CGMS-XXXIX-ESA-WP-02
Prepared by ESA
Agenda Item: C.3
Discussed in Plenary

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, MTG and Post EPS (now EPS SG) 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.

A 7th Core Explorer is under selection out of 3 pre-selected. Progress in the preparation of the forthcoming Explorer missions ADM-AEOLUS, Swarm and EarthCARE is described.

GMES represents the major new initiative of European efforts in Earth Observation. The start of the GMES pre-operational services took place in 2008, with the provision of the relevant data. The first GMES dedicated satellites (the "Sentinels") will be launched in 2013. Related activities are under way at all stages within the Agency, the EC and at Member States level.

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, MTG and post EPS (now called EPS Second Generation in EUMETSAT documents) 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. GMES represents the major new initiative of European efforts in Earth Observation. The start of the GMES pre-operational services took place in 2008, with the provision of the relevant data. The first GMES dedicated satellites (the “Sentinels”) will be launched in 2012-2013. Related activities are under way at all stages within the Agency, the EC and at Member States level.

2. STATUS OF THE EARTH EXPLORER MISSION

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, 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. ADM-AEOLUS

The Atmospheric Dynamics Mission 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, and is expected to improve weather forecasts globally. It will further provide information for the study of the global circulation including general transport properties of the troposphere and lower stratosphere.

The Aeolus mission will provide data 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 provision of global wind profiles in cloud-free air will help to accomplish several objectives of the Global Climate Observing System and improve our understanding of the Earth's global energy budget. Aeolus will also provide profiles of backscatter and extinction coefficients (so-called spin-off products), which will allow the retrieval of cloud and aerosol information.

The main space element of 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.

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

2.2.1. AEOLUS PROJECT STATUS

Most of the flight equipments have been delivered, and the satellite bus as been integrated, functionally tested and put in storage. ALADIN telescope and receiver integration and initial performance testing have been completed as well.

The laser transmitter is continuing to be the greatest development challenge. Severe difficulties have been experienced for all UV laser optics caused by so called laser induced contamination (LIC). This causes a 50% drop in laser energy after a few hours operation in vacuum. Since there was little or no heritage of this effect in the laser research community, i.e. most laser applications operate in pressurised conditions, it was necessary to invest a significant effort in investigating possible solutions to this problem. Laboratory level sample tests demonstrated that oxygen of very low quantity (10's of Pascal) is sufficient to eliminate the LIC effect by actively cleaning the surfaces during laser operation. A so called in-situ cleaning system (ICS) has been agreed to be the most adequate LIC mitigation design for ALADIN.

The basic principle of the system is to provide a low pressure, oxygen purged environment to pressure sealed versions of the three main ALADIN optical units by means of oxygen storage tanks and associated pressure regulation and feed installations. It has further been decided to change the operational principle of the ALADIN instrument and in particular the laser transmitter from burst mode to continuous mode with approximately half the pulse repetition frequency. This has been done in order to obtain adequate beam quality through the laser amplifier and UV conversion stages and thereby restore performance margins with respect to end of life conditions.

The integration of a first version of the Level 1B processor within the Aeolus Payload Data Segment (PDS) has been completed. The European Centre for Medium-Range Weather Forecasts (ECMWF), in charge of generating the so-called consolidated Aeolus wind products (Level 2B), implemented a first version of the Level 2B processor and conducted initial interface tests with the ESA developed PDS. ECMWF will also be involved in system level validation tests of the Aeolus Ground Segment closer to the launch and contribute to CalVal activities post launch.

The detailed analysis and design of implementing continuous mode operation of the Aladin instrument is nearing completion. The essential modifications to the instrument electronics have been verified through interface compatibility tests and authorization to program the flight components will be given shortly. The results of these successful tests have also allowed defining the modified software requirements for continuous mode. The corresponding new software version will be implemented and verified by the software supplier, SciSys (UK), during the coming 9 months.

Analysis and investigations are continuing by the Project together with Astrium on the end-to-end performance of the mission. Special attention is put on the ground echo calibration and possible improvements to the Rayleigh data processing.

The integration and alignment activities on the first laser transmitter flight model are continuing at SG Pomezia. Although activities are progressing slower than planned all performance tests have been successful so far. In particular the alignment and compensating lens selection for the amplifier section has been completed with excellent performance. The careful characterization of the laser at each integration step continues in order to avoid fatal events.

The continuous slip in the schedule for the transmitter integration is obviously of great concern to the Project and intensive management actions have taken place with Selex-Galileo with the objective to better adhere to the agreed milestones and delivery dates.

The ALADIN Instrument qualification review is planned for mid-2012 leading to a launch in the second half of 2013. The Verta-2 launch on VEGA remains baseline. The Project is looking forward to the first qualification flight beginning of 2012, after which some critical environmental levels can hopefully be relaxed, e.g. mechanical shock at stage separation and the induced thermal flux during upper stage maneuvering.

2.2.2. AEOLUS SCIENCE

Various activities in support of Aeolus science are being performed.

The Royal Dutch Meteorological Institute (KNMI), together with partners at the Norwegian Meteorological Institute (met.no) and the University of Stockholm (MISU), are concluding a study looking into the optimization of the Aeolus atmospheric vertical sampling strategy. The objective was to investigate and make recommendations for the Aeolus operational sampling in order to allow for a maximum mission impact in weather forecasting and atmospheric general circulation modelling in the troposphere and stratosphere.

The retrieval of atmospheric winds with a space-borne lidar is particularly challenging in atmospheric scenes with both large dynamical and optical variability, e.g. when strong wind shears are occurring at cloud boundaries. One way of dealing with this difficulty is to sample the atmosphere more densely using the Aeolus particle backscatter channel. However, since the number of available vertical samples is limited, a trade-off between vertical coverage and the necessary wind precision must be made. The team performed a thorough investigation of the Aeolus operational concept, mapped the spatial and temporal occurrence of strong wind shear or turbulence in combination with strong extinction or backscatter variability in the atmosphere, quantified the quality of simulated Aeolus Horizontal Line-of-Sight (HLOS) wind profiles, and finally quantified the impact of the different vertical sampling scenarios for NWP and for the analysis of stratospheric winds.

The recommendations from the team are fed directly into the work on the Aeolus ground segment and on the phase E1 and E2 operations and CAL/VAL preparations.

The recent change in the operational principle of the ALADIN instrument, and in particular of the laser transmitter from burst mode to continuous mode with approximately half the pulse repetition frequency, calls for a continuation of this activity. The team will now investigate the impact of the new data quality and coverage on weather forecasting. Especially topics concerning data representativity, measurement information content and thereby an optimization of the horizontal and vertical data averaging will be studied in grate detail. The output will feed directly into the on-going revision of the Mission Requirements and the Ground Segment development.

A study looking into the contribution of so-called Brillouin scattering to the shape of the lidar signal, as backscattered by molecules in the atmosphere, has been performed by the Free University of Amsterdam together with partners from the University of Nijmegen, Eindhoven and the Royal Dutch Meteorological Institute. The team validated the so-called Tenti model, which is used by the lidar community world-wide to estimate the shape of lidar molecular backscatter. The team compared the Tenti model output with measurements of Rayleigh and Brillouin scattering, performed in air, N2, and O2 at temperatures and pressures representative to the Earth's atmosphere. The team found that the Tenti model can be further optimized in order to provide a more precise description of atmospheric backscatter. The update of the model is taking place in a follow-on activity, performed by the Free University of Amsterdam. The model improvements are expected to feed into and further optimize the data processing in the Aeolus Ground Segment. The activity shall be concluded by December 2011.

The VHAMP activity, investigating the impact of continuous mode wind profile measurements on weather forecasting and making recommendations for the sampling strategy and observation processing to maximize the mission impact, was kicked off on 1st April 2011 and will run until 31 March 2012. The first progress meeting was held on 16 June, and the activity is on-schedule.

In a complementary impact study by ECMWF, an optimization of the use of the continuous mode Aeolus wind profile measurements in the ECMWF forecast assimilation system is investigated to ensure forecast impact. The activity was kicked off on 1st April 2011 and will run until 1st October 2012.

These parallel activities will evaluate the Aeolus data impact and needs by both global (ECMWF) and regional (KNMI and partners) weather forecast communities. Their output will be coordinated during common progress meetings and shall be used to advise the ground-segment development and the planned updates of the Mission Requirements Document.

The Aeolus Mission Advisory Group (MAG) met for the 23rd Aeolus MAG meeting at ESA-ESTEC on 11 and 12 May, 2011. A special session on the ALADIN instrument was arranged on day one with presentations by ESA, industry, the DLR Aladin Airborne Demonstrator team (A2D, an airborne prototype of the Aeolus lidar instrument) and the CALIPSO PI, Dr. Dave Winker. Scientific sessions followed on day two of the MAG. Members reported on the A2D campaign analysis, the scientific studies on the impact of Aeolus continuous mode operation on NWP and recommendations for the on-ground data processing, the potential of Aeolus aerosol products for assimilation, and the influence of turbulence on Aeolus wind observations.

2.2.3. AEOLUS CAMPAIGNS

The so-called ALADIN Airborne Demonstrator (A2D) is based on the ALADIN instrument pre-development model. It was first functionally tested using DLR's research aircraft Falcon in 2005 and a first ground-based campaign was conducted in 2006. Given the challenging environmental conditions on board the aircraft (especially micro-vibrations and temperature, pressure variations) the overall stability of laser and transmit/receive optics was considered insufficient to allow an immediate continuation of campaign activities. Various design modifications were implemented during the period 2006-2008 and stable operation of the Lidar system was first demonstrated in an airborne campaign in 2007. Additional successful ground-based and airborne campaigns were conducted between spring 2008 and autumn 2009, and the acquired observational data are currently used to validate the Aeolus performance model and critical elements of the Level 1B algorithm. The autumn 2009 campaign (base airport: Keflavik/Iceland) provided particularly useful measurements of surface echoes over snow/ice and over open sea under various wind conditions.

As a next step the A2D data will be used to validate the overall calibration scheme and the retrieval of horizontal line of sight winds (Level 2B).

The importance of co-located under-flight measurements by wind lidars for the Aeolus Cal/Val was emphasized during the 23rd Aeolus MAG, and supported by the experience from the CALIPSO Cal/Val program.

2.3. EARTHCARE

2.3.1. 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.

2.3.2. 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)

2.3.3. PLANNING

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

Phase B1 activities were completed in the frame of the System Requirements Review that took successfully place from December 2008 to February 2009. The overall spacecraft configuration resulting from this review is in line with the Phase A concept presented at the Users Consultancy Meeting. The Phase B2 activities have further developed the spacecraft and its payload design and the Preliminary Design Review process was initiated end 2009.

Whilst the development of the two passive instruments, BroadBand Radiometer and Multi-Spectral Imager, is ongoing nominally, the ATLID instrument configuration has been changed from a mono-static to a bi-static concept to reduce the effects and criticality of the laser induced contamination. This re-design exercise, presently being finalized, led to a postponement of the Phase C/D to ensure that all impacts of the changes (especially mass, volume and power) are properly acknowledged at spacecraft level.

2.3.4. CURRENT STATUS

The Cloud Profiling Radar, procured by JAXA in the frame of the ESA-JAXA Cooperation Agreement for EarthCARE, development is synchronized with the satellite program and is proceeding nominally.

During the recent period, the Phase C/D clarification and negotiation process initiated at the end of previous quarter continued, taking also into account the Independent Assessment conclusions. The Statement of Compliance documents to the ESA Applicable Documentation set have meanwhile been agreed between ESA and ASTRIUM to establish the Phase C/D implementation baseline. The formal negotiations with the Prime regarding the overall contract costs are currently on-going. The Base Platform and ATLID procurement process continued in ASTRIUM-UK, ASTRIUM-F and ASTRIUM-D. This allowed the selection of the sub-contractors in charge of major EarthCARE elements such as Structure and Solar Array to take place.

In Japan, the Ground Segment System Design Review took place with contributions from ESA Project team, ESOC and ESRIN.

The contractually established launch date of September 2013 is presently being revised with Industry to reflect the ATLID reconfiguration impact on the scheduled. The EarthCARE Preliminary Launcher Vehicle Analysis study is ongoing nominally and Arianespace has delivered the first trajectory and separation analysis for consideration by the project.

The EarthCARE JOINT MISSION ADVISORY GROUP (JMAG) met in May (European/Canadian members) and in June (Japanese members with limited European participation). Both meetings were focused on discussion of the outcome of the EarthCARE Mission Independent Assessment, and on the proposed changes to the ATLID instrument, which were found acceptable by the JMAG. The next full meeting of the JMAG is planned to take place in October 2011.

The ESA-funded development of the theoretical basis for EarthCARE Level 2 algorithms has been progressing nominally within the ATLAS, IRMA and RATEC studies.

2.4. SWARM

2.4.1. 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.

2.4.2. 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.

2.4.3. PROJECT STATUS

The development of the three satellites is well advanced. The three structures of the satellite are ready within the integration room of ASTRIUM GmbH in Friedrichshafen. Most of the flight units for the three satellites are already delivered and are already integrated on the two first satellites. The Swarm Project passed successfully the CDR and is moving forward toward the delivery test of the first satellite. Meanwhile, the development of the ground segment infrastructure has also completed its CDR for both the data centre and the operation centre. A contract has been set up with EUROCKOT for the procurement of the launch services.

The first satellite (already tested in Thermal Vacuum) has been equipped with the S- Band Transponder, the GPS Receiver, the Absolute Scalar Magnetometer (ASM) and a dummy EFI. This first satellite was awaiting the refurbishment of the Power Conditioning Unit (PCDU). Following the completion of the TV test on Satellite 2, the industrial team will be redeployed in order to conduct the Integrated Satellite Tests (IST) and the Abbreviated Functional Tests (AFT) of the first satellite. Then, the Satellite 1 will resume its test campaign starting with the Mechanical and Electromagnetic Compatibility (EMC) tests during the period from end of July 2011 till mid August 2011.

The second satellite fully equipped with its payload has successfully completed the mechanical test. In addition, the Thermal Vacuum (TV) test is almost completed. So far the TV test is successful as only minor problems have been encountered with no impact on the integrity of the satellite and its payload. The Electrical Field Instrument (EFI) integrated on the satellite 2 is a flight model equipped with a reduced version of the software. It will be replaced by a modified Electrical Field Instrument (EFI) and equipped with upgraded software after the satellite test campaign.

The third satellite is awaiting the delivery of the Accelerometer (ACC) and EFI, while the ACC is completing its last environmental tests, the EFI repair of the Universal Asynchronous Receiver Transmitter (UART) is still ongoing. In order to safeguard the Satellite 3 schedule and maintain the capability for repairing off line the EFI instrument it has been decided to prepare an EFI dummy in case a modified EFI would not be available in due time for integration on the Satellite 3.

The last GPSR (GNSS Receiver), S-Band Transponder and Vector Field Magnetometer digital processing units are now delivered. The ACC FM1 and 2 are also delivered.

The six ASM (Absolute Scalar Magnetometer) instruments (nominal and redundant) are delivered to the prime contractor and installed on the satellites. The ASM mounted on the Satellite 2 showed an excellent behavior during the TV test.

An EFI EM with a modified communication interface was delivered to ASTRIUM in order to verify its compatibility with the satellite and complete the suite of IST test. These tests were very fruitful as they ascertained that the remedy action implemented on the EM was sound and confirmed the need to implement the same modification on the three flight models.

The launch date remains in July 2012, as imposed by the current launcher schedule. The current development plan for the satellite is to complete the test activities for the three satellites with the shock test (upon delivery of the adapter by Khrunichev) in February 2012 and to store the satellites up to the launch date.

2.4.4. SCIENCE

Several studies are completed 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 results with respect to the recovery in the 1D case as well as in a full 3D retrieval.

The studies "Ionospheric Current Quantification and Modeling for Improved Magnetic and Electric Field Analysis for Swarm" and "Air Density Models Derived from Multi-Satellite Drag Observations" are also completed.

2.5. EARTH EXPLORER NUMBER 7 AND 8

A call for Earth Explorer Core ideas for Earth Explorer-7 was issued in 2005. Twenty-four proposals were received and after evaluation mission concept assessment studies of six candidate Earth Explorer missions were performed. A User Consultation Meeting was held in Lisbon in January 2009, and the subsequent evaluation by the Earth Science Advisory Committee in early 2009 led to a recommendation for the down-selection to the following three 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.

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

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

After approval of these three candidate missions for EE-7, they entered feasibility studies at Phase-A level in early 2009.

A call for the Earth Explorer Opportunity Mission EE-8 was issued on 2 October 2010. By the deadline of 1 June 2010 thirty-one proposals were received, reflecting the high interest in the ESA EO science program by the scientific community. The proposals are currently being evaluated, after which up to three missions will be selected for studies at Phase-A level.

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 become 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 400 users, dozens of service providers, developers and strategic partners. They address all areas of the priorities identified by the EC: Marine monitoring, land monitoring, emergency response, atmosphere monitoring, and security. 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 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. The launch of MSG-3 is planned for June 2012 and MetOp-B for April 2012.

Regarding the future generations:

Post MSG (MTG): The MTG space segment will consist of a twin configuration, MTG-I (Imaging mission) and MTG-S (Sounder mission). Significant progress has been made with the preparation and timely delivery of the data pack for System Requirements Review, and the start of several critical Best Practice Procurements. The target launch dates are 2017 for MTG-I and 2018 for MTG-S.

The GMES Sentinel-4 instrument will be embarked on the MTG-S satellite. Final negotiations for the Phase B2/C/D activities have been completed in January and the consortium, led by Astrium (D), formally kicked off in mid February.

Post MetOp/EPS (MetOp-SG (naming tc)/EPS-SG): Following a consolidation of the mission and programmatic requirements, two parallel Phase A/B1 studies will be kicked off by end 2010. Based on the results of the Phase 0 studies, a dual satellite configuration has been endorsed by the EUMETSAT Council in June 2010. Activities are coordinated with those of GMES Sentinel-5. The target launch date is 2019/2020 for the first satellites. ESA is preparing a program proposal for MetOp-SG in preparation for the ESA Ministerial Council in late 2012. Elements of this program proposal have been presented to the PB-EO in late September 2011.

3.3. GMES SERVICES COMPONENT

GMES stands for the Global Monitoring for Environment and Security and is a joint initiative of the European Space Agency and the European Union 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 three components: a service component, a space component, and an in-situ 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 6th Framework program. To date more that 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 GMES Services from which customized services to meet national and local needs can be derived. These services, currently funded by the EC 7th Framework program, address the following themes: Emergency Response, Marine Monitoring, Land Monitoring, Atmosphere Monitoring, and Security.

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 as observations from other contributing European and national missions.

Following completion of the GMES Service Evolution study, all activities initiated within the initial stage of the GSE program are now completed. Six service networks are currently ensuring continuity of services to users for a further three year period, and working towards long-term sustainability, within the GSE Service Extension.

Five GSE service networks are progressing in the second yearly phase of service extension and have continued service deliveries to users throughout the last reporting period. The sixth service network, GSE Food Security, which kicked-off in mid 2010, will enter its second phase following the annual review in July 2011.

4. GMES SPACE COMPONENT

4.1. BACKGROUND

GMES represents the major new initiative of European efforts in Earth Observation. The start of the GMES pre-operational services took place in 2008, with the provision of the relevant data. The first GMES dedicated satellites (the “Sentinels”) will be launched in 2012-2013. Related activities are under way at all stages within the Agency, the EC and at Member States level.

The ESA GMES Space Component (GSC) program, foresees the development of the following:

Sentinel-1 mission: two C-band SAR satellites to provide continuity to ERS, ENVISAT, with enhanced capabilities, and to maintain the cooperation with Radarsat. The first Sentinel-1 satellite is planned to be launched in May 2013

Sentinel-2 mission: two multispectral optical imaging satellites to provide continuity (and enhanced capability) to the data so far obtained from SPOT and Landsat. The first Sentinel-2 satellite is planned to be launched in November 2013

Sentinel-3 mission: two ocean and global land monitoring satellites providing ocean color, sea surface topography and sea and land surface temperature. It will provide enhanced capability and 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. The first Sentinel-3 satellite is planned to be launched in October 2013

Ground segment of the above three Sentinel missions. The GSC program funding includes the Sentinel-3 ground segment marine part and flight operations segment to be developed by EUMETSAT

Sentinel-4 mission: two units of an instrument for monitoring of atmospheric composition from the geostationary orbit, to be embarked on the two planned MTG-S satellites (2018 and 2024)

Sentinel-5 Precursor mission: satellite for atmospheric composition monitoring, filling the data gap between ENVISAT and Sentinel-5. The UVN instrument is provided as specific national contribution by The Netherlands. The planned launch date of the Precursor is end 2014.

Development and pre-operational access to Earth Observation data from contributing missions required by the GMES services, up to end 2013.

The funded activities also include the studies or technology developments:

Sentinel-5 Phase A/B1 and pre-developments activities. Sentinel-5 is a low-Earth orbit element devoted to the monitoring of atmospheric composition. The instrument is planned to be embarked on the EPS-SG satellites

GMES Space Component evolution studies and technology developments

Study of a Jason follow-on satellite based on Cryosat (Jason-CS).

The development phases of the Sentinel-5 and Jason-CS will be opened for subscription between 2011 and 2012.

4.2. PROGRAMMATIC ASPECTS

On the European Union (EU) side, GMES related funding was approved at the end of 2006 as part of the Space Theme of the Seventh Framework Programme (FP7). The pledged funding covers in particular the following activities which are delegated to ESA based on specific agreements:

development of GMES-dedicated satellites and ground segment

coordinated provision of observation data for GMES (data access).

The EC-ESA delegation agreement governing the EU funding contribution to the development of the first Sentinels was signed in February 2008. An amendment related to Segment 2 activities was concluded in January 2009, while a second amendment was planned for the end of 2010 to implement the new funding allocated to the program by the EU with the adoption of the GMES

Regulation. Overall, the financial contribution of the EU to the GMES Space Component development and data access represents 28%, while the rest is covered by ESA Member States. The overall GSC funding committed so far is 2.25 billion Euros.

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 EU.

The EC issued a Communication in November 2008 called "Global Monitoring for Environment and Security (GMES): we care for a safer planet". This Communication presents the basic elements and principles relating to GMES governance, and provides the ground for the preparation of the future EU GMES operational program, stipulating in particular the need for appropriate financing of GMES by the EU on the long term.

The GSC Long Term Scenario covering the period 2014-2030, has been finalized and released, and serves as the basis, as far as the space component is concerned, for the preparation of the EU GMES operational program.

In 2010, the EU Parliament and Council adopted the Regulation on the "European Earth monitoring program (GMES) and its initial operations (2011-2013)" allocating funds for the initial operations period (2011-2013) and laying the groundwork for the next EU multiannual financial framework spanning 2014 to 2020, during which an estimated 800 M€ per year will be needed to operate the program.

In the recent period the revised Long-Term Scenario of the GMES Space Component (GSC LTS) was presented to PB-EO on 19-20 May 2011. The document was well received and commented by delegations. Following request from the European Commission (EC), a brief overview of the updated GSC LTS was also presented to the GMES Committee on 18 May 2011.

The Contract Proposal for the Launch Services for GMES Sentinel-2A and Sentinel-3A2 was approved at the 29-30 June 2011 IPC. The Contract Proposal was accompanied by an Information Note concerning the procurement of the "Launch Services for the GMES Sentinel-2B and Sentinel-3B" addressing the back-up policy that the Executive proposes to implement for the GMES Sentinels 2 and 3.

4.3. STATUS OF THE SENTINELS

The Critical Design Reviews of the first units of Sentinel-1, -2 and -3 satellites have started and are set to end by early 2011. The Sentinel-4 B2/C/D/E1 phase is planned to be kicked-off by the end of 2010, while the Sentinel-5 precursor phase A/B1 studies were kicked-off in June 2010.

Sentinel-1 progressed with phase-D activities in the second quarter of 2011, completing the test campaigns for the last Engineering and Engineering-Qualification models (EMs and EQMs) of some equipment, and the production of several Flight models (FMs).

All Sentinel-2 action items pertaining to the closeout of the satellite system CDR have been satisfactorily completed, and a large number of system level documents have been updated accordingly. A Sentinel-2 satellite CDR closeout report has been distributed by the project to PB EO Board members at the end of May 2011 as requested, to evidence the close out of all main issues that were raised during the review.

With the exception of the Sea and Land Surface Temperature Radiometer (SLSTR), the Sentinel-3 program is proceeding quite well. Instrument integrated EM testing are on-going and PFM manufacturing has started at all levels, so far without significant technical anomalies.

The Sentinel-4 Phase B2, C/D and Support to E1 industrial contract with Astrium GmbH was signed in March 2011. The System Requirement Review (SRR) was completed by the end of June emphasizing the importance of a properly timed delivery of the instruments in compliance with MTG needs.

During the reporting period, all ESA Best Practice procurements for Sentinel-5 Precursor TROPOMI payload elements were finalized. The list of GMES Sentinel-5 Precursor Level-2 products was defined, with the involvement of all key European experts.

The two parallel Sentinel-5 Phase A/B1 studies, kicked off in January and March 2011, are proceeding in close coordination with the Phase A/B1 studies of MetOp-Second-Generation. The expected duration of the studies is 20 months.

4.4. STATUS OF JASON-CS

The design of the Jason-CS space segment continued, with much progress concerning the European payload elements. In particular the altimeter, now called Poseidon-4 to emphasize the continuity with the Jason program, was developed further. The radar PCR was held in May and June 2011, to decide, among others, the details of the up- and down-conversion in the transmit and receive chains. Further concepts, in particular the pulse timing patterns and, associated with this, the possibility of operating in low-resolution and SAR mode simultaneously, will be studied next. On-board SAR processing will also be investigated to avoid downloading prohibitively large data volumes due to an extended use of the SAR mode. The Microwave Radiometer has also been progressing well, and the implementation of a third frequency is being investigated.

4.5. GROUND SEGMENT

The GMES ground segment will include the flight operation segment and the payload data ground segment. The latter will provide the interfaces to the GMES contributing missions and ensure the required level of inter-operability between the missions. Specific activities have been concluded, others are on-going, for the provision of EO data for the EC's GMES services on Land, Marine and Atmosphere Monitoring, and Emergency Response and Security.

5. REFERENCES

Complementary to this report is the information contained in the "CGMS Consolidated report" and in CGMS-39-ESA-WP-01 regarding present missions.

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