Earth Observation

Missions in Operation

The year saw the consolidation of the Envisat ground-segment operations through routine support from Artemis and the holding of the first Envisat user meetings. Envisat services were progressively opened to users through the release of 40 different types of data products, and by year end some 400 user teams were being actively supported while the spacecraft had completed almost 10 000 orbits.

The ERS-2 Wind Scatterometer was brought back into operation in 2003, the distribution of SCATT data having been halted in 2001 due to gyroscope problems. However, thanks to improved attitude control and development of a new processor, the delivery of SCATT Near Real Time (NRT) data products could be resumed. Consequently, the European Centre for Medium-Range Weather Forecasts (ECMWF) restored the use of ERS SCATT NRT products for their data-assimilation operations.

During 2003 there was a very strong increase in demand for ERS-2 High-Resolution products, with some 15000 HR products shipped, more than 60% of which were destined for operational and commercial use.

Missions under Development

Earth Explorer Missions

CryoSat

Designed to measure variations in the thickness of the polar ice sheets and floating sea ice, CryoSat will be used to study the mass balances of the Antarctic and Greenland ice sheets, to investigate the influence of the cryosphere on global sea-level rise, and to provide important observations of sea-ice thickness for use in Arctic and global climate studies. The Greenland ice cap, for example, is showing signs of accelerated melting and if it disappeared completely it would raise the ocean level globally by 7 m. CryoSat’s unique ability to track such changes will provide a new and highly valuable tool for monitoring such developments.
The project is now well advanced, with almost all flight-model equipment now delivered to the satellite prime contractor, EADS Astrium in Friedrichshafen (D), and integration progressing according to plan. An important milestone in the development of the ground segment was the installation of the Payload Data Segment processing facility at the Kiruna (S) receiving station.

CryoSat is scheduled to be launched from Plesetsk by a Rockot vehicle in late 2004.

**SMOS**

The SMOS (Soil Moisture and Ocean Salinity) mission, a cooperative venture involving ESA, CNES (F) and Spain’s CDTI, will observe two key variables of the Earth system, namely soil moisture over land and salinity over oceans. The satellite uses a generic Proteus platform and an innovative two-dimensional interferometer called MIRAS operating at L-band (1.46 Hz) with aperture synthesis.

Today’s observed decrease in ice cover can dramatically change the balance between fresh and salt water in the Arctic Basin. The highly accurate monitoring of ocean salinity that will be provided by the SMOS mission is therefore key to understanding the impact of climate change on ocean circulation, where even small variations can have dramatic impacts on Europe, for example if the Gulf Stream should be weakened.

Several important milestones were achieved in 2003:

- Full programme implementation was endorsed by both ESA’s Earth Observation Programme Board and CNES’s Conseil d’Administration.
- The industrial contract for the payload was signed with EADS CASA (E) as prime contractor and a consortium of more than thirty companies in countries ranging from Finland to Portugal.
- The payload successfully passed its Preliminary Design Review (PDR), and is now ready for the detailed design phase and the release of engineering and structural/thermal model production.

SMOS is still scheduled for launch in early 2007.
ADM-Aeolus
The Atmospheric Dynamics Mission will provide the first ever measurements of wind profiles from space. It uses a novel technique to measure the Doppler shift of laser light backscattered from the Earth’s atmosphere. Aeolus will provide accurate wind fields over areas with notoriously bad coverage, data that has been identified on several occasions as the critical missing link in the observation of storms as they build up over the Atlantic Ocean. These storms often cause huge damage in Europe, and the tidal surges they produce have a devastating effect in coastal areas. Advance warning will therefore be a major asset.

Phase-B of the industrial contract for the satellite’s design and development was completed on schedule with a successful Preliminary Design Review in September. The contract for all subsequent phases, up to the In-Orbit Commissioning Review, was signed on 22 October.

Results obtained with a pre-development model of the instrument are quite encouraging. This model forms the basis for the instrument subsystem procurements which are now all underway. The two halves of the flight-model silicon-carbide primary mirror have been fabricated and successfully brazed together. Flight models of other schedule-critical elements, such as the laser pump diodes, are all being fabricated. All significant subcontractors have now been selected, and the vast majority have begun work.

The schedules committed to by the subcontractors allow an unchanged launch date of October 2007.

GOCE
The Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) mission is the first of the Earth Explorer Core Missions planned as part of the Agency’s Earth Observation Envelope Programme (EOEP). Its aim is to provide unique models of the Earth’s gravity field and of the geoid on a global scale and with unprecedented accuracy and spatial resolution.

During 2003, the detailed design of the satellite was consolidated through the successful completion of the various equipment-level Preliminary Design Reviews. Manufacture and testing of equipment development models also proceeded according to plan. Towards the end of the year, the emphasis was on the timely preparation of the integration activities for the Engineering Model Test Bench that will be used to verify the GOCE platform’s functional and electrical performance, including real-time closed-loop tests.
Work on the ground segment proceeded at a good pace. The contractor responsible for the development of the Payload Data Segment (PDS) was selected during the summer, and the PDS System Requirements Review was successfully completed by the end of the year.

A launch-services procurement contract was signed with Eurockot in November for an August 2006 launch.

**Earth Watch Missions**

**MetOp**

Following the restructuring of the MetOp programme to take into account the late delivery of some customer-furnished instruments, notably IASI, a revised integration logic was adopted which means that, for cost-efficiency reasons, the MetOp-2 spacecraft will be the first to fly, at the end of 2005. Meanwhile, MetOp-1 will be completed with a not fully-flight representative payload in mid-2004, and will serve as a proto-flight model to complete the qualification. Thereafter it will be stored and refurbished with flight instruments prior to its nominal launch in 2010.

Progress within the revised programme has been very good. The MetOp-1 spacecraft was integrated and by the end of the year had achieved many of its testing goals. In parallel, integration of the MetOp-2 payload and service modules was completed, and preparation for their thermal-vacuum testing is well underway. A 'first' was achieved at the end of the year with the successful control of the spacecraft by the Eumetsat ground segment.

**Meteosat Second Generation**

Commissioning of the MSG-1 satellite was completed in June by Eumetsat, with ESA support. The excellent quality of the Spinning Enhanced Visible Infrared Radiometer (SEVIRI) and Geostationary Earth Radiation Budget instrument (GERB) images was confirmed by the user community. Commissioning of the ground segment, including all image-processing facilities, was followed and completed by a successful System Commissioning Results Review and Routine Operations Readiness Review. Following a drift manoeuvre to its final orbital location, MSG-1's routine-operations phase will start in February 2004.

MSG-2 integration and test activities were completed in April, and in June the satellite was put into storage until April 2004. Thereafter, some units will be reintegrated and the final tests and preparations for the January 2005 launch conducted. The MSG-3 activities will continue until the de-storage of MSG-2.

In parallel with these activities, the final round of negotiations with industry for procurement of the fourth flight unit (MSG-4) was concluded in January. The preliminary authorisation to proceed was formally given to industry in April.

**InfoTerra/TerraSAR**

Consolidation of the InfoTerra/TerraSAR element of the Earth Watch programme was carried out from January to June, followed by the ongoing Consolidation Phase 1-2, to be concluded with the Preliminary Design Review in December 2004.

The first objective of the TerraSAR mission is to provide geo-information services to commercial users exploiting joint data products from TerraSAR-L and TerraSAR-X, the latter being developed concurrently as a German national programme.

TerraSAR-L will provide ESA with its most powerful radar-imaging mission to date, giving global coverage from a 14-day repeat, 620-km altitude orbit and 20 minutes of data
acquisition per orbit over a five-year period. The platform, which is based on the novel ‘Snapdragon’ configuration, has a total launch mass of 2.4 t, to be accommodated on the Soyuz Fregat ST launcher. The principal payload is an L-band SAR instrument that, in addition to standard strip-map and ScanSAR operations, has full polarimetric, repeat-pass ScanSAR interferometry and wave-mode capabilities.

The TerraSAR-L ground segment will provide the operational link between the spacecraft and the commercial users via the TerraSAR Exploitation Service Infrastructure (TESI).

Fuegosat
In 2003, work in the GMES-related Fuegosat Consolidation Earth Watch Programme Element focused on the refinement of user requirements and the prototyping of services based on existing operational assets, such as MSG, or precursors, such as MODIS. Gaps requiring additional dedicated observations were identified, and the potential offered by dedicated assets was demonstrated with the German Bird satellite. Technologies and algorithms developed in previous projects were enhanced and evaluated, and system-architecture concepts established.

Preparation of Future Missions
These activities addressed future Earth Explorer and Earth Watch missions designed to improve our knowledge of the Earth system and to deploy space-based solutions in critical areas such as climate-change detection, environment monitoring, sustainable development, risk management and other areas of relevance to the initiative for Global Monitoring for Environment and Security (GMES), in addition to well-established areas such as operational meteorology.

Earth Explorer Missions
Activities were conducted at Phase-A (study) level for three candidate Earth Explorer Core Missions: EarthCARE, SPECTRA and WALES. EarthCARE features a unique combination of active and passive sensors co-located on the same platform to improve our knowledge of the role of clouds, aerosols and radiation in climate. WALES would further improve the modelling of water vapour in the atmosphere by using accurate observations provided by a four-wavelength differential absorption lidar. The studies have shown that these missions would considerably reduce the uncertainty surrounding the impact of the above climatic factors, allowing us to better estimate the effect of greenhouse and other gases on the Earth’s climate, which is a major concern for Europe. The SPECTRA mission would observe selected sites around the globe in the visible to thermal infrared part of the spectrum, to study land processes and address key aspects of the energy, water and carbon cycles.

Three candidate Earth Explorer Opportunity Missions – ACE+, EGPM and Swarm – were also the subject of Phase-A studies. In the ACE+ mission, a constellation of small satellites would provide accurate profiles of atmospheric-water-vapour concentration by applying radio-occultation techniques to the signals from navigation satellites such as GPS and Galileo, as well as X- and Ka-band signals exchanged between the ACE+ satellites. In the Swarm mission, a constellation of small satellites would measure the Earth’s electric and magnetic fields with high accuracy to address a wide range of scientific and application issues. This mission would also contribute to global science in the context of the Sun–Earth connection.

EGPM would be ESA’s contribution to the Global Precipitation Measurement (GPM)
mission. By sampling precipitation globally every three hours, GPM would help to improve precipitation modelling and support daily-life applications such as enhanced weather and water-resource predictions, enhanced agro-meteorological models, and improved prediction of floods, which in 2002 caused 100 BEuro worth of damage in Central Europe. EGPM would also address issues of particular concern in northern latitudes, such as the detection of light rain and frozen precipitation.

**Earth Watch Missions**

While MSG-1, launched in 2002, was entering its operational phase and three more MSG satellites were under development, ESA and Eumetsat were preparing the Meteosat Third Generation (MTG), with the preliminary definition of mission requirements, observation techniques and sensor concepts. MTG will considerably improve Europe’s short-range weather-forecasting capabilities, including for example anticipation of extreme weather events, and the monitoring of air quality and pollution.

Considerable effort was also devoted to preparing for the implementation of the GMES initiative. While services were being consolidated under EC and ESA programmes (especially the Agency’s GMES Service Element of the Earth Watch Programme), preliminary concepts were being identified for future space systems that would guarantee the continuity of service provision.

**Basic Activities**

Technology development, in coordination with TRP/GSTP and other Agency technology-development programmes and with non-ESA programmes through harmonisation, forms an essential part of the preparatory activities. Major achievements in 2003 for the above missions included completion of the pre-development model for the Doppler wind lidar for the ADM-Aeolus mission, the tile demonstrator for the L-band TerraSAR, and major components of the airborne hyperspectral sensor APEX.

**Services Development and Applications**

The first steps of the ‘Oxygen’ initiative aimed at harmonisation of the European ground-segment infrastructure were initiated, facilitating greater access to Earth-observation data. The first version of the Earth Observation portal (www.eoportal.org) was opened to the public, the ground network between facilities was being extended, and the common archiving systems were put in place.

ESA and EC coordination activities preparing for an autonomous European Global Monitoring Capability for Environment and Security (GMES) made significant progress during 2003. Ten major actions were started under the ESA GMES Service Element (GSE) to consolidate a set of new operational, satellite-based, environment-monitoring information services. These services aim to provide vital monitoring information needed by local, regional and national policy-makers across Europe to aid them in formulating, implementing and assessing the impact of environment and security policies. The GSE actions started in 2003 will provide information on the marine environment, coastal-zone management, the Arctic environment, urban development, soil and water quality in Europe, food security in Africa, and risk assessment for floods, forest fires and geo-hazards. More than half of the 175 organisations so far engaged in GSE are users.

The GMES Steering Committee, jointly chaired by ESA and EC, organised extensive consultations with GMES end-user communities and stakeholders throughout ESA and EU Member States, including the accession countries, during 2003. Three GMES Forums were co-organised by ESA and EC, in Noordwijk (NL) in January, Athens (GR) in June, and Baveno (I) in November. These well-attended events saw an active exchange of views between end-users and stakeholders from all over Europe. The GMES Interim Report co-authored by ESA and EC, laying down recommendations for the future steps needed to implement GMES, was discussed and reviewed in depth during the Baveno Forum.

Significant progress was made on the Data User Element, in developing and validating new EO-based information services, in close cooperation with key end users such as national Ministries and regional authorities for
the environment, agriculture and forestry. Services being developed include land-slide, snow, glacier and forest-monitoring systems.

ESA project-coordination offices were opened at the University of Jena (D) and at the UK Meteorological Office’s Hadley Centre, to ensure effective day-to-day linkage between on-going ESA exploitation projects and international cooperative actions within the framework of IGOS and IGBP.

ESRIN also organised ESA’s participation in the 9th Conference of Parties (COP9) of the UN Framework Convention on Climate Change (UNFCCC), held in Milan (I). ESA’s presence, for the second time, was well received and reinforced the excellent relationship that the Agency has developed in the last three years through the Treaty Enforcement Support using Earth Observation (TESEO) initiative, and its continuity in the DUP/DUE programmes.

Throughout 2003, ESRIN continued to grow European industry capabilities in offering EO-based services through ESA’s EO Market Development (EOMD) programme. The major achievement was to successfully attract and engage large (non-EO) companies to evaluate the types of EO services available to date for their business or operational needs. These large companies include offshore and onshore oil and gas and mining operators, offshore engineering companies, major civil-engineering constructors, renewable-energy industries (wind, hydro and solar), transport operators, re-insurance companies and food commodity traders.

Over 30 small, specialised, value-adding companies were testing out how EO services need to be tailored, packaged, supplied, delivered and supported in close partnership with these larger industries that represent potential customers. These services make use of both ESA (ERS and Envisat) and non-ESA mission data, and cover a range of land and ocean applications, including precise land-motion mapping, space maps, geological mapping, bathymetry, wind/wave/current information, and so on.

The first commercial service-provision contracts were secured, and with several joint ventures and partnerships were set up to further develop the business. In this domain, in 2003 ESA began an in-depth review of the whole EO service industry, to better understand the complete range of services available today, the problems that these small companies are facing, and how development financing can be better used to help grow a strong and vibrant European industry. First results were presented at a two-day workshop titled ‘European EO Services: Today’s Industry, Tomorrow’s Markets’, held at ESRIN in November and attended by more than 80 service companies.

The link with the wider meteorological community was strengthened through various activities in connection with organisations representing such users. Following the launch of the Meteosat Second Generation satellite MSG-1 in August 2002, ESA and Eumetsat announced a joint Announcement of Opportunity (AO) for the use of its data for research. A similar opportunity was being prepared during 2003 ahead of the launch of MetOp in 2005.

Since 2003 ERS and Envisat have been part of the space-based component of the World Meteorological Organization’s Global Observing System. ESA has, therefore, re-joined the Coordination Group of Meteorological Satellites (CGMS) and participated as a full partner in its annual meeting in Ascona (CH). In addition, a joint ESA/WMO AO for the use of Envisat data was issued.

In the domain of Education, a major upgrade of Eduspace, the Earth Observation web portal developed for Secondary Schools under the auspices of Eurisy (www.eduspace.esa.int), was successfully achieved, and the French, German, Spanish, Danish and Italian versions of the portal became available to the public. By the end of the year almost a thousand schools, some outside Europe, were already registered and many teachers had proposed portal improvements, particularly in the study-case area.

Events and courses dedicated to teacher trainers were supported by ESRIN both within
and outside Europe, and a limited number of trainees and national fellows were hosted in Frascati. ESRIN also participated very actively in the Working Group on Education of the Committee on Earth Observation Satellites (CEOS) and in Module 1 (Capacity Building) of the World Summit on Sustainable Development (WSSD) Follow-up.

**International Charter on Space and Major Disasters**

Under the Charter, satellite imagery was provided to emergency and rescue organisations coping with major disasters on 16 occasions during the year. They included the floods in Argentina and the Rhone delta (F), forest fires in Canada and Portugal, and the earthquakes that destroyed the town of Boumerdès in Algeria and the city of Bam in Iran.

European civil-protection authorities increasingly use the mechanism of the Charter as a valuable source of information for their operations, with the rescue teams receiving space-acquired data within as little as 8 hours. Images collected during emergencies by satellites such as Envisat, Radarsat, Spot and Proba are also key to effective reconstruction and the planning of preventive measures for the future. Snapshots of flooded areas, burnt forests or damaged buildings are available very quickly, thanks to efficient teamwork across all ESA establishments, ranging from ground-segment operators to international-affairs specialists.

This pragmatic European initiative has attracted the attention of most of the World’s space agencies, from Argentina to Japan. The United Nations sees it as an example of inter-national cooperation that delivers tangible results from space. The Charter is the precursor of an operational information system, using sustained satellite resources, that should become available through the GMES programme. It contributes fundamentally to the protection of Europe’s own citizens and to the provision of humanitarian relief by Europe wherever it may be needed in the World.