Operations and Infrastructure

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

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

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

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

Ongoing Missions

Rosetta

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

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

Ulysses

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

Huygens

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

XMM-Newton

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

Integral

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

Cluster II

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

The Main Control Room at ESOC

Mars-Express

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

SMART-1

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

ERS-2

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

Envisat

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

Proba-1

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

Missions in Preparation

CryoSat

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

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

GOCE

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

ADM-Aeolus

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

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

Venus Express

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

BepiColombo/Solo

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

Herschel / Planck

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

LISA Pathfinder

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

Flight Dynamics

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

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

Space Debris

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

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

Ground Systems Engineering

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

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

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

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

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

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

Third-Party Support

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

Network of Centres Initiative

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

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

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

ESA Site Management

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

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

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

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

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

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

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

The restyled ESOC Rotunda

The corporate IT Service Desk at ESRIN

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

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

ESA Corporate Information Technology

The volume of IT users increased beyond expectations in 2004, with the office-automation services growing to include 4000 users, mostly at the four main sites in Europe, but also including small ESA sites ranging from Washington to Beijing, as well as many travelling users exploiting mobile connections. A typical ESA day now involves more that 500 000 messages being transmitted and delivered, corresponding to 10 Gbytes of information.

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

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

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

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

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