

Earth Observation

Missions in Orbit

ERS

Launched: April 1995

ERS-2 again proved to be a very robust satellite throughout 2002, providing high-quality data to the scientific and commercial user communities, supporting the Envisat calibration and validation campaign, and helping civil-protection agencies by providing data on natural disaster zones. The current exceptionally good payload and platform performance bodes well for several more years of satellite operation. The satellite has been operating in a gyroless mode, and attitude accuracy in this mode has been confirmed by both tests and interferometric applications.

The ERS archive now contains more than 11 years of continuous high- and low-bit-rate data from both satellites (nearly 1.5 million SAR scenes) and 7 years of atmospheric data from ERS-2. The development of new applications in the field of interferometry, together with the introduction of an imagery policy in line with the prevailing market, resulted in an increase of some 70% in the number of scenes distributed, to over 16 000.

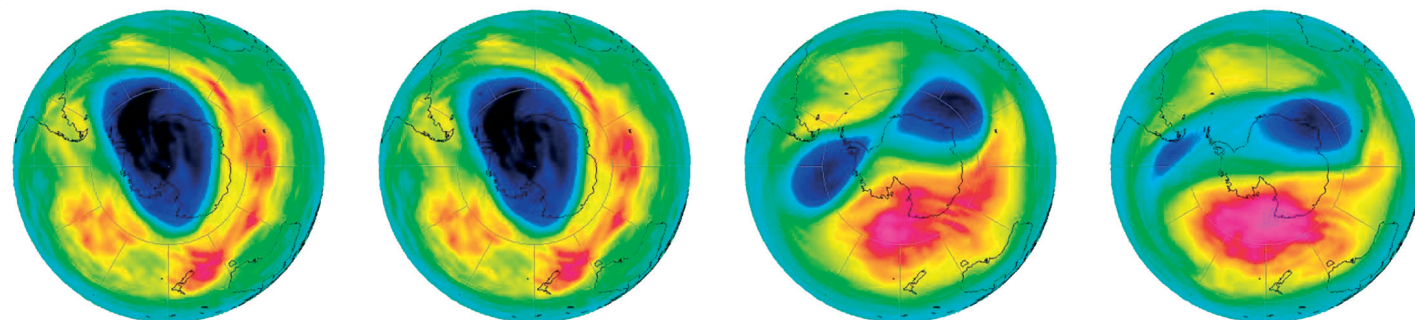
Envisat

Launched: March 2002

Launched on 1 March by an Ariane-5, Envisat reached its final orbital position on 3 April, and since then has been orbiting in its assigned 35-day repeat cycle, 30 minutes ahead of ERS-2. Both satellites are controlled to fly over the same ground track with ± 1 km accuracy.



The first image from Envisat's MERIS instrument, showing the complex river system of Casamance in West Africa



Forecasted breakup of the ozone hole over Antarctica between 18 and 28 September 2002, based on ERS and Envisat data (Copyright: KNMI and ESA)

The MSG-1 spacecraft in the Integration Hall in Kourou, French Guiana, shortly before launch



During the first weeks of the mission, all of the satellite's instruments were progressively switched on. The first images acquired by the ASAR and MERIS instruments were presented to the media on 28 March. The Commissioning Phase continued with the verification of all instrument modes. The Calibration Review in early September confirmed that all instruments were operating nominally, with very stable performance.

The Envisat mission has been operating without the Artemis data-relay satellite (not available until early 2003), resulting in a very high workload for the Kiruna (S) ground station, which was having to handle the recovery of the full global mission (involving 14 orbits per day). The ad-hoc installation of a reception/transmission capability in Svalbard (N) provided an improvement in ground-segment performance from early November. Despite some early problems with Payload Data Segment (PDS) performance, the calibration/validation teams had received sufficient data to allow a successful Calibration Review in September and for the Validation Workshop in December. These events highlighted the Earth Science community's enthusiasm for the quality of the data being provided by all of Envisat's instruments.

Meteosat Second Generation (MSG)

Launched: August 2002

After an extensive System Validation Test, a Readiness to Ship Review in March released MSG-1 for transport to Kourou for launch on an Ariane-5 vehicle fitted with three special shock-attenuation devices. After its successful launch on 28 August and excellent injection into Geostationary Transfer Orbit (GTO), the satellite was thoroughly checked out and moved, by means of three burns of its liquid apogee motor, to its final orbital position. ESOC then handed over control of the satellite to Eumetsat for the commissioning phase, which will last until March 2003.

The first images from the Spinning Enhanced Visible Infrared Radiometer (SEVIRI) and the Geostationary Earth Radiation Budget (GERB) instrument have proved to be of excellent quality. The launch of MSG-1 took place during the Johannesburg World Summit on

Sustainable Development, which provided an excellent opportunity to demonstrate the benefits of Earth-observing systems for sustainable development, particularly for the African continent given the satellite's equatorial location.

Missions under Development

Earth Explorers

The Earth Explorer Missions are research/demonstration missions intended to advance our understanding of the Earth's environment and to demonstrate new observing techniques. They are part of the Agency's Earth Observation Envelope Programme (EOEP), and can either be large missions labelled *Core* missions, or smaller missions, the *Opportunity* missions.

CryoSat

Launch: Second half of 2004

CryoSat is an Opportunity mission designed to measure thickness variations in the polar ice sheets and the thickness of floating sea ice. Its data are to 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 project is now in the middle of the main development phase (Phase-C/D) and some items of flight-model equipment have already been delivered to Astrium GmbH (D), the satellite prime contractor. Development of the ground segment is progressing according to plan.

GOCE

Launch: February 2006

The Gravity Field and Steady-State Ocean Circulation (GOCE) mission is the first Earth Explorer Core mission. Its two main instruments – the Electrostatic Gravity Gradiometer (EGG) and the Satellite-to-Satellite Tracking Instrument (SSTI) – will deliver data that will enable scientists to derive unique models of the Earth's gravity field on a global scale and with unprecedented accuracy and spatial resolution.

GOCE passed several important milestones in 2002, the most important one being the



The CryoSat spacecraft

successful conclusion of the Space Segment Preliminary Design Review in April. The year also saw the continued build-up of the industrial consortium through a competitive selection process for all equipment contracts, with authorisation to industry to proceed with space-segment development (Phase-C/D) having been given in May. The Ground Segment Requirements Review was successfully concluded in November.

ADM-Aeolus

Launch: October 2007

The Atmospheric Dynamics Mission (ADM) is an Earth Explorer Core mission that will provide global wind profiles throughout the atmosphere up to 16 km altitude. The measurements will be made by a Doppler wind lidar operating in the ultraviolet. It will be the first time ever that wind profiles have been measured from space and this experimental mission is expected to show the great usefulness of complete wind data sets for Numerical Weather Forecasting. The resulting time series of measured wind fields will also be useful for studies of climate and the transport of chemical species and energy.

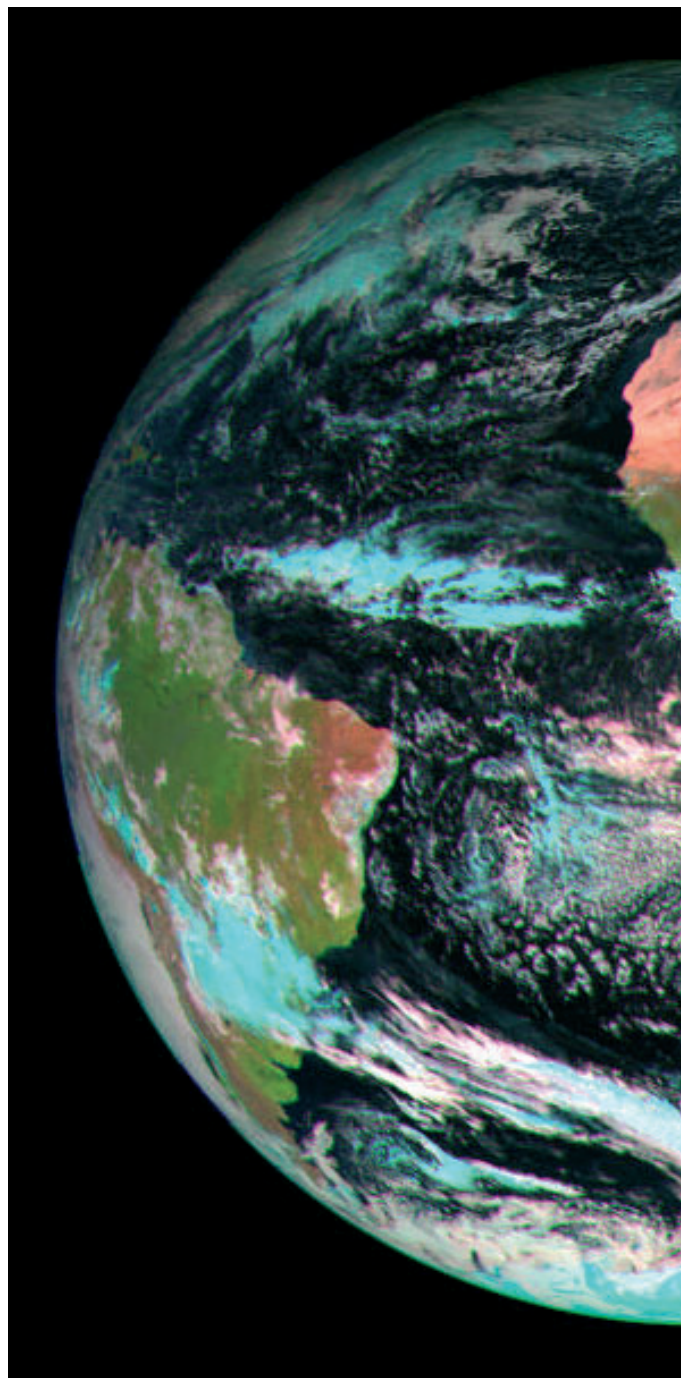
The industrial contract was kicked-off with Astrium Ltd. (UK) as prime contractor on 1 July 2002. Astrium SAS in Toulouse (F) is the subcontractor selected to develop the instrument, and Astrium GmbH in Friedrichshafen (D) is subcontracted for the platform's electrical subsystems. The satellite's design, which has been consolidated around a 1.5 m-diameter telescope, is already sufficiently advanced to allow the Invitations to Tender (ITTs) for the majority of the onboard subsystems and equipment to be issued in early 2003.

SMOS

Launch: Early 2007

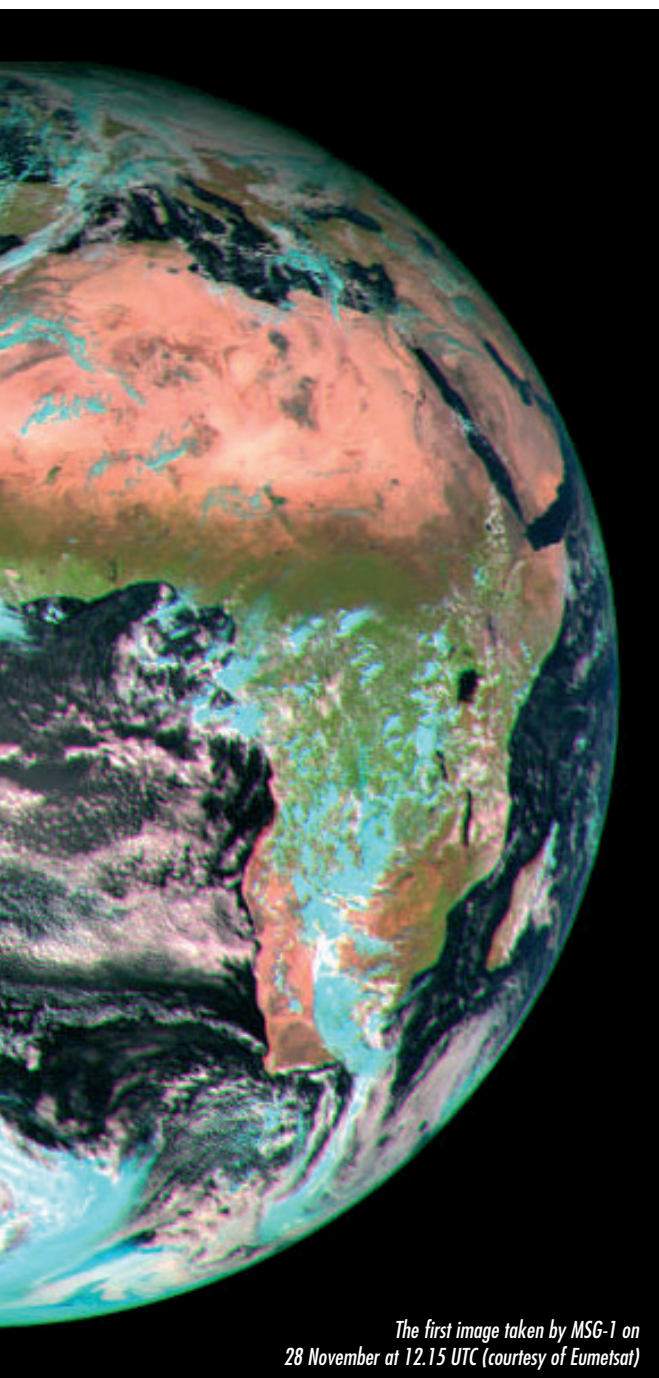
The Soil Moisture and Ocean Salinity (SMOS) is an Opportunity mission that will observe two key variables of the Earth's system, namely soil moisture over land and salinity over the oceans, to advance the development of climatology, meteorology and hydrological models. It will also provide new insight into snow and ice structure, thereby helping to advance our understanding of the cryosphere.

SMOS re-uses the generic Proteus platform developed by CNES, accommodating an innovative instrument designed as a two-dimensional interferometer acquiring brightness temperatures at L-band (1.4 GHz). The promising results of Demonstrator Pilot Projects, funded by the ESA Technology Research Programme and led by EADS-CASA (Spain), to consolidate this novel instrument technology enabled the SMOS project to enter its main design and development phase (Phase-B) in November.



Preparation of Future Missions

In 2002, preparatory activities included the evaluation of candidate future Explorer Opportunity missions and initiation of the corresponding Phase-A activities, together with pre-development of three instruments and the preparation of Phase-A activities for Core missions.



The first image taken by MSG-1 on 28 November at 12.15 UTC (courtesy of Eumetsat)

Core Missions

Phase-A studies were started for three candidate missions: EarthCARE, SPECTRA and WALES. Scientific Mission Advisory Groups were set-up, Phase-A system studies were contracted to industry, and the other necessary scientific and technical support activities were initiated.

Opportunity Missions

Twenty-five proposals were received and these proposals, backed by dozens of scientists from all of ESA's Member States and other countries, embraced all of the themes of the Agency's Living Planet Programme. They also showed the wide interest of the Earth Sciences community in the programme. Small satellites in constellations and formations were also proposed. After careful scientific, technical and programmatic evaluation, the Earth-Observation Programme Board (PB-EO) approved the Executive's proposal to start Phase-A studies for ACE+, EGPM and SWARM. Scientific Mission Advisory Groups have been set-up and the Phase-A system studies and other scientific and technical support activities will be started in 2003.

Interactions continued during the year with the Canadian Space Agency (CSA) and NASDA regarding the implementation of the SWIFT payload on the Japanese GOSAT mission (formerly GCOM-A1). The SWIFT instrument will measure winds in the stratosphere, which is important to understand stratospheric transport mechanisms and interactions between the stratosphere and troposphere.

Instrument Pre-development

The Atmospheric Laser Doppler Instrument (ALADIN) is an incoherent Doppler wind lidar for measuring tropospheric wind profiles by detecting the Doppler shift of ultra-violet laser pulses backscattered by atmospheric aerosols and molecules. The pre-development programme consists of two parallel breadboarding activities for the laser transmitter, the manufacture and testing of a complete pre-development model of the instrument's receiver, and various supporting studies, including early assessment of the lifetimes of laser pump diodes.

The Airborne Prism Experiment (APEX) is an airborne hyperspectral imager, developed jointly through the PRODEX and EOEP programmes. Intended to be available for flight campaigns in 2005, this pushbroom instrument uses specially developed components, including an advanced HgCdTe hybrid detector array, and will support future satellite missions such as SPECTRA.



The MetOp-1 payload module at ESTEC for testing

The L-band SAR pre-development programme is intended to demonstrate the performance of the TerraSAR L-band synthetic aperture radar antenna, which features seven transmit/receive modules. The effort combines contributions from the EOEP, TRP and GSTP programmes.

Earth Watch activities

Following MSG-1's launch, mentioned above, the second Meteosat Second Generation flight unit, MSG-2, was taken out of storage in September and its spacecraft environmental acceptance tests were successfully completed in December. The MSG-3 subsystems and the MSG-1 engineering model remain in storage. In parallel with these activities, the final negotiations with industry for the procurement of a fourth flight unit (MSG-4) were initiated.

MetOp

Launch: mid-2005 (MetOp-1)

The MetOp-1 payload module, the first flight model, was integrated and successfully completed its thermal-balance/thermal-vacuum testing in ESTEC's Large Space Simulator. Electrical, radio-frequency, electromagnetic-compatibility and various other functional and performance-related tests have confirmed almost all other aspects of the design. Similar progress has been made for service module, but with the thermal-vacuum testing taking place at the Intespace facilities in Toulouse (F).

The first flight models of the GOME-2 and ASCAT instruments and the engineering model of GRAS have successfully participated in the payload module testing. The US-provided instruments – AVHRR, HIRS, AMSU, SEM and SARR – and the Eumetsat-developed MHS also

participated in these tests. Progress was also made with the IASI instrument's delayed development, which achieved Critical Design Review status in mid-year. Problems with its detectors will require further work-arounds, but should not impact the launch schedule. The first flight model of the GRAS instrument is now in its acceptance review cycle.

The Eumetsat-developed ground-segment is also making good progress, and ESA and Eumetsat are working on a joint Research Announcement of Opportunity for the scientific exploitation of MetOp/EPs data.

InfoTerra/TerraSAR and Fuegosat

The consolidation phases for the InfoTerra/TerraSAR and the Fuegosat Earth Watch elements, approved at the Ministerial Council in Edinburgh in November 2001, were started.

The InfoTerra/TerraSAR programme was originally conceived to provide services for institutional and commercial users wishing to exploit data acquired simultaneously from two satellites flying in tandem – TerraSAR-L and TerraSAR-X. Owing to the early implementation of TerraSAR-X by Germany as a national programme, the consolidation phase will now address the mission architecture of the L-band component, as well as alternative joint exploitation scenarios.

Fuegosat is a demonstrator mission for a future Fuego constellation, aimed at providing early forest-fire warning and monitoring in the Mediterranean region and at similar latitudes across the rest of the world. The initial consolidation-phase actions are to refine the mission and system concepts and learn from the precursor German BIRD mission.

Exploitation, Applications Development and International Cooperation

Applications Development follows a logical path, commencing with *scientific activities*, which lead to the *Data User Programme*, which acts as an incubator for the concepts being developed. The final steps in the maturation process are the *Market Development* activities and the *GMES Service Elements*.

As part of the support to science issues, every effort is made to ensure easy data access for

the research and development investigators and for the various teams responding to Announcements of Opportunity. At the end of 2002, some 800 Envisat projects were about to start, covering such diverse topics as atmospheric chemistry, hazards, topographic mapping, sea-ice monitoring and renewable resources. Much effort is also expended in developing sophisticated algorithms and products that will be useful during the subsequent steps (DUP, MD and GSE).

Data User Programme (DUP)

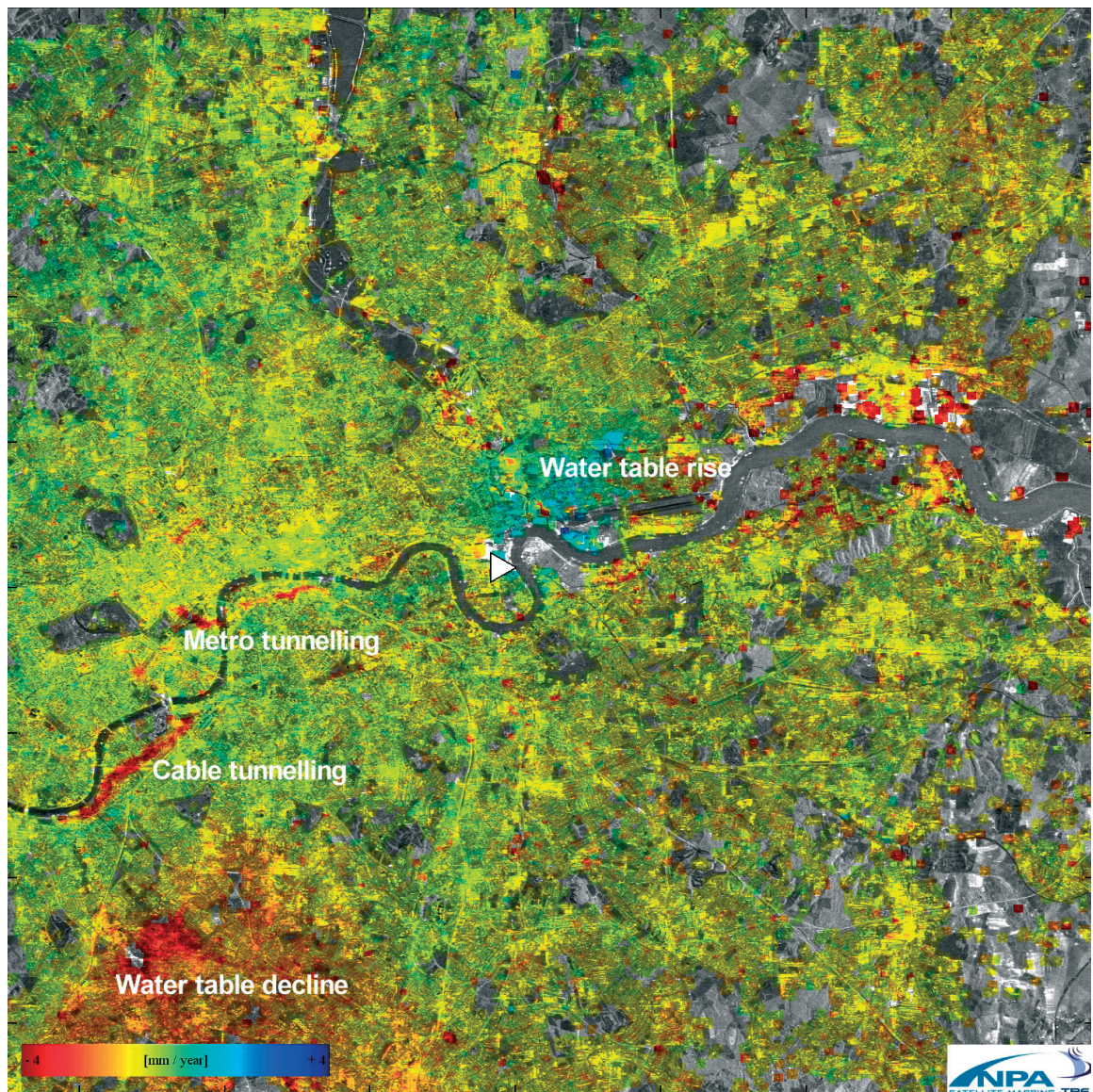
Thus, the objective of the Data User Programme is to bridge the gap between EO research at the level of pilot projects and the sustainable service provision of EO products as useful information, as opposed to mere data.

Dialogue with end-user organisations through Europe has been given a high priority to increase awareness of the practical benefits that operational Earth observation can bring to both the governmental and non-governmental sectors in the Member States and developing countries. New information service developments were started under the DUP in response to clearly prioritised needs – and with active support – from key user bodies. These services include landslide monitoring, forest monitoring for the Kyoto Protocol, and habitat monitoring for threatened species. User bodies include Secretariats and National Points of Contact for international environmental treaties, as well as environmental and planning agencies from ESA's Member States.

A typical DUP activity is the joint ESA/UNESCO project to provide EO imaging and products to conservation groups and authorities that are monitoring and protecting the habitats of mountain gorillas in national parks located in Uganda, Rwanda and Congo. Other typical projects are the modelling of emission from vegetation fires by producing an inventory of trace gases and fire burn scar detection in the Kruger national park in South Africa.

Market Development

Practical achievements resulting from the first EOEP-1 Market Development actions have included a number of follow-on service contracts with commercial clients and the creation of new joint ventures between small



Map of subsidence in central London derived from ERS satellite data. The image shows the annual deformation rate of 'individual permanent scatterers' (Copyright: NPA 2002 – image produced under licence to Tele-Rilevamento Europa – PS technique patented by POLIMI)

EO value-adding companies and large information service providers. New activities were started to integrate specialist services exploiting Envisat from the EO value-adding sector with regional or global geo-information providers. The services ready for market development include marine monitoring and forecasting, digital cartography, large-area bathymetry, and oil-spill and ship detection. Geo-information providers include oceanographic service companies for the offshore industry, the European aviation industry and European government authorities involved in maritime monitoring. Last but not least, a major review of the present state of the EO value-adding sector was initiated in order to orient ESA's future EO exploitation

programmes for maximum effectiveness in this critical sector.

GMES

The first year of the Earthwatch GMES Services Element was characterised by active communications with European end-user bodies, and by strengthened cooperation between ESA and the European Commission. The GMES Steering Committee, jointly chaired by ESA and the EC, and the first GMES Forum, held in Brussels in July, provided valuable guidance to both the ESA and EC GMES programmes.

The first ESA GMES Invitation to Tender (ITT), aiming to deliver cost-effective information

services in response to European policy needs, drew a very large response from end-users, industry and research communities alike. The resulting contracts will start in early 2003. These and other GMES Activities in 2003 will contribute to the joint ESA-EC report being prepared for end-2003.

In addition, efforts are being made to ensure the availability of data from non-ESA missions for European scientists, under the Earthnet and ALOS programmes.

Earthnet

In 2002 several new Earth-observation satellites were successfully launched by third parties – AQUA by NASA, NOAA-17 by NOAA, and ADEOS-II by NASDA. They are among the missions short-listed by the PB-EO to be handled by Earthnet. Operations have already been started for the first two missions and activities have also been initiated to support enhanced user access to data from ESA's Proba mission.

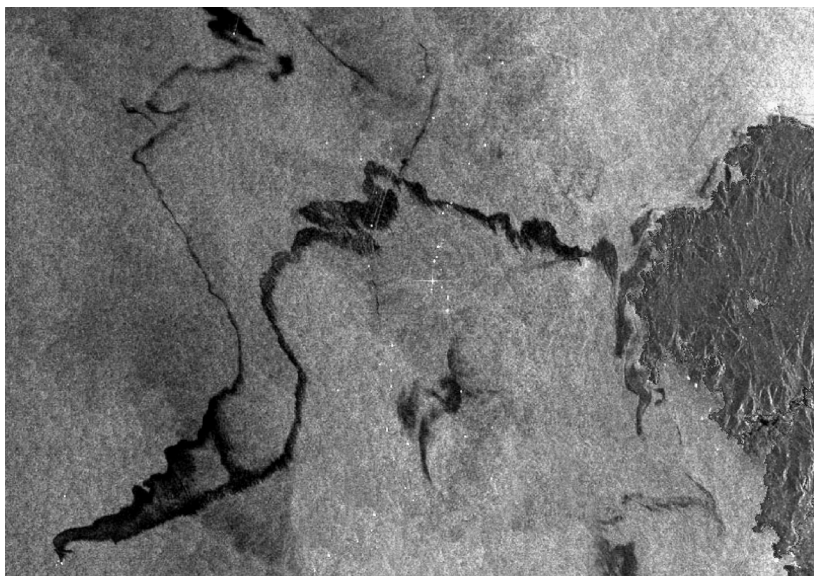
Work on the preservation of historical data has progressed satisfactorily, with most of the Landsat, JERS and AVHRR data copied onto sustainable media. It is being complemented by technological developments to ease the future transcription of Earth-observation datasets (from ESA and Third Party missions) onto the most advanced media available.

Advanced Land Observation Satellite (ALOS)

After an open competitive-tender action, the ADEN Payload Data Segment Development Contract was awarded in July to Vega (UK). Development is proceeding as planned and should lead to acceptance of the complete reference platform at the end of 2003. The ALOS launch is scheduled for mid-2004. In cooperation with CNES and NASDA, considerable effort has been devoted to supporting a simulation of the complete mission. The anticipated user requirements are based on SPOT-5 and Envisat experience.

Space for Sustainable Development

The 16th CEOS Plenary held at ESRIN (I) in November concluded a busy, but very successful year for ESA's Chairmanship of the Committee on Earth Observing Satellites (CEOS). One of the highlights was the adoption and launch of a WSSD Follow-up



Programme by the international space community, which reflects ESA's strong efforts at the Summit.

CEOS was accredited as an intergovernmental organisation through ESA, who attended the WSSD as a formal observer and participated in the negotiation of the final documents adopted by Heads of State. José Achache, ESA's Director of Earth Observation, addressed the Summit's Plenary Session and presented an official statement highlighting the role of space observations as part of an integrated global observing system. The ESA effort invested at the WSSD has paid off in that the Summit's 54-page Plan of Implementation contains 12 specific references to Earth observation, clearly demonstrating that the Summit recognised the importance of space technology for sustainable development. This outcome is a substantial improvement compared to the Rio 1992 Agenda 21, where the need for global observations is barely visible.

To turn words into action, ESA has launched the 'TIGER Project' as its contribution to the WSSD Follow-up Programme. This project aims to provide Earth-observation data from Envisat and other ESA missions to assist in integrated water resources management, primarily in Africa, focussing in particular on aquifer monitoring, wetlands mapping and vegetation monitoring for food security. Efforts are being made to develop a sustainable dimension for the project by involving partners with a long-term strategic

An image taken by Envisat's ASAR instrument in November showing the extent of the oil spill off the Iberian peninsula from the stricken tanker 'Prestige'

interest in this domain. In this context, contacts are made with the World Bank, the African Development Bank, and the European Commission. UNESCO has joined the TIGER project by contributing its field network of hydrologists within the framework of the International Hydrology Programme (IHP).

A high-level ESA team visited China in October and it was agreed to set-up a substantial cooperation in the field of remote sensing. The content and timetable for the

project are currently being decided upon, but it is likely to include arrangements for two scientists from the Chinese Academy of forestry to gain experience at ESRIN by working on Envisat data.

The International Charter for Space and Natural Disasters has already been activated 12 times. In this context, ESA provided major support to Portuguese, Spanish and French civil security authorities for the management of the Portuguese oil spill.