Reaping the Rewards

Coordinating Europe's Earth Observation Ground System

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The torrents of data from a wide range of different Earth observation satellites must be handled in a harmonised way for maximum benefit. This image shows the eruption of Mt. Etna on Sicily 25 November 2006, seen by the MERIS instrument aboard ESA's Envisat

The Global Monitoring of Environment and Security (GMES) programme is based on a fleet of European Earth observation satellites, built and operated by ESA, member states and commercial entities. GMES will also offer data from non-European satellites. In order to provide operational and sustainable user services and to avoid unnecessary duplication in technologies, the challenge is to harmonise the various approaches to the ground segments of the different satellites and to involve the users. To begin this harmonisation process, a Ground Segment Coordination Body was created to adopt a common, coordinated and cost-effective approach that responds to the needs of Earth observation users.

Introduction

The demand for Earth observation (EO) data has evolved dramatically in recent years: the volume of requested data has increased by a factor of 10 over the last 8 years, and more than 80% of the users request data from more than one satellite or satellite operator.

This, in turn, increases the challenge for satellite operators, space agencies and providers of EO data to offer the access to the different data as coherently

and easily as possible. It also demands optimisation in allocating the available financial resources to handle an increasing number of different EO missions through closer cooperation in developing the ground segment, the operations and exploiting the data.

A task force set up by ESA's Earth Observation Programme Board (PB-EO) in 2003–2004 came up with a set of recommendations on how to deal with these challenges. One was the creation of a Ground Segment Coordination Body (GSCB), composed of member-state agencies managing EO data ground segments.

GSCB was established in June 2005 and shares the expertise in the development and operation of payload ground segments of missions such as:

- Meteosat, MSG and MetOp by Eumetsat;
- TerraSAR-X, Rapid Eye, TanDEM, EnMAP and third-party missions handled by the German Aerospace Center (DLR);
- Radarsat-1 and -2 by the Canadian Space Agency (CSA);
- COSMO-Skymed by the Italian Space Agency (ASI);
- Spot, Topex-Jason and Pleiades by the French Space Agency (CNES);
- ERS-1 and -2, Envisat, Earth Explorer missions and third-party missions by ESA.

The group coordinates and shares its findings with other coordination and standardisation entities such as CEOS (Committee on Earth Observation Satellites), OGC (Open Geospatial Consortium) and CCSDS (Consulta tive Committee for Space Data Systems), and it plans for regular consultation with industry and commercial missions.

European GMES Earth Observation Missions

The first task of GSCB was to coordinate the ground segment and data management of the most important European and Canadian EO missions during the lifetime of GMES. These existing and planned missions are outlined below.

COSMO- SkyMed (Italy)

COSMO-SkyMed is funded by ASI and the Italian Ministry of Defence. The system, now being built, consists of a constellation of four low Earth orbit mid-sized satellites, each carrying a multi-mode high-resolution X-band Synthetic Aperture Radar (SAR), and a global ground segment. Launch of the first is planned for 2007.

The primary mission is to provide services for land monitoring, territory strategic surveillance, management of environmental resources, maritime and shoreline control and law enforcement, topography and scientific applications.

Pleiades (France)

The Pleiades optical system will consist of two small satellites (1 tonne each) offering resolutions of 70 cm panchromatic and 2.8 m multispectral with a field of view of 20 km, better than its Spot predecessors. In addition, the system can acquire near-instantaneous stereoscopic doubles (or even triples) of 20 x 300 km, and provide highly accurate pinpointing of the images (< 1 m with ground control points) for optimal use of the data in geographical information systems. The first launch is planned for 2009.

TerraSAR-X (Germany)

Based on their experience with SAR technology from various national (SIR-C, SRTM) and ESA missions (ERS, Envisat), DLR and Astrium signed a public-private partnership agreement in March 2002, under which DLR is procuring from Astrium the innovative TerraSAR-X satellite.

The 1023 kg satellite will deliver X-band SAR data in various modes. The Spot-Light mode will yield the finest resolution data, with 1 m pixels for a 10 x 10 km image. The ScanSAR mode will deliver 16 m resolution in a 100 km-wide swath. A special 'split antenna' mode will allow experimental in-track interferometry, such as the mapping of moving objects. The satellite will fly in a 514 km-high dawn-dusk orbit and is scheduled for launch in February 2007 from Baikonur.

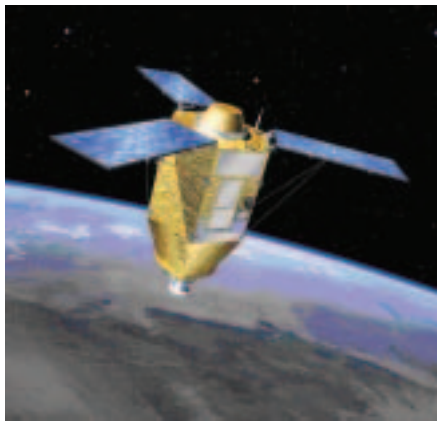
TanDEM-X (Germany)

In 2003, DLR issued a call for proposals for a national follow-on to TerraSAR-X. One of the two accepted proposals is TanDEM-X, which consists of a near-identical satellite flying in a close tandem configuration with TerraSAR-X by 2009. This will allow interferometric digital elevation models to be generated globally to the highest precision ('DTED-3' quality, with 10 m footprint and 2 m vertical accuracy).

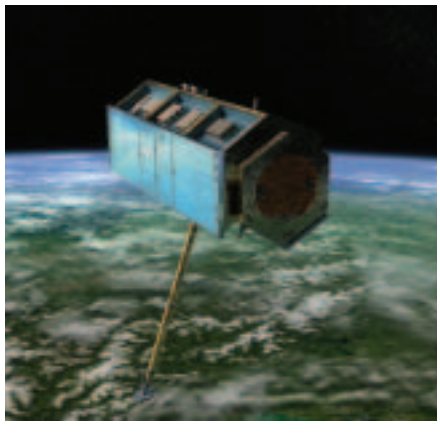
EnMAP (Germany)

The second national German mission, to be launched around 2010, is the hyperspectral EnMAP (Environmental

The Pleiades satellite



The TerraSAR-X satellite



Mapping and Analysis Programme). EnMAP covers the spectral range 420–2450 nm with more than 200 bands of 5–10 nm spacing. The 30 m pixels cover a swath of 30 km; off-nadir viewing enables 5-day repeat coverage. EnMAP will help the study of ecosystems and the monitoring of natural resources.

Radarsat-1\2 (Canada)

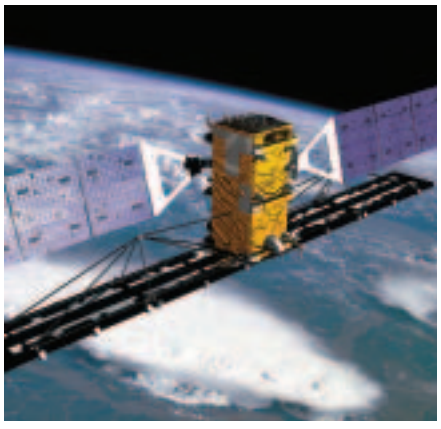
The Radarsat-2 follow-up to Radarsat-1, launched in 1995, is a collaboration between government (CSA) and industry (MacDonald, Dettwiler and Associates Ltd). It is designed to provide C-band SAR data similar to those from Radarsat-1 for continuity. Significant technical improvements were made, including a 3 m high-resolution mode, a full range of signal polarisation modes to improve discrimination between various surface types, superior data storage and more precise measurements of satellite position and attitude.

Radarsat-2 will operate in a Sun-synchronous orbit identical to that of Radarsat-1 but with an offset. It is planned for launch around March/April 2007.

Envisat (ESA)

Envisat was launched on 1 March 2002 and since then has operated with a 35-day repeat cycle, 30 minutes ahead of ERS-2. The instruments address four major areas: radar imaging; optical imaging over oceans, coastal zones and land; observation of the atmosphere; altimetry.

The Radarsat-2 satellite



The Envisat satellite

About two-thirds of the data are transmitted to the ground via ESA's Artemis relay satellite, providing Europe with data acquisition for any location worldwide. A total of 78 product types is generated, amounting to 250 GBytes per day. Most of these products are available on the Internet in near-realtime.

The Envisat data are used in many fields of Earth science, including atmospheric pollution, fire extent, sea-ice motion, ocean currents and vegetation change, as well as for operational activities such as mapping land subsidence, monitoring oil slicks and watching for illegal fisheries.

GMES Sentinels (ESA)

Drawing on the preliminary work of the definition studies (Phases-A/B1), the key aspects of the individual Sentinel missions are described below.

Sentinel-1

Sentinel-1 will provide continuity of ERS and Envisat SAR data, but at higher ground resolution and data-take per orbit. It will carry a SAR in a precisely controlled dawn-dusk Sun-synchronous orbit, at about 700 km altitude with an exact repeat of 12 days and a swath of about 240 km. The first launch is planned for 2011.

A Sentinel-1 concept

Sentinel-2

Sentinel-2 will provide improved continuity for the Spot multispectral optical data, carrying a push-broom imager operating in the visible/near-IR and shortwave IR in a Sun-synchronous orbit at about 800 km altitude. The resolution in the visible and near-IR channels will be 10 m. The swath width of the multispectral imager will be about 280 km, ensuring systematic coverage of all land surfaces every 10 days. The first launch is planned for 2011.

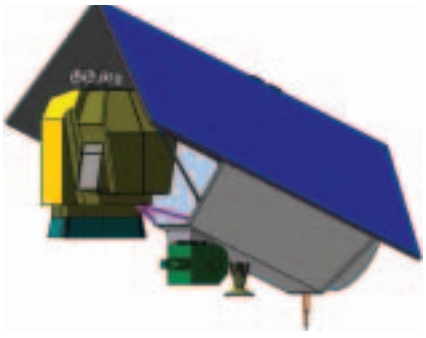
Sentinel-3

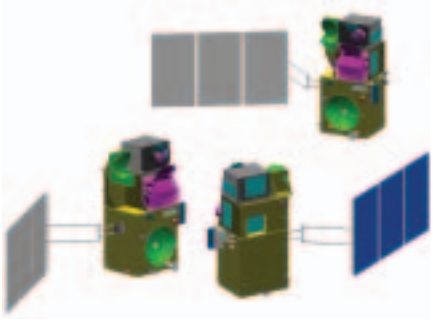
Sentinel-3, with a first launch in 2012, will monitor oceans and land/ atmosphere at a global scale. It will carry, in a Sun-synchronous orbit of around 800 km altitude:

- a microwave altimeter, with a microwave radiometer for atmospheric correction and a satnav receiver for precise orbit determination;
- a 15-channel super-spectral imager for ocean/land colour observations;
- a visible/IR imaging dual-view radiometer for sea/land surface temperature observations.

The land imaging mission will provide continuity for Spot's Vegetation instru-

A Sentinel-2 concept





A Sentinel-3 concept

ment, providing global coverage every 4 days.

All Sentinels will fly in a two-satellite constellation to satisfy the coverage requirements. All have design lifetimes of 7 years and, depending on their mass, are compatible either with the Soyuz (Sentinel-1: 2.5 tonnes) or the Vega launchers (Sentinel-2: 800 kg; Sentinel-3: 1.3 tonnes).

Eumetsat Missions

Meteosat First Generation

The first generation of Meteosat geostationary satellites has provided images of the full Earth disc and data for weather forecasts in a continuous and reliable stream for a quarter of a century. The first was launched in 1977, with the last (Meteosat-7) following in 1997 and still operational. These satellites provide data 24 hours a day from the three spectral channels (visible, IR, water vapour) of the main instrument every 30 minutes.

Meteosat Second Generation

The Meteosat Second Generation (MSG) is a significantly improved follow-on system. It consists of four geostationary meteorological satellites, along with their ground infrastructure, that will operate consecutively until 2018. MSG has brought major improvements in response to user requirements and serves the needs of Nowcasting and Numerical Weather Prediction, in addition to providing important data for climate monitoring and research. The key instrument is the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) radiometer, which delivers daylight images of weather patterns with a resolution of 3 km. The Geostationary Earth Radiation Budget (GERB) instrument measures the Earth's radiation balance.

Eumetsat Polar System

The Eumetsat Polar System (EPS) is Europe's first polar-orbiting operational meteorological satellite system. It is the European contribution to the Initial Joint Polar-Orbiting Operational Satellite System (IJPS) with the US National Oceanic & Atmospheric Administration (NOAA). The prime objective is to provide continuous, long-term datasets for operational meteorology, environmental forecasting and global climate monitoring.

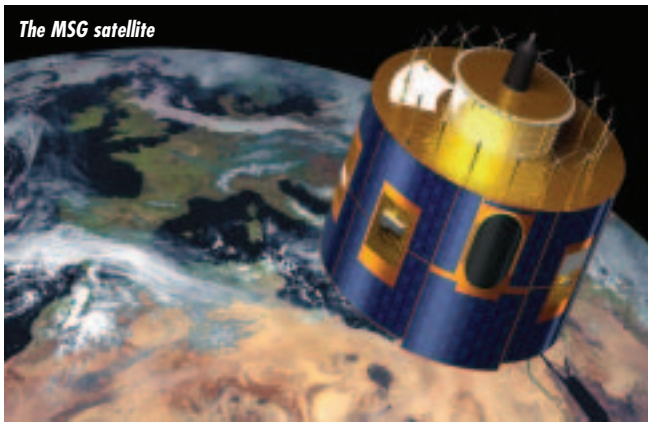
EPS consists of a series of three MetOp satellites, together with their ground system, with an operational life of at least 14 years. The first was launched in October 2006. MetOp is flying in a Sun-synchronous orbit at an altitude of about 840 km, carrying a payload of 11 instruments that includes a new generation of operational instruments developed by Eumetsat, ESA and CNES, in addition to core instruments already flown on NOAA satellites. Global data from new NOAA satellites hosting a subset of MetOp instruments will also be received and processed by the EPS ground segment.

GSCB in GMES and GEOSS

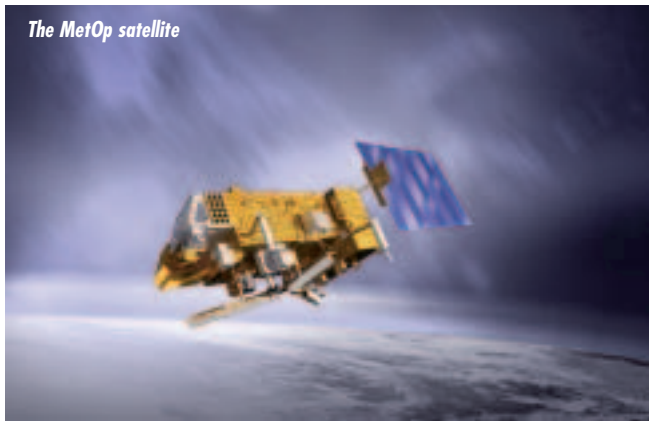
The GMES programme is based on a fleet of European satellites built and operated by ESA, ESA member states and commercial entities. It will also provide access to data from non-European satellites. GMES will therefore rely on existing, planned and new dedicated space and *in situ* observation capabilities to provide services to users. This open approach involves a complex scenario of data-providers, operators and system developers.

GSCB is intended to respond to this need for harmonised and coordinated ground-segment services at the European level, in particular for providing EO data to the GMES services.

The results from GSCB will be fed into the work plan of the Group on Earth Observation (GEO) and will contribute to similar activities under way beyond Europe, in an effort to built existing systems and initiatives into a single system, the 'Global Earth Observation System of Systems' (GEOSS), within 10 years.



The MSG satellite



The MetOp satellite

GSCB Work Plan

Based on an initial 3-year plan defined at the end of 2005, GSCB began to work on the more critical domains for which harmonisation at the European level would bring cost savings in the ground segments and a discernible improvement in access to the EO data for users and service providers.

The first (and main) project, the Heterogeneous Mission Accessibility (HMA) study, aims at the joint definition and adoption of inter-operability standards required to guarantee seamless and harmonised access to heterogeneous EO datasets.

The initial step is to define standards for the discovery, cataloguing, ordering, accessing and delivery of EO data. To do this, the GSCB is relying on the experience of its members, while following international standards and coordination with the European Commission's INSPIRE programme. The first standardisation version through the Open Geospatial Consortium (OGC) and the European Committee for Standardisation (CEN) is targeted for 2007, with initial implementation in 2009. Standardisation through the European Cooperation on Space Standardisation (ECSS) will follow.

The following steps of the project are devoted to defining the harmonised format of EO data products and their quality certification and reporting. The first milestone for the data and quality harmonisation definition is 2008.

The second project is the definition of the Payload Ground Segment reference architecture by identifying the different building blocks and interfaces, and exploiting the experience of the different ground segment operators. The adoption of a reference EO ground architecture for a simple, user-friendly, cost-efficient and inter-operable infrastructure will eventually be recommended, to:

- ease the implementation and integration of new missions and EO data;
- reduce competitiveness in ground segment development by industry;
- serve the European EO data user community in a harmonised way;
- provide a unified European technical standard towards GEOSS.

The third project is the definition and adoption of a common strategy for the long-term preservation of EO data. The strategy will define the technical and managerial approach and provide recommendations for data access, security and archive operations, maintenance and evolution, including data reprocessing and data integrity. The activity will capitalise on policies already in force for preserving digital data archives (at ESA, national space agencies, Eumetsat) and will consider European Union initiatives like the CASPAR project. The first strategy proposal is planned for 2007.

Other areas of common interest are:

- the sharing of telecommunications networking infrastructure, both ground and satellite. The concept relies on the cost-benefit advantages of procuring a common higher capacity network infrastructure, aggregating the needs from different EO operators, rather than proceeding with independent procurements;
- the optimisation of security requirements for the future benefit of dual European missions;
- the identification and sharing of tools for the description, test data generation and manipulation of EO products and ground system interfaces.

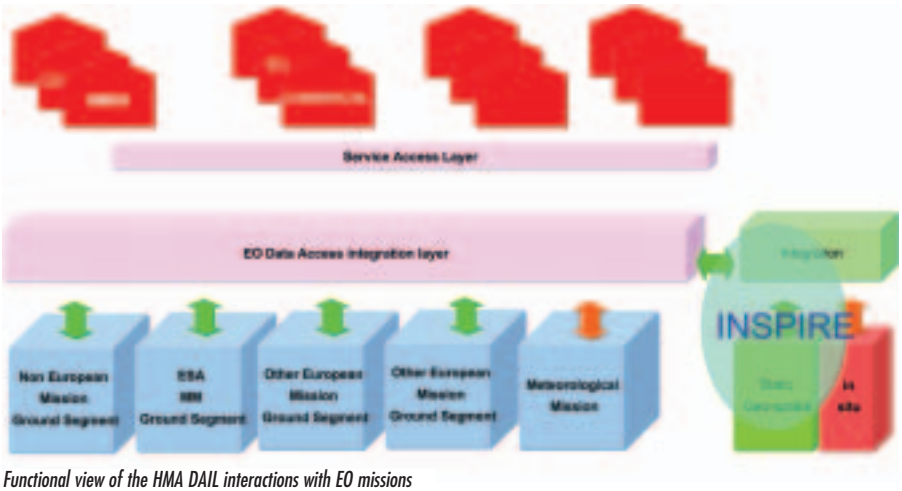
GSCB is not a new standardisation body. Its purpose is to identify and promote the use of a common set of standards to perform the above activities. In doing so, it liaises with the various existing standardisation bodies or initiatives, such as OGC, GEO and INSPIRE.

Achievements

The major achievement of GSCB is the Heterogeneous Mission Accessibility project, started in mid-2005 as part of the GMES Preparatory activities, to:

- consolidate the interoperability scenarios and the related requirements;
- define the EO Data Access Integration Layer (DAIL) architecture;
- define and prototype the interoperable protocol for cataloguing, ordering, mission planning and data distribution;
- define the approach for user and security management;
- address the interoperability requirements arising from, for example, data quality and formats, data policy and Service Level Agreements.

HMA is focused on defining, and later implementing, the interoperability concept across the ground segment of the missions contributing to the GMES



Functional view of the HMA DAIL interactions with EO missions

initial phase. It provides a harmonised and standardised access to ESA and third-party mission data through the DAIL, which is a set of standard functions and interfaces. The concrete implementation of DAIL will take into account the requirements of specific missions and the constraints of national facilities.

In the initial phase, HMA gathered the experience of the agencies and EO data ground segment operators by collecting the detailed descriptions of all the data access functionalities used in the existing operational ground systems. The output is a set of specifications for data discovery, cataloguing, ordering and programming services across a range of satellites.

These results were validated by the System Requirements Review in April 2006.

In parallel, the detailed work on the interface specifications derived from the scenarios was performed and submitted to the OGC, an international standards organisation that is leading the development of standards for geospatial and location-based services, and reviewed in close cooperation with the INSPIRE initiative headed by the European Commission. Several standardisation workshops have been organised for discovery and catalogue services to exploit the synergies among the EO datasets (targeted in the HMA) and the geospatial information (addressed by INSPIRE).

In September 2006, the DAIL architecture was assessed and reviewed by all the project partners and external advisors from the Food and Agricultural Organisation of the United Nations, INSPIRE and GEO.

Additional contracts will be in place in early 2007 to implement DAIL and the interfaces in the ground segments of participating missions. The implementation phase will include an HMA testbed to allow testing and evolution of standards proposed to OGC, and the standards compliance test of any entity implementing them.

Conclusions

In response to the increasing need for Earth observation data to monitor the state of our environment and support policy decisions and investments, Europe has introduced the GMES programme. Driven by the needs of users for highly sophisticated geo-information products, GMES will also minimise the effort required for cross-use of the data from these systems.

GSCB was created to harmonise the development of the different ground infrastructures and to ensure maximum data availability for a wide variety of users. Although GSCB is not a standardisation body, this coordinated approach has made a significant contribution towards the definition of interoperability and inter-accessibility standards.

The Body has to cope with the challenge of different national programmes and of bringing together systems already in operation with others still in planning. Various GSCB initiatives are being organised to foster the exchange of information among mission-developers in Europe and Canada, the most important being the HMA study.

A GSCB workshop in 2007 will bring together key players in the ground segment industry and governments. Updates on the initiatives and studies under way will be presented and advice from participants will be sought on how the GSCB can do better. esa

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