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STATUS OF THE ESA EARTH OBSERVATION MISSIONS

CGMS is informed of the status of the European Space Agency Earth Observation missions. Two of them, MSG and Metop are in co-operation with EUMETSAT. The second ERS satellite, launched in 1995, is currently in operation. Envisat is ready for launch. The Earth Explorer and Earth Watch missions are undertaken under the so-called Envelope Program, a rolling program designed to underpin European efforts in EO from space. For the full implementation of Earth Watch missions a new Earth Watch programme has been proposed.

STATUS OF THE ESA EARTH OBSERVATION MISSIONS

1. - INTRODUCTION

The recently created Earth and Environment Monitoring Directorate of the European Space Agency (ESA) is currently running a number of Earth Observation (EO) programmes. Two of these, MSG and Metop are in co-operation with EUMETSAT. The second ERS satellite, launched in 1995, is currently in operation. The Envisat satellite, which mission objectives and system description were presented at XXVII CGMS in ESA's Working Paper 01, is ready for launch. The research oriented Earth Explorer and the initial phases of the operational service oriented Earth Watch missions are undertaken under the so-called Earth Observation Envelope Program, a rolling program designed to underpin European efforts in EO from space. For the full implementation of Earth Watch missions a new Earth Watch programme has been proposed.

2. - STATUS OF THE ERS MISSIONS

The ERS-1 spacecraft, which ceased its operations in March 2000, is regularly tracked to predict and avoid possible interference with the orbits of other missions. All services are provided by ERS-2, which remains operational. All LBR instruments are operated on a global basis (Wind and SAR can not be operated in parallel), SAR in response to user requests with an average duty cycle of some 10 minutes per orbit. All LBR and SAR data with the exception of WSC data are distributed nominally.

The Platform, Payload and the Instrument Data Handling and Transmission (IDHT) system have been working nominally and no anomaly was observed. Special effort has been dedicated to recover the attitude stability, assuring the quality of the data products, somewhat degraded since January 2001, following problems on the Gyroscopes. The Attitude and Orbit Control System (AOCS) was operating in Extra Back-up Mode (EBM) until the beginning of June, when the Zero Gyro Mode (ZGM) was loaded and activated on-board ERS-2. The commissioning of the ZGM lasted until end July. During this month the pointing performances of the satellite have been analyzed and the results are exceeding the objectives.

Further improvements for the yaw pointing accuracy are being made until end of September. The ZGM operations are very promising for further long operational lifetime of the spacecraft.

3. - STATUS OF THE ENVISAT PROGRAM

3.1- Satellite

The satellite programme continued on the schedule. All three air shipments to French Guyana went according to plan. The satellite is assembled and functional in the clean room in Kourou. The first phase of the launch campaign was completed by mid-July 2001. The Final Mission Analysis Review with the launcher authority was successfully completed in mid-June.

Two presentations on the qualification status of Ariane 5 for Sun Synchronous Orbits confirmed that all new hardware developments are qualified and that no structural modification of the Vehicle Equipment Bay is required. For the guidance software, the piloting laws are now stable for the ENVISAT orbit, the remaining simulation still having to be performed on the launcher validation facility.

While all work was organised for the October 2001 launch slot, the recent Ariane 5 upper stage failure, 12 July for the launch of ARTEMIS and BSAT, put into question the ENVISAT launch date. The Inquiry Board delivered its final conclusions and recommendations 1 August 2001.

On this basis, Arianspace established a workplan with the launcher industrial prime, EADS, and steps have already been taken by EADS to prepare immediately for the required tests. Accordingly, Arianespace plans to perform its next Ariane 5 launch end November 2001, with ENVISAT on board. The ENVISAT launch campaign should therefore resume early October (7 weeks before launch).

3.2- Ground Segment and Operations

The Delta Ground Segment Readiness Review is planned for mid September 2001. The objective is to verify that all GSRR actions have been completed and that the remaining activities are precisely defined and planned commensurate with the time available until launch.

3.3- ENVISAT Calibration and Validation (CAL/VAL)

The composition of the various Calibration and Validation teams has now reached a stable configuration. The requirements in terms of data circulation in support of the Cal/Val during the Commissioning Phase and until Launch +9 months have been firmly established.

A second rehearsal test with more than 160 cal/val team members was held 25/29 June 2001. The real platform was used; the archive was populated with simulated products.

A workshop on the Atmospheric Chemistry Validation of ENVISAT was held at ESTEC 16/18 May 2001. More than 120 participants attended. The workshop allowed each of the PIs participating to the Validation of the ENVISAT Atmospheric Chemistry products to present their plan of activity, to know what their colleagues are planning to do, to discuss methodologies and interfacing, and to exchange opinions among them.

A workshop on ENVISAT Near Real Time products for Meteorology applications was held at ESRIN (Frascati, I) on 5 July 2001. Over 40 participants attended a very lively meeting.

3.4- PI Interface Status

The 673 ENVISAT AO projects accepted some 3 years ago have been reviewed. The ENVISAT AO PIs are currently being contacted in order to inform them about the status of the mission and on their assigned quota.

The ENVISAT AO projects have been classified and grouped in order to define clusters of projects (and consequently community of users) dealing with the same application-type, sensors/products, techniques or study-areas.

In some cases (AO ENVISAT projects already started with ERS data), the interaction between PIs and correspondents already resulted in the submission of progress reports to the Agency (via the AO website).

4. - STATUS OF THE EARTH EXPLORER MISSION

4.1 – Scope of the Earth Explorers

The Earth Explorers are research oriented space missions tackling critical Earth science issues. There are two types of such missions, subject to different financial limits and programmatic functions i.e.

- *Opportunity* Missions designed to be a fast and flexible response to a single critical scientific issue and subject to strong financial (<110 MEURO) and development constraints (30 months for phase C/D).
- *Core* Missions, < 400 MEuro, more complex and larger in scope missions, which must tackle a range of fundamental problems of wide community interest whilst remaining well focused. It must be supported by a wide (international) community of scientists.

The financial limits only relate to the ESA contribution, but the Earth Observation Envelope Program is designed to encourage international co-operation. In the context of international co-operation, a core mission would be expected normally to be led by ESA, but can include important contribution from partner Agencies.

In the past years, four missions have been selected for implementation, namely two *Core* missions:

GOCE (Gravity and steady-state Ocean Circulation Explorer)
ADM-Aeolus (Atmospheric Dynamics Mission)

and two *Opportunity* Missions, out of 27 proposals:

- Cryosat (Polar Ice Monitoring)
- SMOS (Soil Moisture and Ocean Salinity)

A third mission ACE (Atmospheric Climate Experiment), consisting of a constellation of micro-satellites with GNSS atmospheric sounding receivers, is maintained as a hot stand-by mission to replace either of the above if unforeseen problems were encountered.

4.2- GOCE

The aim of the GOCE mission is to provide global and regional models for the Earth's gravity field and for the geoid, its reference equipotential surface, with high spatial resolution and accuracy. Such models will be used in a wide range of research and application areas,

including global ocean circulation, physics of the interior of the Earth and leveling systems based on GPS.

The mission responds to the requirements put forward by many international scientific programs such as the WOCE, CLIVAR and GOOS. It is designed for the determination of an accurate description of the ocean dynamic topography and, thereby, the mean ocean circulation, as an essential complement to the precise monitoring of ocean temporal variability already provided by altimetry.

The gravity vector cannot be measured directly in orbit, but can be inferred from other observations. The GOCE carries a gravity gradiometer that measures gravity gradients and GNSS (Global Navigation Satellite Systems) receivers for precise satellite position.

4.2.1- GOCE project status

Phase B of GOCE Space Segment has reached its mid point. The status of the consolidation activities has been assessed during a Preliminary Baseline Meeting (PBM) which took place mid of June 2001. Presently, there are two satellite configurations maintained in parallel based on two different micro-propulsion technologies.

Concerning the build up of the industrial consortium, the prime Alenia Spazio has completed the negotiations with the contractors, which have to provide support to the system level activities. A crucial decision to be taken during the coming period will be the one related to the micro-propulsion thrusters.

4.2.2- GOCE science

The Project Scientist organised the first International GOCE User Workshop at the European Space Technological Centre (ESTEC, Noordwijk-NL) see:

http://www.estec.esa.nl/conferences/01C08

to report on Level 2 data processing plans and to promote higher-level data product activities. Over 80 scientists attended from a large number of countries in western and Eastern Europe. The scientific manuscripts presented at the Workshop will be collected in a Workshop Proceedings (WPP) to appear later this year.

The launch is foreseen mid October 2005.

4.3- ADM-Aeolus

The scope of the Atmospheric Dynamics Mission, Aeolus, is to demonstrate the possibility of providing observations of winds at arbitrary altitudes in clear air. This will help to correct a major deficiency in the current (meteorological) operational observing network. The data will be assimilated into Numerical Weather Prediction models. The mission will also provide data needed to address some of the key concerns of the World Climate Research Programme i.e. quantification of climate variability, validation and improvement of climate models and process studies relevant to climate change. The data will help as well to accomplish some of

the objectives of the Global Climate Observing System, by contributing directly to the study of the Earth's global energy budget by measuring wind fields globally in clear air. It will further provide information for the study of the global circulation and relate features such as precipitation systems, the El Niño and the SO phenomena and stratospheric/tropospheric exchange.

The main space element of the ADM is the ALADIN instrument i.e. a Doppler wind Lidar intended to provide profiles of the tropospheric wind above or in absence of thick cloud.

4.3.1- ALADIN activities

Pre-development activities are ongoing for the ALADIN lidar instrument. The two parallel design studies led by Alcatel Space Industries and Astrium SAS have been concluded in April 2001.

Proposals for a pre-development model have been received on 21 June and evaluated. Work will start in September 2001. Endurance tests of pump diode laser stacks, indispensable to evaluate key reliability issues of the transmitter laser, have started. Reviews are planned for September-November 2001. A science study on wind dynamics has been completed and two new science studies on error correlation and data assimilation have been kicked-off.

Several studies on signal processing, the impact of backscatter fluctuations on meteorological situations, sampling of cloudy scenes using Lidar Technology Experiments LITE observations, error correlation and wind profile statistics are on-going. Another study addressing the assimilation of Aeolus observations is in preparation.

At the end of April the ADM-Aeolus mission was presented to the workshop on long-term future of the basic sounding and imaging missions which was held in Geneva, Switzerland at the World Meteorological Organization (WMO). This was part of a meeting of the WMO Expert Team on Observational Data Requirements and Redesign of the Global Observing System (ET-ODRRGOS). ADM-Aeolus was one of the candidates that could become a core element of the new system.

4.3.2 Aeolus Procurement Activities

A Phase A study for the Aeolus mission was completed in February 2000. The study concluded that there were no problems of technological principle for the mission, apart from issues associated with the ALADIN instrument, where work is underway.

The nucleus of a project team has been set up at ESTEC in the first half of 2001. This team has produced and issued the Invitation to Tender for the satellite (including instrument) and for a ground processor to produce Level 1b products. The ITT also covers some elements intended to be built into an Airborne ALADIN demonstrator. The ITT covers all stages of the procurement including Phases B/C/D and E1.

Proposals against the ITT are expected in November of this year. Contract award is expected in April 2002. Launch is planned for mid 2007.

4.4- CRYOSAT

The goals of CRYOSAT are to measure fluctuations in marine and land ice mass fluxes within the limit set by natural variability. Predicting future climate and sea level depends on knowledge of such fluctuations, while present observations are deficient in time and space. CRYOSAT and International Programs will provide a decade of focussed study of the roles of the cryosphere.

The technical concept consists of a single spacecraft in a high inclination (92 degree) orbit, carrying a Ku-band altimeter, measuring altitude with detailed precision, capable of operating in conventional pulse limited mode, synthetic aperture mode and interferometric mode.

4.4.1 Project status

After the successful completion of the Phase A/B performed under severe time constraints (one year in total), the major recent achievement was the approval by the Earth Observation Programme Board (PB-EO) of the full implementation of the CryoSat programme covering the usual Phase C/D/E1 phases and an exploitation during 3 years in orbit.

For the satellite development, the Prime Contractor (Astrium GmbH) is now concentrating his activities in the consolidation of the detailed design of the CryoSat satellite, taking into account the inputs resulting from the selection of the industrial partners and the recommendations issued by the System Design Review (SDR) Board. A Design Consolidation Meeting (DCM) scheduled in September 2001 is the next milestone which will authorize the Prime Contractor to proceed with the core of the Phase C/D activities.

The development of the Ground Segment has also been initiated: European Space Operations Centre (ESOC, in Darmstadt-D) has established the requirement for the development of the Flight Operation Segment (FOS). Concerning the Payload Data Segment (PDS), the Invitation to Tender was issued in July 2001. The requirements applicable to the whole CryoSat Ground Segment will undergo a detailed review end October 2001.

After a technical audit conducted in spring 2001 in Russia, it is foreseen to issue the Invitation to Tender for the CryoSat launcher mid-October 2001.

Due to the necessary consolidation exercise needed prior releasing the core of the Phase C/D activities, the CryoSat launch is now re-scheduled mid April 2004.

4.4.2 CRYOSAT Calibration and validation activities (CAL/VAL)

The CryoSat Scientific Advisory Group (CSAG) has met at regular intervals and progress has been achieved on the Calibration and Validation document. This will be the base for the Cal/Val Announcement of Opportunity. A new CryoSat Web Site is presently under development to facilitate the release of this Announcement of Opportunity late September 2001.

In this perspective, CryoSat will take benefit of a joint ESA/NASA flight campaign during which simultaneous laser and radar altimeter measurements will be made over the Greenland ice sheet. Preparations are underway to run this campaign in 2002.

4.5- SMOS

In spite of the fact that both Soil Moisture (SM) and Sea Surface Salinity (SSS) are used in predictive atmospheric, oceanographic, and hydrologic models, to date, no capability exists to measure directly and globally these key variables. The main objective of SMOS is to deliver a crucial variable of the land surface: SM as well as SSS fields.

Over land, water and energy fluxes at the surface/atmosphere interface are strongly dependent upon Soil Moisture (SM). Evaporation, infiltration and runoff are driven by SM while soil moisture in the vadose zone governs the rate of water uptake by vegetation. Soil moisture is thus a key variable in the hydrologic cycle. For the oceans, Sea Surface Salinity (SSS) plays an important role in the northern Atlantic sub polar area where intrusions with a low salinity influence the deep thermohaline circulation and the meridional heat transport. Variations in salinity also influence the oceans near surface dynamics in the tropics where rainfall modifies the buoyancy of the surface layer and the tropical ocean-atmosphere heat fluxes. SSS fields and their seasonal and interannual variabilities are thus tracers and constraints on the water cycle and on the coupled ocean-atmosphere models.

Low frequency microwave measurements (around 1 GHz) offer a unique means to achieve such goals. At such wavelengths, the measured signal is directly related to the brightness temperature of the surface (negligible atmospheric contribution), which in turn, through the emissivity, is directly linked to the dielectric constants of the target (i.e., moisture or salinity). Actually, the sensitivity of brightness temperature to soil moisture and salinity is optimum in the L band (1.4 GHz). The mission should also deliver information on surface temperature, vegetation and biomass through the multi-angle dual polarisation observations.

The launch is foreseen for 2006.

4.5.1 Project status

At the Preliminary Concept Review held end of March 2001 the baseline configuration was selected. The L-band radiometer concept consists of three arms with three segments each on which the antenna elements are distributed. Aperture synthesis is used to increase resolution. In the proposed concept the instrument is mounted on a Proteus bus. Phase is continuing with the detailed definition of the selected baseline.

4.5.2 SMOS Science

Several scientific studies are ongoing to refine the mission and the derived observation requirements and to support system trade-off by establishing the performance of the various system options and the impact on the relevant research areas. Data retrieval algorithms and processing strategies are being developed.

A study to develop algorithms to retrieve salinity from the measured brightness temperatures, and to evaluate realistic performance targets (i.e. accuracy of retrievals) for SMOS independent of the influence of Faraday rotation effects started in July 2001.

Campaigns are ongoing to validate the observation technique and the retrieval of soil moisture and sea-surface salinity.

4.6- Next Explorer Core missions

A new call of ideas for the new cycle of *Core* Missions was issued in June 2000, with deadline 1st September 2000, for scientists in the ESA Member States and Canada. The research themes were:

Theme 1: Earth Interior
Theme 2: Physical Climate
Theme 3: Geosphere/Biosphere
Theme 4: Atmosphere and Marine Environment

The general selection procedures, including a public consultation workshop (Granada III at end of October 2001) will identify up to three missions to go into phase A study. A final selection of an ordered pair for implementation is expected in 2003, with launches in 2008 and 2010.

Five missions are currently subject to pre-Phase A study:

- ACECHEM, Atmospheric Composition Explorer for Chemistry and Climate; a satellite carrying limb sounder operating in the mm-wave range and in the medium infrared , flying in formation with MetOp for synergetic exploitation of the observation of the nadir-looking instruments of MetOp (AVHRR, IASI and GOME-2).

- EarthCARE, to study clouds, aerosols and radiation by a combination of active (radar and lidar) and passive instruments (multi-spectral imager, broadband radiometer and infrared Fourier transform spectrometer).

- SPECTRA, Surface Processes and Ecosystems Changes through response analysis, based on a payload including hyperspectral sensor operating in the VNIR and SWIR and including thermal channels, to study the carbon, water and energy cycles.

- WALES, Water Vapour Lidar Experiment in Space, to provide accurate vertical profiles of water vapour concentration with high resolution by means of a differential absorption lidar.

- WATS – Water Vapour and Temperature in the Troposphere and Stratosphere- to provide accurate dense, stable mapping of atmospheric humidity by means of a constellation of micro-satellites that exploit GNSS occultation signals and occultation of signals in X- and Ka band between the micro-satellites.

4.7- Next Explorer Opportunity missions

The call for ideas for the second cycle of Earth Explorer *Opportunity* Missions has been released in early June 2001.These are intended to be very cost effective missions, implemented over short time scales, possibly exploiting new approaches to development and opportunities for international co-operation. This call will result in the pre-selection of up to six candidates Earth Explorer *Opportunity* Missions for feasibility and concept study. This pre-selection will be in order of priority.

The first three of these missions will be the subject of feasibility studies (i.e. Phase A). Following completion of these studies, the priority order will be revised (if necessary) on the basis of the technical and programmatic status of each mission. The first two missions (in order of priority) will be selected for full development and launch.

The first mission is intended for immediate implementation and launch in 2007. The second mission will be selected for preparation for later implementation and launch in 2009 though the frequency of launches will, to a certain extent, be a function of complexity and cost. A third mission will be maintained in reserve in case one of the two selected missions fails to meet financial or technical constraints.

Deadline for receipt of outline proposals is 1st October. Announcement of results of evaluation will be 31 May 2002.

5. - EARTH WATCH

A programme has been proposed to the ESA Council at ministerial level planned in November 2001. Central to the definition of Earth Watch missions are the interest of Eumetsat and the initiative for Global Monitoring for Environment and Security (GMES) which is at the heart of the European Strategy for Space defined with the European Commission. Earth Watch missions also target areas of high commercial value in what is expected to be a developing market for Earth Observation products and services.

5.1- Operational Meteorology and Climate Monitoring

Preliminary architecture studies of post-EPS systems will start soon following the results of discussions with EUMETSAT.

5.2- Global Monitoring Missions

Initiation of phase A studies for the Ocean Earth Watch was approved in May 2001.

5.3- Advance Imaging Missions

The missions candidate to start in 2002 address application areas of high strategic and economic value: agriculture, forestry, risk management, environment monitoring, cartography, utilities, telecommunications and planning, marine and coastal, security, etc. using a variety of radar (in L- C- and X-band) and optical (multi- super- and hyper- spectral systems) techniques. These missions are based on national initiatives e.g. Radarsat, COSMO, and industrial initiatives, e.g. InfoTerra/TerraSAR and FuegoSAT.

6. - REFERENCES

Further information about the ENVISAT and Earth Explorers missions can be found on the following WWW addresses which offers the possibility to download many supporting relevant documentation:

http://www.esa.int
http://envisat.esa.int
http://www.estec.esa.nl/explorer/

The special ESA Bulletin, June issue, dedicated to ENVISAT, has been released.