



Decision-makers need to be convinced of the benefits that GMES can create for national and local communities
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→ GLOBAL MONITORING FOR ENVIRONMENT AND SECURITY

GMES Space Component getting ready for operations

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Next to Galileo, Global Monitoring for Environment and Security (GMES) is one of the two European Union flagship programmes in space, and another example of how space policy can contribute to improving European citizens' lives.

While the future of Galileo is secured through the EC's proposal to provide sufficient operational funding within the general budget of the EU, the long-term future of GMES has yet to be secured. Unexpectedly, last year the EC proposed to finance GMES outside the EU Multi-Annual Financial

Framework (MFF), which covers the period 2014–20, suggesting instead to organise the required funding through a new intergovernmental mechanism.

In the GMES Space Component, the Sentinels and ground segment are currently in the final stages of their development and are getting ready for launch from 2013 onwards. Pre-operational data delivery from existing national and third party missions is well under way. What is most urgently needed now is securing the operational funds and consolidating the governance including Sentinel ownership and data policy.



← From left, Vittorio Prodi, Chairman of the Sky & Space Intergroup, European Parliament, Antonio Tajani, Vice-President of the EC, responsible for Industry and Entrepreneurship, and Jean-Jacques Dordain, ESA Director General, before the Conference on EU Space Policy in Brussels, November 2011

Why GMES was initiated?

The EU and ESA have developed the GMES initiative as Europe's answer to the vital need for joined-up information about our environment, to understand better climate change, and to support the civil security of European citizens.

Through a unique combination of satellite, atmospheric and Earth-based monitoring systems and models to convert observations into information services, GMES will provide vital new insight into the state of the land, sea and air, providing policymakers, scientists, businesses and the public with accurate, up-to-date, global information.

The GMES initiative was born in 1998 in Baveno, on the shore of Lake Maggiore in northern Italy, when the main national space agencies, ESA, the EC and Eumetsat came together to discuss how these challenges could be met.

Since then, significant achievements have been made: pre-operational services in the main environmental domains have been developed and the first elements of the necessary space observation infrastructure are close to completion. The first satellites will be ready for launch from 2013 onwards, and the programme will become operational in 2014.

What is GMES?

To accomplish its objectives, GMES has been divided into three main components: 'Space', 'In situ' and 'Services'.

The Space Component, led by ESA, comprises five types of new satellites called Sentinels, which are being developed by ESA specifically to meet the observational requirements of GMES services. In addition, access to data

from the 'Contributing Missions' ensures that European space infrastructure is fully used for GMES. An integrated ground segment infrastructure enables access to data from Sentinels and Contributing Missions.



GMES will provide us with crucial imagery and data on the environment, which will enable us to understand better and mitigate climate change. It will also make our agriculture and fishery more efficient. This in turn will guarantee better food quality and food security. It will also be of great help in crisis response in emergency situations during natural or manmade disasters.

J.M. Barroso, President of the European Commission,
November 2011



The *In situ* component, under the coordination of the European Environment Agency (EEA), is composed of atmospheric and Earth-based monitoring systems, and based on established networks and programmes at European and international levels and on ad hoc measurement campaigns enabling to collect environmental data from, for example, field instruments, vessels, aircraft or observation balloons.

The EC is in charge of implementing the services component and of leading GMES politically. GMES services will provide essential information in five main domains, atmosphere, ocean and land monitoring, as well as emergency response and security. Climate change has been added as a new GMES service and cuts across all these domains. In terms of security, GMES is a purely civil system addressing civil security needs.

GMES is moving from its research and development phase towards operations sequentially. Although defined to start from 2014 onwards, linked with the availability of operational funding, the operational programme integrates individual elements into the overall system as they reach their respective operational stages.

Who are the users of GMES?

Based on global observations, GMES services, developed in close collaboration with users, will provide essential information in three Earth-system domains (atmosphere, marine and land) and three cross-cutting domains (emergency management, security and climate change).

These services, once operational, will provide standardised multi-purpose information common to a broad range of EU policy-relevant application areas:

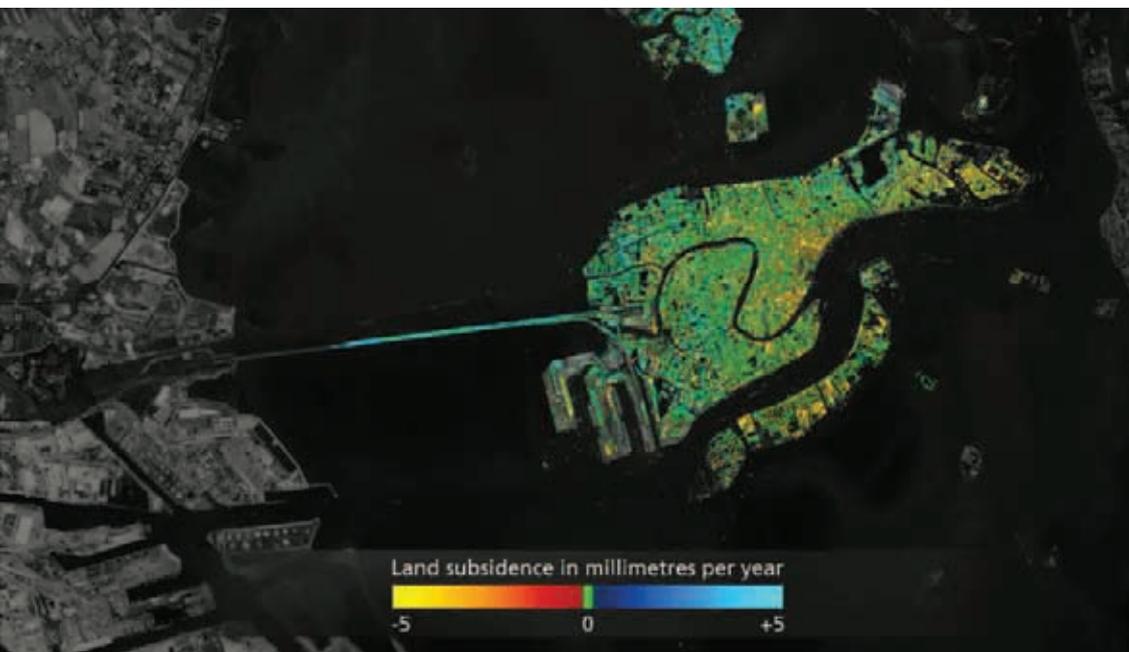
- GMES Marine Monitoring Service: focused on areas such as marine safety and transport, oil spill monitoring, water quality, weather forecasting and the polar environment.
- GMES Land Monitoring Service: focused on areas such as water management, agriculture and food security, land-use change, forest monitoring, soil quality, urban planning and natural protection services.
- GMES Atmosphere Monitoring Service: focused on areas such as air quality, ultraviolet radiation forecasting, greenhouse gases, ozone layer and climate change studies.
- GMES Emergency Management Service: provides information to mitigate the effects of natural and manmade disasters, floods, forest fire, earthquakes and to support humanitarian aid.
- GMES Security Service: provides support in areas such as peacekeeping efforts, maritime surveillance and border control.

The data gathered within these services will also feed Climate Change activities.

In addition to the above services, GMES serves other users such as public entities in Member States at national, regional or local level (for example, environmental agencies, mapping bodies, emergency services, urban planning bodies), European agencies (such as the European Environment Agency, the European Maritime Safety Agency, the European Centre for Medium-Range Weather Forecasts, Eumetsat and the European Union Satellite Centre), private business and individual citizens. A large variety of commercial industry segments will also benefit through the development and provision of operational geo-services.

At a regional level, GMES is already used to monitor air quality, map coastlines, regional areas and urban expansion and to manage marine and agricultural resources. GMES also plays a key role in disaster management and prevention.

On air quality, for instance, GMES currently provides daily (three-day) air quality forecasts and historical records of key industrial pollutants such as ozone, nitrogen dioxide, sulphur dioxide and aerosols for the major cities and regions of Europe. The forecasts form the basis for the management of health risks of citizens suffering from asthma or other symptoms. The



← Very high resolution map of land subsidence in Venice (mm/year), with data collected from May 2008 to April 2010 showing over 1.5 million point measurements (ESA/DLR)

historical records support regulation of the EU's Air Quality Directives that are implemented by regional authorities of national governments. A fully operational Air Quality Service in Europe could not be sustained without GMES.

In another domain, the GMES Emergency Response Service has been activated more than 50 times in Europe between September 2010 and September 2011. Crisis situations associated with the floods in Poland and Hungary in 2011 were supported by this service. Geo-information products and situation maps specifically dedicated to the preparedness and recovery phases of these events were delivered. Loss of this GMES service would increase the risks to lives and livelihoods of European citizens.



↑ Floods of the Hérault in south-eastern France in November 2011 monitored with GMES Contributing Missions (COSMO-SkyMed and SPOT-5, SAFER)

Socio-economic benefits of GMES

According to the EC staff working paper Memo/11/469, 'Money where it matters – how the EU budget delivers value to you', published in conjunction with the EU MFF proposal, GMES could provide economic benefits

of around €6.9 billion per year for industry, or 0.2% of EU annual Gross Domestic Product (GDP). Natural and manmade catastrophes in Europe, America, Asia and Africa, coupled with increased security needs, have further reinforced the case for improved monitoring systems.

GMES has great potential for businesses in the services market, which will be able to make use of the data it provides free of charge. Over the period 2006–30, the potential GMES benefits accumulated would be comparable to 0.2% of the EU current annual GDP. The benefits from all the GMES services in full use would equal €130 billion (2005 prices) or around €6.9 billion per year.

Obviously there are different methods that can be used when assessing the socio-economic benefits of GMES. Matters are complicated by the fact that some of the effects are not quantifiable. It is useful to perform a meta-analysis of studies that have been carried out.

The ESPI Report 39, 'The Socio-Economic Benefits of GMES' published in November 2011 follows this line by comparing a study by PricewaterhouseCoopers (PwC) and another one by Booz&Co. An important result is that both studies, although employing different approaches, reach similar conclusions regarding the order of magnitude of potential socio-economic benefits of GMES.

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€1 invested in GMES brings a macro-economic return of €10

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The PwC study establishes three categories of potential GMES benefits: efficiency benefits, European policy formulation benefits and global action benefits, and assesses them separately. The Booz&Co study, based on a literature review, looks at different funding levels and performs an impact analysis in the areas of climate change, environment and security and industrial development.

Moreover, it differentiates between static and dynamic scenarios. A dynamic scenario, unlike a static one, allows for interaction between relevant ecosystems in the realm of GMES. From both studies, a benefit–cost ratio of about 10 can be derived. This means that for every €1 spent by the European taxpayer on GMES, a public return of €10 can be expected.

In short, the European dimension of GMES will lead to economies of scale, facilitate common investment in large infrastructures, foster coordination of efforts and observation networks, will enable harmonisation and inter-calibration of data, and provide the necessary impetus for the emergence of world-class centres of excellence in Europe.

In addition to these economic benefits, GMES will provide strategic benefits by providing Europe with better information globally and therefore allowing Europe to assume a stronger role on the political stage and the global marketplace.

GMES Space Component led by ESA

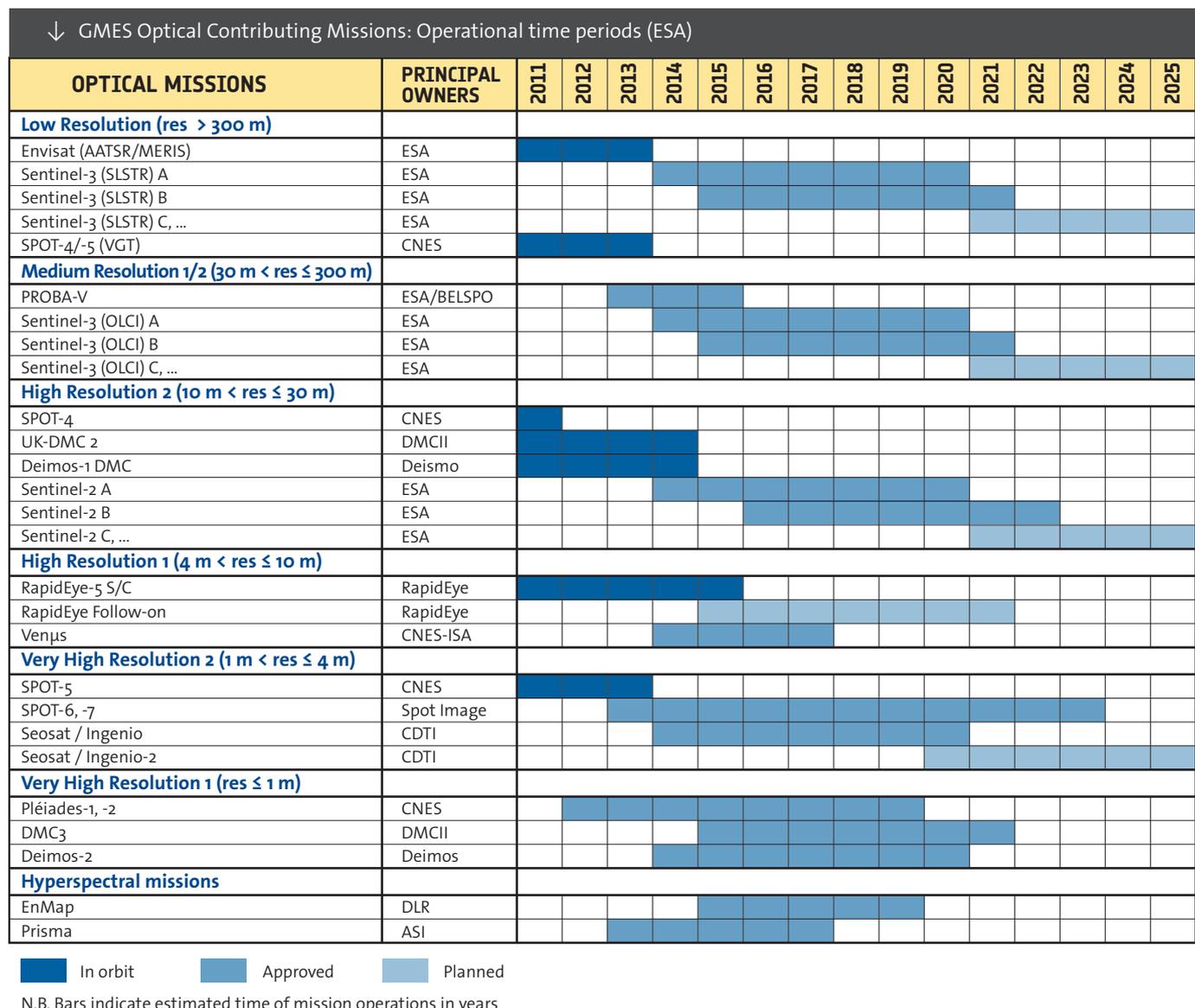
The objective of the GMES Space Component (GSC) programme is to fulfil the space-based observation

requirements in response to European policy priorities and GMES users needs in the environmental and security domains. The Space Component comprises two types of satellite missions, ESA's five families of dedicated Sentinels and missions from other space agencies, called Contributing Missions.

This component is coordinated by ESA, based on ESA's more than 30 years experience in developing and operating satellites as well as providing access to third party missions to users.

GSC Space Segment

While the Sentinel satellites are currently developed specifically for the needs of the programme, the Contributing Missions are already providing a wealth of data for GMES services, and will continue to deliver complementary data after the Sentinels are in orbit. They are operated by national agencies or commercial





sentinel-1

sentinel-2

sentinel-3

sentinel-4

sentinel-5 precursor



↑ Sentinel-1



↑ To be launched in 2015, Sentinel-5 Precursor will be a satellite with a UV/IR spectrometer, developed to avoid a gap between Envisat and the launch of Sentinel-5 on a MetOp Second Generation satellite



↑ Sentinel-2



↑ The Sentinel-4 mission consists of two instruments carried on the Meteosat Third Generation Sounder satellite, to be launched in 2019



↑ Sentinel-3

entities within ESA or EU Member States, Eumetsat or other third parties. The conditions under which their data are made accessible to GMES (e.g. Ordering mechanisms, processing level, delivery timeliness, data licensing, etc.) are contractually stipulated with the mission owners.

The evolving constellation of Contributing Missions, with their own ground segment, is interfaced through the Coordinated Data Access System (CDS) to provide data to users.

The GMES dedicated missions include the development of a series of two spacecraft of the Sentinel-1, Sentinel-2 and Sentinel-3 missions. The first will be launched in 2013. These missions carry a range of technologies, such as radar and multi-spectral imaging instruments for land, ocean and atmospheric monitoring:

- Sentinel-1: a C-band Synthetic Aperture Radar (SAR) sensor to provide a high revisit time all-weather day-and-night supply of imagery and ensures continuity of ERS-2/Envisat SAR data. It supports services related to the monitoring of Arctic sea-ice extent, routine sea-ice mapping, surveillance of the marine environment (including oil-spill monitoring and ship detection for maritime security), monitoring of land-surface for motion risks and mapping to support humanitarian aid and crisis relief actions.
- Sentinel-2: a medium-resolution optical sensor, to provide continuity of SPOT- and Landsat-type data for services related to, for example, land management by European and national institutes, the agricultural industry and forestry, as well as disaster control and humanitarian relief operations.
- Sentinel-3: a suite of instruments to measure sea-surface topography, sea- and land-surface temperature and ocean- and land-surface colour with high-end accuracy and reliability in support of ocean forecasting systems, and for environmental and climate monitoring.
- Sentinel-4/-5: spectrometer instruments at high temporal and spatial resolution to be carried on Eumetsat satellites (Meteosat Third Generation and MetOp Second Generation, respectively), which will benefit services to monitor air quality, stratospheric ozone, solar radiation and climate monitoring. Taking the planned launch date for MetOp-SG (2019) into account, a Sentinel-5 precursor mission is being developed for launch in 2015, in order to fill the gaps between Envisat and Sentinel-5 for atmospheric monitoring.

Studies are also performed for the evolution of the GSC system, in response to user requirement evolutions and

technology developments. For low-inclination altimetry, a Jason-CS mission is being developed, which is a further development of CryoSat-2 and continues measurements obtained currently by Jason-2/3.

GSC Ground Segment

The Ground Segment, through which the data are streamed and made available to GMES services, completes the Space Component. It is composed of Core and Collaborative Ground Segments.

The Core Ground Segment, having GSC-funded functions and elements, provides the primary access to Sentinel Missions and coordinates access to complementary EO data from Contributing Missions.

The GSC Core Ground Segment interfaces with the GSC Collaborative Ground Segment, which is comprised of elements funded by third partners, i.e. not via the ESA/EU funded GSC programme. It provides complementary access to Sentinel missions, e.g. through specific data acquisition, processing, dissemination or specific data products.

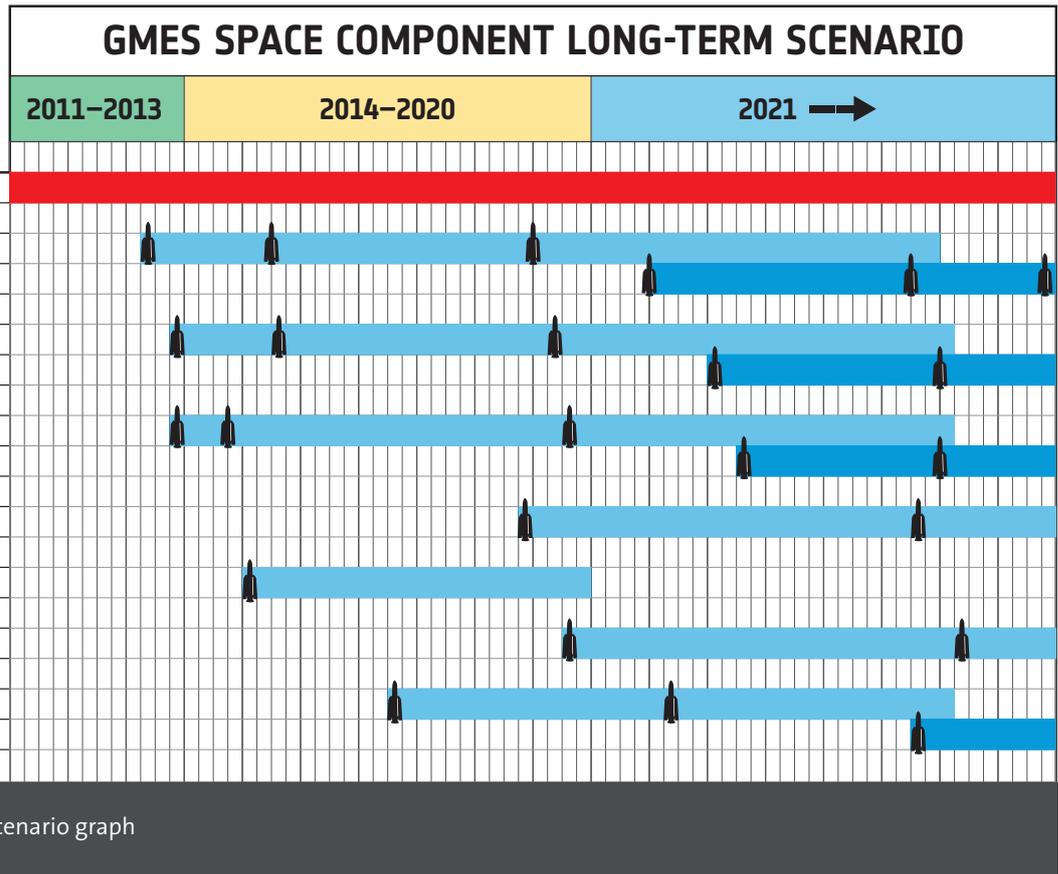
ESA ensures integrity and coordination of the GMES Space Component. Within the GSC Core Ground Segment, ESA will:

- assume the overall technical coordination related to EO data access, including interfaces to GMES Contributing Missions and the coordination of ground segment interface/standard developments;
- operate the Core Ground Segment for the Sentinel-1 missions, for the Sentinel-2 missions and for Sentinel-3 missions (for the land user community) and the operations of the Coordinated Data Access System (performed by existing facilities or industry under contract of ESA);
- ensure the technical integration of new missions and the technical evolution of the Core Ground Segment, while maintaining its operational services;
- ensure coordination of Ground Segment aspects with Eumetsat for the marine part of Sentinel-3, for Sentinel-4 and for Sentinel-5 missions.

Users need long-term guaranteed observations

Continuity of observations is the prerequisite for an operational service. This principle is clearly visible in meteorology. A similar goal is to reach such an operational status for environmental monitoring.

The user-driven nature of the GMES Space Component programme and the prerequisite of its affordability and



sustainability impose that the forecast of the long-term operational needs are based primarily on periodically updated requirements of the GMES services user community. Once operational services are in place, the evolution of their requirements will continue to drive the GSC.

At the same time, industrial and technology development will impact the GSC capabilities and influence the way the system fulfils the user needs. The baseline technology for the space segment should remain stable for a period ranging between 10 and 20 years per satellite generation (depending on the kind of mission), in analogy to other operational Earth observation programmes such as Meteosat, SPOT, MetOp, Landsat or NOAA/AVHRR.

Regarding the ground segment, more frequent adjustments will be made to take account of advances in computational facilities and user interface technologies due to the shorter cycles of technology renewal.

Therefore, it is essential in GMES to preserve the co-existence of mechanisms enabling the long-term operations of series of satellites, together with mechanisms enabling development activities considering the introduction of new technologies.

Stimulating growth

Access to Sentinel data is governed by the Sentinel data policy, which is formulated within the framework of a wider GMES data and information access policy.

Under the EU's responsibility, the overall GMES Data and Information Policy has the following objectives:

- Promoting the use and sharing of GMES information and data
- Full and open access to information produced by GMES services and data collected through GMES infrastructure, subject to relevant international agreements, security restrictions and licensing conditions, including registration and acceptance of user licenses
- Strengthening Earth observation markets in Europe, in particular the downstream sector, with a view to enabling growth and job creation
- Contributing to the sustainability and continuity of the provision of GMES data and information
- Supporting the European research, technology and innovation communities

These objectives, which also apply to the Sentinel data policy aim at maximising the beneficial use of Sentinel data for

the widest range of applications and intend to stimulate the uptake of information based on Earth observation data for end users. Thus it responds directly to the increasing demand for Earth observation data in the context of climate change initiatives and in support for the implementation of environmental and security policies.

The principles of the Sentinel Data Policy are:

- In principle, anyone can access acquired Sentinel data; in particular, no difference is made between public, commercial and scientific use and in between European or non-European users (registration is required).
- The licences for the Sentinel data itself are free of charge.
- The Sentinel data – as far as generated out of the Core Ground Segment – will be made available to the users via a ‘generic’ online access mode, free of charge. ‘Generic’ online access is subject to a user registration process and to the acceptance of generic terms and conditions.
- Additional access modes and the delivery of additional products will be tailored to specific user needs, and therefore subject to tailored conditions. In the event security restrictions apply to specific
- Sentinel data affecting data availability or timeliness, specific operational procedures will be activated.

The principles of this policy have been defined by ESA and the EC and were approved by ESA Member States in September 2009. In 2012, the EC is expected to issue a legal act on the overall GMES Data and Information Policy, of which the Sentinel Data Policy will be one specific element. For the Contributing Missions, the data policy of the mission owners will be respected for the purpose of providing data to GMES service users.

Funding – the main challenge today

ESA and EU Member States have funded the development of the GMES Space Component. To date, around €2.3 billion have been invested, of which ESA Member States provided 72% and the EU 28%. The EU provided an additional €0.7 billion for the services domain while ESA Member States provided €0.2 billion during the initial period for the build-up of GMES services.

Details of the GSC co-funding, including technical, managerial and financial issues, are laid down in an agreement between ESA and the EU on the GSC implementation, concluded in February 2008 and amended in January 2009 and June 2011.

GSC funding is expected to be complemented after decisions made at the ESA Ministerial Council in 2012 to complete the GSC build-up, and by the next EU MFF for the years 2014–20, in order to achieve the operational

configuration of the GMES Programme. An average amount of €834 million per year has been identified for the operation of the overall GMES programme. The portion needed for the GSC is described in the GSC Long-term Scenario prepared by ESA and amounts to about €640 million per year.

However, in June 2011, the EC unexpectedly suggested to finance GMES outside its next MFF, citing the risk of potential cost overruns in the operational phase, albeit confirming the overall funding need of €834 million per year.

Any EU funding instrument outside the MFF budget has already been criticised by several key EU Member States, Members of the European Parliament, European users, in particular the EEA, international research organisations and a number of business and industry associations. The ESA Council Chair, on behalf of ESA Council, also raised concerns and urged decision-makers to move GMES back on budget, i.e. within the MFF. The Chair also stated that in the absence of EU commitments for the availability of operational funding beyond the middle of 2014, ESA would be instructed not to launch the Sentinel satellites.

It shall also be pointed out that the risk of cost overruns within the operational phase is marginal, since these costs can be capped at the pre-estimated level, as listed in the GSC Long-term Scenario, and the operational performance of the GSC overall system will be performed within the limits of the available budget.

Nevertheless, the EC proposal for the next MFF will undergo an intense negotiation process until the end of 2013 involving the EU Council and European Parliament.

GMES is unique

The combination of space and *in situ* observations to create information services through a comprehensive system, as currently built up through GMES, is unique. It provides not only strategic information and significant socio-economic benefits to Europe, but also demonstrates how Europe can work together by pooling expertise and resources to achieve a common goal. GMES also creates new business opportunities and new high-end jobs in many disciplines, most of them outside the space domain.

Decision-makers need to be convinced of the benefits that GMES can create for national and local communities. For GMES to become fully operational, and allowing Europe to reap these benefits, an adequate funding level within the EU MFF is essential. To achieve this, GMES needs political support, today more than ever. ■