

STATUS OF THE FUTURE ESA EARTH OBSERVATION MISSIONS

CGMS is informed of the status of the future European Space Agency Earth Observation missions. Two of them, MSG and Metop are in co-operation with EUMETSAT. The Living Planet Program has three lines of implementation: Earth Explorer satellites, Earth Watch satellites plus services & applications demonstration.

The 7th Core Explorer is under selection. The first Explorer launch is now foreseen in October 2008.

The Earth Watch includes since January 2002 the Global Monitoring for Environment and Security (GMES) services element.

The ESA GMES space component programme Phase 1 is well advanced. Five families of Sentinels are planned. The Sentinel-1 development phase was kicked off in April 2007. The Sentinels 2 and 3 were kicked in spring 2008.

STATUS OF THE FUTURE ESA EARTH OBSERVATION MISSIONS

1 INTRODUCTION

The Earth Observation Directorate of the European Space Agency (ESA) is currently running several programmes. Two of these, MSG and Metop are in co-operation with EUMETSAT. The Living Planet Program has three lines of implementation: Earth Explorer satellites, Earth Watch satellites plus services & applications demonstration. After failure of the launcher, Cryosat-2 recovery mission is planned for 2009. The Earth Watch includes since January 2002 the Global Monitoring for Environment and Security (GMES) Services Element. The GMES Space Component Programme Phase 1 has initiated, after approval at the Ministerial Conference in December 2005; Phase 2 is being presented for approval to the next Ministerial in November 2008. A new batch of Explorers is under assessment.

2 STATUS OF THE EARTH EXPLORER MISSIONS

2.1 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 programmatic functions i.e.

Core Missions, are ESA-led and dedicated to long term research objectives. They are complex and large 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.

Opportunity Missions are smaller-scale projects, not necessarily led by ESA. They are designed to be a fast and flexible response to a single critical scientific issue and subject to strong financial and development constraints.

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, a number of missions have been selected for implementation, and are well advanced: namely three *Core* missions:

GOCE (Gravity and steady-state Ocean Circulation Explorer)
ADM-Aeolus (Atmospheric Dynamics Mission)
EarthCARE (clouds, aerosols and radiation)

and three *Opportunity* Missions:

Cryosat (Polar Ice Monitoring)
SMOS (Soil Moisture and Ocean Salinity)
Swarm (The Earth's magnetic field and environment explorers)

2.2 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.

2.2.1- GOCE project status

The development of the GOCE mission is completed, for both the space segment and the ground segment. The satellite proto-flight model is presently at Plesetsk Cosmodrome, where it has been declared launch-ready. Technical issues with the upper stage of the launch vehicle have however prevented the launch from taking place, and awaiting the resolution of these issues the foreseen launch date is the end of October 2008.

The ground segment has successfully passed all development milestones, including the Operations Readiness Review demonstrating the flight readiness of all elements : the Flight Operations Segment, the Payload Data Ground Segment (i.e. data processing up to Level 1b), the High-Level Processing Facility (responsible for the generation of the Level 2 products), the Calibration and Monitoring Facility and the Reference Planning Facility.

2.2.2- GOCE science

Following the release of the Announcement of Opportunity for the Data Exploitation of GOCE data (L1B and L2 products) in early October 2006, 69 Principal Investigator-led project proposals from 26 countries have been accepted. Based on queries from the scientific community the expectation is that this number will grow significantly once the GOCE data are distributed.

2.3 ADM-AEOLUS

The Atmospheric Dynamics Mission ADM-Aeolus will demonstrate the possibility of providing observations of winds at altitudes between the surface and about 30 km. 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 cloud free air. It will further provide information for the study of the global circulation and more general transport properties of the troposphere and lower stratosphere. ADM-Aeolus will also deliver profiles of backscatter and extinction coefficients, which will allow to retrieve cloud and aerosol information.

The main space element of the ADM-Aeolus is the ALADIN instrument i.e. a Doppler wind Lidar intended to provide profiles of the horizontal wind in the troposphere and lower stratosphere above or in absence of thick clouds.

ADM-Aeolus data will need intensive evaluation in view of a possible operational follow-on.

2.3.1 Aeolus Project Status

The Phase C/D Contract for the Satellite was signed in 2003. The Critical Design Review was held in autumn 2005.

Most of the flight equipments have been delivered, and the satellite bus is integrated. ALADIN telescope and receiver integration and initial performance testing are completed as well.

As expected the laser is proving the greatest development challenge. The laser diodes have been successfully qualified, but confidence testing is continuing to obtain more lifetime data. The optics coating qualification is mostly completed; due to the high optical power densities, the lifetime of these coatings is particularly critical. Testing has revealed several new phenomena, which leads to redesign of some laser components. A lifetime test will be performed on the qualification laser model in 2009.

ECMWF is implementing a level 2B/C processor within the ECMWF's forecast system, with the aim to contribute to ADM cal/val during the commissioning phase and to routinely generate level 2 products.

2.3.2 Aeolus Science

Various activities in support of Aeolus science are being performed.

ECMWF (European Centre for Medium-Range Weather Forecasts) carried out a study on the “expected benefits of DWL for data assimilation”. Radiosonde/profiler denial and (simulated) Aeolus observations had been used for a 6 week period. The study extended the assimilation ensemble method to assess the impact of adding simulated Aeolus data to the 2004 Observing System. The method was calibrated by assessing the impact of radiosondes and wind-profiler data in the same way (i.e. by a data-denial ensemble). The additional benefits from the Aeolus data were mainly in the Tropics and over ocean regions in both hemispheres, e.g. the North Atlantic storm track - these are widely acknowledged as priority areas for improvement. The ensemble results were consistent with independent measures of information content.

KNMI (Royal Dutch Meteorological Institute) has assessed the added value of Aeolus data in numerical weather prediction (NWP) to enhance the predictive skill of high-impact weather systems. A new system for studying impact is tested focusing on the sensitivity observing system experiment (SOSE) concept. Three scenarios, namely ‘ADM tandem’ (two ADM satellites in similar orbits), ‘ADM dual perspective’ (two ADM satellites measuring different components) and ‘ADM smart tandem’ (two ADM satellites in different orbits), have been considered for an ADM-Aeolus follow-on mission providing different coverage.

In summer 2008, KNMI has started a study to define the preferred sampling schemes of ADM.

2.3.3 ADM-Aeolus Campaigns

An airborne version of the ALADIN wind-lidar has been made with equipment developed during the pre-development phase. This ALADIN Airborne Demonstrator (A2D) was functionally tested in flights in 2005, and has performed a first in ground-based campaign in 2006. However, the frequency stability of the transmitter laser was insufficient for extended airborne campaigns. After modifications of the laser, airborne operation was successfully tested in proving flights in early 2007, and a second ground-based campaign has been completed in summer 2007. The data have been used to validate the ADM performance models.

A first airborne campaign has been completed in spring 2008, and a second airborne campaign is prepared for Nov 2009. The data from the airborne campaigns are important for the testing and the validation of the Level 1B processor.

2.4 EarthCARE

2.4.1 Objectives

EarthCARE addresses the interaction and impact of clouds and aerosols on the Earth’s radiative budget. The difficulty of representing clouds and aerosols and their interactions with radiation constitutes a major source of uncertainty in predictions of climate change. EarthCARE will help in improving numerical models of atmospheric

circulation. Accurate representation of cloud processes is also critical for the improvement of NWP.

2.4.2 Concept

EarthCARE will be implemented in cooperation with JAXA and consists of a single satellite in low Earth sun-synchronous orbit at about 400 km altitude. The EarthCARE mission is centered on the synergetic use of the data provided by the following active and passive sensors:

Backscatter Lidar (ATLID) - ESA High Spectral Resolution Lidar

Cloud Profiling Radar (CPR) - JAXA/NICT 94GHz Doppler Radar

Multi-Spectral Imager (MSI) - ESA 7 channels, 150 km swath, 500 m pixel

Broadband Radiometer (BBR) - ESA 2 channels, 3 views (nadir, fore and aft)

2.4.3 Planning

The EarthCARE programme entered its implementation phase in February 2008 and the industrial contract has been signed in May 2008.

Phase B activities are presently ongoing with the goal of consolidating system trade-offs and configuration of spacecraft and instruments prior to the System Requirements Review scheduled for later this year.

The launch is planned for September 2013.

2.5 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 focused 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 interferometry mode.

Cryosat was the first Earth Explorer satellite to be launched, but the original Cryosat spacecraft was lost in a launch failure on 8 October 2005. Owing to the importance of Cryosat for the worldwide scientific community, a plan to recover the Cryosat mission, by building the Cryosat 2 satellite, including redundant SIRAL instrument was

developed. The launch of Cryosat 2 is planned for November 2009 on a Dnepr launch vehicle, most likely from Balkinour.

2.5.1 Project status

Following the approval ESA's Earth Observation Programme Board on 24 Feb 2006, the rebuild of the satellite is progressing according to planned schedule. The announced delay of the launch from March to November 2009 is mainly due the change of the launch vehicle. The satellite is fully integrated and will soon start the environmental tests. The second System Validation tests (SVT-2) was successfully completed. Similarly, validation tests of the ground segment are progressing according to planned schedule. The Flight Acceptance Review is expected to take place in March 2009.

2.5.2 Cal/val campaigns

The CryoVEx2008 campaign consisted in using coordinated airborne and ground activities was performed during April and May 2008. The main focus of the 2008 activities were to address remaining data gaps from CryoVEx2006 on the sea ice validation dataset through joint ground, helicopter and airborne measurements over sea ice near Alert, Canada. Additional coordinated activities took place over North Greenland and Devon Island (Canada) involving scientist mainly from Denmark, UK Germany and Canada.

The team will meet in spring 2009 to agree on findings and preliminary planning for the Commissioning phase.

2.5.4 Studies

Several scientific works on the cryosphere and related climate change issues have been published during last, year including the Report of the Intergovernmental Panel on Climate Change. The scientific community is now waiting to confirm those findings and looking forward to gaining more insight in the variation of the ice fields using Cryosat data.

2.6 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.

2.6.1 Project status

The SMOS project is conducted in cooperation between ESA, CNES and CDTI under the overall responsibility and leadership of ESA.

The Payload Module (PLM) is developed by an industrial consortium led by EADS-CASA under direct contract from ESA. The PLM development has been completed, following the integration of the Protoflight Model at EADS-CASA and its subsequent transfer to ESTEC, where the environmental test campaign was successfully completed by end June 2007. The PLM has been transferred to ALCATEL Cannes where it was merged with its dedicated recurrent PROTEUS platform.

The satellite platform and associated satellite operations ground segment are based on the existing PROTEUS bus developed by CNES and ALCATEL. The satellite AIT programme, including two System Validation Tests involving the operations ground segment, has been completed. The satellite is now in storage until final preparations for the launch campaign.

The Data Processing Ground Segment (DPGS) at ESAC (Villafranca, Spain), is under development, with an initial version already installed and tested.

All activities are being put in place, with a launch date planned in for 15 April 2009.

2.6.2 SMOS Science

A study of L-band radiometry for sea ice applications has started with the University of Bremen.

2.6.3 SMOS Campaigns

An airborne SMOS demonstrator campaign over the Gulf of Bothnia has been conducted, using the full instrument suite planned for the SMOS cal/val program, with HUT-2D, EMIRAD, PARIS-GPS and dGPS instrumentation. Data evaluation is still ongoing.

The DOMEX-2 Antarctic campaign schedule is being re-evaluated in order to maximize overlap between Concordia field radiometer measurements and the SMOS cal/val activities during commissioning.

2.7 SWARM

2.7.1 Objectives

Swarm will provide the best-ever survey of the geomagnetic field and its temporal evolution. Swarm will offer new insights into the composition and processes in the interior and surroundings of the Earth, thereby improving our knowledge of the climate. It will provide also supplementary information for studying the interaction of the magnetic field with other physical quantities present in the Earth system. Furthermore, it is also sensitive to ocean circulation. Practical applications such as space weather, radiation hazards, navigation and resource exploration could benefit from Swarm.

2.7.2 Concept

The Swarm concept consists of a constellation of three satellites in three different polar orbits between 300 and 530 km altitude. Two satellites will fly in close tandem at 480 km initial altitude and one at 530 km altitude, in orbits drifting relative to each other, thus sampling the field in varying geometries and at all local times. High-precision and high-resolution measurements of the strength and direction of the magnetic field will be provided by each satellite. In combination, they will provide the necessary observations that are required to model various sources of the geomagnetic field. GPS receivers, an accelerometer and an electric field instrument will provide supplementary information for studying the interaction of the magnetic field with other physical quantities in the Earth system, and for improving the modeling of the geomagnetic field.

2.7.3 Project status

The development of the three satellites is in progress with the delivery this year of the engineering models at unit and instrument level for the electrical verification at satellite level. The structural model of the optical bench is completed and tested. The structural model of the boom and its mechanisms is assembled and ready for the environmental test campaign. The development and manufacturing of the satellite structure is well advanced with the first panels ready for assembly. The satellite CDR is planned to start in February 2009.. Meanwhile, the development of the ground segment infrastructure has been initiated for both the data centre and the operation centre. The ground segment PDR is ongoing in this last quarter of 2008. Three launchers have been investigated for the launch of Swarm. A preliminary coupled Load analysis (CLA) demonstrated the compatibility of EUROCKOT and DNEPR with Swarm. Studies are still ongoing for VEGA. The launch is planned for the last quarter of 2010.

2.7.4 Science

Several studies are ongoing for the preparation of the level 2 processing. The first one "*The Preparation of the Swarm Level 2 Data Processing*" is a synthesis of all the previous and ongoing studies and should pave the way for the future level 2 algorithms development.

The first set of thematic studies "Comprehensive magnetic field inversion analysis for Swarm is complemented by a study about the mantle conductivity "*Mapping 3-D Mantle Conductivity from Swarm Constellation Data*". The study team presented their progress with respect to the recovery in the 1D case as well as in a full 3D retrieval. For the 1D retrieval an alternative implementation to improve the depth layering was introduced by Oleg Pankratov, which will be considered for updating the algorithms and implementation of the 1D method. First tests with a full 3D retrieval based upon the time domain approach were successful. The spectral domain for 3D retrieval needs to be adjusted accordingly. The final meeting is scheduled for 12 and 13 November 2008.

The MTR for study *Ionospheric Current Quantification and Modelling for Improved Magnetic and Electric Field Analysis for Swarm* was held in ESTEC at 3 July. The aspects of the study related to TEC, plasma bubbles and current correction estimation from single satellite approaches were discussed and reviewed. A simulated data set for each of the satellites will be provided as well based upon the existing implementation of the coupled Ionosphere-thermosphere model but tailored to CHAMP and Swarm selected cases. A comparison of the CTIP model results and the Arecibo radar was also discussed.

A midterm meeting was successfully held for the study "*Air Density Models Derived from Multi-Satellite Drag Observations*" on 2 September 2008 at ESTEC. The multi-satellite approach for accelerometer calibration with GPS was tested and compared with the single satellite approach. In addition, an evaluation of aerodynamic and radiation pressure modelling was presented. The single satellite results with real satellite data (CHAMP and GRACE) were compared with existing air density models and geophysically interpreted. The next progress meeting is scheduled to take place at the beginning of February 2009.

2.8 Earth Explorer Number 7

A call for Earth Explorer *Core* ideas was issued in 2005. The twenty-four proposals received were evaluated by scientific peer review panels and by technical and programmatic panels. The strong response to the call issued by ESA as well as the scientific excellence of all the proposals showed the growing interest in and importance of Earth observation in Europe.

After evaluation by the Earth Science Advisory Committee in 2006, ESA has initiated assessment studies for six mission concepts:

BIOMASS: aims to quantify the forest biomass, the extent of forest and deforested areas and the delimitation of flooded forests by means of P-band SAR.

TRAQ: observation of primary constituents for monitoring air quality in the troposphere.

PREMIER: to provide high resolution measurements, using mm-wave and IR limb sounding, aimed to study processes in the upper troposphere and lower stratosphere.

FLEX: to produce global scale maps of vegetation photosynthetic activity, to contribute to biosphere and global C cycle studies.

A-SCOPE: mapping the source and sink of CO₂ on a scale of 500 km or better. It will use a lidar-based sensor.

CoReH₂O: estimates of snow water equivalent and depth on land and sea ice, based on Ku- and X-band SAR observations.

The assessment studies will be completed in the second half of 2008, after which a down-selection of mission candidates to a maximum of three will take place and feasibility studies at Phase A level will be initiated. A User Consultation Meeting will be held in January 2009 in order to collect feedback from the scientific community before the down-selection is done. Phase-A studies will start around mid 2009.

3. EARTH WATCH

3.1 Initial Actions

These are the operational missions of ESA for partners. Three elements were approved in Edinburgh in 2001:

TerraSAR Consolidation, phase B and pre-development of a mission deploying a SAR operating in L-band. This activity has been completed.

Fuegosat Consolidation, born as a demonstrator of a constellation of satellites with IR sensors for (Forest) fire monitoring, it has been redirected to be come an element of the EC – ESA initiative on Global Monitoring for Environment and Security (GMES).

The GMES Service Element (GSE) is ongoing with the consolidation of a number of operational services involving more than 200 users, numerous service providers, developers and strategic partners. They address all areas of the priorities identified by the EC, in particular, ocean monitoring, land management, crisis management, and also potential new services as humanitarian aid and atmospheric composition monitoring. The GSE has been fundamental in identifying the requirements for the GMES Space Component.

3.2 Operational Meteorology and Climate Monitoring

ESA is co-operating with Eumetsat on the development/deployment of new series of meteorological satellites: MSG (Meteosat Second Generation) and MetOp. MSG-1 was launched in August 2002; MSG-2 in December 2005. MetOp-A was launched after 5 attempts on 19th October 2006.

Regarding the future generations:

Post MSG (MTG): The two Phase A industrial studies for Meteosat Third Generation will be concluded in November 2008. The reference system configuration for the space segment was decided in April 2007. The MTG space segment will consist of a twin configuration, MTG-I (Imaging mission) and MTG-S (Sounder mission). Activities are coordinated with those of GMES Sentinel-4. The target launch dates are 2015 for MTG-I and 2017 for MTG-S.

Post MetOp/EPS: Following a consolidation of the mission and programmatic requirements, two parallel phase 0 studies were kicked-off. Based on initial study results, a successful Preliminary Assessment Review (PAR), led by EUMETSAT, was held at the end of June 08. The goal of the PAR was to determine which missions, out of those identified by users with associated priorities, have the potential to be implemented within the PostEPS programmatic constraints. The next milestone is now the mid-term review, which will take place in Nov/Dec 08 and will be followed by a User Consultation at EUMETSAT, so to consolidate the observation mission and payload selection. Activities are coordinated with those of Sentinel-5. The target launch date is 2019.

3.3 GMES services element

GMES stands for the Global Monitoring for Environment and Security. GMES is a joint initiative of the European Space Agency and the European Commission to provide Europe with an independent global information system which will support Europe's policies on environment and security. GMES will be a major European contribution to GEO.

GMES has four components: a space component, an in-situ component, a data integration component, and a service component. Work to implement GMES services started as early as 2002, via the ESA GMES Service Element which was approved by ESA member states in 2001. This was complemented by several dedicated projects carried out within the European Commission Research Framework programme. To date more than 400 user organizations from 40 countries, each of whom has a legal mandate or statutory responsibility regarding specific environmental or security policies, have been receiving and evaluating GMES services. Building on this the European Commission is implementing a suite of pan-European Fast Track Services from which customised services to meet national and local needs can be derived. These address Emergency Management, Marine monitoring, Land Cover Monitoring, Atmospheric composition, and Security issues.

As a result of this broad-based, early engagement of users in GMES, as well as dedicated consultations with member states organized by the European Commission, the future long-term needs for GMES observations, including those of the space component, have been established. The requirements for the GMES space component are thus directly traceable to European policies, directives laws, and will be served by a space infrastructure that includes dedicated (Sentinel) missions as well observations from other contributing European and national missions.

4. GMES SPACE COMPONENT

GMES represents the major initiative of European efforts in Earth Observation. In order to guarantee an operational start of GMES services in 2008 and the availability of the first GMES dedicated satellites (the "Sentinels") in 2011-2012, activities are under way at all stages within the Agency, the EC and at Member States level.

The ESA programme proposal for the GMES space component encompasses the development of the Sentinels and the coordination with and access to other national and European missions, the so-called GMES "contributing missions". The ESA GMES Space Component programme activities have been initiated (Phase 1 of Segment 1) following a positive outcome of the ESA ministerial Conference in December 2005. Phase 2 has been approved in September 2007.

Five families of Sentinel missions are planned.

Sentinel-1, a C-band SAR mission to provide continuity to ERS, ENVISAT and maintain the cooperation with Radarsat

Sentinel-2, a multispectral optical imaging mission to provide continuity to the data so far obtained from SPOT and Landsat

Sentinel-3, an ocean and global land monitoring mission providing ocean colour, sea surface topography and sea and land surface temperature. It provides continuity to data as those of MERIS, RA-1 / RA-2, (A)ATSR. It will also provide continuity to the data so far provided by the Vegetation sensors on SPOT-4 and 5.

Sentinel-4, a geostationary element for monitoring of atmospheric composition

Sentinel-5, a low-Earth orbit element devoted to the monitoring of atmospheric composition

In order to fill the data gap between ENVISAT and Sentinel-5 (the latter being a dedicated payload to be embarked on post-EPS), a Sentinel-5 precursor mission is planned with a launch around 2014.

Two units of each of the Sentinel-1/-2/-3 are required to fulfil the user requirements expressed by the GMES services.

The Sentinel-1 development phase (B2/C/D/E1) has been kicked-off in April 2007. The Sentinel-2 and Sentinel-3 development phase have both been kicked-off in October 2007. The Phase A of Sentinel-4 is planned to be started by the end of 2008. The Sentinel-5 Phase A will start later, synchronised with the post-EPS schedule.

The ground segment will include the flight operation segment and the payload data ground segment. The latter will provide interface to the GMES contributing missions and ensure the required level of inter-operability between the missions. Specific activities have been initiated to prepare the provision of EO data for the EC's GMES "fast track services" on land, marine and emergency response, and the pilot service on atmosphere, which shall reach pre-operational status by end 2008.

On the EC side, GMES related funding has been approved end 2006 as part of the Space Theme of the Seventh Framework Programme (FP7). The funding covers in particular the following activities which are delegated to ESA based on specific arrangements with the EC:

- development of GMES-dedicated satellites
- coordinated provision of observation data for GMES.

The delegation agreement between the EC and ESA governing the EC funding contribution to the development of the first Sentinels has been signed in February 2008.

As part of FP7, additional funding has also been allocated to the GMES services and the in situ component, both under the responsibility of the EC.

At programmatic level, the preparation of the ESA Council at Ministerial level in November 2008, where the Segment 2 of the GMES Space Component shall be approved, is under way.

5. REFERENCES

Further information about the various ESA missions can be found on the following WWW addresses which offer the possibility to download many supporting relevant documentation:

<http://www.estec.esa.nl/explorer/>
www.esa.int/metop
www.esa.int/msg
<http://www.esa.int/esaLP/LP>