS-43
EMCS/
PEMS
PCDF
TEXUS-44/45
FOTON-M1
MASER-11
MARES
MAXUS-8
MSL
BIO, FSL, EPM with COLUMBUS
LAUNCH MID-2013
OPERATIONAL
AR5-ECA QUALIF. LAUNCHED FEBRUARY 2005
FIRST LAUNCH DECEMBER 2007
READY FOR LAUNCH MAY 2009
DEFINITION PHASE
MAIN DEVELOPMENT PHASE
STORAGE
LAUNCH/READY FOR LAUNCH
OPERATIONS
ADDITIONAL LIFE POSSIBLE

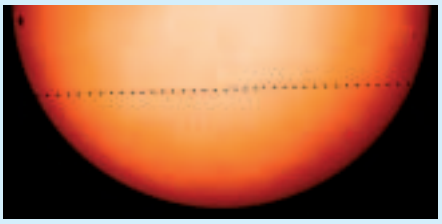
Ulysses

On 17 November 2006 Ulysses reached 70ºS solar latitude, marking the start of the third South Polar Pass. Preparations for the next nutation season, predicted to start in February 2007 and last for approximately 12 months, continued. During this period, the motion of the spinning spacecraft is disturbed by non-symmetric heating of the axial boom. Activities included scheduling and testing in connection with the planned use of ESA's Kourou and New Norcia ground stations that will be employed to fill gaps in coverage arising from incomplete spacecraft visibility from NASA's Canberra Deep Space Network complex. A joint ESA/NASA Nutation Readiness Review was held in JPL on 24 January. The subsystems and science instruments remain in good health.

At the beginning of November, more than 80 scientists from Europe and the US gathered in Oxnard, CA, to pore over the latest results from the Heliospheric Network. The Network is the collective name for the international fleet of spacecraft studying the Sun and heliosphere, of which Ulysses is a key member. The four themes of the Workshop were 'The Outer Heliosphere and Interstellar Connection', 'Solar Wind Transients', 'Energetic Particles' and 'Solar Cycle Variations'. With its comprehensive dataset already covering almost a full 22-year magnetic cycle of the Sun, Ulysses is playing a central role in all of these areas.

SOHO

On 8 November 2006, Mercury passed directly between the Sun and Earth. The innermost planet was seen not as a bright point in the sky but as a tiny black dot, silhouetted against the brilliant surface of the Sun. In previous centuries, transits (especially of Venus) were used to measure the Sun-Earth absolute distance. Nowadays, they are mostly observed for enjoyment. For the SOHO instrument teams, however, a transit provides a unique opportunity for better characterising their imagers and



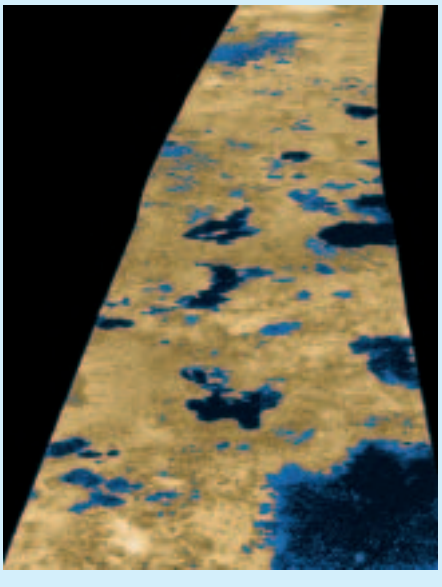
Mercury's path across the solar disc as seen by SOHO/MDI

spectrometers. The data that MDI, CDS and EIT recorded during the transit are being used to characterise better the point spread function of the optics, understand image distortions better and improve stray light models. There was also considerable public interest in this event, with over 2.4 million requests to the SOHO web server and a total download volume of over 215 GByte on that day. The next Mercury transit is on 9 May 2016.

Cassini-Huygens

The nominal 4-year Cassini-Huygens mission ends in June 2008; a 2-year extended orbiter mission is being contemplated. Extended mission scenarios were extensively discussed at the Cassini-Huygens Project Science Group (PSG) held in Pasadena on 16–20 October 2007, and the selection of the 2-year extension trajectory in January 2007 will be on the agenda of the next PSG meeting. NASA's decision on the extended mission is expected in early 2007.

On the science side, the confirmation that the northern 'lakes' contain liquid methane (*Nature*, 4 January 2007) provides another piece of the puzzle regarding the complex methane hydrological cycle on Titan.



Radar data from the 22 July 2006 flyby of Titan by Cassini provides convincing evidence for large bodies of liquid on the moon. Intensity in this colorised image is proportional to how much radar brightness is returned (more specifically, the logarithm of the radar backscatter cross-section). The colours are not representative of what the human eye would see. The lakes, darker than the surrounding terrain, are emphasised by tinting regions of low backscatter in blue; radar-brighter regions are shown in tan. The strip of radar imagery is foreshortened to simulate an oblique view of the highest latitude region, seen from a point to its west. The image is centred near 80ºN/35ºW and is about 140 km across; the smallest details are about 500 m across. (NASA/JPL/USGS)

XMM-Newton

XMM-Newton operations continue smoothly, with the satellite, instruments and ground segment all performing nominally. A total of 594 proposals were received in response to the 6th Announcement of Observing (AO-6) opportunity; the requested time was 6.9 times more than that available. Proposals were received from 425 different principal investigators from 29 different countries. Including co-investigators, a remarkable 1550 individual scientists were involved in the response to AO-6.

An international team of astronomers has found a black hole where few thought they could exist – inside a globular star cluster. These are dense bundles of thousands to millions of old stars. Computer simulations show that a black hole formed in a globular cluster will be rapidly ejected owing to gravitational interactions with the cluster's myriads of stars. Black holes are, by definition, invisible. However, the region around them can become bright, particularly in X-rays, when nearby gas falls onto the black hole and is heated to high temperatures. Using XMM-Newton, the team

found a bright variable X-ray source in a globular cluster around galaxy NGC-4472, about 50 million light-years away. The extreme brightness and variability indicates that the source is almost certainly a black hole. But what sort? It could be a black hole with a mass a few times more than our Sun (these are relatively common in our Galaxy) or it could be an intermediate-mass black hole. These are black holes with masses of 100–1000 solar-masses and are intermediate between the million or more solar-mass giants found at the centre of many galaxies and the few stellar-mass black holes resulting from stellar explosions. Such a black hole may have a better chance of surviving in a globular cluster. How such objects form and evolve is a key question for astronomers which these observations may help to answer.

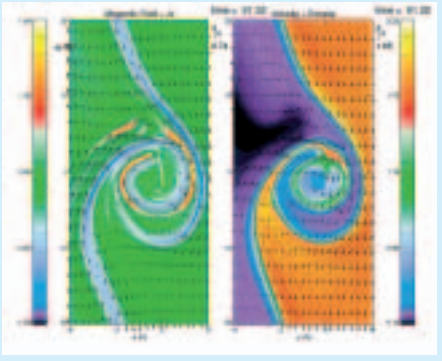
Cluster

The four satellites and instruments are operating nominally. Constellation manoeuvres were executed in November-December 2006 to change the configuration from a 10 000 km tetrahedron to a multi-scale configuration (like a 'flat pyramid'), where the distance between Cluster-3 and Cluster-4 is 500 km and between C1, C2 and C3 is 10 000 km.

JSOC and ESOC operations are following the master science plan. The data return from September to December 2006 was on average 99.1%.

The Cluster Active Archive (CAA) is operating nominally. User access is growing every month and a total of 351 users were registered at the end of December (about a 30% increase from last report). The system was optimised to increase the efficiency of the ingestion process and all data delivered are online. The CAA team is developing new software to provide additional quicklook plots and on-demand plots to the users.

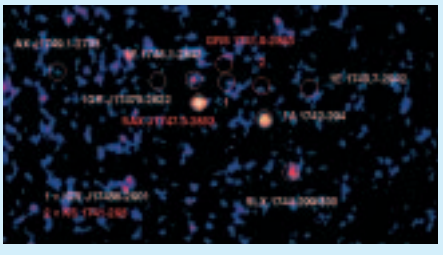
As of end-December 2006, 560 papers were published in the refereed literature and 30 PhDs had been obtained using Cluster and Double Star data. N. Nykyri from Imperial College (UK) published a paper in *Annales Geophysicae* using Cluster data, showing that, surprisingly, reconnection can take place within giant vortices produced by Kelvin-Helmlotz instabilities. Previous studies favoured one of these processes to occur, depending on the interplanetary magnetic field, but not both at the same time.



Magnetohydrodynamic simulation result of the Kelvin-Helmholtz wave. The magnetic field (arrows) and the z-component of the current density Jz (colour coded) are plotted on the left panel. The right panel represents the plasma flow (arrows) and the plasma density (colour coded). The black lines are magnetic field lines. Magnetic reconnection is initiated in the centre of the vortex. (N. Nykyri, Imperial College, UK)

Integral

Integral operations continue smoothly, with the satellite, instruments and ground segment all performing nominally. The 9th annealing of the SPI spectrometer was successful. Targets selected in response to AO-4 are being performed. AO-5 observations will start in August 2007 and will include Key Programme peer review-selected observations of the galactic centre and Cygnus regions and an extragalactic field. A Key Programme is a scientific investigation that requires a significant fraction of the annual observing time in order to achieve its objectives. Now that the AO-5 Key Programme observations are known, potential Integral users will be able to propose for targets in these fields that are not part of the original scientific investigations, using the large fields of view of the Integral instruments.



One of the most interesting regions for Integral is the galactic centre as it contains many bright hard X-ray and gamma-ray sources – at least it normally does! Whenever the galactic centre region is visible, Integral makes frequent and regular observations in order to study this variability. Surprisingly, in April 2006 nearly all the well-known sources around the galactic centre were too faint to be detected. The figure shows an image of the galactic centre with circles indicating the positions of the normally bright sources. Old favourites include the normally bright black hole candidate and the micro-quasar 1E 1740.7-2942.

Integral's view of the centre of our Galaxy

Mars Express

The spacecraft successfully passed through the Mars solar conjunction, and signals were picked up again. Mission science resumed on 6 November 2006, following a small orbit control manoeuvre required to return to the nominal orbit. This ended a 10-week science blackout period (except for some radio science) induced by the longest eclipses experienced so far, while at aphelion, being followed by the solar conjunction.

During the blackout, all the instruments were in hibernation (except for a very small window during which HRSC and OMEGA were active). After, all payloads began functioning normally again. The only problem related to the pre-heating of OMEGA. With the instrument having been off for an extended time, coupled with the generic reduction of heater power during the

blackout, it took much more heating to get the OMEGA interface back to the required temperature. The problem was fixed with a minimal loss of OMEGA science.

The problems in operating the SPICAM instrument, as reported earlier, continue. These affect about 50% of the data, but the instrument can still perform its science observations and it continues to deliver excellent science data.

A Mars Express science team meeting was held at ESTEC 5–7 December 2006. Discussions included the requirements on the evolution of the orbit, and agreed to change the orbit, at the earliest convenience, to a '18/5 resonance'. This predominantly influences the night-day distribution of pericentre passages such that the visible-light instruments will also have (provided a mission extension is approved) excellent observation opportunities. The meeting also discussed the data-return allocation for the first quarter of 2007.

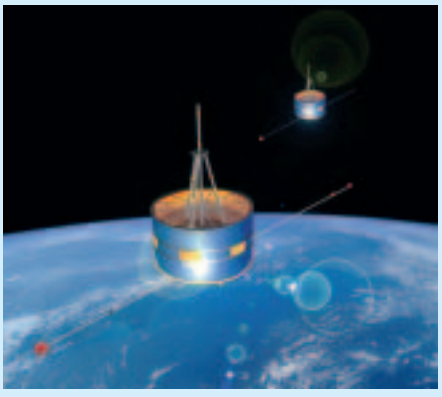
A very successful dedicated session on Mars Express took place at the American Geophysical Union meeting on 11 December 2006.

The Second Mars Express Science Conference will take place in ESTEC on 12–16 November 2007, possibly including a topical workshop on 'The Meaning of Methane on Mars' and dedicated sessions on future Mars Exploration in Europe.

A few major Mars Express papers based on MARSIS results have been submitted for publication, and more are in preparation. One was published in *Nature* on 14 December 2006 and describes the impact of the fact that MARSIS found evidence that buried impact craters – from about 130–470 km in diameter – are under much of the northern lowlands.

Double Star

The Double Star mission has been extended a second time, from January 2007 up to end-



September 2007. Operations of the equatorial TC-1 satellite will end then with entry into the Earth's atmosphere; it will have operated more than 2 years beyond its nominal lifetime of 1.5 years.

The two satellites and their instruments are operating nominally. TC-1 successfully passed the long eclipse season in November 2006.

The European Payload Operation System (EPOS) coordinates the operations for the seven European instruments and is running smoothly. Data are acquired using the VILSPA-2 ground station and the rate has reduced to 2–2.5 h per day because TC-2's apogee is now in the southern hemisphere.

A study on substorm generation mechanisms was published in *Geophysical Research Letters* by Takada et al. from IWF (Austria) using Double Star and Cluster data. It examined the bursty bulk flow (BBF) events observed at Cluster and magnetic dipolarisation observed at Double Star. It showed that 33% of dipolarisations are associated with BBFs. This suggests that BBFs dissipate over a limited range, around 4–8 Earth-radii, and that the magnetotail topology is a key element in the dissipation. Such studies help to further the understanding of the generation and development of magnetospheric substorms.

Rosetta

Rosetta is cruising towards Mars, which it will pass at an altitude of 250 km at 01:57 UT on 25 February 2007. This is one of the mission-critical operations, requiring intense preparations, because the spacecraft has to achieve the proper trajectory for the subsequent Earth-gravity assist in November 2007. Frequent tracking passes for precise orbit determination are carried out, including the use of the 'Delta-DOR' technique, based on radio signal interferometry using two ground stations in parallel. This technique is being used both with NASA Deep Space Network stations and with the ESA Deep Space Antennas at New Norcia and Cebreros. At ESOC, the special spacecraft configurations and operations timeline around Mars closest approach have been defined and validated using the spacecraft simulator and the Rosetta Engineering Model. A simulations campaign, required to train all the mission controllers in the execution of all nominal and contingency operations for this critical phase will be performed in January-February 2007. The Rosetta Science Operations Team in close collaboration with the Experiment Teams and the Mission Control Team at ESOC prepared the science operations sequences for the Mars flyby, which will include a Mars observation campaign and a joint observation campaign of Jupiter with NASA's New Horizon Mission to Pluto, which will perform its Jupiter-gravity assist when Rosetta is close to Mars.

After the periodic checkout of the Attitude and Orbit Control Subsystem in October 2006, a small (10 cm/s) trajectory correction was executed on 13 November, to improve the targeting of the Mars swingby. The payload was inactive until 22 November, when the first payload active checkout campaign of the mission began. This consisted of a month of intense payload operations, including activation and checkout of all instruments, pointing and calibration activities. In addition, onboard software maintenance, followed by inflight verification tests, were carried out on several instruments, including OSIRIS, ROSINA, RPC, MIDAS and the Lander Philae. OSIRIS observed Lutetia, Rosetta's second asteroid target, on 3 and 4 January 2007,

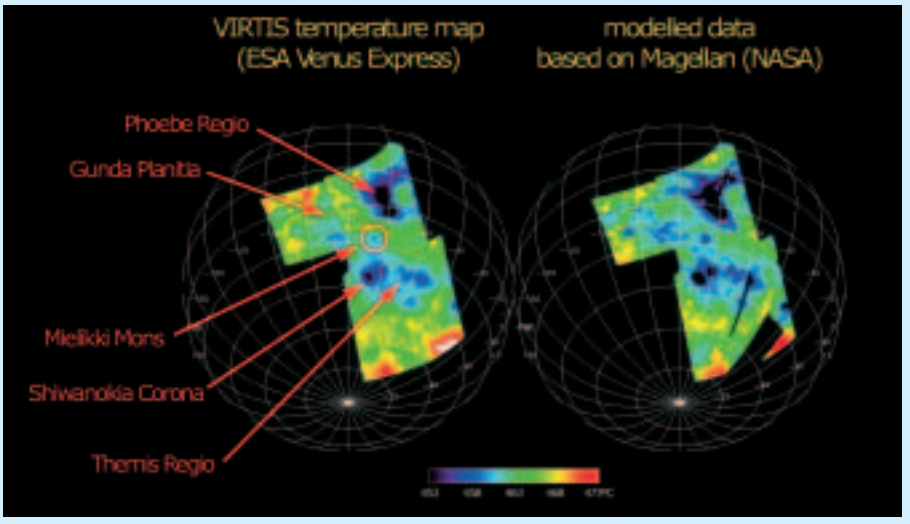
With the completion of the payload active checkout on 22 December, the critical period

of the Mars approach began. From mid-January 2007, all spacecraft operations will focus on determining and achieving the correct trajectory for the swingby. This will include further trajectory corrections in February if necessary.

Venus Express

The mission is now well into its nominal operational phase and the day-to-day activities have reached a routine level. Nevertheless, the small teams working on science planning in the PI institutes and the science operations centre in ESTEC, as well as the mission operations team in ESOC, are very busy because new onboard activities are carried out eveery day. Several measurements addressing a large number of scientific topics are made daily and these have to be carefully planned to match the different constraints. The available data link and the thermal environment are normally the most constraining restrictions. Between mid-October and early November 2006, Venus passed behind the Sun ('superior conjunction') and all the instruments were switched off for about 3 weeks. The most critical spacecraft parameters could be monitored on a daily basis in spite of the very limited telemetry link.

The spacecraft and the active instruments all work very well and provide a continuous stream of data for the individual science teams. The data acquired so far have addressed topics in all of the seven Science Themes that were defined as part of the scientific objectives of the mission. Among the many interesting results are the crisp VIRTIS images of the south pole double vortex structure and the measurements of the global wind fields at different altitudes and latitudes. Both topics are strongly related to the unexplained atmospheric super-rotation that makes the atmosphere circle the planet in only 4 days, while the rotation rate of the solid planet is as slow as one revolution in 243 days. Another important result is the construction of the first surface temperature maps (see the illustration), relying on usage of the near-IR windows where it is possible to see very deep, and even down to the surface, through the thick and hot carbon dioxide-rich atmosphere.



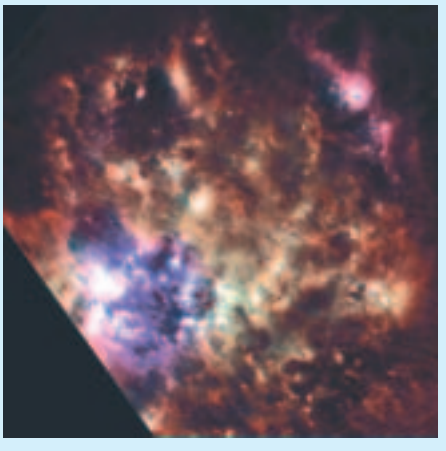
The map above left shows the surface temperature derived from several VIRTIS measurements during orbit 122 on 10 August 2006; the map at right shows a synthetic temperature distribution created from a topographic map based on data from NASA's Magellan orbiter (1990–1994) and assuming a temperature dependence on altitude, with the temperature decreasing linearly with increasing altitude. Comparing such maps can reveal surface hotspots due to, for example, volcanic eruptions or fresh lava fields

Akari (Astro-F)

The Akari IR surveyor, a Japanese mission with ESA participation, has completed its first scan of the entire sky. During this phase, it supplied the broadest wavelength coverage of the Large Magellanic Cloud to date, and provided fascinating new images of this galaxy.

The Large Magellanic Cloud is the closest neighbouring galaxy to the Milky Way. The far-IR view by Akari reveals the distribution of interstellar matter (dust and gas) over the entire galaxy. Dust grains in these interstellar clouds are heated by the light from newborne stars, and they subsequently reradiate this energy as IR. This emission indicates that many stars are currently being formed. The nature of the Large Magellanic Cloud is further revealed by the contrasting distribution of the interstellar matter and the stars. The interstellar matter forms a disc structure, while the stars are located in the 'spindle' in the lower half of the image. This shows that the two components are clearly displaced. Astronomers believe that the observed star formation and the displacement were both triggered by the gravitational force generated by our own Galaxy. These and new data obtained by Akari will unlock the secrets of how both the Large Magellanic Cloud and our own Galaxy formed and evolved to their current states.

ESA's contributions to the mission are working well: regular and efficient ground



This false-colour view of the Large Magellanic Cloud is a composite of images taken by Akari at 60, 90 and 140 micron. Interstellar clouds in which new stars are forming are distributed over the entire galaxy. The bright region at bottom-left is the 'Tarantula Nebula' – a highly productive factory of stars. (JAXA)

station coverage from Kiruna (S) and pointing reconstruction software, developed at ESAC. The ESAC team is in close contact with the Open Time users in Europe, to maximise the overall scientific return of the pointed observations programme, despite increasing operational constraints. More than 100 European observations were performed in the period.

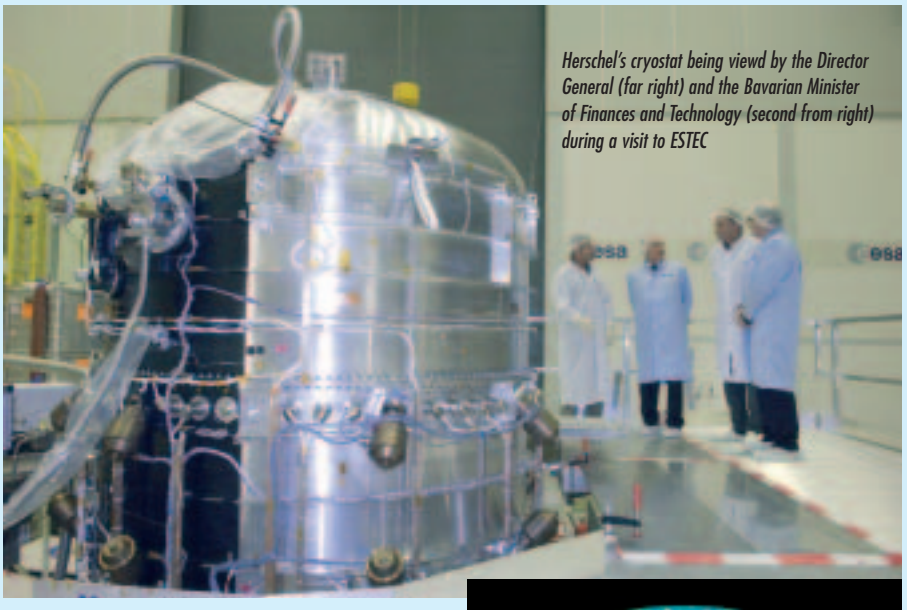
COROT

COROT, the satellite developed by CNES to detect exoplanets and to probe stellar interiors, arrived at Baikonur Cosmodrome on 14 November 2006. The checkout and launch campaign proceeded normally until the filling of Fregat's with hydrazine. Originally planned for 21 December, the launch was delayed owing to a Fregat leak, which turned out to be a false alarm.

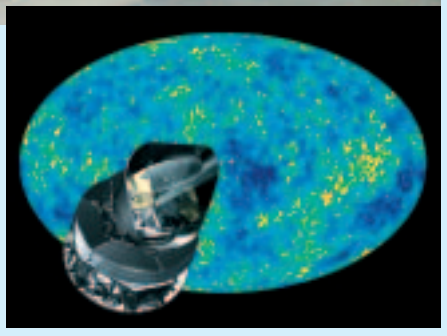
The launch took place 27 December at 14:43:00 UT. The first complete Soyuz 2-1b/Fregat injected COROT into an orbit so near-perfect that the planned inclination correction was cancelled. As a consequence, COROT began operations with a larger propellant reserve than expected, which may be used for a mission extension. The satellite and all the scientific instruments were switched on and tested during the first 7 days in orbit; all systems were found to be nominal. The telescope door was planned to be opened in mid-January, with science operations starting at the beginning of February. ESA's contribution to this mission included the telescope baffle and onboard processing units.

Herschel/Planck

The development activities in industry for Herschel and Planck flight hardware are progressing well, with the delivery of the Service Modules and the completion of the Herschel cryostat qualification testing. The cryogenic qualification test campaign of the Herschel cryostat continued with the verification of the launch autonomy capability



Herschel's cryostat being viewd by the Director General (far right) and the Bavarian Minister of Finances and Technology (second from right) during a visit to ESTEC



In 2003, NASA's WMAP satellite provided the first detailed all-sky map of temperature irregularities in the Cosmic Microwave Background. That map is shown behind Planck as a false-colour image of the whole sky, highlighting the structure of the Universe about 300 000 years after the Big Bang. The cosmological information that astronomers look for is buried in the precise shape and amplitude of all the little bumps and wiggles in this map. Planck will enormously improve the sharpness and clarity of all the features in the map and increase the amount of useful cosmological information by around a factor of 15

of the system, the demonstration of a very low cryostat internal straylight level and measurement of the electromagnetic sensitivity of the SPIRE Engineering Qualification Model focal plane unit. A final qualification step will be the demonstration of the lifetime of the cryostat. This will be measured with near-orbital temperatures in the Large Space Simulator at ESTEC in February 2007. The Herschel Service Module FM completed its electrical, functional and performance testing and was delivered to Astrium for system integration.

The Planck spacecraft FM integration is in the final stage. The LFI and HFI instruments were integrated in the Payload Module, with the final stage being the mating of the Payload Module with the Service Module in early 2007. The FM acceptance tests will continue throughout the year.

The Herschel telescope is being stored until its integration with the spacecraft.

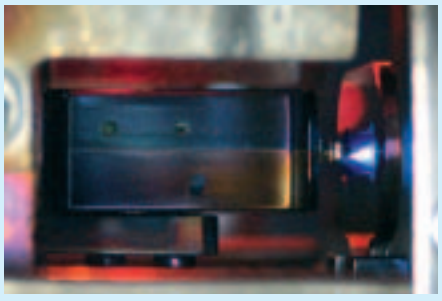
Both Planck instruments have been delivered and are being integrated with the spacecraft. The Herschel instruments are undergoing their final phase.

LISA Pathfinder

All SMART-2/LISA activities are proceeding largely according to schedule. The main system activity in the reporting period was the consolidation of the satellite design and the modification of the LISA Technology Package (LTP) Central Assembly (LCA) accommodation inside the spacecraft. The LCA will now be installed on eight struts; the hyperstatic mounting will guarantee LTP Zerodur structural integrity during launch and the high level of thermal stability needed during the science phase.

In parallel, many satellite subsystems and equipment have undergone their PDRs and

The LISA Technology Package Central Assembly, showing the two inertial sensors, containing the proof masses, the Zerodur optical bench and side slabs supported by eight carbon fibre struts



A caesium ion slit emitter during validation testing for LISA

some CDRs have been conducted. The PDRs for the two European micropropulsion technologies (needle indium thrusters and slit caesium thrusters) took place. Many development tests are being performed to prove the readiness of the technologies for the final selection in the second half of 2007.

Many LTP CDRs have already taken place; good progress is being made despite the many technical challenges. The most critical subsystems are still the inertial sensor vacuum enclosure, the electrostatic suspension front-end electronics and the caging mechanism. The caging mechanism assembly breadboard showed that the design is viable; manufacture of the qualification model is under way. The front-end electronics breadboard tests were performed, and the Engineering Model is now under test.

NASA has made progress on its Disturbance Reduction System (DRS) contribution to LISA Pathfinder: the first colloidal micropropulsion cluster has been assembled and is ready for acceptance. The other cluster is under assembly.

The Ground Segment, consisting of the Mission Operation Centre and Science and Technology Operation Centre, has been defined and underwent the PDR in October.

The launch is expected to take place at the end of 2009.

Microscope

CNES approved extra funding to ONERA for the T-SAGE accelerometer development for Microscope, which proved more complex than originally envisaged. CNES continued system-level work in particular on magnetic field effects that require shielding on the payload.

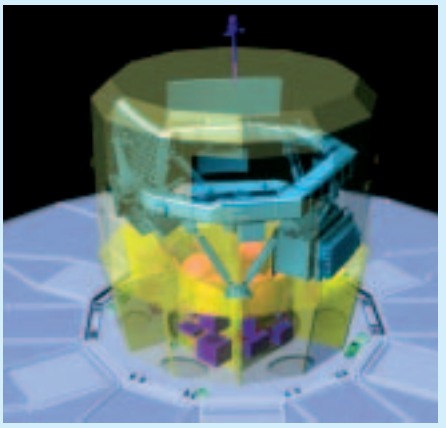
Progress on the Electric Micropropulsion System, to be provided by ESA, is under way within LISA Pathfinder.

The inertial sensor (ONERA) and the Field-Emission Electric Propulsion (FEEP) remain the most critical technologies to qualify. The next ESA/CNES electric propulsion system key-point review now coincides with the LISA Pathfinder Interim Test Review, planned for mid-2007.

Gaia

The competitive selection of subcontractors for the software, flight and ground equipment continues in quite good agreement with the schedule. More than two-thirds of the suppliers for spacecraft equipment have been selected and the remaining part of the competitive bidding phase is going according to plan. The progress of this activity is highly critical for maintaining the schedule and the launch date.

The flight CCD production continued satisfactorily and the handover of the procurement contract from ESA to the Prime



Artist's impression of the Gaia satellite

Contractor is imminent. Polishing of the technology mirror was successful and the companies to produce and polish the flight mirrors have been selected. The schedule for a launch at the end of 2011 is maintained.

The Announcement of Opportunity for the Gaia Data Analysis and Processing Centre was released and a response was submitted by a European Consortium of scientific institutes. Their proposal is under evaluation by an ESA team and a recommendation will be submitted to the Agency's advisory structure in early 2007.

JWST

Nine out of the ten specific JWST critical technologies have reached Technology Readiness Level 6, including the lightweight beryllium optics (primary mirror), wave front sensing and control (WFSC), near-IR detectors, mid-IR detectors, micro-shutter assembly, large cryogenic structures (Backplane Stability Test Article, or BSTA), sunshield membrane, cryogenic ASIC and cryogenic heat switch; the tenth technology (MIRI cryocooler) is under testing and should be completed before the end of January. TRL-6 requires a system or subsystem model or prototype demonstration in a relevant environment (ground or space) and is one of the main formal criteria to pass the gate to mission implementation phase (Phase-C).

JWST's Sunshield Pathfinder at NASA

BepiColombo cruising to Mercury using ion propulsion

The NIRSpec assemblies' procurement campaign has concluded and the industrial consortium is complete. The detailed design phase of all the SiC ceramic parts were completed and the release of the manufacturing of the remaining optical bench and camera optics ceramic blanks is imminent.

Problems encountered with acoustic and random vibration tests for the micro shutter assembly (MSA) developed by NASA were solved and verified by test. This enabled the MSA to pass the TRL-6 gate

Subassemblies and parts for MIRI's Instrument Verification Model are nearing completion. The system-level integration is due to start early March. The instrument-level CDR kicked off in early December; the Board meeting is planned for mid-February. The finalisation of the detailed design phase for the filter wheel assembly remains the main open engineering issue.

The Definition Phase of the Launch Services began with Arianespace. This will cover activities from now until 3 years before launch, and is meant to assist NASA and JWST Prime Contractor NGST during development of the mission.

BepiColombo

The proposed core team for the satellite industrial procurement was strengthened in the autumn. The contract proposal was submitted at the end of the year to ESA's Industrial Policy Committee for approval. The BepiColombo cost-at-completion will be submitted to the Scientific Programme Committee (SPC) for approval in February 2007.

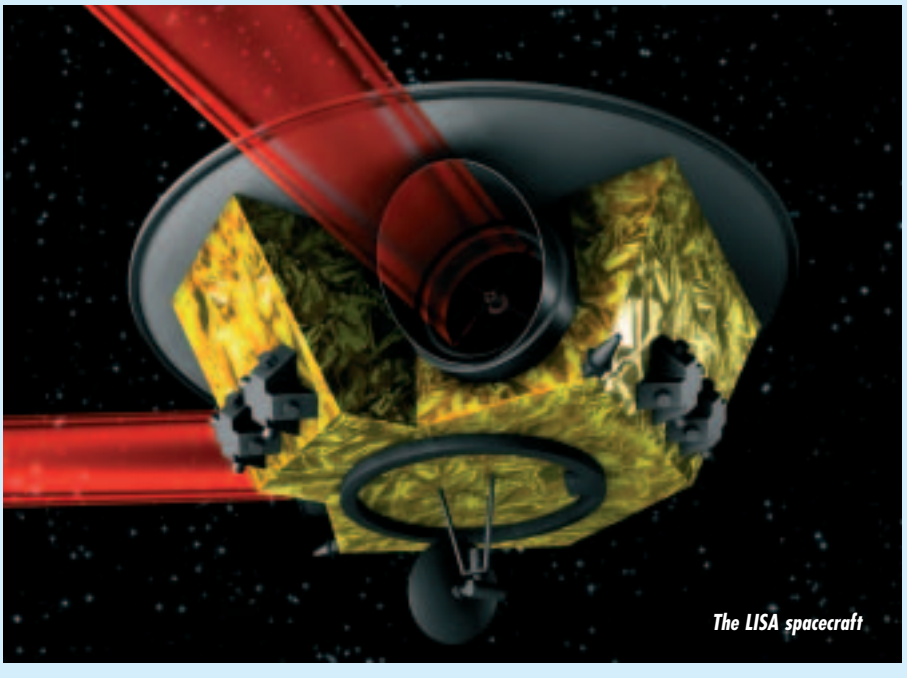
The Mercury Polar Orbiter (MPO) Science Working Group meeting was held at ESTEC 29–30 November. The instrument design and prototyping is proceeding according to plan and the interface definition and payload accommodation work is now proceeding on the basis of the selected spacecraft design. The commitment from the Lead Funding Agencies to support the BepiColombo payload was formalised in a Multi-Lateral Agreement between ESA and those agencies. The involved SPC delegates supported the iterations on this document, which will be submitted for final approval to the SPC in February 2007.

The Memorandum of Understanding with JAXA for the Mercury Magnetospheric Orbiter (MMO) was approved by JAXA and the SPC.

Detailed work with the launch provider has begun and the launcher performance has been confirmed.

LISA

The main activity of the Mission Formulation has been completed, with the definition of a reference baseline architecture for the mission. Some recent achievements, though, indicated the possibility of simplifying the architecture of the scientific complement and for this reason it was decided to extend the Mission Formulation contract until mid-2008. This extension will allow finalisation of a system trade-off involving in-field guidance, a technique that allows pointing the laser beam within the telescope field-of-view, in order to compensate for seasonal constellation breathing, as opposed to moving the whole telescope to obtain the correct pointing towards the opposite spacecraft. This activity will be completed by September 2007 and will be followed by the definition of requirements. In parallel, a LISA simulator is being developed to support the requirements definition process.



The LISA spacecraft

The first round of the Mock LISA Data Challenge (MLDC) was completed in December. These challenges are blind tests and serve the dual purpose of fostering the development of LISA data analysis tools and capabilities and of demonstrating the technical readiness achieved by the gravitational-wave community. Ten groups took part to the first round of MLDCs.

Cooperation with NASA is proceeding well; the two projects are operating like a single virtual project, providing good results.

The review for the prioritisation of the NASA Beyond Einstein programme initiated by NASA HQ and performed by the National Research Council is under way.

GOCE

The completion of the gradiometer flight hardware is progressing well. The first two pairs of Accelerometer Sensor Heads (ASHs) have been integrated and aligned. In parallel, the final functional testing of the Gradiometer Proto-Flight Model (PFM) electronic units, namely the three Front-End Electronic Units, the Thermal Control Electronic Unit and the Gradiometer Accelerometer Interface Electronic Unit, was performed. The integration and test of the sixth ASH, which suffered significant delays in the last quarter of 2006, was completed at the beginning of January 2007. All six ASH FMs have therefore been completed – a major milestone for GOCE.

Astrium GmbH pre-delivered the Platform PFM to the prime contractor Alcatel Alenia Space Italy (AAS-I) at the beginning of October 2006. Since then, AAS-I has mechanically and electrically integrated the Gradiometer PFM electronic units and the upgraded Gradiometer Core Structural & Thermal Model on the Platform PFM and started Gradiometer instrument functional testing.

For the ground segment, the Acceptance Review of Version 2 of the Level 1 to Level 2 High Level Processing Facility of the European GOCE Gravity Consortium was held in October 2006; in addition, a bridging phase was kicked-off in November. The On-Site Acceptance Test of the Reference Planning Facility was completed at ESRIN in October. The ground segment overall validation activities were kicked off and are expected to last until summer 2007.

Finally, the third in a series of International GOCE User Workshops was held at ESA-ESRIN 6–8 November 2006. This workshop was timed to take place prior to the closure of the GOCE Data Announcement of Opportunity, released in October 2006. Plenary sessions were designed to provide potential users of GOCE data products with the opportunity to obtain the latest information on the spacecraft and mission performance, as well as details on flight operations, calibration and validation, ground segment operations, data products and user services.

CryoSat-2

During the last quarter of 2006 the build-up to the system-level delta-CDR continued, through a number of lower-level delta-CDRs, and in late November the system-level review itself started. This review process is intended to scrutinise the parts of the satellite design that have changed, for reasons of obsolescence, design improvement or to cope with the redundancy that was introduced into the payload. This process has been very efficient and most of the updated satellite equipment has been released for manufacture, while unchanged equipment had been released already. In many cases, equipment manufacture is now well underway.

The carbon-fibre composite antenna reflectors for SIRAL have been manufactured and an aluminium layer deposited. The thermal stability of these antennas is of crucial importance to the overall mission performance.

In November the solar array test sample was delivered to ESTEC. This consists of a representative composite of solar array substrate, with inserts, solar cells and other electrical hardware. Following preliminary testing, it was placed in a thermal cycling facility where it will undergo a representative set of cycles to simulate the full mission lifetime. This accelerated cycling should be completed by March 2007.

Some production problems have occurred, including the delay in the Star Tracker delivery, as mentioned in the previous *Bulletin*. As expected, that delay has been ameliorated by harmonising deliveries with another ESA project. Overall, the problems have been absorbed within the schedule without affecting the launch date, which remains March 2009. However, there is now negligible scope to absorb any further slippage.

SMOS

During execution of the antenna pattern measurement campaign at the Technical University of Denmark, one antenna showed abnormal behaviour. Detailed analyses revealed a problem with the way the antenna patch was produced and soldered to the support, resulting in the need to reprocure all the antenna patches and solder them with an improved process. All of this rework was completed, including the mounting of the antennas in the LICEF receivers and the mounting of the LICEF receivers in the arms and the hub of the proto-flight model of the payload.

The last remaining subsystem for the payload, the 12 Command and Monitoring Nodes and the Command and Correlator Unit, completed their AIT programme and were delivered to EADS CASA. With that, the payload integration was completed in 2006. Electrical functional tests at payload level began in early January 2007, to be followed by deployment tests of the three arms.

The integration of the SMOS platform, based on the recurrent Proteus bus, was completed at Alcatel Alenia Space (Cannes, F). After the successful Corot launch using the same

platform, the communication protocol between payload and platform will be verified on the generic simulator bench with the payload engineering model.

For the ground segment, most of the elements of the Flight Operations Ground Segment were delivered and installed in the respective facilities at Toulouse (Satellite) and ESAC (Payload). The Data Processing Ground Segment is lagging behind but not significantly. Installation work at ESAC (computer and operator rooms, offices, antenna base) is progressing nominally.

ADM-Aeolus

Integration of the Platform FM at Astrium Friedrichshafen (D) continues. Most units have now been integrated.

Thermal/mechanical problems with the laser continue. A Tiger Team is investigating their systematic resolution; results are expected in February. In October 2006, the Aladin Airborne Demonstrator completed its first ground campaign at the Lindenberg site of the German Meteorological Office (DWD). About 100 h of data were obtained in parallel with five other lidars and a series of ground instruments. This will allow confirmation of important instrument design assumptions.

A review of the Ground Segment Design in November 2006 concluded that the design was good for the present stage of the project.

Launch of Aeolus is now expected in June 2009.

Swarm

The definition phase of the satellite and its instruments (Phase-B) is ongoing and will be completed in early 2007 by the Satellite PDR. The PDR of the Absolute Scalar Magnetometer (ASM) and Electrical Field Instruments (EFI) was completed. The procurement activity of the satellite's instrument and equipment is well advanced and will be completed within the early Phase-C of the project.

MetOp

MetOp-A, launched successfully on 19 October 2006 from Baikonur Cosmodrome in Kazakhstan, passed through its early operations phase, under ESOC control, without incident. This phase included the automatic deployment sequence of the solar array, release of the reaction wheels, attitude acquisition and deployments of the payload antennas (ASCAT, LRPT, CRA and GRAS). The orbit was adjusted to reach the final operational orbit. Activities were completed by 22 October, when control of the satellite was passed to Eumetsat.

The satellite In-Orbit Verification phase was then started, with the successive switch-on and check-out of the payload instruments. A delay is required in this process to allow the cooled instruments (IASI, AVHRR, HIRS and GOME) to decontaminate their sensitive optical and thermal surfaces.

By the end of 2006, all instruments had been switched on and first-light data were available. No major anomalies were encountered with the instruments; their performances were as expected. The Eumetsat data-processing ground segment performed well during this phase. One anomaly with the LRPT (Low-Rate Picture Transmission) downlink transmitter was encountered; a failure of Side-A was identified. No definite cause for this failure has been so far established. Operations have continued with the B side. No mission impacts are implied with this anomaly.

Other than this, all anomalies so far have been minor and could be corrected by procedural or software updates.

Following in-orbit verification, the work of the MetOp Single Space Segment team switched to a support role for Eumetsat, who are now starting the Commissioning phase, including calibration/validation, for the overall system. This should be completed around March, and routine operations will then begin.

The project and industrial activities are now transitioning into a standby mode, with MetOp-1 (MetOp-B) and MetOp-3 (MetOp-C) in storage, waiting for the restart in 2009 for the next launch (MetOp-B) in 2010.

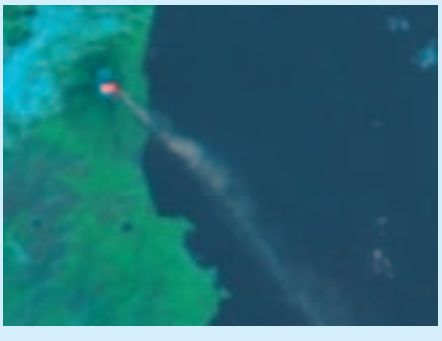
MSG

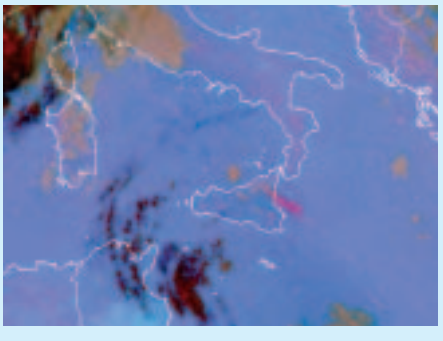
Meteosat-8/MSG-1

The autumn eclipse season ended on 15 October 2006, with fully nominal satellite behaviour. Instrument performance remains of excellent quality.

Meteosat-9/MSG-2

Meteosat-9 also showed fully nominal





Mount Etna's latest eruption was captured on 24 November 2006 by MetOp-A and Meteosat-8. Ash fell on Catania, closing Fontanarossa airport. The satellites witnessed the thin ash cloud and its movement towards the south-east. They also recorded the heat emitted from the new lava flows. Left: Metop-A, AVHRR, 09:30 UT, RGB composite, VIS0.6, VIS0.8, IR11.0; right: Meteosat-8, 12:00 UT, RGB Composite, IR12.0-IR10.8, IR10.8-IR8.7, IR10.8 (Eumetsat)

behaviour at the end of the autumn eclipse season. Winter decontamination took place for the SEVIRI instrument on 11 December. On 22 December, Meteosat-9 celebrated its first year in orbit. It remains the hot backup for Meteosat-8.

MSG-3
It is planned to move MSG-3 from intermediate storage in the Alcatel Alenia Space cleanroom into long-term storage in spring 2007. Launch is projected for early 2011.

MSG-4
MSG-4's Thermal Vacuum Test and Optical Vacuum Tests were successfully completed. MSG-4 is now prepared for its final test in the Compact Antenna Test Range. The Pre-Storage Review is planned for April 2007, after which MSG-4 will be prepared for long-term storage. Launch is planned for no earlier than 2013.

Human Spaceflight, Microgravity & Exploration

Highlights
The highlight of the period was the Celsius mission of Christer Fuglesang, who performed three EVAs during his 13-day mission, and the completion of the very successful long-duration Astrolab mission by Thomas Reiter, who spent 171 days in space. They were both brought back to Earth by Space Shuttle *Discovery* during the night of 22 December. Fuglesang was the first Nordic citizen to fly in space, while Thomas Reiter is now the European record-holder for the longest cumulative time spent in space.

The Heads of the International Space Station partners met at ESA Headquarters on 23 January 2007 to review ISS cooperation. The Heads of Agency expressed their continued appreciation for the outstanding work by the ISS crews and ground personnel to bring the Station to its full productive capacity.

Space Infrastructure Development
The period was characterised by the successful STS-116 assembly flight 12.A1, including the three EVAs conducted by Fuglesang.

For ATV-1 'Jules Verne', a successful thorough review was conducted in front of several NASA officials, including the Administrator and senior officials. The Flight Model testing and integration activities are progressing well. The launch target date is no earlier than July 2007.

The provision of additional ATVs to NASA is under discussion.

With the Columbus module in storage at the Kennedy Space Center (KSC, Florida), the Flight Acceptance Review 1 close-out was completed. The next System Validation Test (SVT2b), involving the EuTEF external payload and the Columbus Control Centre (CoI-CC) is being conducted. A delay in Soyuz flights and reassessment of activities before STS-122 may result in a delay of the Columbus launch. The Flight Operations Readiness Review was successful at the beginning of December at CoI-CC, and included experts from ESA, NASA, the German Aerospace Agency (DLR), the Japanese space agency (JAXA) and industry. It concluded that ESA and its partners are on track for the launch of Columbus.

The Technical Assessment Board for the Atomic Clock Ensemble in Space (ACES) Space Hydrogen Maser (SHM) was concluded, confirming the SHM design feasibility and readiness to start development of the Engineering and Flight Models.

The Eurobot Wet Model (EWM) was built and tested at Alcatel Alenia Space (AAS-I); technical issues are being addressed and solved.

Utilisation
A series of experiments was performed by Thomas Reiter and Christer Fuglesang (ALTEA-CNSM, Altcriss, Low-Back Pain, Neocytolysis). A NASA experiment (Tropi) was successfully run in the European Modular Cultivation System in the Express

Thomas Reiter works with the Cognitive Cardiovascular (Cardiocog-2) experiment in Zvezda. Cardiocog-2 is being used to determine the impact of weightlessness on the cardiovascular and respiratory systems and cognitive reactions. The results will help in developing countermeasures to keep crewmembers healthy during long missions

Rack in the Destiny module. ESA's GRAVI experiment is in progress with the support of the Norwegian User Support and Operations Centre (USOC).

For ISS Increment-15, the utilisation package for Charles Simonyi, who will be launched as a 'space tourist' onboard Soyuz-14 in April 2007, is being prepared following the agreement with Roskosmos.

Discussions with ASI are progressing concerning a joint utilisation plan (including scientific and educational and public outreach) for Paolo Nespoli's mission during STS-120 for further formal submission to NASA.

The USOCs are focusing their efforts on Columbus commissioning and utilisation preparation.

The payload development for Foton-M3, with an expected launch around mid-September 2007, is in its final stage, with the integration of flight payloads scheduled to start in late spring.

Astronauts
The period was dominated by the two highly successful missions carried out by Christer Fuglesang (Celsius) and Thomas Reiter

(Astrolab). In particular, Fuglesang performed three EVAs: two as planned and a third added as a contingency during the mission. The Space Shuttle mission, launched on 9 December, delivered a new ISS Truss segment, Station supplies, equipment and research payloads, such as additional shielding panels to protect the Russian Zvezda Service Module from micrometeoroids and space debris. The crew also undertook a major reconfiguration of the ISS power supply and thermal control system, patching in the new set of solar wings and radiators delivered by Shuttle *Atlantis* in September 2006. This reconfiguration prepares the way for further growth of the ISS, including the arrival of Columbus later this year.

Thomas Reiter took up his duties as ISS Flight Engineer on 4 July 2006, thereby reopening the third permanent crewmember slot, which had had to be discontinued following the Shuttle's grounding after the *Columbia* accident in February 2003. During the Astrolab mission, Reiter carried out numerous operational and maintenance activities for both the US and Russian segments, and operated research facilities in support of international science experiments. He conducted a programme of European experiments in human physiology and psychology, microbiology and plasma physics, and performed technological demonstrations and industrial and educational experiments for universities and schools.

This was the first long-duration mission for an ESA astronaut aboard the ISS, providing invaluable experience in the operations of such missions.

A series of debriefings on the two missions was held at the European Astronaut Centre in Cologne throughout January.

ATV, Columbus and payload training was conducted November – December with several astronauts from ESA, Roskosmos and NASA.

Exploration

Mission-system activities continued under prime contractorship of Alcatel Alenia Space-Italy. The System Requirements Review is scheduled to start mid-February. In the meantime, a Concurrent Design Facility (ESTEC) study was carried out addressing the ExoMars alternative launchers with positive results.

The Rover Vehicle contract was kicked off, while negotiations on the industrial teaming for the main subsystems are under way.

Several Invitations to Tender (ITTs) were released, including the Rover Chassis and Locomotion Design and Breadboarding, the Drill Breadboarding and the Rover Operation Control Centre hardware, software and Mars Simulation Terrain.

The Pasteur Payload Confirmation Review is under way. Science Peer Review meetings were completed and Technical Panel work is being conducted.

Following the selection of the ExoMars Project Manager, Don McCoy, the selections for the second management layer in the ESA project team is under way; the nominations of a Payload and AIV manager, a System Engineering Manager and a Rover Manager are expected in the near future.

The Mars Sample Return Phase-A2 1-year study is under way under the prime contractorship of AAS-I. The study, due to end in autumn 2007, is focusing on refining the mission architecture. A Mission Definition Review is due in the coming months, marking the start of the study's second phase. This will concentrate on the Pre-Phase-A of 'precursor missions'. Two studies of these missions were included in the original contract. Two additional studies are subject to a change-to-contract notice in the original contract; proposals were due in the last week of January (restricted competition procurement).

A series of ITTs was released on various technology aspects, such as the integration of radioisotope heater units, low-temperature sterilisation, and a vision-based hazard avoidance system experiment; proposals were due by the end of February 2007 or early March.

The approved activities (Planetary Protection, Radiation Effects and Radioisotope Power Sources) are being committed. Further ITTs (mainly in Entry, Descent and Soft-Precision Landing and Autonomous Rendezvous) are under preparation.

Phase-B2 of the ARES air-revitalisation system was concluded with a final review. Further ARES activities are being prepared and discussions held with international partners to find a suitable location for an ARES flight experiment aboard the ISS. The SpaceHaven Habitation study was also completed. Future activities in this domain will be the subject of a Request for Quotation.

Significant progress has been made in developing the science-driven scenario. The consolidation of scientific interests and priorities will be completed at a science workshop planned for 14–15 May in Athens. This workshop is organised by an ad-hoc group of the European Science Foundation in close collaboration between D/SCI and D/HME. Work on the industrial/ economic-driven scenario is underway. A milestone will be a workshop organised by the Fraunhofer Institute for Industrial Engineering on 26–27 April in Stuttgart with representatives from the (non-space) applied research and industrial community to assess the broader innovation potential of enabling space exploration capability development and research.

The Edinburgh workshop was held on 8–9 January to review the status of the scenario and architecture work as well as to discuss the drivers for different stakeholder groups and discover the status of the exploration initiatives of European nations and other international partners.

The work on the framework strategy document for space exploration with 14 space agencies worldwide has progressed well. The document is being finalised along with the principles for the international coordination mechanism and the open reference architecture.