

→ OBSERVING EARTH, FOR A SAFER PLANET

GMES Space Component: status and challenges

Josef Aschbacher, Thomas Beer, Antonio Ciccolella, M. Pilar Milagro & Eleni Paliouras
GMES Space Office, ESRIN, Frascati, Italy

Managing natural resources and biodiversity, supporting rescue teams after natural disasters, predicting the spread of oil spills, adapting to sea-level rise, monitoring the chemical composition of our atmosphere, planning new roads and bridges: all depend on accurate information delivered in time to make a difference.

GMES (Global Monitoring for Environment and Security) is the European initiative for setting up a wide capability for Earth observation, and is the most ambitious Earth observation programme to date.

The idea is to pull together observations from satellites, airborne sensors and ground stations and, when appropriate, combine them with models to get timely and accurate information especially relating to the

environment and security. In other words, it will provide a comprehensive picture of the 'health' of Earth at any moment.

GMES has the goal of delivering operational information services for environment and security in six areas: Land, Marine, Atmosphere, Emergency Response, Security and Climate Change. To accomplish this, GMES has been organised into three main components: Services, Space and *In situ* Components.

ESA Member States have invested significantly in the set up of GMES by creating and funding the ESA optional GMES Space Component (GSC) Programme. The programme is co-funded by the European Commission. The majority of the GSC build-up is ensured, with only minor elements remaining to be funded.

→ GMES Space Office

The GMES Space Office, located at ESRIN (Frascati), is the focal point in preparing programmatic aspects of GMES for ESA's Directorate of Earth Observation Programmes and ESA itself. It also interfaces with key external organisations, in particular the European Commission (EC) that leads the overall GMES programme.

Preparing and funding the operational phase is the responsibility of the EC as overall GMES leader. This is envisaged through an EU operational GMES programme in the next EU Financial Framework starting in 2014. This is the biggest challenge ahead and the most critical factor for GMES – including the Space Component – to succeed.

GMES Space Component

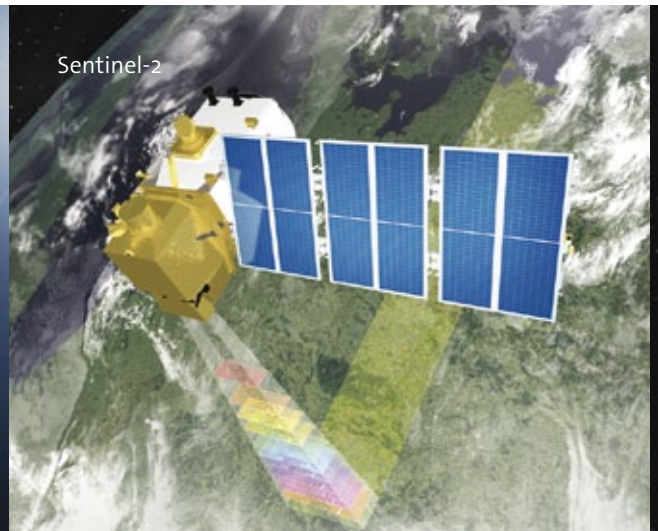
The GMES Space Component programme will fulfil space-based observation requirements responding to European policy priorities. To achieve this, two types of missions will provide the essential space-based information: the Sentinels, developed specifically for GMES, and the GMES Contributing Missions, owned by various national and/or commercial entities and built for their own use but providing valuable complementary observation capacity to GMES.

Integrating these diverse resources into the one homogenous architecture of the overall GMES Space Component is a clear challenge, both technically and programmatically. The integrated ground segment enables this. It operates and provides access to Sentinel data, and interfaces with Contributing Missions in order to obtain a coordinated data stream to GMES services.

Sentinel-1



Sentinel-2



We must guarantee the success of our flagship projects Galileo and GMES. GMES is now making a critical transition from research to operations. Both represent long-term commitments for the EU. We must ensure that long-term funding or governance issues do not get in the way of their success.

JM Barroso, President of the EC

→ Sentinel missions

The backbone of the ESA GSC Programme are the Sentinel missions. Five families of Sentinels are being developed today. In addition, the Jason-CS mission is expected to become part of the GSC programme after the next ESA Ministerial Conference in 2012.

Sentinel-1

A C-band imaging-radar mission, providing all-weather, day-and-night imagery, with improved revisit frequency and coverage. The radar operates in four modes, with the interferometric mode as the default mode. The instrument operates at ground resolutions of 5 m and higher. The interferometric mode has a swath width of 250 km, enabling global coverage about every two days in mid-latitudes with the nominal two-satellite configuration. The first satellite will be launched at the end of 2012.

Sentinel-2

A multispectral imager mission, with 13 spectral bands and resolutions of 10, 20 and 60 m. With a swath width of 290 km,

it offers a high repeat cycle of six days at the equator and three days in mid-latitudes in the two-satellite configuration. The large number of channels and high revisit time offer a major improvement compared to today's land mapping missions. The first satellite will be launched in 2013.

Sentinel-3

A satellite carrying a suite of different instrument packages, the Sea and Land Surface Temperature (SLST) radiometer to measure surface temperatures, the Ocean and Land Colour Instrument (OLCI) to measure ocean chlorophyll activity and land surface vegetation, and the Radar Altimeter (RA) package to measure sea-surface topography for primarily marine dynamics and climate change studies. The OLCI and SLST offer almost daily coverage in mid-latitudes, with a ground resolution of 300 m. The first satellite will be launched in 2013.

Sentinel-4 & Sentinel-5

Instrument packages devoted to atmospheric composition monitoring, from geostationary and polar orbit respectively, to combine high temporal and geometric resolutions. The former, to be launched in 2018, is planned to fly on the MTG mission while the latter will fly on post-EPS, to be launched in 2020. The Sentinel-5 precursor mission, planned for launch in 2014, will bridge the data gap between Envisat and Sentinel-5 in atmospheric observations.

Jason-CS

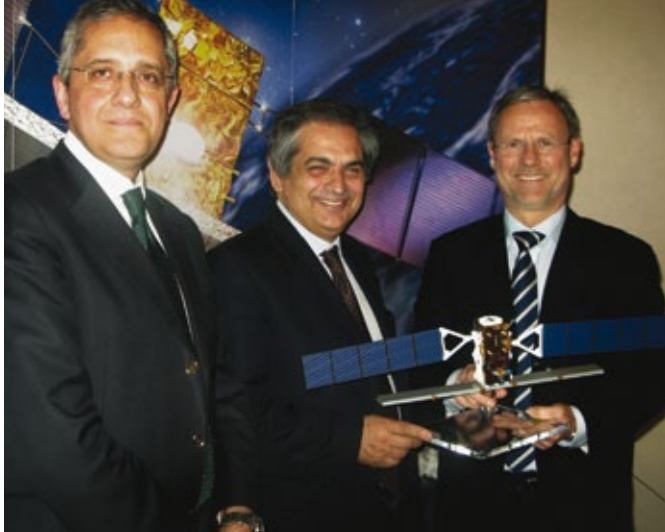
This satellite will carry a radar altimeter package to continue the high-precision, low-inclination altimetry missions of Jason-2 and 3. It will complement the high-inclination measurements on Sentinel-3 to obtain high-precision global sea-surface topography for the marine and climate user community. The satellite is planned for launch in 2017.



Sentinel-3



EC President JM Barroso highlights GMES as key European space programme at the 'Space conference' held in October 2009 in Brussels (EC)



A step forward for GMES: Luigi Pasquali, CEO of Thales Alenia Space Italy (left), Enrico Saggese, President of the Italian space agency ASI and Volker Liebig, ESA's Director of Earth Observation (right) celebrating the contract awarded to Thales Alenia Space to build Sentinel-1 B and 3 B

GMES Contributing Missions

Around 30 Earth observation missions, operated by European national or multinational organisations, are in orbit today or will be flying within the next few years. A portion of this vast resource of satellites and sensors can be made available to GMES, after having satisfied their prime national, security or commercial customers.

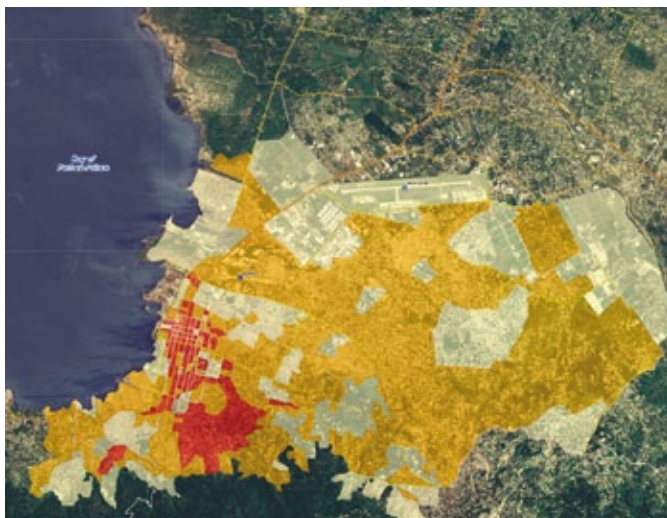
The missions include investments made via public, commercial and Public-Private partnership financing.

The Sentinel missions have been designed to be complementary to European Contributing Missions, as known at the time of the adoption of the GSC Programme in 2005. Therefore, these two resources provide complementary observations with a large variety of sensors and relatively high observation frequency.

↓ The pyramids of Giza, just 20 km outside Cairo, seen by TerraSAR-X in July 2007. The radar beam makes it possible under certain conditions to recognise structures below

ground level, especially in arid areas with loose types of soil. This opens up new options for archaeology and constitutes yet another application for TerraSAR-X data (DLR)





Damage evaluation map based on satellite data over the Port-au-Prince area of Haiti, following the magnitude 7 earthquake and aftershocks that hit the Caribbean nation on 12 January 2010, based on data from SPOT-5, ALOS and GeoEye-1 satellites (CNES, JAXA, GeoEye, SERTIT)

The list of Contributing Missions will evolve over time. Typical examples today include the German TerraSAR-X, Tandem-X, Enmap and RapidEye missions, the French SPOT and Pleiades satellite series, the Italian Cosmo-Skymed and Prisma missions, the Spanish SeoSAR, SeoSAT and DMC-Deimos missions, the UK DMC mission, the ESA/Belgian Proba mission as well as Eumetsat's MSG and MetOp missions.

The Canadian Radarsat missions (Radarsat, RSC) are also included, given the Cooperating State agreement with ESA. In addition, other non-European missions are added depending on a case-by-case basis. Several smaller, R&D missions are also provided to GMES, though within the limits of their respective data access and dissemination schemes.

Currently data from these missions are obtained based on competitive bulk procurement contracts ESA has concluded or is concluding with the respective mission operators. The data policies of the suppliers are respected. GMES covers the cost to obtain these data for use by approved GMES services today.

In order to establish a longer-term and more stable data access regime, the Sixth Space Council in May requested ESA and the EC to start formal dialogues with those Member States that own satellite missions in order to discuss long-term data access schemes for the period from 2014 onwards. This process is ongoing and its findings will be reflected in the future governance of the GMES Space Component.

Sentinel data policy – 'free and open'

The Sentinels are funded by ESA and EU Member States. Therefore they can define a data policy that is in fully in

line with the objectives of GMES. The EC and ESA have defined Sentinel data policy principles, which should eventually lead to a Sentinel data policy:

- Anybody can access all Sentinel data. In particular, no difference is made between public, commercial and scientific use.
- The licenses for the Sentinel data itself are free of charge.
- The Sentinel data will be made available to the users via a generic online access mode, free of charge. Generic online access is subject to user registration and 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 that affect data availability or timeliness, specific operational procedures will be activated.

These Sentinel data policy principles were approved by ESA Member States in September 2009. EC approval is expected in 2010.

GMES history

The GMES initiative began some 12 years ago when the main national space agencies, ESA, the EC and Eumetsat, started to discuss opportunities for Europe to establish an environmental and security information system. It became apparent that in an increasingly integrated world, where access to global information determines a region's political and strategic position, it was necessary to establish a system that supports European and national policies through adequate information. Since then, the first ideas have developed into reality, with the launch of the first operational satellites within the next years.

→ GMES milestones

- 1998** 'The Baveno Manifesto' founds the GMES initiative, presented at Baveno, Italy
- 2000** GMES partnership formed between Member States, space agencies, industry representatives, user organisations and the EC
- 2001** ESA Ministerial Council, Edinburgh: first GMES services are funded by ESA Member States (in parallel, EC funds GMES services through FP6)
- 2001** EU Summit, Gothenburg: Heads of State and Government request that 'the Community contributes to establishing by 2008 a European capacity for Global Monitoring for Environment and Security'
- 2004** EC Communication, 'GMES: Establishing a GMES capacity by 2008' introduces an Action Plan for a GMES capacity by 2008
- 2004** EC/ESA Framework Agreement signed, providing the basis for cooperation in space, including GMES
- 2005** ESA Ministerial Council, Berlin: optional ESA GMES Space Component (GSC) Programme adopted and first funds committed to specific GMES space hardware
- 2007** European Space Policy adopted, recognising GMES as a flagship of the European Space Policy, next to Galileo
- 2008** GMES Forum in Lille, France: five Core Services are officially launched: Marine monitoring, Land monitoring, Atmosphere monitoring, Emergency response and Security
- 2008** EC Communication, GMES: We care for a Safer Planet' establishes a basis for financing, operational infrastructure and management of GMES
- 2008** EC-ESA Agreement on GMES provides legal basis for EC FP7 contribution to GSC Programme
ESA Ministerial Council, The Hague: major ESA funding for GSC build-up
- 2010** GIO Regulation: EC proposes regulation for GMES Initial Operations (GIO), providing legal basis and EC funding for an operational GMES programme
- 2012+** Sentinel launch: Sentinel-1A scheduled for launch, followed by successive Sentinel launches to complete operational space-based observation capacity
- 2014+** EU Operational GMES Programme: aimed at ensuring long-term sustainability of operational programme

Funding the GMES Space Component

The GSC programme is organised in two overlapping phases, the build-up phase and operational phase. The current build-up phase coincides with the timeframe defined in the ESA GSC Programme Declaration, which lasts from 2006 until 2017. The operational phase is defined in accordance with the availability of operational funding from the EU, which is expected from 2014 onwards. This may not necessarily coincide with the operation of the Sentinel missions, which will commence after the Initial Orbit Validation period following each satellite's launch. Because these periods vary from Sentinel to Sentinel, and in order to define an operational period for programmatic purposes, this is linked with the establishment of the EU operational GMES Programme and the related funding for GMES including the GMES Space Component.

The GMES Space Component has been funded in successive steps. The first part of €268 million (2008 e.c.) was obtained at the 2005 ESA Ministerial Conference. This was supplemented by another €522 million (2008 e.c.) from ESA Member States in 2007 through subscriptions outside the frame of a Ministerial Conference. In 2008 and 2009, EC funding was committed through the signature of the EC/ESA Agreement on GMES and its First Amendment. The EC contribution amounts to €626 million (2008 e.c.), provided through its Seventh Framework

Programme. At the 2008 Ministerial Council, ESA Member States provided an additional €831 million (2008 e.c.). This brings the total GSC Programme funding to €2.3 billion (2008 e.c.), of which ESA Member States provide 72% and the EC 28%.

The EC has provided additional funding for GMES services and the *in situ* component in the order of €500 million.

For the GSC Operations phase, the EC is expected to take responsibility for financing the operational capacity, which includes the procurement of recurrent Sentinel satellites, access to Contributing Missions and routine Sentinel operations. ESA Member States are expected to contribute by financing R&D activities for the evolution of the GSC such as the development of next-generation satellites and ground segment infrastructure.

The EU GMES Operations Programme is expected to start in January 2014. In order to implement tasks attributed by the EC to ESA for the GSC operation a new agreement will need to be signed. The negotiation and approval process is expected to last about one year, therefore making EC funds effectively available for GSC operations from 2015 only. Because the first three Sentinels will be in orbit in 2013, it is necessary to bridge this period and to prepare transitional funding (GMES Initial Operations, GIO). The different elements concerned are the operation of the Sentinel-1, 2 and 3 A units, the launcher procurement for the Sentinel-1,

2 and 3 B units, advance procurements of critical parts and elements for the Sentinel-1, 2 and 3 C units and data access to Contributing Missions during the year 2014.

The total amount is €563 million (c.e.c.). It is important to note that these are not programme cost overruns, but necessary outstanding investments that would mostly occur in the next Financial Framework. Not being able to organise these funds in a timely manner will lead to a significant delay in providing the full operational service as well as incurring additional costs in the order of at least €400 million. The EC Regulation (*COM(2009) 223 final*), which is currently being negotiated by the European Parliament and EU Council, would cover part of these costs. However, according to current discussions, these amounts are by far not sufficient. Additional efforts are needed.

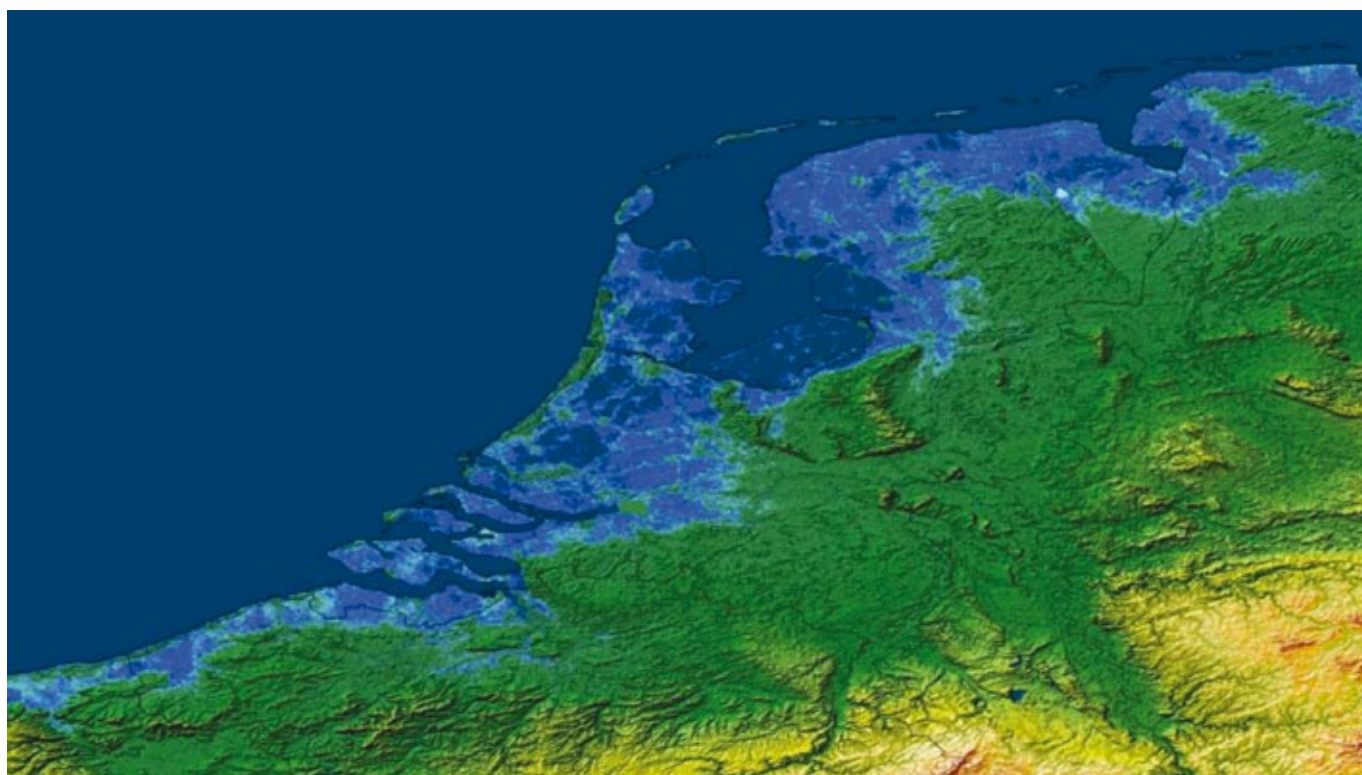
Governance of GMES and the GMES Space Component

The EC issued a Communication on '*GMES: Challenges and Next Steps for the Space Component*' in October 2009 (*COM(2009)589 final*), in which the respective roles of the European Union (EU), the EC and ESA within GMES in general, and within the GSC in particular, are addressed.

New terminology and concepts have been introduced. The EC leadership of the overall GMES programme has been reiterated, declaring the intention to be the GMES Programme Manager and to organise itself accordingly. ESA has been reconfirmed as the Coordinator of the GMES Space Component ('GSC Coordinator') while the European Environment Agency is proposed to coordinate the *In situ* Component.

ESA's function as GSC Coordinator has been described at a high level in several policy documents related to European Space Policy, including several Space Council Orientations, in EU and ESA policy documents and in EC Communications related to GMES. Based on the most recent EC Communication, a more detailed document was discussed at the EO Programme Board in February 2010, and updated for the May 2010 meeting, further explaining the role of ESA as GSC Coordinator. Accordingly, ESA would take prime responsibility – and be accountable – for the overall performance of the GSC throughout its lifetime.

Based on endorsed EU user needs, the GSC Coordinator will derive, and agree with the EC, space-based observation requirements, define the content of the GSC, define the end-to-end GSC architecture and be responsible for the development of dedicated infrastructure, i.e. the Sentinels and corresponding ground segment.



↑ Possible sea-level rise impacting the costs of in the Netherlands and Germany. Digital elevation data was used to create this traditional topography map, onto

which two layers are overlaid showing possible sea-level rises of 0.65 m (dark blue) and 1.3 m (light blue) (ESA/EAPRS/De Montfort Univ.)

↓ Non-exhaustive list of Synthetic Aperture Radar and Optical GMES Contributing Missions. The list is indicative and will evolve in order to keep up with new user requirements

GMES CONTRIBUTING MISSIONS		PRINCIPAL OWNER	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
MEDIUM / HIGH RESOLUTION	Sentinel-2A	ESA																
	Sentinel-2B	ESA																
	Sentinel-2C	ESA																
	SPOT 4	CNES																
	SPOT 5	CNES																
	SPOT Follow-on	InfoTerra/Astrium																
	RapidEye - 5 S/C	RapidEye																
	RapidEye Follow-on (TBC)	RapidEye																
	UK-DMC & UK-DMCII	DMCII																
	Deimos-1 DMC	Deimos																
	Seosat / Ingenio	CDTI																
	EnMap (Hypersp.)	DLR																
	PRISMA	ASI																
	Venus (Hypersp.)	CNES-ISA																
VERY HIGH RESOLUTION	Pléiades 1 & 2 (VHR)	CNES																
	HiRos (TBC)	DLR																
SAR MISSIONS	ERS-2 (C-Band)	ESA																
	Envisat ASAR (C-Band)	ESA																
	Sentinel-1A	ESA																
	Sentinel-1B	ESA																
	Sentinel-1C	ESA																
	TerraSAR-X (X-Band)	DLR																
	TerraSAR-X -2 (X-Band)	DLR																
	TanDEM-X (X-Band)	DLR																
	Cosmo-Skymed (X-Band) -S/C 1,2,3	ASI																
	Cosmo-Skymed (X-Band) -S/C 4	ASI																
	Cosmo-Skymed 2nd gen (X-Band)	ASI																
	Radarsat-2 (C-Band)	CSA																
	RCM (C-Band)	CSA																
SeoSAR/PAZ (X-Band)	CDTI																	

in orbit approved planned

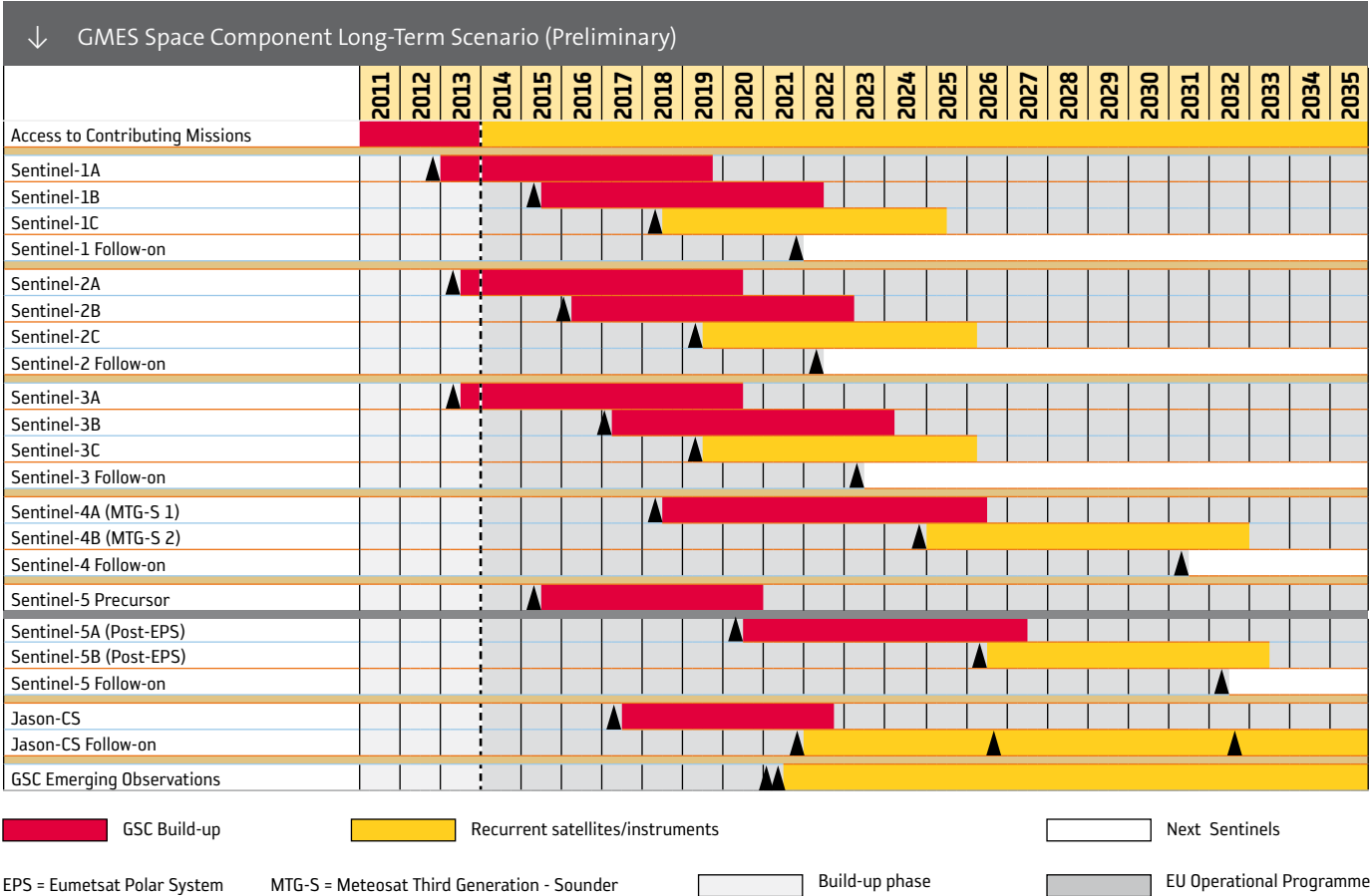
Apart from being the development agency for the GSC, ESA will also procure recurrent elements funded by the EU on its behalf, ensure the operation of Sentinel missions and organise the access to Contributing Missions.

Regarding the GSC operation, EU and ESA Member States have already identified Eumetsat as the operator of the marine part of Sentinel-3 and of Sentinel-4 and 5, while ESA was identified as *ad interim* operator of Sentinel-1, 2 and the land part of Sentinel-3; it does not exclude that this function might also become permanent.

The ESA tasks will be carried out through industrial contracts in the EU/ESA Member States. Flight operations will be performed at the European Space Operations Centre (ESOC), Darmstadt, and payload operations will be managed from ESORIN, ESA's centre for Earth observation in Frascati. The ground segment build-up and operations rely on a decentralised approach whereby the main facilities are also developed and operated in individual Member States.

The overall coordination of GMES activities will be ensured through a newly established GMES Partners Board, which is to be chaired by the EC and comprises the EU Member States as members, and Switzerland, Norway and several European organisations including ESA as observers. The Partners Board is an advisory body. Budget and implementation decisions are made at the respective decision bodies of the funding organisations, in particular the ESA Programme Board for Earth Observation and Council for funds from ESA Member States and the respective EC Programme Committees for funds provided by the EU. The ESA and EU decision bodies have met jointly, and may continue to do so on an ad hoc basis if joint decisions on GMES issues involving the GMES Space Component are required.

This set-up, to govern issues related to the GSC build-up and initial operations, is currently in place and is expected to cover the period up to the end of 2013. It may be modified once the EU GMES Operational Programme is in place from 2014 onwards.



Major challenges still ahead

GMES and the GMES Space Component have progressed reasonably well over the past years. The excellent cooperation between the two key organisations, the EC and ESA, together with their respective Member States, has been instrumental in this achievement. It also confirms that a balanced approach between ‘user-pull’ and ‘technology-push’ is required, as neither of them would succeed alone in obtaining a long-term sustainable space applications programme that serves European and national policy needs.

Once operational, GMES will be unique in the world. GMES will provide what is done successfully today in meteorology, namely to combine satellite and *in situ* observations with forecast models, to obtain information services needed by institutions and individual citizens alike. GMES will extend this concept to domains such as agricultural monitoring and food supply forecasting, fisheries, ship-routing, urban planning, climate change studies, emergency response, humanitarian aid, external EU actions, border surveillance or maritime security, to name just a few.

Such an integrated Earth observation system does not exist in any other country or region. Europe will prove that the combined efforts of all its Member States, coupled with strong institutional leadership, will lead to major societal and economic benefits for its citizens.

The biggest challenge, however, is to ensure the programme’s sustainability. Sufficient funds need to be allocated in the next EU Financial Framework in order to allow the full operation of GMES including the GMES Space Component. As significant funding is required it will necessitate the full political support of the EU Member States. ESA and its Member States can and will certainly assist in the best possible way, although it can only do so within the institutional limits given that the prime responsibility for GMES lies with the EU.

ESA and its Member States have clearly identified what is needed for the GMES Space Component. The GSC Long-term Scenario was acknowledged by the Space Council as the basis for developing a long-term funding strategy up to 2030. The same document was elaborated in close consultation with the ESA Programme Board for Earth Observation and ESA Council. The EC has taken on board the financial estimates required for the GSC operation in its recent GMES Communication. But ensuring that they will actually be obtained in the next Financial Framework remains a challenge as the need for space-related funding will be weighed against other needs of the EU, such as agriculture, regional development, etc. Therefore the GMES community must be adamant in presenting a unique and strong mandate to the EC and EU, and their Member States in order to succeed in the negotiation of a strong GMES budget in the next EU Financial Framework.