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IMPACT ASSESSMENT

Accompanying document to the

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

"Global Monitoring for Environment and Security (GMES): Challenges and Next Steps for the Space Component"

{COM(2009) 589 final}
{SEC(2009) 1439}
{SEC(2009) 1441}

This report commits only the Commission's services involved in its preparation and does not prejudge the final form of any decision to be taken by the Commission.

IMPACT ASSESSMENT

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1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1. Organisation and timing

This Impact Assessment accompanies a Commission Communication entitled "Global Monitoring for Environment and Security (GMES): Challenges and Next Steps for the Space Component". A general description of GMES can be found in Annex I, a list of abbreviations is contained in Annex VI. The political context for presenting this proposal at this time is explained below in section 2.1.

The Impact Assessment was elaborated in consultation with a Steering group to which representatives of the following DGs were invited: ENV, BUDG, SG, RTD, AGRI, ESTAT, JRC, RTD, TAXUD, DEV, AIDCO, ECHO, INFSO, TREN, RELEX, MARE, REGIO and JLS. The Steering group met twice[1] and was consulted on the draft submitted herewith.

The Impact Assessment was discussed by the Commission's Impact Assessment Board (IAB) on 9 September 2009. In the discussion, as reflected in the IAB opinion issued on 11 September 2009, the author DG agreed to indicate more explicitly the interactions between GMES components; that costs and benefits depend on all components; to clarify the issues of ownership and funding of the Space and other components; to better explain the timing of the proposal; and to present more clearly the positions of stakeholders on the different IA options.

As a consequence, the present Impact Assessment report has been modified as follows:

– Section 1.3 has been expanded to better reflect the positions of stakeholders with respect to the GSC financing, and has integrated the former Annex III;

– Section 2.1 has been integrated with a chapter on the policy context and timing of the foreseen Communication and with an additional chapter justifying the focus on the Space component;

– At the beginning of section 4 and in chapter 5.1 it has been made clear that while all options are centred on the Space component, costs and benefits depend more in general on variations of the whole GMES system, i.e. on variations also of the in situ and services components;

– Section 4.2.3 on data and information policy has been integrated to better explain the rationale behind full and open access;

– Section 4.2.4 on financing schemes has been modified to clarify that different co-financing options are open for the other GMES components;

– A specific section on ownership has been added (4.2.4.3).

1.2. Stakeholders consultation

- This Impact Assessment is based on a number of external studies (see Annex II) and a multiannual consultation process of stakeholders which has been organised by the European Commission's GMES Bureau[2]. This consultation process was launched with the

[1] On 15 July 2009 and 23 July 2009.

[2] The GMES Bureau is the Commission's focal point for all GMES matters. It was initially created in 2006 with a mandate of three years. In 2009, the mandate has been extended until end 2010. From the administrative point of view, the Bureau is a Unit of DG Enterprise and Industry

Communication entitled “GMES: from concept to reality”[3] and led to the adoption of the 2008 Communication entitled "GMES: we care for a safer Planet"[4]. Further consultation was performed in order to prepare the Commission proposal for a Regulation on the European Earth observation programme (GMES) and its initial operations (2011-2013) (the "GMES proposal")[5]. This multiannual consultation process included:

- thematic workshops with users of Earth observation-based information services;
- the establishment of 'Implementation Groups' composed of user representatives. The Implementation Groups prepared recommendations concerning the scope, architecture and implementation plans for each thematic area in the service component, including the necessary infrastructure requirements;
- the consultation of national GMES coordinators, appointed by their respective Member States, in the framework of the GMES Advisory Council, an expert group with the mandate to provide strategic advice to the GMES Bureau, foster the co-ordination between European and national activities, and facilitate consensus-building in the relevant communities around the development of GMES;
- regular bilateral meetings between the European Commission's GMES Bureau and stakeholders from industry, regions and other players; and
- conferences[6] dedicated to GMES by successive EU Presidencies.

1.3. Key issues regarding the GMES Space Component emerging from the stakeholders consultation

The stakeholder consultation referred to in section 1.2. has clearly demonstrated that users cannot rely on research projects only. They need access to reliable and accurate data and information that is made available in a timely fashion, which requires a sustainable Earth observation infrastructure.

Operational information services depend on a continuous flow of inputs from the GMES infrastructure component. The present analysis focuses on the GMES Space Component (GSC), i.e. Earth observation satellites producing data needed for GMES.

The GSC depends on the space infrastructure mission lifecycle, which is driven by service requirements and which determines the roles and responsibilities of the various actors, funding sources and decision-making process. This lifecycle includes the following stages:

- development stage; and
- exploitation stage, which could include recurrent elements of an operational series[7].

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3 COM (2005) 565 final of 10 November 2005

4 COM(2008)748 final of 11.12.2008.

5 COM(2009) 223 final of 20.5.2009.

6 See e.g. the conference organised by the Austrian presidency in June 2006 “A Market for GMES in Europe and its regions - the Graz Dialogue”, the Munich conference "The Way to the European Earth Observation System GMES - Munich Roadmap" organised by the German presidency in April 2007, the “Bridging the Gap: Responding to environmental change - from words to deeds” conference, hosted by the Slovenian presidency in Portoroz in May 2008, the GMES Forum organised by the French presidency in Lille in September 2008, and the conference entitled "Towards eEnvironment" which took place on 25-27 March 2009, in Prague.

7 For instance, regarding the Sentinel missions, the recurrent units are defined as those units that follow after the completion of the full operational capability. In addition, it is essential that also during the

Stakeholders agree that the main challenge today is to ensure the implementation of the second stage mentioned above. This is true for a major part of GSC missions, including the ESA Sentinels and most of the national missions in Europe.

The current situation presents gaps and cannot guarantee the availability and continuity of the whole GSC mission range and mission lifecycle described above. The availability of GSC missions covering the second stage of lifecycle, i.e. exploitation including recurrent elements of operational series, should be specifically considered. This would imply organising different funding and associated procurement policies.

In addition, stakeholders underlined the importance to:

- establish operational financing sources and the associated industrial policy for infrastructure and data;
- ensure that the GSC corresponds to the requirements of the GMES services component;
- ensure a stable programmatic approach for the GMES mission lifecycle with special focus on a sustainable approach for recurrent elements of operational series;
- identify how the GSC can benefit from existing and planned national, intergovernmental and commercial missions and how GMES can generate a positive impact on these missions;
- finalise content and costing of the GSC through overall consensus of the long-term GSC implementation plans to be coordinated by ESA;
- identify operating entities and specify their roles;
- establish decision-making processes for the GSC within the GMES overall governance.

The contributions of two intergovernmental organisations – the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) to the public consultation "Reforming the budget, changing Europe"[8] are of particular interest to highlight the position of their Member States, which include several EU Member States. ESA[9] calls for a "*multi-annual commitment of funding to establish and sustain spaced-based infrastructure and services for which the EU is to be the major user. The EU should consider addressing these issues in its future budgets and the rules which govern expenditure. Potential actions could include establishing a dedicated budget line for necessary operational satellite-based systems, beginning with the Global Monitoring for Environment and Security services, and rules relating to EU ownership of related assets*."

EUMETSAT recommended that the EU budget "*plan for the co-existence of separate funding mechanisms […] covering Research and Development activities on the one hand and operational activities on the other hand*."

At an Information Day organised in September 2009 with industry on the data policy of the GSC, two main issues were raised by industry stakeholders: (i) the downstream services industry welcomes the proposed free and open access to Sentinels data, which they expect to open new market opportunities; and (ii) the existing satellite data providers have a more "wait-and-see" attitude as they see at the same time opportunities from "data buy" contracts to

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operational stage R&D elements are implemented, e.g. for the development of the next generation Sentinels, which will incur the need for R&D funds.

8 SEC(2007) 1188 final of 12.9.2007.

9 ESA contribution is signed by the agency's Director-General, who has consulted ESA Member States in the ESA Council on it.

feed GMES services and threats from competition between their data and Sentinel data in some limited domains.

Member States representatives in the GMES Advisory Council, a group assisting the Commission in the development of GMES, have also expressed in various occasions their support to the EU engagement in and financing of GMES Space component operations. For instance, when discussing in March 2009 the preparation of the proposal for a GMES programme and its initial operations, Member States supported the establishment of a budget line for operating satellites, and some even questioned whether the potentially available budget would be sufficient. The ESA representative underlined, in that occasion, that the Space Agency's Programme Board on Earth observation delegates "*clearly stated that they will not contribute to the operation of the Sentinels, then it is the EC responsibility, as it represents the users' communities, to find the necessary funding sources*". This position was not challenged by any EU Member States' delegates, who on the contrary called on the Commission to make all efforts to fill the budget gap. Germany informed the Commission in writing that "*Germany will continue to provide active support to the European Commission in developing the programme and taking on responsibility for the long-term operation of GMES*"[10]. A comparable position had already been expressed e.g. by Spain at the 198th meeting of the ESA Council on 15 February 2008 and France at the 203rd ESA Council of 15 October 2008.

2. WHAT IS THE CHALLENGE?

2.1. Overall context and objectives

2.1.1. Political context and timing of the proposed Communication

GMES has been an EU initiative for more than 10 years. This initiative has been shaped under the current Commission mandate towards an EU Programme. In the last Communication on GMES, adopted in November 2008, the Commission presented:

– the need for an EU GMES Programme to be proposed already in 2009;

– the architecture (including the space, service and in-situ components) and governance that needs to be put in place;

– the method to estimate the financing needs of GMES.

There has been strong political support for the approach proposed by the Commission by Member States both at the EU Council and at the Councils of important stakeholders (ESA, EUMETSAT). The Competitiveness Council in December 2008 invited the Commission to implement quickly as from 2009 its Communication; the Space Council in May welcomed the Commission proposal for the GMES Regulation. The ESA Council in November 2008 allocated additional funding to the development phase of the space component and invited the EU to complete all necessary preparations for the operations and replenishment of the developed infrastructure. The Communication was thus followed by a proposal for a Regulation on the European Earth observation programme (GMES) and its initial operations (2011-2013).

The main objective of the foreseen Communication on the GMES Space Component is to present the position of the Commission vis-à-vis the political expectation of EU Member States and Member States of the main intergovernmental stakeholders. In particular, it aims at

[10] See the letter from the German Infrastructure Ministry to H. Zourek dated 9 February 2009.

outlining the key actions to be taken in order to ensure a sustainable environmental data flow from space.

Thus, without prejudice to the future decisions that will be taken by the Commission in the context of the preparation the financial framework post-2013, a Communication on the space component before the end of 2009 is necessary for the following main reasons:

- to facilitate the negotiations with Council and Parliament for the GMES Programme Regulation, that needs to be adopted early in order to be implemented in 2011. Member States have asked the Commission to put priority on the space component in the context of this proposal. Clarity on the intention for the long-term arrangements will facilitate adopting arrangements on the short-term.
- to prepare the ground for an analysis of all components by the Commission for the period post-2013. This analysis needs to be performed in order to feed the discussions and the assessment of the priorities of the various Community programmes in the broader context of the definition of the next Multiannual framework.

2.1.2. Background

In the last thirty years, substantial R&D efforts in the field of Earth observation have been made by the EU, the European Space Agency (ESA) and their respective Member States, with a view to developing Earth observation infrastructure information services. These efforts led to the development of world-class scientific Earth observation satellites, operational meteorological satellites managed by European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)[11] and operational imaging missions at national level (both civil and military). However, at European level no coherent for operating environmental satellites was in place. Without such an operational framework, it would be difficult for the EU to obtain sufficient information on the state of the environment and climate change. GMES has been launched to respond to this need.

2.1.3. EU objectives

The general EU objectives for GMES are to

- enable sustainable Earth observation information services, tailored to the needs of users, including public policy makers and private citizens. The GMES service component will allow public policy makers in particular to
  - prepare national, European, and international legislation on environmental matters, including climate change;
  - monitor the implementation of this legislation;
  - access comprehensive and accurate information concerning security matters (e.g. for border surveillance).
- ensure the continuous availability of the observation infrastructure necessary for the thematic areas in the GMES service component, either through the establishment of partnerships with infrastructure owners, or through the development of new infrastructure in the event existing infrastructure is not sufficient to produce the data needed;
- give a boost to the Earth observation sector in Europe, by creating opportunities for increased private sector usage of Earth observation-based information sources, and by

[11] Like ESA, EUMETSAT is an intergovernmental organisation outside the EU framework.

facilitating market uptake by value-adding service providers, many of which are small and medium enterprises (SME).

2.1.4. Content of GMES

As outlined in Article 2 of the Commission proposal for a Regulation of the European Parliament and the Council on the European Earth observation programme (GMES) and its initial operations (2011 – 2013)[12], GMES consists of the following:

(a) a service component ensuring access to information covering the following thematic areas:

- land monitoring;
- emergency management;
- security;
- monitoring of the marine environment;
- atmosphere monitoring;
- climate change adaptation and mitigation;

(b) a space component ensuring sustainable space-borne observations for the thematic areas referred to in point (a);

(c) an *in situ* component ensuring observations through airborne, seaborne and ground-based installations for the thematic areas referred to in point (a).

2.1.5. The focus on the Space component

The foreseen Communication should be seen in the context of the 2008 Communication, which presented the full architecture of GMES and made clear that the Space developments are driven by the user needs.

All components are intrinsic parts of the GMES architecture. They all have specific characteristics which need to be addressed. The infrastructure component generates data. The services component processes these data in order to produce information for users. The interactions between components have been established following the user needs definition process and the result is implemented in each component of GMES. More specifically, the content of the space component depends on the needs of the services, which in turn have been derived from user needs. The space component is therefore not analysed in isolation. On the contrary, the zoom on the space component following the overarching analysis contained in the 2008 GMES Communication fully takes into consideration the other components.

The foreseen Communication focuses on the space component where there is still an urgent need to define a more concrete basis to ensure the functioning of the Sentinels, notably in view of the implementation of the proposed GMES Programme regulation currently under co-decision.

Regarding the in-situ and service components, work on the stabilisation of the cost estimates is ongoing. For the in-situ component, the 2008 Communication acknowledged that it mostly falls within the remit of Member States. According to the subsidiarity principle, Community action for this component should focus on coordination and some specific limited infrastructure aspects, notably linked to global networks. For the services, the next step is to

[12] COM(2009) 223 final of 20 May 2009 (the "GMES proposal").

launch the process for reaching a common vision with Member States on the basis for cost estimates for the services beyond the initial operations.

In any case, long-term commitments on the space component by the EU would pave the way to ensuring the sustainability of the services, and overall coherence across components will be maintained in the programme proposal to be submitted for the period after 2013.

2.1.6. Timeline and financing

GMES is a system of systems that relies on inputs from existing satellite constellations, *in situ* installations and service infrastructure. Different components or sub-components of GMES could therefore enter into operation at different stages. The Commission thus used the concept of gradual implementation in the 2005 GMES Communication, starting with three fast-track services[13], and later the term "modular approach"[14]. From a governance perspective, three stages of GMES can be distinguished, namely (i) pre-operational activities lasting up to the end of 2013, financed through FP5, FP6 and FP 7, (ii) GMES initial operations (2011 – 2013), to be financed on the basis of the regulation proposed by the Commission on 20 May 2009, and (iii) GMES exploitation post-2013, which will continue to be accompanied by research activities.

Within FP 6, the EU has spent EUR 100 million on GMES projects, whereas ESA invested another EUR 100 million in the GMES Service Elements projects. In the space theme of the specific programme "cooperation" of FP 7, the EU will make available approximately EUR 430 million for GMES information service projects between 2007 and 2013. Additionally, EUR 624 million from the space theme of FP 7 will be used to contribute to the development of the ESA Space component programme[15], which amounts to EUR 2246 million (2008 prices) in total, including funds contributed by ESA Member States[16].

First information services in the field of emergency management and land monitoring are being financed under preparatory actions in addition to some other operational elements in the land domain (Corine Land Cover, Urban Atlas).

At the beginning of the next decade (2011 – 2013), services could be provided on a larger scale, in line with the GMES proposal. This proposal is intended not only to transform GMES from a political initiative into a coherent programme, but also to ensure the financing of services and the GMES space component, necessary for the operation of GMES during the period 2011 - 2013. The Commission proposes that the overall financial envelope for GMES initial operations should be EUR 107 million, 40 million of which are to be dedicated to the operation of the Space component. It is envisaged that this financial envelope will be complemented by an amount of EUR 43 million from the space theme of the Seventh Framework Programme for research actions accompanying GMES initial operations.

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13 See the Communication entitled "Global Monitoring for Environment and Security (GMES): From Concept to Reality" COM(2005) 565 final of 10.11.2005 (the "2005 GMES Communication"), p. 7 – 8.

14 See the Communication entitled Global Monitoring for Environment and Security (GMES): we care for a safer planet", COM(2008)748 final of 12.11.2008 (the "2008 GMES Communication"), p. 6, and the Commission Staff Working Document accompanying the Communication "Global Monitoring for Environment and Security (GMES): we Care for a safer planet" - Impact Assessment, SEC(2008) 2808 of 12.11.2008, p. 20.

15 For more details, see section 2.2. below.

16 See also the Commission Staff Working Document accompanying the proposal for a regulation of the European Parliament and the Council on the European Earth observation programme (GMES) and its initial operations (2011 – 2013), Impact Assessment and ex ante evaluation, SEC(2009)639 of 20 May 2009, p. 2 (the "Impact Assessment accompanying the GMES proposal").

Should the Regulation be adopted by Council and Parliament without significant budget changes, the estimated overall amount made available to the GSC (including FP 7 funds for satellite development and funds for data access and Sentinel operations in the GMES initial operations envelope) would be around EUR 233 million in 2013.

In coherence with the strategy adopted and investments made so far, it is foreseen that the exploitation of GMES continues after 2013, on the basis of a Basic Act that will be proposed by the Commission in 2011 at the latest, as part of the preparation of the next multiannual financial framework. The detailed exploitation costs post-2013 will be analysed in the Impact Assessment accompanying the proposal for such Basic Act. With regard to the GSC, in its Resolution adopted at the 6th Space Council meeting[17] of 29 May 2009, the Council recalled the need to define, at national and European levels, a sustainable funding approach for the GMES Space Component based on an assessment of the overall financing needs for this infrastructure.

2.2. Problem definition

2.2.1. The GMES Space Component

As mentioned above, GMES services depend on the sustainability of the GMES infrastructure components, in particular the space component. Space data is a key input into the GMES service component. If the flow of space data is interrupted or comes to an end, for instance because the underlying infrastructure is not operational any more, this means that a given service cannot be provided.

The thematic areas within the GMES service component will rely both on access to data from existing Earth observation satellites owned by third parties, including EU Member States, intergovernmental organisations such as ESA and EUMETSAT, non-EU countries and private entities (hereinafter referred to as "data access"[18]), and on space infrastructure developed specifically for GMES. Given that it is a major principle of GMES that the Community should not duplicate existing capacities in Europe, the selection of the latter infrastructure was based on a detailed "gap analysis", in order to establish to what extent the user requirements compiled by the EU could not be met by existing or planned infrastructure.

The result of this "gap analysis" led to the definition of the content of the ESA GMES Space component programme referred to above, to which the EU contributes financially. This programme aims at developing a number of satellite missions known as “the Sentinels”, as follows:

- Sentinel-1: high-resolution synthetic aperture radar (SAR) imaging, which can be used for imaging even in the case of cloud cover;
- Sentinel-2: high-resolution multispectral imaging;
- Sentinel-3: global ocean and land monitoring;
- Sentinel-4: geostationary atmospheric monitoring;

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17 The Space Council is a joint and concomitant meeting of the Council of the EU and the ESA Council meeting at ministerial level, in line with Article 8 of the Framework Agreement between the European Community and the European Space Agency, published in OJ L 261/66 of 6.8.2004.

18 Existing space missions that will provide data for GMES include Spot, TerraSAR-X, EUMETSAT satellites, CosmoSkymed, DMC Deimos, Ikonos, GeoEye, and Quickbird.

- Sentinel-5: low-orbit atmospheric monitoring[19].

The first constellations of Sentinels that are currently developed in the framework of the ESA GSC programme include the first two Units of Sentinel 1 to 3, the first two Units of Sentinel 4 and the Sentinel 5 precursor, i.e. 7 satellites and two instruments flown onboard of EUMETSAT satellites. These missions are necessary to fill gaps regarding space data needed for GMES services. The technical content of the Sentinels missions and the launch schedule are described in more detail in Annex IV.

2.2.2. What is the problem?

The ESA GSC programme comprises the development of an initial constellation of the Sentinels, but not their exploitation once in orbit. Exploitation activities include the control of the satellites themselves, of the instruments onboard, the processing of observation data collected through these instruments and the timely distribution of data to GMES users. Exploitation activities are necessary to collect the environmental data that will serve as an input for the thematic areas within the GMES service component. The problem is therefore to manage and finance:

- the exploitation of the initial constellations of Sentinels developed by ESA in the framework of the ESA GSC programme, after the end of the development phase, and;
- the renewal of the Sentinels, many of which have a life span of around seven years, in parallel to the exploitation of the initial constellations of Sentinels, thereby paving the way for long-term continuity of data collection.

The financing and management of the exploitation of the Sentinels has been discussed in several documents, including the Commission Communication entitled "Global monitoring for Environment and Security (GMES): we care for a safer planet"[20]. As outlined in chapter 5 of this Communication, a future Community Programme should contribute to the sustainability of the space infrastructure, notably to the in-orbit availability and operations. Nevertheless, it was not possible to take any binding decisions concerning the financing of the exploitation of the Sentinels on the EU side, as the period in questions goes beyond the current financial framework. A decision on the financing of the space component therefore needs to be prepared soon, in the context of the preparation of the next multiannual financial framework.

ESA Member States have made clear that the Sentinel infrastructure represents their contribution to the GMES Space Component and that their financial effort[21] is made on the assumption that EU will take over the responsibility for the exploitation and renewal across time of an equivalent infrastructure, under EU funding.[22] It is thus unlikely that, in the absence of EU commitment, an organisation other than the EU would assume responsibility

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19 See V. Liebig/J. Aschbacher/S. Briggs/G. Kohlhammer/R. Zobl, GMES - Global Monitoring for Environment and Security: The Second European Flagship in Space, ESA Bulletin 130 (May 2007), 14 – 15.

20 COM (2008) 748 final of 12 November 2008

21 See section 2.1.4.

22 See e.g. the minutes of the 198th meeting of the ESA Council on 15 February 2008, p. 4, and the minutes of the 203rd meeting of the ESA Council on 15 and 16 October 2008, p. 6.

for the GSC beyond 2013. Consequently, the GMES service component as it is currently conceived could not exist[23].

2.3. Does the EU have the right to act?

It is envisaged that the legal basis for operations post-2013 will continue to be the title on Industry in the EC Treaty (or of the Treaty on the functioning of the EU, once ratified)[24], which does not establish an exclusive competence for the EU. It is therefore necessary to ensure that the subsidiarity and proportionality principles are respected.

2.3.1. Subsidiarity

Subsidiarity means that the Community shall take action only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States and can therefore, by reason of the scale or effects of the proposed action, be better achieved by the Community.

The Community contribution to the exploitation and eventually the renewal of space infrastructure developed at European level is fully in line with the subsidiarity principle, for the following reason:

Assuming responsibility for the exploitation and possibly the renewal of space infrastructure developed with Community and intergovernmental funds cannot be sufficiently achieved by the Member States because of the costs incurred. It is precisely for this reason that in the field of space-based observation for operational meteorology, European States have pooled their resources to develop and exploit meteorological satellites in the framework of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). European States also developed demonstrators of environmental satellites either through ESA or through national space agencies. They could, however, not find a way to co-operate with regard to the funding of sustained operational programmes in the field of environmental monitoring similar to those in meteorology. However the need for continuing such observations is becoming critical, in consideration of the increasing political pressure for public authorities taking informed decisions in the field of environment, security and climate change.

2.3.2. Proportionality

Any action by the Community shall not go beyond what is necessary to achieve the objectives of the EC Treaty. The EU action under consideration in this document relates to the exploitation and renewal across time of the Sentinel infrastructure. The data expected to flow out of this infrastructure is of common public interest and its continuous availability is recognised as being essential in the field of environment, security, and climate change monitoring, both for public policies and for boosting the development of downstream applications. As outlined in section 2.2.1, it is a major principle of GMES that the Community should not duplicate existing capacities in Europe. The selection of the Sentinel infrastructure was thus based on a detailed "gap analysis" to establish to what extent the user requirements compiled by the EU could not be met by existing or planned infrastructure. The scope of the Sentinel infrastructure currently under development is the result of an existing consensus, and

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[23] See also recital 12 of the proposal for GMES Regulation. Although it would be possible to provide some services only on the basis of *in situ* data, or data from missions other than the Sentinels, such services would not be comparable any more to the thematic areas in the GMES service component.

[24] See also the proposal for a Regulation of the European Parliament and the Council on the European Earth observation programme (GMES) and its initial operations (201 – 2013), COM(2009)223 final of 20.5.2009.

therefore does not overlap with other Space infrastructure, nor does it crowd out private investment. Consequently, the financing of this space infrastructure does not go beyond what is necessary to achieve the objectives of GMES and is therefore fully in line with the proportionality principle.

3. OBJECTIVES

3.1. General objectives

The general objectives of the proposed Communication correspond to the EU objectives for GMES itself, as outlined in section 2.1. above, without pre-judging future decisions to be taken in the preparation of the next multiannual financial framework.

3.2. Specific objectives

The specific objectives of the EU actions relating to the GMES space component (i.e. the Sentinels) are to:

- ensure the continuous availability of environmental data collected through a set of space-based sensors as an input for the thematic areas in the GMES service component; through:

– the continuous exploitation of the Sentinels and accompanying research activities through adequate governance and financing structures;

– the timely definition, development and procurement actions for renewing the Sentinels as necessary;

- stimulate, by lowering the costs of access to earth observation data, the growth of the Earth Observation downstream sector in terms of jobs, innovation and international competitiveness.

3.3. Consistency with other EU policies

GMES is the second flagship programme of the European space policy. The importance of GMES has been underlined in many official documents[25]. Whereas the overall GMES initiative, including its service component, concerns several EU policies, including climate change adaptation and mitigation, environment, transport, external relations, and development aid[26], in the field of the GSC it is mainly the European Global Navigation Satellite Systems (GNSS) programmes (Galileo and EGNOS[27]) that are of relevance. This is because the GNSS programmes are the only other space infrastructure programmes managed directly by the Community. Lessons learnt from other major infrastructure programmes to which the Community contributes, including the Single European Sky ATM Research (SESAR) programme in the field of air traffic management, and ITER in the field of nuclear fusion, will be taken into consideration, where appropriate.

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25 For an overview of these documents, see the Commission Staff Working Document accompanying the 2008 Communication - Impact Assessment, SEC(2008) 2808 of 12.11.2008 (the "2008 GMES Impact Assessment"), Annex IV. GMES also was a key topic of the orientations adopted at the 6th Space Council of 29 May 2009.

26 For an overview see the Commission Staff Working Document accompanying the proposal for a regulation of the European Parliament and the Council on the European Earth observation programme (GMES) and its initial operations (2011 – 2013), Impact Assessment and ex ante evaluation, SEC(2009)639 of 20 May 2009 (the "Impact Assessment accompanying the GMES proposal"), section 3.4 and Annex IV.

27 the European Geostationary Navigation Overlay Service (EGNOS), a predecessor of Galileo

It should be underlined that major differences exist between Galileo and GMES. Technically speaking, GMES and Galileo cover two different fields: GMES is essentially an Earth observation programme, whereas Galileo is a satellite navigation programme.

Nevertheless it is of paramount importance to avoid inconsistencies between Galileo and GMES, to use synergies to the maximum extent possible, and to take into consideration lessons learned from Galileo and EGNOS. In order to ensure coherence between Galileo and GMES, staff members of DG TREN and DG ENTR are in regular contacts at working level.

4. POLICY OPTIONS

It has been recalled that GMES comprises a services component and an infrastructure component, the latter comprising in turn in situ infrastructure and space infrastructure.

As the scope of the current report only covers the space infrastructure, options are modulated on the GSC, assuming that the in situ and services components are adequate and do not change in any of the options.

4.1. Definition of the options

The policy options at hand to address the objectives as defined in Chapter 3 above are as follows:

- Option 1:

Option 1 corresponds to the baseline scenario. Under the baseline scenario, the EU would not assume responsibility for the exploitation of the Sentinels after GMES initial operations (2011 – 2013). This means that the EU would not exploit the GSC at all beyond 2013. As outlined in section 4.2.4, it cannot be assumed that another entity would be willing to finance the totality of the Sentinel exploitation costs. Consequently, no data collected through the Sentinels would be available for the thematic areas in the GMES service component.

- Option 2:

Comprises the EU financing and management of the exploitation only of the first constellations of Sentinels, but not the renewal of the Sentinels[28]. The first constellations of Sentinels are currently being developed in the framework of the ESA GSC programme and include the first two Units of Sentinel 1 to 3, the first two Units of Sentinel 4 and the Sentinel 5 precursor, i.e. 7 satellites and two instruments flown onboard of EUMETSAT satellites. It is therefore assumed that under Option 2 no data from Sentinels will be available beyond the first constellation of Sentinels.

- Option 3:

Comprises the EU financing and management of (i) the exploitation of the initial constellations of Sentinels, and (ii) the renewal of space infrastructure to ensure sustainable observation over time, taking into consideration that most of the units of the Sentinels currently developed have a nominal lifetime of seven years and that the thematic areas in the GMES service component rely on a continuous access to the corresponding data. Decisions on the renewal will have to be taken in parallel to the exploitation of the initial constellations of Sentinels.

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[28] The assumptions concerning financing schemes are discussed in more detail in section 4.2.2. In particular, a PPP is not envisaged at this stage.

4.2. Underlying assumptions

4.2.1. Accompanying research activities

In options 2 and 3, exploitation activities will be accompanied by research activities carried out with a view to optimising existing technologies and preparing new generations of earth observation instruments of relevance for GMES. These R&D activities could be financed e.g. through the Community framework programmes for research, technological development and validation activities, and ESA programmes.

4.2.2. Data access activities

Both options 2 and 3 include data access activities, i.e. access to data from existing Earth observation satellites owned by third parties including EU Member States, intergovernmental organisations such as ESA and EUMETSAT, non-EU countries and private entities. It should be recalled that, without the Sentinels, access to data from third party missions is insufficient to meet service requirements[29], even when coupled with *in situ* data.

4.2.3. Full and open access to GMES data and information

The objective of full and open access to GMES data and information was endorsed by the Commission in chapter 3 of the 2008 GMES Communication and is contained in Article 8 of the GMES proposal. The rationale for this approach was already outlined in the Impact Assessment reports accompanying those documents.

In a nutshell, the reason why GMES data and information should be fully and openly accessible is that full and open access will help to promote the widest possible use and sharing of data and information. Downstream service providers could use GMES information and data as an input to provide and market innovative services. Studies have identified the cost of data as a major obstacle to the development of this market and a barrier to entry[30]. This was also demonstrated during the review of the Directive on the re-use of public sector information (the PSI Directive)[31]. These findings have been confirmed by the industry stakeholders' consultation process, in particular at the 11 September 2009 Sentinel data policy information day.

Generally speaking, the GMES Data and Information policy should help to promote the widest possible use and sharing of Earth observation data and information in line with the framework for the dissemination of environmental and geospatial information (SEIS and INSPIRE)[32]. Further, it is recalled that the Community has endorsed the principle of full and open access to Earth observation data when it adopted the Resolution of the Third Earth Observation Summit on 16 February 2005. This Resolution includes a reference to the 10-Year Implementation Plan of Earth Observation System of Systems (GEOSS), which contains the principle of full and open access.

Additionally, it should be noted that beneficiaries of Community funding would be mostly public authorities. This is why, at least in an initial period, it seems advisable to make

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29 See also section 2.2.1

30 See e.g. ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 13.

31 Directive 2003/98/EC of the European Parliament and of the Council of 17 November 2003 on the re-use of public sector information, OJ L 345/90 of 31.12.2003. Respondents to the public consultation in the framework of the review (available at http://ec.europa.eu/information_society/policy/psi/docs/pdfs/online_consultation/report_psi_online_consultaion_stakeholders.pdf) have signalled that the high prices charged for PSI may be limiting the economic development of particular sectors.

32 See p 5 of the 2008 Communication.

available data fully and openly, especially considering the current small size of the sector. A full and open data policy also means that at least in the short and medium run, the provision of GMES services would not be based on a concession or Public Private Partnership (PPP) scheme[33].

In the light of the above elements, it is considered disproportionate to analyse alternative options to full and open access, given that this issue has already been subject to various assessments in the recent past and that the policy for the distribution of GMES data and information has been agreed upon by the Commission. The Commission will however continue to explore whether the development of market opportunities and cost-based user charges could eventually allow the reduction of the proportion of public investment in the long run.

4.2.4. Financing schemes

Without prejudice to possible co-financing schemes to be explored for the other GMES components, this section addresses the financing schemes available for the GSC.

Under options 2 and 3, it is assumed that the Community funds and manages the totality of the costs relating to the exploitation of the initial constellation of Sentinels, and (for option 3 only) the renewal of the Sentinels, under a data policy that is based on full and open access[34]. Nevertheless, the potential financial effort that it will be possible to deploy under the Community budget is not yet known, as priorities and allocations of the new multiannual financial framework (beyond 2013) will be established at a later stage.

In the following paragraphs the potential for co-financing by public or private entities is assessed.

4.2.4.1. Co-financing of the GSC by other public entities

In theory, the Community could contribute to the costs of the renewal of Sentinels and/or the exploitation of the initial constellation of the Sentinels only partly, should financing from other entities in the public sector complement Community financing.

It is assumed that the exploitation of the Sentinel infrastructure would be too costly for a single Member State. This is the reason why the EU has become active in the field of operational Earth observation, in line with the principle of subsidiarity.

Theoretically, it would be possible that a group of Member States establishes a new intergovernmental organisation in order to finance the exploitation and renewal of the Sentinels. This, however, would be extremely burdensome (needing the creation of a large management and technical team) and time consuming, as an international treaty would have to be concluded by the Member States concerned[35]. Further, the establishment of a new intergovernmental agency would be in contradiction the European Space policy[36], as it would result in the exploitation of a strategic infrastructure serving EU policy objectives in a non-EU framework

Concerning existing intergovernmental organisations, ESA Member States have clearly indicated that they expect the EU to take responsibility over the operation of the ESA-

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33 For a discussion of PPP, see section 4.2.4.2 below.

34 See section 4.2.4.

35 See also the Impact Assessment accompanying the 2008 Communication, SEC(2008) 2808 of 12.11.2008, p. 22.

36 See the Resolution of 21 May 2007 on the European Space Policy, adopted at the 4th Space Council meeting, 2007/C 136/01.

developed infrastructure. In the past exploitation of space assets developed by ESA have been outsourced to other entities after the end of their development phase, such as Arianespace in the field of launchers, EUTELSAT regarding satellite communications and EUMETSAT in the field of operational meteorology. Up to now, ESA has thus focussed its activities rather on the development of major European space infrastructures, but not their exploitation.

Generally speaking, a co-financing could be more costly than Community financing only, for the following reasons:

- First, past experience shows that it is of key importance to keep the governance framework as simple as possible. In the case of Galileo, the Commission thus underlined the importance "to have a single Programme Manager on the side of the public sector that is accountable for the entire Galileo programme, that has management and/or contractual control over all the subordinate implementation levels, that has access to both financial resources and to the political authorities, and that can provide the necessary arbitrage between all elements of the programme. A split responsibility with different reporting and accountability lines will cause fractures in the programme and have structural, negative impacts"[37].
- The importance of robust programme management and a clear governance framework was also underlined by the Court of Auditors special report 07/2009 on the "management of the Galileo programme's development and validation phase" (the "Galileo Special Report"). In particular, the Court of Auditors made reference to the importance of "setting clear, realistic and acceptable objectives", of "defining appropriate strategies and instruments to pursue them", of "providing for risk management at the programme's outset" and "taking timely decisions on all programme features"[38]. The more players are involved in decision-making, the more difficult it is to fulfil these tasks.
- Further, the Galileo Special Report states that the tasks of supervising complex technological activities can be seriously constrained by governance issues[39], in particular if the role of the partners is not defined clearly[40].
- A co-financing of the exploitation and/or renewal of the Sentinels by different public entities would mean that funds come from different sources. Consequently, different financial, accounting, control and procurement rules could apply to the management of the exploitation of the Sentinels. This could lead to a governance structure for GMES that is too complex and ultimately to higher costs, as has happened in the case of Galileo[41]. This rationale applies to a large extent independently of the actual percentage of contribution by other public players. Even a small contribution by a public entity other than the EU could mean that the multiple sets of financial and procurement rules could apply to the management of the exploitation of the first constellation of the Sentinels. Additionally, the negotiation of agreements between different public funding entities will entail transaction costs independently of the level of contributions, although it can be assumed that these costs would be negligible compared to overall costs.

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37 See Communication from the Commission to the European Parliament and the Council - Progressing Galileo: re-profiling the European GNSS Programmes, COM(2007) 534 final of 19.9.2007.

38 See the Galileo Special Report, p. 36 – 37.

39 See the Galileo Special Report, p. 27.

40 See the Galileo Special Report, p. 33.

41 Regarding the financing of instruments on satellites owned by third parties, specific solutions could be necessary.

4.2.4.2. Co-financing of the GSC by the private sector

It could also be theoretically possible that a Community contribution to the costs of the renewal of Sentinels and/or exploitation of the initial constellation is complemented by financing from the private sector. A financial contribution of a private company to the costs of exploitation and renewal of the Sentinels could only be expected if the private company is allowed to develop a business model whereby it recoups its costs through user fees. Most likely the public side would co-operate with the private company in a concession-type PPP.

A PPP for the exploitation and /or renewal of the Sentinel infrastructure would, however, face the following challenges:

- like Galileo, GMES is a complex high tech project that poses higher technological risks than for instance the construction of a motorway;
- revenue generation is difficult to predict, especially in the presence of fragmented and non structured users' communities, as it is the case for Earth observation;
- as in the case of Galileo, a concession for GMES would start after rather than before system design. The concession holder would thus have to commit itself to financing and operating a system that had been conceived and handed over by the public sector[42].

For these reasons, it would be difficult for a private company to accept the transfer of market risk, which is a precondition for a functioning PPP. Regarding design risk, the private company would need an assurance that the design (prepared by the ESA during the development phase) "had no inherent problems that might result in a faulty or underperforming system (for which the concession holder would be responsible during operation)."[43] It would be difficult to transfer this risk because of the technical complexity of GMES and the outputs expected of the concession holder during exploitation.

Additionally, the fact that data would sold on a commercial basis would deviate from the objective of full and open access and therefore strongly limit the use of GMES information and, consequently, the related benefits. The objective of full and open access to GMES has already been endorsed by the Commission in the 2008 communication and the GMES proposal.

In this context, it should be underlined that the development of downstream services is significantly constrained in Europe because of the conditions of access to and the price of Earth observation data[44]. If Sentinel data is sold at commercial prices, the risks remains that one of the key problems that GMES is supposed to tackle would remain unsolved, which would mean that the general and specific EU objectives referred to in sections 3.1 and 3.2. would not be met.

Taking into consideration the lessons learnt from the Galileo PPP and the objective of full and open access to GMES data, a PPP for GMES does not seem to be a viable solution for the moment. In any event, the Commission will continue to explore whether the development of market opportunities and cost based user charges could eventually allow the reduction of the proportion of public investment in the long run.

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42 See the Galileo Special Report, p. 24 – 25.

43 See the Galileo Special Report, p. 25.

44 See ECORYS Study on the Competitiveness of the GMES Downstream Sector, executive summary, page 11: "In terms of data input, this has been proven to be a major concern for service providers. They indicate that the costs are increasing, which could hamper profitability and innovation".

4.2.4.3. Ownership of the GSC

Ownership of the Space observation infrastructure confers exclusive rights and control over it and thus allows the owner to determine how a given space infrastructure should be used. In particular, the owner has the right to determine how the data produced by an Earth observation infrastructure is collected and distributed. This is of key importance, as infrastructure is not a goal in itself, but an instrument to produce data needed for the implementation of several EU policies.

The owner also has some obligations, e.g. under EU environmental legislation or in the event the space object causes damage on the Earth or to another space object.

As outlined above, it is currently not envisaged to implement the Space component of GMES as a PPP in the short to medium run. Private ownership of the Sentinels is thus a purely hypothetical option, as no private entity would be willing to take over ownership.

This means that, in practice, the question is whether ESA should remain owner (as it is the owner of the Sentinels which it develops according to Article IV of Annex III to the ESA Convention), or whether ownership should be transferred to the EU, normally following launch and in-orbit validation.).

In all comparable programmes, the EU has become owner of the infrastructure it develops. This is the case not only for Galileo[45], but also for SESAR, ITER and several JTI, including ARTEMIS (embedded systems) and ENIAC (nanoelectronics). Finally, it should be underlined that in the field of operational meteorology, EUMETSAT owns the satellites, which are developed by ESA.

As with Galileo, the transfer of ownership itself would not imply specific costs.

Different options for ownership of assets in the other components will be analysed at a later stage.

5. ANALYSIS OF IMPACTS OF OPTIONS

Options have been analysed both qualitatively and quantitatively. For the quantitative part, a cost-benefit analysis has been performed based on available data. To this purpose, all figures have been expressed in 2009 prices. A discount rate of 4% in real terms was used to calculate Net Present Values (NPVs), in accordance to the Commission Impact Assessment Guidelines.

A number of assumptions have been made that are set out below.

5.1. Assumptions concerning cost-benefit analysis

First of all, due to the nature of GMES as a system comprising services and infrastructure components, it should be stressed that costs and benefits depend on the whole GMES system and not just on one of its components. More specifically, benefits depend on the availability of services, which in turn rely on the availability of adequate infrastructure (space and in situ). As a consequence, variations in costs and benefits are driven by variations in all GMES components.

However, due to the limited scope of the present report to the space infrastructure component, it is assumed that in all options in situ infrastructure and services components are constant,

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[45] See Article 8 of the Regulation No 683/2008 of the European Parliament and of the Council of 9 July 2008 on the further implementation of the European satellite navigation programmes (EGNOS and Galileo), OJ L 196/1 of 24.7.2008.

both in terms of costs and benefits. The analysis focuses therefore on costs and benefits variations arising from variations in the space component.

5.1.1. Benefits

Benefits arising from GMES have been quantified in the study entitled "Socio-economic benefits analysis of GMES" by PriceWaterhouseCoopers (the "PWC study") of October 2006[46]. The PWC study monetises and expresses in present value terms the projected economic benefits (inclusive of societal, environmental and other economic benefits) with respect to a baseline scenario without GMES.

The PWC study results have been used in the present Impact Assessment[47]. As a consequence, the PWC study limitations apply. These are discussed in more detail in Annex V. It can be considered that the PWC assumptions for the "GMES full service scenario' and the corresponding assumptions for the Space component are in line with the current GMES thinking and with the Space component described in the ESA Long Term Scenario (see next section on costs).

In the PWC study, GMES benefits have been grouped into three high-level categories, based on the different framework conditions necessary for the benefits to materialise in addition to the availability of the GMES services, which in turn depend on the continuous availability of the GSC:

- **Category 1** benefits are efficiency benefits linked to the use of GMES-related information in the implementation or enforcement of legislation or policies that are already in place. Continuous availability of GMES services (and hence the GSC) is needed for these benefits to materialise. Therefore they are supposed to start from 2014 (and even before actually, linked to the implementation of GMES initial operations in 2011-2013). For instance, the quick availability of reference maps and damage maps in the context of the GMES Emergency Response service will immediately deliver efficiency benefits within the existing mechanisms for civil protection in Europe.
- **Category 2** benefits are linked to the availability of more and better information during the policy formulation stage. The result would be better policy making at European but also at national and regional level, easier and more efficient implementation and ultimately an improved delivery of policy objectives. For instance, the Land services of GMES will provide information on land use and other land parameters all over Europe, plus detailed, higher resolution maps of urban areas (Urban Atlas). This information will allow better shaping and targeting, among others, of regional policies and better urban planning at local level.
  There is however a built-in delay between the availability of information and the materialisation of the benefits, linked to the policy cycle. As a consequence, these benefits are assumed not to materialise before 2012 and to grow progressively afterwards.
- **Category 3** benefits are, as in category 2, linked to the availability of more and better information from GMES services during policy formulation, but this time at global level, i.e. linked to the signature and implementation of international treaties (e.g. on climate change, desertification, deforestation). As a consequence, there is a much bigger time delay before they materialise, but at the same time their magnitude once the treaties are effectively implemented is much more important than in the other categories. An example

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46 Available at http://esamultimedia.esa.int/docs/GMES/261006_GMES_D10_final.pdf.

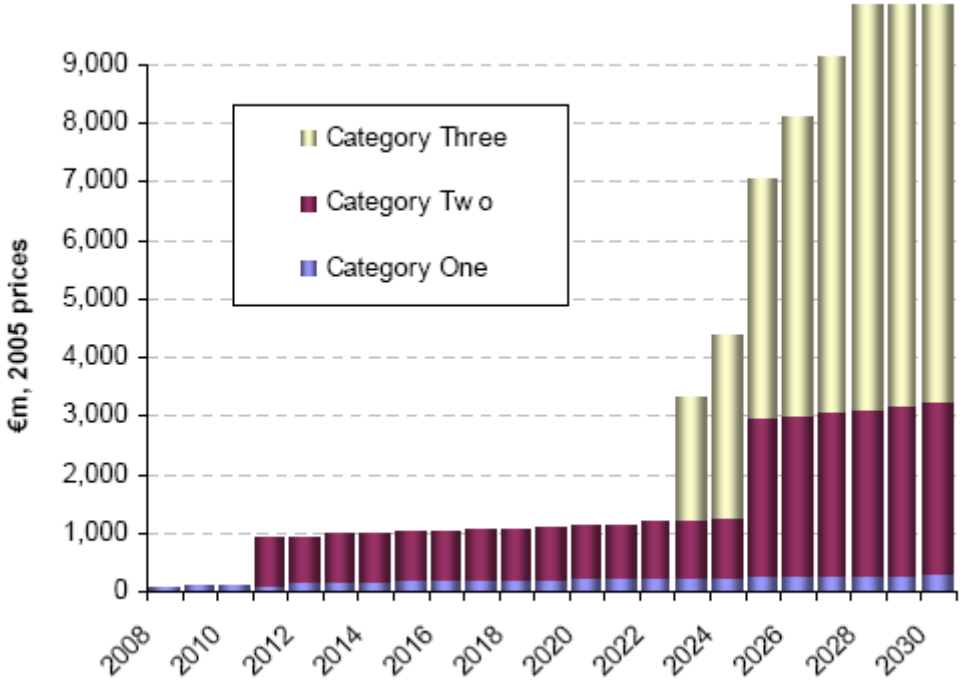
47 The PWC study expresses results in 2005 prices. These have been converted to 2009 prices using a 2% constant inflation rate

of this category is the contribution that GMES will give to climate change-related policies, through long-term data series on several parameters (including sea surface temperature, sea level rise, CO_2 distribution).

Benefits are calculated not only for Europe, but also take into consideration the global level. This concerns in particular climate change, biodiversity, deforestation monitoring, marine monitoring (including oils spills) and services in support of development aid[48].

The PWC study is based on conservative estimates. Whenever stakeholders or secondary sources suggested a range, rather than an absolute number, the lower end was retained. A sensitivity analysis on these assumptions was also performed. For the period analysed (up to 2030), with the use of higher-end range values as assumptions feeding into the GMES benefit assessment, the Present Value of projected benefits increases considerably from €34.7 billion to €70.9 billion. When Terminal Values are taken into account, projected economic benefits increase to €173.3 billion[49].

However, for the purpose of this Impact Assessment the conservative figures have been used. Corresponding benefits for the whole period up to 2030 are summarised in the figure below[50].



Source: PWC study, Figure 7-2: Summary of projected economic benefits: GMES 'full service' scenario – Excludes Terminal Values

The uneven profile of the benefits is due to the assumption, in the PWC study, that category 2 and 3 benefits begin materialising at specific points in time.

The PWC study also identifies significant socio-economic benefits without monetising them:

- Europe as a global partner (climate change mitigation, development and aid)

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48 With a focus on Africa, see PWC study, p. 82.

49 All figures of the sensitivity analysis are expressed in the PWC study as "present values, discounted to 1/1/2006 at 4% real"

50 PWC study, page 163.

- preservation and management of natural resources (urban and rural policy, agriculture policy, water quality, management of wetlands)

The PWC study stresses[51] that GMES offers significant strategic and political benefits for Europe. Although such benefits are inherently non-quantifiable they are a capital element of the GMES benefit case. They concern Europe's leadership on global policy issues that have long term consequences for the quality of life and security of its citizens.

In addition to the above, it should be stressed that the PWC study does not quantify some other economic and social benefits generated by exploitation and renewal of the Sentinels both in the satellite manufacturing industry and the Earth observation service sector. These could be called the "GMES economy" benefits, and are linked i.a. to creating and maintaining of a highly skilled workforce and to the innovative potential of Earth observation technologies and techniques, in particular for the switch to a low carbon economy.

To conclude, it can be said that quantification of benefits in the present assessment is very conservative. When comparing the options, some qualitative elements have also been provided concerning the categories of benefits outside the PWC study scope.

5.1.2. Costs

As the PWC study benefits refer to the full provision of GMES services rather than the implementation of the GSC only, the full costs of GMES services provision had to be taken into account for a cost/benefit comparison to make sense.

In the quantitative analysis of options, therefore, the following cost categories have been factored in:

- Services component operation costs, derived from current costs in the FP7 projects preparing pre-operational services and projected towards steady-state in the period 2014-2030;
- Space component operation costs[52]. Regarding the latter, the costs of the ESA Long term Scenario are taken into consideration. These are taken from the European Space Agency's Long Term Scenario (ESA LTS), a cost assessment prepared by the ESA secretariat and discussed in ESA and EUMETSAT governance structures[53]. The ESA LTS has been recognised as a basis for costs estimations by the 6th Space Council[54]. The cost profiles are provided below, while a detailed description of the planned launches dates, Sentinels characteristics and lifetime is presented in Annex IV.

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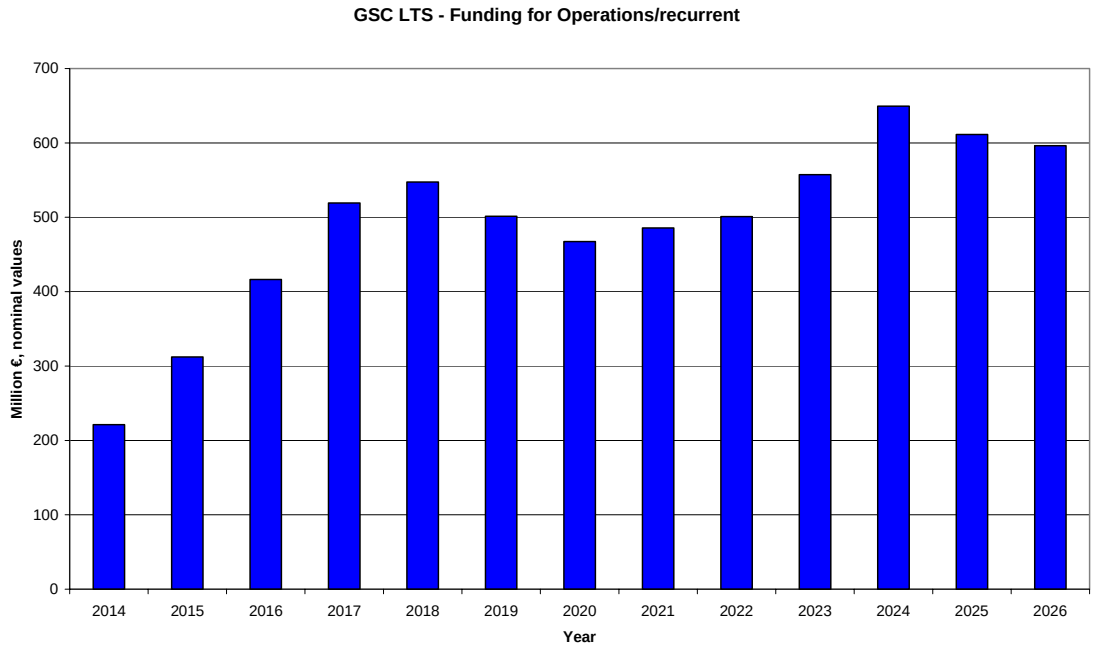
51 PWC study executive summary, page 1

52 See also section 5.2.1.1.

53 Costs are expressed in the ESA LTS in nominal prices, calculated with 2008 as a basis and using a fix 2,3% annual inflation rate. For the present analysis, these costs have been converted to 2009 prices.

54 Council Resolution on "The Contribution of space innovation and competitiveness in the context of the European Economic Recovery Plan, and further steps" – 10500/09 of 29 May 2009



Source: ESA Long-Term Scenario

5.2. Option 1: Baseline

Under the baseline scenario, the EU would not assume responsibility for the exploitation of the Sentinels after GMES initial operations (2011 – 2013).

5.2.1. Economic impact of Baseline

The baseline would have an impact both on the satellite industry and service providers. As the baseline would not only entail the end of the EU involvement in the GSC, but also the end of the GSC itself, important know-how in the European satellite industry would be lost. This would also mean that the global competitive position of the relevant companies will be impaired. Additionally, research actions accompanying exploitation activities would become redundant, which would have negative consequences for innovation and the introduction and dissemination of new technologies. These impacts would not only concern the large system integrators, but also SMEs that supply components and sub-components. The baseline scenario could thus lead to the disintegration of industrial teams, loss of employment opportunities in a high tech sector and a negative impact on the growth potential of the companies producing and operating Earth observation satellites.

Without EU intervention in the GSC[55], no service providers could become active. Additionally, providers of downstream services (i.e. providers that use the GMES service component financed or co-financed by the EU as an input for their own services) might not be able to offer innovative services owing to the lack of affordable upstream services. This would mean that the multiplier effect of the EU investment in operational services would be forgone. This would also hamper innovation in the European Earth observation service sector. As the downstream sector is composed predominantly of SMEs[56], which are essential for the

[55] Regarding the importance of public intervention, see also ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 82.

[56] See ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 88, and the impact Assessment accompanying the GMES proposal, p. 20 - 21

Lisbon Growth and Jobs Strategy[57] the lack of EU action would be particularly detrimental for job creation and growth in the service sector.

Additionally, the baseline would have an impact on public authorities at European, national, regional and local level. The provision of accurate Earth observation services allowing these authorities to prepare and implement environmental legislation is a key EU objective for GMES. Without the GSC, public authorities would have either to continue their activities without Earth observation-based information (with corresponding suboptimal results in cost-effectiveness of their policies), or tender ad-hoc services (with corresponding duplications and higher costs for data access, should data be available, or sub-optimal information in the absence of data). This could ultimately mean that policy formulation and implementation becomes less efficient and therefore more costly for tax payers.

The baseline would have a serious impact in the field of international relations. First GMES is the major contribution to the Global Earth Observation System of Systems (GEOSS)[58]. If the EU did not move forward with operational GMES services before 2014, this would limit its credibility within the Group on Earth Observation (GEO). The same is true for the "GMES and Africa" partnership. It should be reiterated that in the field of Earth observation, the EU will only be a credible partner for developing countries if GMES delivers operational services in addition to existing research projects. The GSC is a prerequisite for this.

5.2.2. Environmental impact of Baseline

As environmental monitoring is the *"raison d'être"* of GMES, the baseline scenario would mean that that the EU objectives for GMES cannot be fulfilled. Without implementation of the GSC, the GMES service component cannot exist. Consequently, the EU would not have access to an autonomous capacity to monitor climate change.

In particular, land monitoring services are important for monitoring of biodiversity and ecosystems, climate change mitigation and adaptation and the management of a wide range of resources and policies, most of which relate to the natural environment: soil, water, agriculture, forests, energy and utilities, built-up areas, recreational facilities, infrastructure and transport[59]. Although authorities at European, national, regional and local level (including environmental agencies) to some extent already use pre-operational or operational Earth observation services, two cross-cutting issues remain. First, existing pan-European services (e.g. the Corine Land Cover service) do not meet all the requirements of users. Secondly, the sustainability of existing services is not ensured, not only in the case of services provided in the framework of research projects but also in general as existing data flows will not be available anymore, for instance after the end of Envisat[60] lifetime). Without GSC, land monitoring services in Europe would thus remain at best fragmented, and in the some cases cease to exist in the absence of input data.

For emergency response, the baseline would mean (i) that the prevention of risks relating to natural disasters (including forest fires and floods) would continue to be difficult owing to the lack of precise risk mapping services, and that (ii) the response to natural disasters would have to rely on rather imprecise maps.

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57 See p 1 of the Communication Think Small First" - A "Small Business Act" for Europe, COM(2008) 394 final of 19.6.2008.

58 See also p 5 of the 2008 Communication.

59 See recital 11 of the GMES proposal.

60 Envisat is an advanced polar-orbiting Earth observation satellite which provides measurements of the atmosphere, ocean, land, and ice. It was launched in 2002 and is planned to be operated until the beginning of the next decade.

GMES Services in the atmosphere thematic area are of key importance for monitoring air quality, greenhouse gases, and ozone. The service in the area of monitoring of the marine environment would allow better oil spill prevention, marine resources management, seasonal forecast, ice surveys and water quality monitoring. Without the GSC, the provision of these services will continue to be difficult. Although services already exist in this field, as in the field of land monitoring the problem is that these existing services do not meet all user requirements and cannot be provided beyond the lifetime of existing satellites.

5.2.3. Social impacts of Baseline

Without the implementation of the GSC, it can be expected that the full potential for growth and job creation will be exploited neither in the satellite manufacturing industry nor in the service sector.

Satellites manufacturing industry in Europe employs approximately 30.000 FTE, with a clear concentration in large installations (the 30 largest units employ 80% of the workforce). Earth observation (EO) covers a share of approximately 15% of the total sales[61]. In the baseline option, part of these jobs would be at risk, as the sector is highly dependent on public demand and long-term programming. As the jobs at stake are high-skills ones, a brain drain towards the US or emerging space powers would be likely.

Concerning the downstream sector, EO is today the smallest of the three value adding space segments (navigation, satellite communication and EO) in absolute numbers. The sector is made up of some 150 companies in Europe and Canada, with an average of 20 staff employed and a turnover of 2 million € per company. Total employment in the sector is estimated to have risen from 2,900 employees in 2002 to 3,000 in 2006.

Under the baseline scenario, existing players in the downstream sector might either leave the market or reduce their activities in the field of Earth observation. This is because the development of downstream services is dependent on reducing the current uncertainty over the conditions of access, price and data policy for GMES data and the real content of services output, which has to date represented an important constraint on investments[62].

5.2.4. Cost-benefit assessment of the Baseline

In the baseline scenario, even in the absence of exploitation or renewal costs for the space infrastructure, there would be costs linked to the storage of about 2 to 3 million Euros per year of the already developed satellites listed in section 2.2.1 (see graphs below[63]). In the absence of the necessary data, no costs will be incurred to operate the GMES service component, which will simply not exist.

On the benefits side, it is reasonable to assume that no benefits at all will materialise, as the baseline is equivalent to the PWC study scenario "without GMES". Moreover, no strategic and political GMES benefits, nor "GMES economy"-related benefits will materialise. As a result, the (small) costs will exceed the benefits and net benefits will be negative throughout the period.

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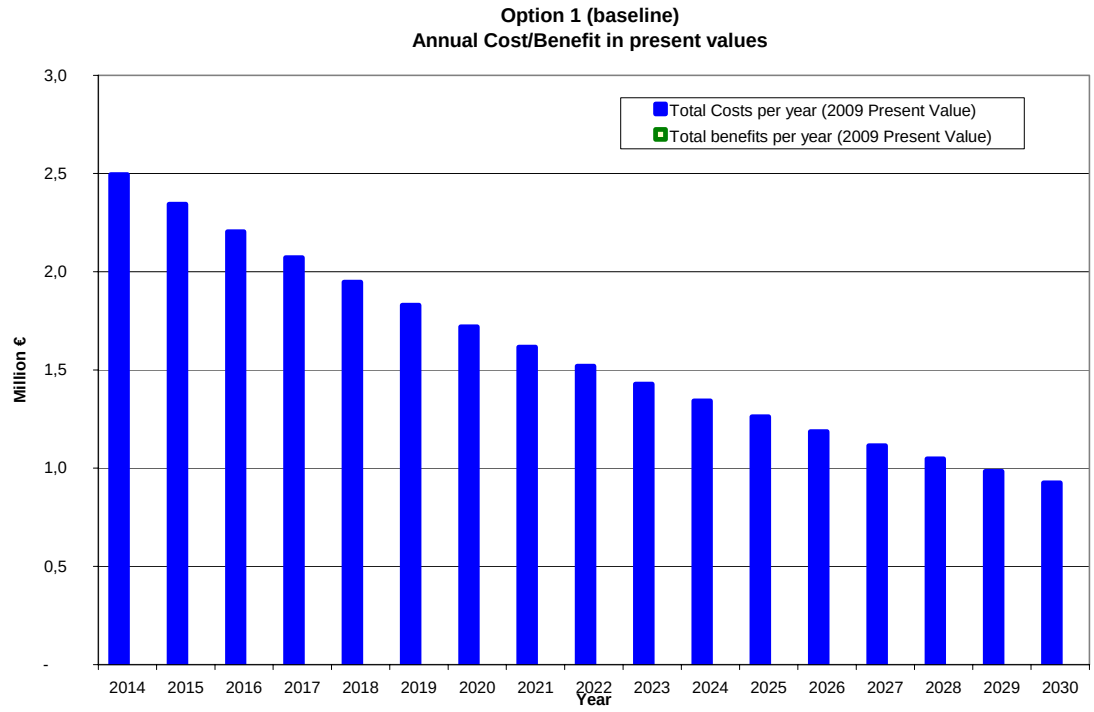
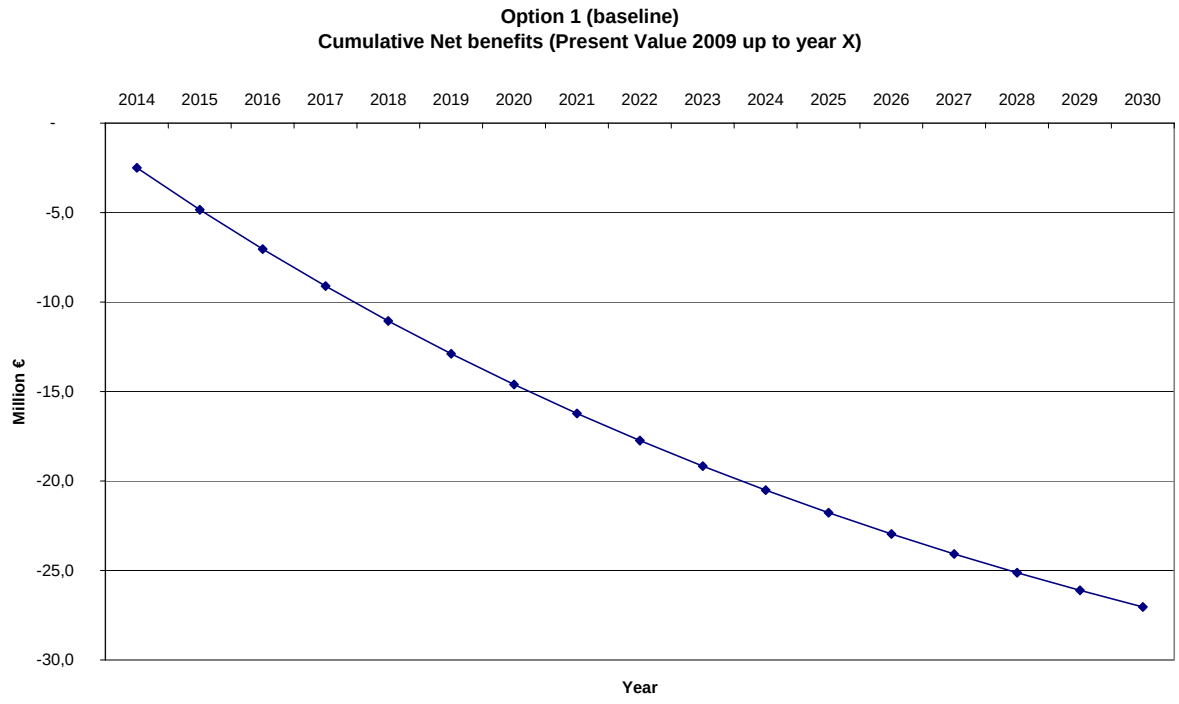
61 Source: ASD-EUROSPACE facts & figures, 13th edition, June 2009

62 See ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 13.

63 The second graph shows the cumulative net present value (in 2009) of a stream of payments starting in 2014 and ending in year X, where X can take on any value between 2014 and 2030





5.3. Option 2

In Option 2, it is assumed that the exploitation of the first constellation of Sentinels is financed by the Community, but not their renewal.

5.3.1. Economic impact of Option 2

The Community financing of the GSC and GMES services would have a positive impact on the competitiveness of EU firms in comparison with non-EU competitors, as the private

sector, including downstream companies, would have planning certainty concerning the availability of GMES services[64]. This is essential for SMEs, which form the backbone of the Earth observation industry in Europe[65]. Nevertheless this positive impact would not be maintained if the Sentinels were not renewed. In other words, option 2 would only constitute a temporary solution.

Further, the positive impact of innovations in the downstream sector, which depends on a flow of data at reasonable conditions[66] and which would significantly contribute to job creation in a high tech sector of strategic importance, would be limited to the first constellation of Sentinels and would thus be in contradiction with the goal of establishing sustainable capacities in Europe.

Finally, EU financing of operational services would constitute a political message also for the external relations of the EU, and would reinforce the credibility of the EU as a partner in the GEOSS and the strategic EU-Africa partnership. This positive impact would be impaired if the Sentinels were not operated on a continuous basis[67].

5.3.2. Environmental impact of Option 2

As long as the Sentinels are orbiting and providing their data, positive environmental impacts will occur owing to better information on the Earth's environment made available to policy makers. It could be assumed that these impacts are present for a short time after the stop of the data flow once Sentinels progressively end their life[68], as policies are implemented and achieve their objectives.

However, it can be assumed that very limited impacts, if any, will be made on long-term environmental policies depending on long-time data series, the most prominent example being climate change policies. As a consequence, the benefits which constitute the bulk of the quantified benefits in the PWC study – and an important part of the strategic and political benefits – will not materialise. This concerns, in particular, the long-term monitoring of climate change.

5.3.3. Social impact of Option 2

The PWC study did not quantify the positive impact of the GSC on the European Earth observation sector in terms of growth and job creation. However, it is possible to derive some data from a study on the competitiveness of the GMES downstream sector performed by ECORYS for the European Commission in November 2008. The study explains that "the public sector has an important influence on the [EO downstream] sector, not only because it sets the legal and regulatory framework for the sector, but also because it has a large influence as a client, by funding the development of the sector and by shaping policies that influence market demand for EO services. […] In terms of data input, this has been proven to be a major concern for service providers. They indicate that the costs are increasing, which could hamper profitability and innovation". The exploitation of Sentinels and the provision of data and sustainable information services with full and open access will be the basis for innovative value added services in Europe, which could reverse the trend of very slow growth in

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64 See, in particular, ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 812.

65 See ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 93.

66 See ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 13.

67 See also section 4.2.5.

68 For detailed schedules, see Annex IV, section 2.6.

employment in this key high tech sector[69]. In option 2, however, this positive impact would be negligible, as the industry stakeholders' consultation has demonstrated that certainty over a long timeframe is a pre-requisite for the creation of new business models, as well as for the stabilisation of existing ones.

Concerning the satellite manufacturing industry jobs, they would be temporarily preserved as compared to the baseline, but for a limited period of time and without a stable perspective.

5.3.4. Cost-benefit analysis of option 2

In Option 2, it is assumed that the full palette of GMES services will be made available until 2020, i.e. in the period when all Sentinels are operating and delivering the necessary space data. 100% of the identified benefits will therefore materialise in the period 2014-2020.

Between 2020 and 2022, in the absence of Sentinel 5 after the lifetime of its precursor, atmosphere data would be limited not only in terms of parameters but also in terms of geographic coverage[70]. As a consequence, very limited atmosphere-related services could be delivered, owing to data access to other missions[71].

As of 2023, only Sentinel 4 would be operational[72]. With the sole flow of data coming from this satellite, it would be impossible to have any of the GMES services provided with a scope foreseen today. In particular, Sentinel 4 is one of the satellites necessary for delivering the GMES Atmosphere service, the other one being Sentinel 5.

Assumptions on **benefits** are therefore as follows:

- From 2014 to 2020 100% of the benefits calculated by PWC materialise;
- From 2020 to 2022, benefits have been reduced proportionally to the limited scope of available atmosphere services:
  - Efficiency benefits are not quantified for single services in the PWC study. It is therefore difficult to estimate the reduction corresponding to a limited scope of the atmosphere service. Assuming that these benefits are distributed equally among the four services (land, marine, atmosphere, emergency), 87.5% of the total category 1 benefits has been accounted for in the period considered. This corresponds to the share of the three non-atmosphere services, plus half of the atmosphere service share;
  - as concerns category 2 benefits, the PWC study identifies 1.6 billion € per annum[73] related to air quality services, out of a total of 2.9 billion € per annum[74]. However, as benefits are linked to improved modelling capabilities through combining environmental and health related inputs, it is assumed that no category

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69 Although nominal revenues of the downstream sector have increased by around 2% per annum on average between 2002 and 2006, employment evolved at a lower pace, slightly under 1%, see ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p.23. See also the Impact Assessment accompanying the GMES proposal, p. 30.

70 Sentinel 4 is a geostationary satellite, orbiting in phase with the Earth and therefore 'viewing' only a portion of it, like it is the case for meteorological satellites (e. g. the geostationary METEOSAT satellites, viewing mainly Europe and northern Africa.

71 The problem is particularly severe in this configuration. While today, in the absence of Sentinels, it is possible to acquire data for pre-operational atmosphere services from the experimental ENVISAT satellite developed by ESA, the latter will not available anymore in 2023.

72 The last year of Sentinel 3B in 2023 does not make a difference for the present analysis.

73 In 2025, nominal undiscounted terms

74 In 2030, nominal undiscounted terms

2 benefits will materialise as soon as Sentinel 5 data flows stop. As a consequence, it is assumed that only half of category 2 benefits will materialise between 2020 and 2022 (coming from non-atmosphere services);

- Category 3 benefits are not present yet.

- From 2023 to 2030:
  - the same assumption as for 2020-2022 have been made for category 1 benefits;
  - no category 2 benefits have been accounted for;
  - no category 3 benefits have been accounted for, as it is assumed that the relevant data series generated until 2022 would not be sufficient to generate them in the following years, and data discontinuity is a major obstacle in the climate domain.

In Option 2, only the following space component **costs** have been extracted from the ESA LTS[75]:

- operation costs of Sentinel 1A, Sentinel 1B, Sentinel 2A, Sentinel 2B, Sentinel 3A, Sentinel 3B, Sentinel 4A, Sentinel 4B, Sentinel 5 precursor;
- access to contributing missions (still necessary for service provision);
- operation of the ground segment.

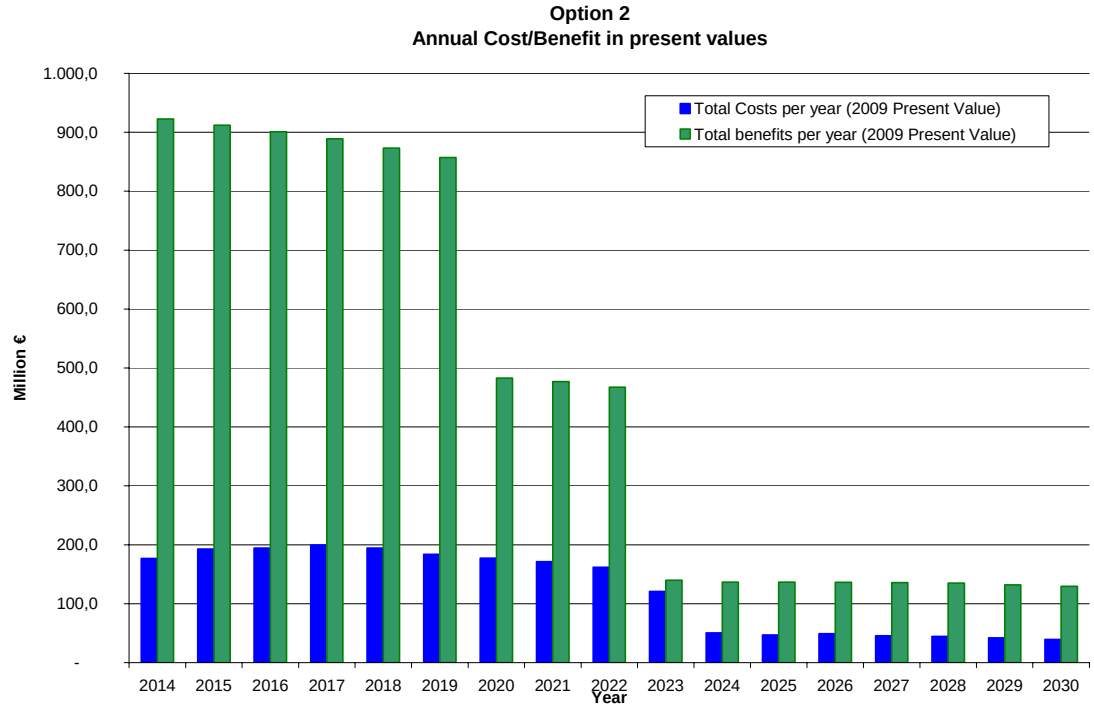
In addition, services operation costs have been taken into account, but limited to the services that can effectively be made available each year depending on the available satellites.

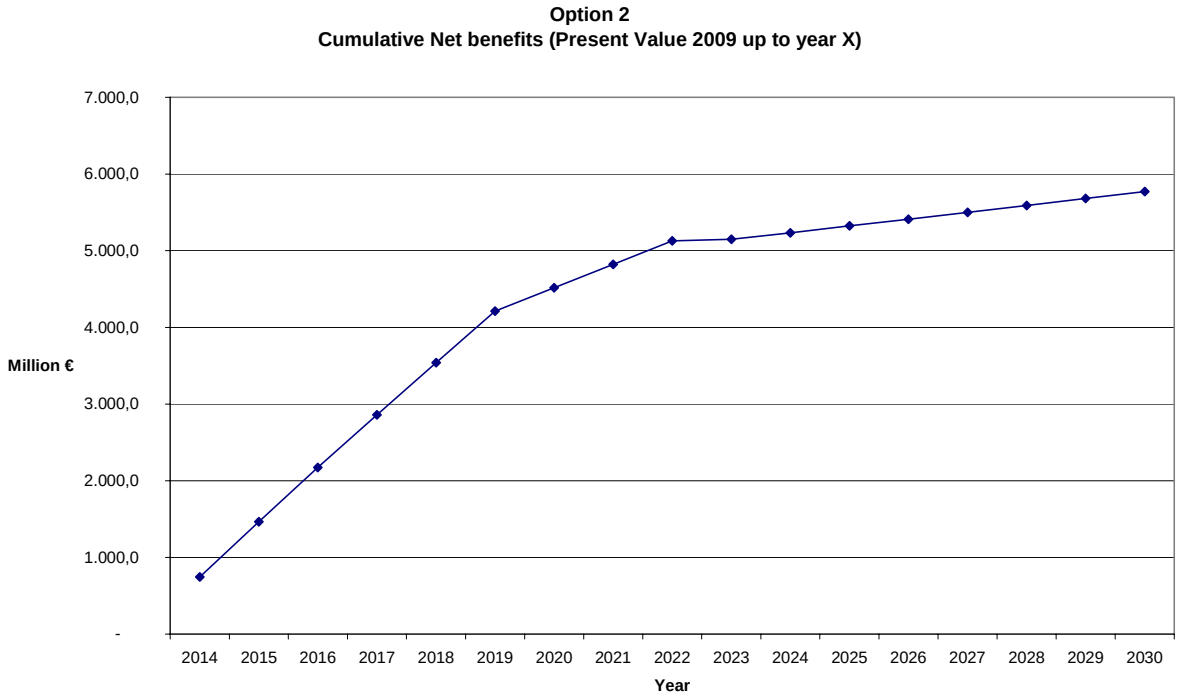
The results of the cost-benefit analysis are summarised in the graphs below[76]. The total cost profile decreases sharply after 2022, as gradually Sentinels end their nominal life. In parallel, while most of the benefits materialise in the first period, no longer-term benefits are enabled and as of 2023 costs approximately equal benefits. Net present value remains positive throughout the period, with an increasing profile up to 2022 and then stabilising.

From the point of view of the possible Community contribution, this option would require an important rise in terms of budgets, even if the increase in non-research appropriations allocated to the GMES successor programme would be partly compensated by a corresponding decrease in the allocations provided by the next research framework programme.

[75] For an overview of missions up to 2030, see section 5.2.5.

[76] See footnote on the graphs for the baseline option. In this case, benefits are also taken into account.





5.4. Option 3

Option 3 is based on the assumption that financing not only of the exploitation of the first constellations of Sentinels, but also their renewal is secured by the Community.

5.4.1. Economic impact of Option 3

The full set of socio-economic benefits identified in the PWC study will apply in option 3, including those related to long-term actions and impacts (category 3 benefits). Moreover, the strategic, political and "GMES economy-related" impacts are expected to materialise as well.

In particular, the positive impact of the Community financing of the GSC and GMES services on the competitiveness of EU firms in comparison with non-EU competitors could be maintained in the long run. This would increase the planning certainty of the private sector concerning the availability of GMES services[77]. This is essential for SMEs, which form the backbone of the Earth observation industry in Europe[78].

Further, the making available of data and information produced by services that are supported financially by the Community according to the principle of full and open access could most likely lead to innovations in the downstream sector, which depends on a flow of data at reasonable conditions[79]. This, in turn, would significantly contribute to job creation in a high tech sector of strategic importance.

Finally, the commitment to finance not only of the exploitation, but also the renewal of the Sentinels would reinforce the credibility of the EU as a partner in the GEOSS and the strategic EU-Africa partnership much more than in option 2.

5.4.2. Environmental impact of option 3

Under Option 3, the full set of socio-economic benefits identified in the PWC study will apply, including those related to long-term actions and impacts (category 3 benefits). This concerns in particular the positive impacts on climate change-related actions, and constitutes the bulk of environmental impacts both in quantitative terms (see cost-benefits analysis below) and in political terms: the EU would have at its disposal strategic information on the pace of climate change to support its leader role in the negotiation of international treaties, such as the global convention on desertification, a new Treaty on de-forestation or a future Treaty for climate change mitigation.

5.4.3. Social impact of option 3

The social impact of option 3 largely corresponds to option 2, with the difference that this impact would be more sustainable in option 3.

Concerning the satellite manufacturing industry, it can be expected that under option 3 new jobs would be created and maintained, increasing demand of highly skilled staff.

Regarding the service sector, given that half of the companies active in the downstream market are small companies employing less than 10 persons[80], the sustained social impact of option 3 would be of particular relevance for SMEs. Additionally, the availability of Sentinel data could be instrumental in reducing the disparities between Member States in the field of Earth observation. This is because downstream services market development, in particular in countries with a weaker industrial base, will most likely accelerate only with the full and open access to inputs from an operational GMES capacity.

5.4.4. Cost-benefit analysis of option 3

As outlined in section 4.2.5, the PWC study monetises and expresses in present value terms the projected **benefits** (inclusive of societal, environmental and other economic benefits) with compared to a baseline scenario without GMES[81].

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77 See, in particular, ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 812.

78 See ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 93.

79 See ECORYS (2008), Study on the Competitiveness of the GMES Downstream Sector, p. 13.

80 See the VEGA study, 2008. The state and health of the European and Canadian EO service industry in 2006.

81 PWC study, page 9.

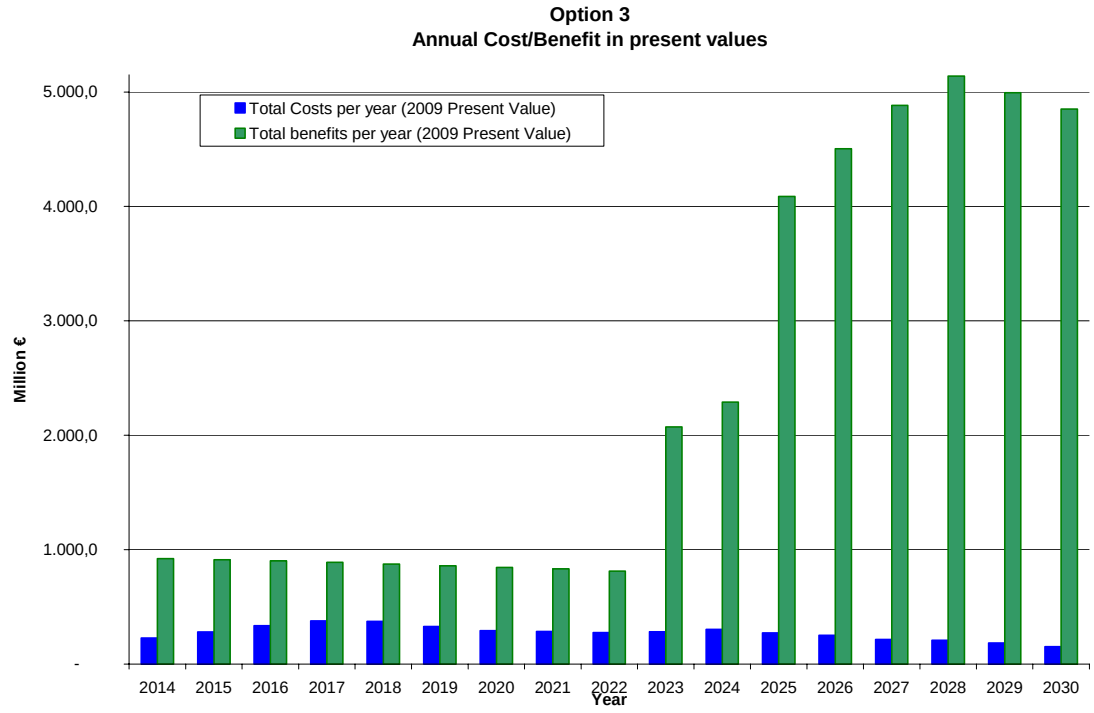
In Option 3, it is assumed that the full palette of GMES services will be made available owing to the permanent availability of space data. Therefore 100% of the identified benefits will materialise.

The full **costs** of the ESA LTS are taken into consideration in option 3, as all Sentinels planned would have to be launched, exploited and renewed, with the corresponding additional costs for the ground segment and the data purchase from other missions necessary to run the GMES services.

The results of the cost-benefit analysis are summarised in the graphs below[82]. The total cost profile reflects the peaks in 2017-18 and 2024 of the GSC-related costs (renewal of the Sentinels).

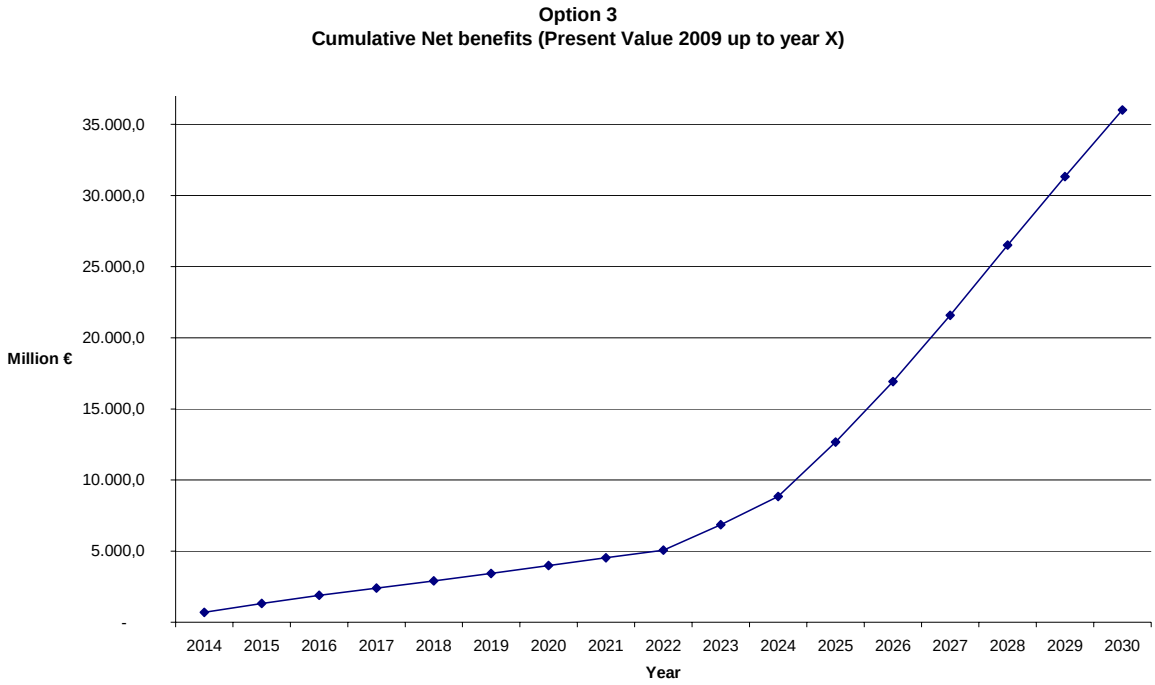
Benefits exceed costs from 2014 and throughout the whole period considered. Benefits increase sharply starting from 2023, when the Category 2 and 3 benefits materialise. As a consequence, net benefits are always positive and show a very high return on the investment in the long term.

Nevertheless, the implementation of this option would require a considerable financial contribution from the Community budget for a long period of time[83]. As such, this option could only be motivated if it is recognised that GMES is a key tool for climate change mitigation and adaptation, which is a priority of the EU.



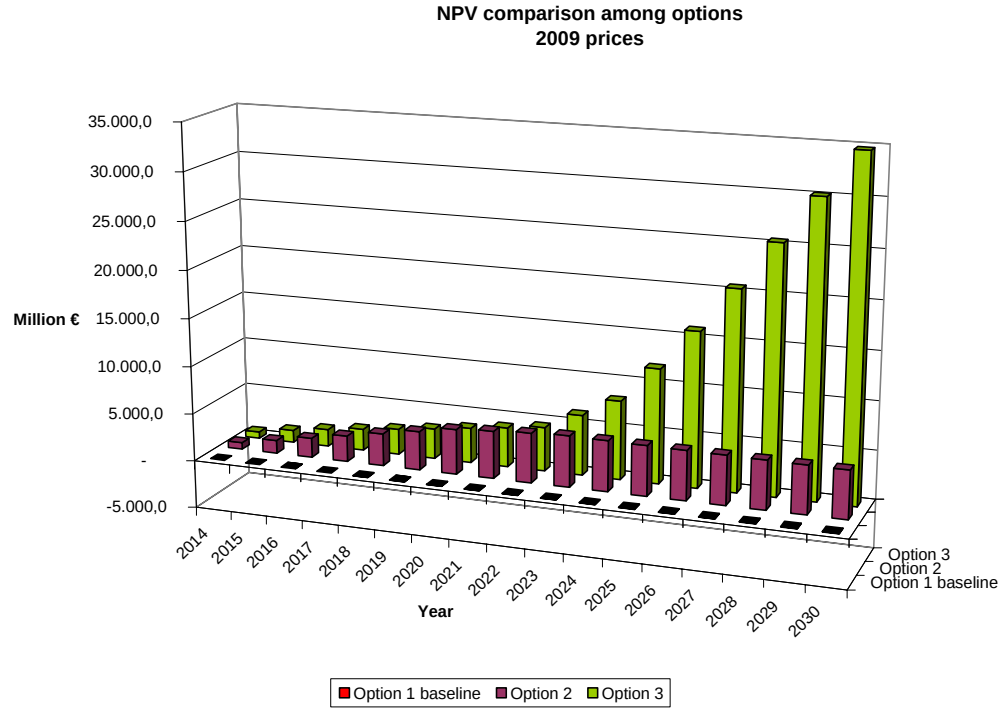
82 See footnote concerning the graphs under options 1 and 2

83 See also the cost table in section 5.1.2.



6. COMPARING THE OPTIONS

In quantitative terms, the options can be compared most easily on the basis of their generated Net Present Values in the period under consideration. Results are represented in the figure below[84].



84 The figure shows, for each option, the cumulative net present value (in 2009) of a stream of payments and benefits starting in 2014 and ending in year X, where X can take on any value between 2014 and 2030

Taking into account also the impacts not included in the PWC study and therefore in the above graph, the following comparison can be made in the light of the objectives defined in chapter 3 (keeping in mind that costs are referred to the GSC, benefits to GMES as a whole):

	Effectiveness	**Efficiency**	**Coherence**
Option 1 (baseline)	Does not achieve any of the objectives Impact on the Community budget, however, would be zero, which means that funds would be available for other initiatives and programmes.	Some (low) costs to achieve no benefits (storage of developed satellites)	No benefits therefore no trade-offs. Strongly inconsistent with the previous EU efforts in developing the GSC and with the positioning of the EU within the global Earth Observation community within the last 10 years. Would be coherent only in case of a major shift of policy priorities in the EU, namely lowering climate change and citizens' security in the political agenda.
Option 2	Achieves the objectives of provision of information services through sustainable infrastructure only for a limited period (up to 2020). Does not achieve objective related to sustainable downstream growth.	A EU budget contribution to the GSC of approximately 200 M€/year on average in the next financial framework would enable achieving benefits between 400 and 900 M€ per year until 2022. After 2020, benefits would drop to about 130 M€/year, approximately equal to costs in the following period. This option has important built-in cost inefficiencies linked to the "stop-and-go approach". The EU would not benefit from economies of scale in the production of recurrent satellite units, which are important in the space sector.	The impact on EU budget, although higher than in the baseline, is likely to be offset by limited environmental and economic benefits. Policy coherence would be dependent on the capacity of the EU and the rest of the European EO community to bridge the gap after the lifetime of the first generation. Inconsistent with EU declared ambitions to lead in the climate change arena (in any event climate change will necessitate long-term monitoring activities).
Option 3	Achieves all policy objectives.	A EU budget contribution to the GSC of approximately 430 M€/year on average in the next financial framework would enable delivering benefits of slightly less than a billion €/year until 2022, then peaking at more than 5 billion €/year as of 2027.	The longer-term investment, higher than in the baseline, would enable positive trade-offs in political priority areas, such as climate change. Coherence with political agenda and EU objectives. Potential for strategic benefits for the EU as global actor. The necessary envelope and corresponding shift from research to operation would require the insertion of GMES among the financing priorities in the next EU financial framework and may imply corresponding adjustments in other policy areas.

7. MONITORING AND EVALUATION

The Communication itself will not directly result in the financing of new activities through the EU budget, in addition to the actions financed through FP7, preparatory actions and GMES initial operations until 2013. The latter activities are not the object of this impact assessment and will be monitored and evaluated according to standard Commission procedures.

Should one of the Options requiring the exploitation of the Sentinels post-2014 be chosen by the next College of Commissioners, the proposal for the relevant basic act(s) will be elaborated in line with applicable rules, in particular regarding the preparation of the next multiannual financial framework. Such basic act(s) would contain detailed provision on the monitoring and evaluation of activities to be financed through the EU budget. The accompanying Impact Assessment would have to analyse monitoring and evaluation mechanisms.

Nevertheless, it is useful to give here an outline of the main lines of evaluation and monitoring mechanisms that could apply in general terms.

Evaluation

In line with standard Commission practices, evaluation tasks will be carried out in three phases (ex ante, interim and ex post). The interim and ex post evaluation will assess whether the operational objectives referred to in chapter 3.3 are met.

Additionally, the Commission will evaluate the progress of exploitation activities before any major decision milestones, including the decision on the renewal of the Sentinels, which may have to be taken before the beginning of one or more financial frameworks due to the long development cycles for satellites. Measures will have to be taken so that, in each policy cycle, decisions are informed by i.a. an update of the cost-benefit case for the various options and a wide stakeholders' consultation, with a focus on user communities, on effectiveness and usefulness of the system.

Monitoring

The Commission will ensure that agreements concluded in the framework of GMES services provide for supervision and financial control by the Commission, if necessary by means of on-the-spot checks, including sample checks, and audits by the Court of Auditors. If need be, the Commission could be assisted by external technical experts when monitoring the implementation of the programme. On the basis of the results of the on-the-spot checks, the Commission will ensure that, if necessary, the scale or the conditions of allocation of the financial contribution originally approved and also the timetable for payments are adjusted.

In addition to financial supervision, the Commission will put in place mechanisms to ensure continuous technical monitoring.

Annex I
GMES: observing the Planet for a safer world – a short description

Managing natural resources and biodiversity, adapting to sea level rise, monitoring the chemical composition of our atmosphere: all depend on accurate information delivered in time to make a difference.

The European Earth Observation Programme (GMES) provides data useful in a range of issues including climate change and citizen's security. Land, sea and atmosphere – each Earth component is observed through GMES, helping to make our lives safer.

The purpose of GMES is to deliver information which corresponds to user needs. The processing and dissemination of this information is carried out within the "GMES service component". The thematic areas within the GMES service component comprise:

- land, marine and atmosphere information – ensuring systematic monitoring and forecasting the state of the Earth's subsystems at regional and global levels;
- climate change information – helping to monitor the effects of climate change, assessing mitigation measures and contributing to the knowledge base for adaptation policies and investments;
- emergency and security information – providing support in the event of emergencies and humanitarian aid needs, in particular to civil protection authorities, also to produce accurate information on security related aspects (e.g. maritime surveillance, border control, global stability, etc.).

The GMES service component depends on Earth observation data, collected from space (satellites), air (airborne instruments, balloons to record stratosphere data, etc.), water (floats, shipboard instruments, etc.) or land (measuring stations, seismographs, etc.). These facilities are called the GMES infrastructure component; non-space based installations in the GMES infrastructure component are generally referred to as "*in situ* component".

By securing the sustainability of an information infrastructure necessary to produce output information in the form of maps, datasets, reports, targeted alerts, etc…, GMES helps people and organisations to take action, make appropriate policy decisions and decide on necessary investments. GMES also represents a great potential for businesses in the services market, which will be able to make use of the data and information it provides according a full an open access principle.

Earth observation-based services already exist in Europe, but they are dispersed at national or regional level and cannot rely on a sustainable observation capacity. With the exception of meteorological services, long-term availability and reliability of information is not guaranteed. This is why, in order to contribute to improve its response to ever growing challenges of global safety and climate change, Europe develops a sustained and reliable Earth observation system of its own.

ANNEX II
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ANNEX III
Technical content of the ESA GSC programme and schedule of launches in the ESA Long term Scenario

1. INTRODUCTION

The objective of GMES is to provide, on a sustained basis, reliable and timely services related to environmental and security issues.

As stated in the European Space Policy Resolution, GMES comprises a service component and an infrastructure component, including space and in-situ. ESA is in charge of the coordination and the implementation of the space infrastructure component starting with the GSC Programme.

The objective of the ESA GMES Space Component Programme is to fulfil the space-based observation requirements in response to European policy priorities with a particular emphasis on the fast track and pilot services identified by the EC for early implementation. It aims at developing a fully operational capability in view of feeding GMES services with satellite data.

The GMES Space Component programme, within its available resources, also aims at the operational provision of satellite data for other European and national services.

In addition, the ESA GSC Programme covers the development (and pre-operations phase) of a Data Access Layer ground infrastructure aiming at feeding GMES Services with satellite data from all missions (ESA, National, EUMETSAT and other Third Party Missions) of relevance to the overall space component of GMES.

The ground segment will be designed in a way to ensure coherence and interoperability between the Sentinel and specific contributing missions in order to fully exploit their data for both GMES and other registered national services.

2. USER REQUIREMENTS PROCESS

The Commission set up Implementation Groups to provide guidance on the definition of the GMES services and to support it in its role of aggregating user requirements, starting with land monitoring, emergency response and marine services and subsequently for atmosphere composition monitoring services. The results were debated and consolidated by the GMES Advisory Council and user requirements were transmitted to ESA. Subsequently, ESA consulted the EC and the Implementation Groups to accurately reflect the related space infrastructure needs in the Sentinel-1 to -5 Mission Requirement Documents prepared by ESA. The need for the long-term availability of low-inclination altimetry missions was expressed by the Marine Core Services Implementation Group and subsequently endorsed by the EC.

The technical objectives of the GSC programme clearly correspond to these user requirements. Regarding data requirements for the GMES services, ESA will prepare a corresponding Data Access Portfolio (DAP) and its future updates. Specific references to the content of these requirements are provided in the following sections. Future updates of user requirements will be implemented in the GSC following the agreed scheme within the GMES Governance. A first preliminary way how this could be treated is described in GAC document GAC-11-04, which will be further refined.

2.1. Space Segment Overview (Sentinel-1 to -5) overview

The key aspects of the individual Sentinel missions are as follows:

- The Sentinel-1 satellite carries a SAR in a well-controlled dawn-dusk sun-synchronous orbit at approx. 700 km altitude with an exact repeat cycle of 12 days in support of multi-pass interferometry. With the SAR swath of approx. 240 km, a 12-day quasi-global coverage is ensured. The ground resolution exceeds that of ERS and ENVISAT in imaging mode. The satellite, weighing about 2.2 tons, is adapted to the large SAR instrument, which features a phased-array antenna with 5 kW total radiated power. A duty cycle of 20% is achieved. Following the launch with a Soyuz-class vehicle, the Sentinel-1 design lifetime is 7 years.
- The Sentinel-2 satellite carries a medium to high resolution push-broom multi-spectral imager operating in the VNIR (Visible and Near-InfraRed) and SWIR (Short-Wave InfraRed) in a Sun synchronous polar (ENVISAT-like) orbit. The imaging ground resolution is 10, 20 and 60 m (depending on channel). The swath width of the multi-spectral imager is approx. 285 km, which ensures systematic acquisition of all land surfaces every 10 days. The satellite, weighing about 1 ton, is launched fits with a Vega class launcher and has a 7 year design lifetime.
- The Sentinel-3 satellite carries a Cryosat-derived microwave altimeter (incl. a microwave radiometer and precise orbit determination device) and two imagers, for ocean/land colour observations (MERIS-like) and for sea/land surface temperature observations (AATSR-like) into an ENVISAT-like orbit. The former imager provides also continuity to the VEGETATION mission. Several lessons learned from ENVISAT are used to optimise the system, e.g. to minimise sun-glint impact, so enhanced continuity is ensured. The satellite, weighing approx. 1.4 tons, supports the 100% instrument duty cycle and is launched with a Vega class small launcher. The design lifetime is 7 years.
- Sentinel-4 and -5 are dedicated to atmosphere composition monitoring. According to the current preliminary concept, the relevant measurements are taken from the geostationary orbit and the low earth orbit respectively.
    - The rationale for the development of Sentinel-4 is to meet the objective of frequent revisit, i.e. to observe rapid changes in atmospheric composition. Thus far no atmospheric composition monitoring is carried out from Geostationary Orbit (GEO), but there is considerable experience from low earth orbit (LEO) with similar instrumentation. The baseline is to implement Sentinel-4 as payload on MTG missions.
    - Sentinel-5 is a component in LEO, exploiting the advantages of such orbits, namely global coverage, better spatial resolution and stronger signal to noise ratio. The experience with GOME, GOME-2, AIRS, IASI, OMI, SCIAMACHY, MIPAS, GOMOS, ODIN, MOPPIT and other sensors provides a very solid scientific and technical basis on which Sentinel-5 builds. The baseline is to implement Sentinel-5 as payload on post-EPS missions.
    - Considering the late availability of the post-EPS satellites, a small Sentinel-5 Precursor mission to be launched in 2013/14 will ensure the continuity of UV-VIS-NIR-SWIR data between ENVISAT and Sentinel-5 on post-EPS, related in particular to atmospheric composition monitoring in the troposphere.

Two spacecraft in orbit are needed to meet the coverage and observation frequency requirements for the Sentinel-1, -2 and -3 missions. However, an incremental deployment of capabilities is assumed.

As regards low-inclination altimetry it is envisaged to carry out study activities for a Jason-Cryosat (Jason-CS) mission. The Jason-CS spacecraft would be based on a platform derived from Cryosat-2 but adjusted to the specific requirements of a 1,300 km orbit. The instrument suite could comprise a recurrent radar altimeter (Jason-2 RA or Sentinel-3 SRAL), a Microwave Radiometer (recurrent from Sentinel-3), a GPS device (recurrent from SWARM or Sentinel-3) a DORIS device (recurrent from Sentinel-3) and a Laser Reflector (recurrent from Cryosat).

Two spacecraft in orbit are needed to meet the coverage and observation frequency requirements for the Sentinel-1, -2 and -3 missions. However, an incremental deployment of capabilities is assumed.

The Segment 1 of the ESA GSC Programme, as approved by the ESA Member States participating in the programme includes the development, launch and in-orbit verification of the first satellite only, of a series for each of the Sentinel-1, -2 and -3 missions.

2.2. Sentinel-4 and Sentinel-5 activities

Two parallel pre-Phase A studies of Sentinel-4 and Sentinel-5 have been initiated in 2007. The objective of these studies is to address the optimum allocation of space resources for atmospheric composition monitoring missions according to requirements expressed by user groups, and is supported by ad-hoc science and instrument studies.

These studies are part of the approved Segment-1 of the ESA GSC Programme.

2.3. Ground segment activities

The Ground Segment comprises the Flight Operations Segment (FOS) and the Payload Data Ground Segment (PDGS). The FOS is responsible for the monitoring and control of the satellites, including flight dynamics operations for orbit control, whereas the PDGS is responsible for the handling of the Sentinel mission data, its reception on the ground, processing, archiving and dissemination.

The ground segment activities for the Sentinel missions comprise the definition of the ground system concept of FOS and PDGS together, followed by the design, implementation, verification and validation of the FOS and the PDGS individually, and concluded with the participation to the integration, verification and validation of the resulting system as a whole, i.e. FOS and PDGS together with the satellite and including the commissioning phase.

2.3.1. Flight Operations Segment (FOS)

The principal FOS components in support to the Sentinel missions are:

- the Ground Station and Communications Network performing telemetry, telecommand and tracking operations. A primary ground station will be used throughout all mission phases, complemented by additional TT&C stations as backup stations or stations used during Launch and Early Orbit Phase (LEOP).
- the Flight Operations Control Centre, including:
  - the Sentinels Mission Control System (MCS), for telecommanding of the satellite and for supporting command request received from the PDGS mission planning system and handling of telemetry from the satellites;

– the specific Sentinels Spacecraft Simulators, supporting operations procedure validation, operator training and the simulation campaign before each major phase of the missions;

– the Sentinels Flight Dynamics System (FDS), supporting all activities related to attitude and orbit determination and prediction, preparation of orbit manoeuvres, spacecraft dynamics evaluation and navigation;

– a General Purpose Communication Network, providing the services for exchanging data with any other external system during all mission phases.

The FOS implementation includes the definition of the FOS architecture comprising a FOS Core Ground Segment used for all Sentinels as well as including Sentinel-specific developments, including security relevant implementations for telecommanding. This includes the completion of the design, implementation, verification and validation of the ground stations, the communication networks as well as the MCS, Simulators and FDS. Developments will reuse existing core facilities such as the infrastructure of the MCS already in use for other earth observation missions.

The FOS activities furthermore include support to the ground system integration, verification and validation with the PDGS and the satellite and all operations preparations activities, simulations sessions for LEOP and simulations in support to commissioning and routine operations. The activities furthermore include the FOS operations during the commissioning phase.

2.3.2. Payload Data Ground Segment (PDGS)

The Payload Data Ground Segment (PDGS) is a distributed ground segment, reusing existing facilities, infrastructure and expertise. Furthermore, the ground segment links and shares already available infrastructure developed for National missions.

It includes the multi-mission payload data ground segment for the access to Sentinel and other missions and the development of this harmonised and interoperable ground segment that will reuse and evolve from existing shared facilities with different missions.

Ground segment activities also cover the extension of the heterogeneous mission accessibility concept to cover product formats, quality reporting and certification across different missions. They also include the finalisation of the architecture of the Sentinel payload ground segment, considering the GMES end-to-end security concept. The Sentinels' algorithms and products definition studies focus on standardisation across similar missions.

The multi-mission PDGS development includes the implementation and evolution of the generic elements (archives, interfaces, catalogues, networks, User Services, etc.) for Sentinel-1, -2 and -3.

In addition, the PDGS includes the specification, design and development of Sentinel-1, -2 and -3 specific PDGS elements (e.g. algorithms & processors, modules related to the customisation/adaptation of mission planning, user services and facilities for acquisition, archiving, dissemination and cal/val functions). These mission-specific elements are then integrated into the configured multi-mission infrastructure which will be deployed in the operational centres. The above will be completed with the operational validation and the transfer to operations.

Ground segment technical evolution must also be addressed to adapt to new technologies and evolving requirements from the GMES Services.

The PDGS activities for the Sentinel missions also include support to the ground system integration, verification and validation with the FOS and the satellite and all operations preparations activities in support to commissioning and routine operations.

All ground segment activities described in this chapter are part of the approved Segment-1 of the ESA GSC Programme.

2.4. Data Access activities

2.4.1. Data procurement

These activities are primarily focusing on providing in a pre-operational manner, Earth Observation data to the GMES Services from 2008 onwards from (private and institutional) national missions, ESA, National, and EUMETSAT missions to GMES Services and other third party missions as identified in the programme proposal (ESA/PB-EO(2005)54, rev.3). These activities concern the set up of a harmonised access to 8 to 12 missions and include the procurement of the actual data on the basis of individual user licenses, or multi-user licenses, or resource buy. This also includes any adjustments on the side of the operators of contributing missions regarding their ground segment and operational interfaces for the data use as well as the adjustments of their ground segment and operational interfaces to adequately provide data to the GMES services and other GMES users as approved by the EC therefore fulfilling their observation requirements.

All Data Access activities described in this chapter are part of the approved Segment-1 of the ESA GSC Programme, for the period up to mid-2010.

Data access activities are currently financed through a dedicated EC-ESA grant agreement.

2.4.2. Data access management and initial operations

This task includes the collection and critical analysis of the data requirements from the complete set of GMES services. The GMES mission capacity planning activity aims at regularly performing a data gap analysis and defining the sensor resources required from the various GMES missions to adequately fulfil these data requirements. The results of these analyses are used for the preparation of the subsequent data access agreements with the EO mission partners for the contribution of their mission to GMES.

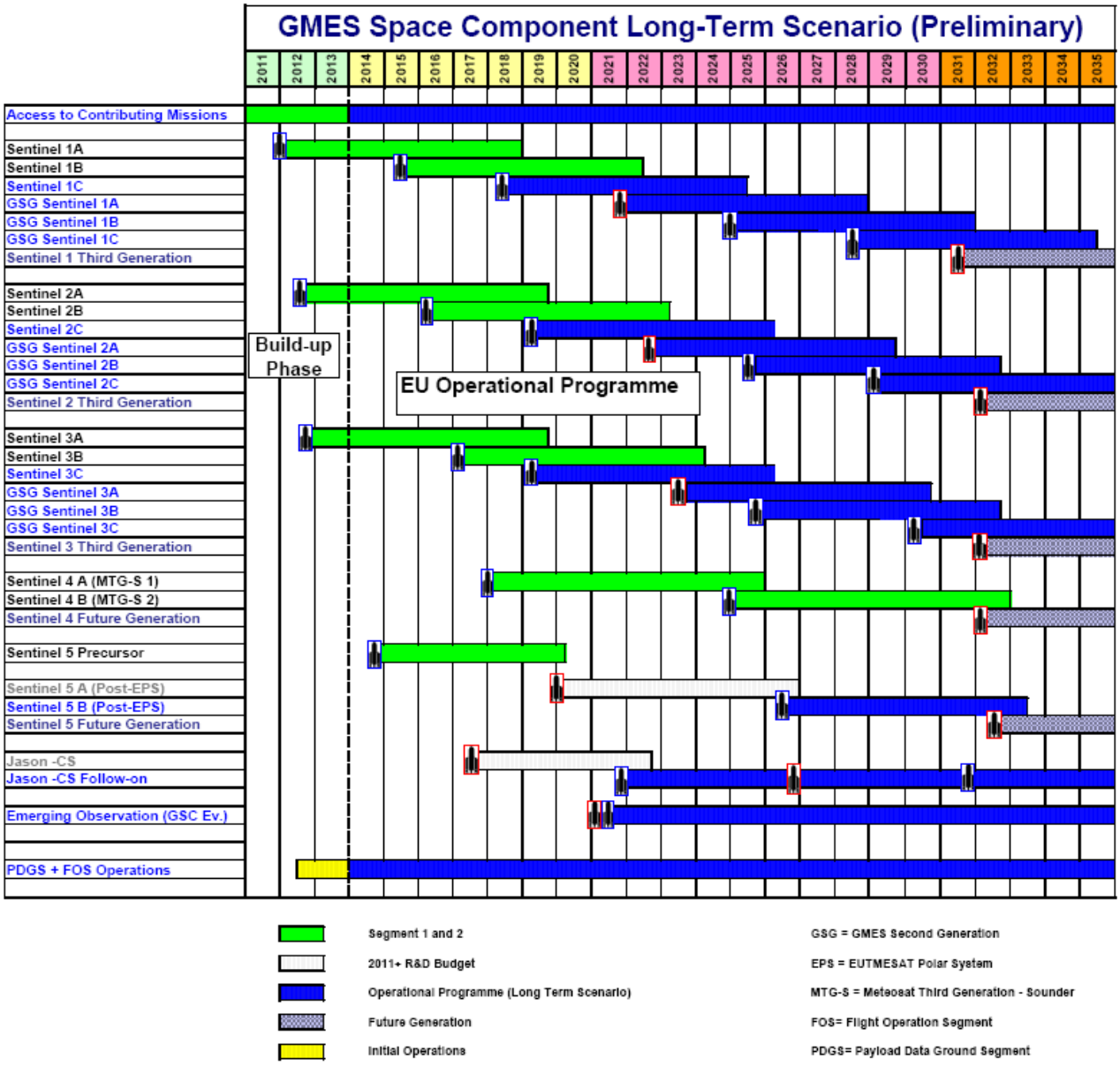
2.5. Pre-Operations

Until the start of the GMES operations phase of the Sentinels (currently assumed in 2012/2013) the GMES services will be provided with Earth Observation data on a pre-operational basis in a coherent manner based on national, EUMETSAT and ESA missions. This includes, in addition to the data processing and access services of relevant GMES missions which are covered in the data procurement budget, the coordination functions that ensure the coherency of the end-to-end data provision and the common ground infrastructure. The coordination functions cover, across all these missions: mission planning, ordering, data request follow-up and helpdesk interface to services, scheduling the distributed ground segment resources, tools development, product/data and data access service quality management, end-to-end data flow monitoring among data access among others pre-operational tasks. Operations of the ground segment facilities supporting data access activities will start from end 2008 to perform: ingestion or collection of data, processing up to the required level, archiving and distribution of GMES product sets as requested by GMES Services, starting from the Fast Track Core Services, the atmosphere and security pilot services and all other approved GMES services, as documented in the Data Access Portfolio and its future updates. This includes the operation of archives and data distribution infrastructure, among others, for this specific set of products.

In addition, pre-operations of the ground segment facilities will start prior to the launch of the Sentinels, and will cover the period from end 2008 to end 2010All Pre-Operations activities described in this chapter are part of the approved Segment-1 of the ESA GSC Programme.

2.6. Launch schedule

The launch schedule according to the ESA LTS is indicated in the figure below.



Annex IV
The PWC study – methodology and limitations

The benefit data for the cost-benefit analysis of the various options have been taken from the most comprehensive and recent study available: the PriceWaterhouseCoopers "Socio-Economic Benefits Analysis of GMES" (report of October 2006).

This Annex summarises the methodology of the PWC Study and its main limitations, in order to put the findings of the cost-benefit analysis into perspective. For more information, the full text of the PWC Study and its annexes are available at the following URL: http://www.esa.int/esaLP/SEMJZ10DU8E_LPgmes_0.html.

1. CONTEXT

The European Space Agency (ESA) Member States requested the ESA executive to procure a study on the socio-economic impacts of GMES in order to back their significant investment decisions. The study, managed by ESA in close cooperation with DG Enterprise and Industry of the European Commission, was concluded in October 2006. PWC worked in direct contact with Commission and ESA staff for progress and review meetings. In addition, an "Expert committee" nominated by the GMES Advisory Council[85] provided advice and guidance on key elements of the analysis, in particular the methodological approach and the presentation of results. Four Expert Committee workshops were organised between April 2005 and May 2006.

The study objectives were:

- to determine the extent of the impact resulting from GMES with respect to a reference baseline of what will happen if GMES is not implemented;
- to characterise the benefits resulting from GMES with respect to:
  - the strategic and political dimension of GMES including considerations such as strategic independence of Europe and support to Europe playing a larger role at global level;
  - the economic and social dimension of GMES including more cost effective information gathering, better targeted policies resulting from improved information and greater pressure to secure international agreements to address common threats and issues facing mankind today.

The study focused on key benefit areas that could arise from GMES. Areas where the extent of the impact/the benefits are low or rather marginal have not been considered. The scope of the analysis excluded any costs consideration. No evaluation of costs against the projected benefits was carried out in the study itself.

2. METHODOLOGY

As a wide range of very different impacts arise due to GMES, a variety of different techniques was required to characterise the associated benefits. The broad parameters of the socio-economic assessment are described by PWC as follows:

[85] A Member States' group advising the European Commission on GMES development

- the study focuses on reflecting the broadest range of societal and economic benefits which might be generated by GMES;

- the method is unconstrained in nature, i.e. the analysis is not driven by any prior assumptions as to where the benefits and impacts may occur;

the assessment considers and expresses potential benefits in both quantitative and qualitative terms on the basis of a pragmatic user-based assessment of the benefits, whereby a wide number of informed stakeholders were asked to consider the magnitude of the contribution made by GMES. Thereafter, this contribution is quantified with reference to respected published sources in the field of economic valuation. This approach is considered less subjective since it involves a process of 'expert' assessment;

- benefits and impacts are characterised with respect to a baseline (without GMES) scenario that is itself stakeholder informed;

- ultimately, projected economic benefits (inclusive of societal, environmental and other economic benefits) are monetised and expressed in present value terms.

2.1. Stakeholders engagement

Stakeholder consultation is at the core of the study. A comprehensive stakeholder consultation exercise was undertaken to support:

- the development of the baseline scenario; and
- the estimation of impacts resulting from GMES,

This process targeted key stakeholders across the range of GMES sectors and geographical areas. The consultation process covered three categories of stakeholders reflecting the key policy areas affected by GMES and geographical areas impacted:

- stakeholders consulted on macro level impacts: efforts were directed towards stakeholders in the European Commission and agencies responsible for development and implementation of European policy domains affected by GMES services. As European level institutions work in close collaboration with Member States, also national counterparts and bodies suggested by the Expert Committee for the study were also consulted.
- stakeholders consulted on micro level impacts. these stakeholders were divided into:
  - direct stakeholders: examples of direct stakeholders include agencies directly producing and using information products on the state of the environment through the application of GMES services (such as the European Environment Agency, the European Maritime Safety Agency, national Environmental Agencies) and the downstream industry;
  - ─ indirect stakeholders: these included for example, companies in production industries which use information about the environment to inform their strategic and operating decisions.

Stakeholders were first listed by the study team, then the list was checked and consolidated by ESA, the European Commission and the Expert Committee to ensure notably a comprehensive coverage of geographic area and policy domains. After prioritisation using an

Influence/interest matrix[86], 104 stakeholders were consulted (the list is annexed to the PWC study). The majority of stakeholders contacted were from European level organisations to ensure complete coverage of policy sectors addressed by GMES.

Stakeholders were consulted mainly through individual interviews (face-to-face, telephone, e-mailing) or workshops. Three workshops were held (GMES and climate change, 29/09/05; GMES and aid and development, 06/10/05; GMES and civil protection and public health, 10/10/05). The structure of individual interviews and workshops is annexed to the PWC study.

When divergent views amongst members of the same workshop were recorded, the study team tried to cross-check these views for internal consistency and, when this did not deliver results, maintained a range of impacts for benefit modelling and sensitivity analysis purposes.

2.2. Approach to benefits assessment

The assessment of GMES benefits presented in the PWC report was based on:

- the stakeholder consultation process referred to above;
- the benchmarking stakeholder inputs and feedback with published sources;
- desk based review of a wide variety of secondary sources;
- comparison of impact estimates against case studies showing what is possible today or in the near future.

To the maximum extent possible, the benefit case was evidence based – reflecting what stakeholders said about the projected practical application of GMES services and the effects that these services might have on policy formulation or practice and the different inputs have been cross-validated.

Ultimately, based upon this feedback, PWC identified the economic value generated by GMES services (in many cases, as manifested through better, or more responsive government policies, made possible by GMES).

The steps for macro economic benefit assessment are summarised below:

(1) Determine the **policy context** through analysis of existing policy documents and stakeholder consultations. The result is a mapping of EC priorities to GMES policy domains and of major issues and areas of potential wider benefits per policy domain, as illustrated below

[86] Stakeholders' groups were positioned with respect to their interest in GMES and their ability to influence GMES evolution.

EC Strategic Policy Priority	GMES Policy Domain
The European Union as a global partner (External policies)	Climate Change Mitigation and Adaptation
	Global environment protection and sustainable development
	Development and Aid
	Common Foreign and Security
Preservation and management of natural resources	Natural resources (agriculture, fisheries)
	Biodiversity and ecosystem management
	European environmental protection
	Risk and civil protection (from natural and technological disasters)
Sustainable growth ▪ Competitiveness for growth and employment ▪ Cohesion for growth and employment	Cross cutting issues including: ▪ Lisbon Agenda ▪ Efficient delivery of public services ▪ Support to strategic industries ▪ Regional policy
Citizenship, freedom, security and justice	Security, Border Control

Major issue	Wider benefit
Global environment	Climate change Desertification Development and aid Humanitarian aid and food security
Security	Common Foreign & Security Policy Border surveillance
Natural resources	Agriculture Biodiversity and ecosystem services Fisheries
European environmental protection	Air quality, Water quality, Land use and regional policy, Urban environment and spatial planning, Marine and coastal environment protection
Risk and civil protection	Floods, Forest fires, Urban subsidence, Landslides, Earthquakes, Industrial accidents
Sustainable growth	Competitiveness

Where stakeholders contacted did not feel sufficiently well informed to estimate this impact, the issue was not included in the report (examples: effectiveness of development aid for long term development and reconstruction; detection of longer term environmental degradation and development of humanitarian crises; improved understanding of carbon and water cycles and their impacts on human well being; improved management of energy resources). Given the time and budget constraints, not all issues could be addressed. However, as the benefits identified were extremely large, it should be taken as an indication that the benefits case presented is actually extremely conservative.

(2) Development and validation with stakeholders of a counterfactual baseline ('Without GMES' Scenario), essentially reflecting actions expected to arise at European or global level in the absence of GMES. This scenario is described in detail in the study, including assumptions for the Space component. It was derived from a range of published sources and also from the stakeholders' consultation. A number of assumptions regarding policy development are described in Annex 8 to the study;

(3) Development of a 'With GMES' Scenario. This was done using the services portfolio of GMES Initial Services and the demonstration projects under ESA (GMES Service

Element) and EC (GMES Integrated Projects) frameworks. A detailed table listing the existing services per policy area (baseline), the additionality of GMES, the beneficiaries and the benefits (macro and micro) is annexed to the PWC study;

(4) Quantification of the additional impact of GMES, through indicators developed for each policy area. Benefits were differentiated over time and combined and discounted to reflect present value assessment of the total benefits (see below for limitations on this assessment).

2.3. Indicators and tools for assigning value

A number of indicators were chosen to measure projected benefits. These were not intended to be exhaustive in nature and capture every conceivable GMES benefit. Rather, they were seen as an accepted means of expressing and valuing change against a particular social, environmental and economic baseline. The PWC study team considered the chosen indicators as appropriate, based on literature review and stakeholders' input.

To minimise the possibility of uncontrolled assumptions influencing this evaluation, a restricted number of standard indicators were adopted, for which extensive peer review was conducted. As a result, the application of these indicators in the context of the impact and benefits analysed was standard practice among many national and international government organisations.

Indicators used in all areas of the benefit assessment are summarised below.

GMES policy domain	Application of GMES services	Potential GMES Impact	Indicator to characterise GMES impact
Global environment	Climate change – reduction in uncertainty	Reduced Global damage costs imposed by climate change, through enhanced mitigation & reduced deforestation	Damage costs per tonne of $Co2^{e}$ Climate value of forests per Ha
	Desertification	Reduced loss of productive land	Economic value per Ha of productive land
Development and aid	Humanitarian aid & food security	Improved health and welfare in Africa	Value of a Disability Adjusted Life Year in Africa
Security	Crises response in Africa	Improved health & welfare of refugees in Africa	Value of a Disability Adjusted Life Year in Africa
Natural resources	Agriculture	Efficiencies in monitoring CAP(b)	CAP monitoring costs
	Biodiversity & ecosystem services	Reduced loss of forests	Existence value of biodiversity per Ha of forest
	Fisheries	Reduced illegal fishing	Value of illegal fish landings (per tonne)
European environmental protection	Air quality	Human health benefits	Statistical value of life in Europe
	Water Quality	Efficiencies in delivering the WFD(a)	WFD monitoring costs Nitrate removal costs
	Land use	Reduced soil quality degradation	Soil Thematic Strategy monitoring costs
		Urban planning efficiencies, energy savings (c)	N/A
	Marine and Coastal environment	Reduced oil discharges	Economic cost of oil spill clean up
Risk & civil protection	Floods	Reduced flood impact in Europe	Health, welfare & property damage costs of flooding
	Forest fires	Reduced forest fire impact in Europe	Health, welfare & property damage costs of forest fires
	urban subsidence & landslides	Reduced geohazard impact in Europe	Health, welfare & property damage costs
	Industrial accidents	Reduced industrial accident impact in Europe	Health, welfare & property damage costs
Sustainable growth	Competitiveness Efficiency savings	Improved cost efficiency for primary users of GMES information	Cost savings of primary users

Source: *PwC analysis*

Notes: (a) Water Framework Directive
(b) Common Agricultural Policy
(c) Addressed in qualitative terms only. Stakeholders did not feel able to express a quantitative role for GMES in this area, nor was an appropriate indicator specified

An example of the use of indicators to quantify projected benefits is as follows:

In the area of marine and coastal affairs, GMES, through the provision of qualitatively improved information regarding the movement and tracking of vessels, could reduce the incidence of illegal oil discharges from vessels in European waters. This effect is expressed in economic terms in the PWC study through the following process:

- Economic costs per tonne of discharged oil are drawn from respected third party sources - these costs represent the social, economic (e.g. impact on tourism, clean-up costs) and environmental loss and damage which are potentially associated with oil spills;
- The views of stakeholders consulted in the course of the study concerning the extent to which illegal oil discharges might be reduced (relative to the prevailing pattern of discharge in European water – the counterfactual baseline) through the use of GMES information are considered; and finally

- The difference in these prevailing rates of illegal oil discharge, with and without GMES, is combined with the economic cost per tonne (as discussed above) to give a total economic benefit associated with GMES.

2.4. Key modelling assumptions and discount rate

There are four main components within the framework employed in this study to express the views of stakeholders in economic terms:

(1) GMES applications, together with the associated projected benefits, are assumed to commence at different points in time due to the different levels of complexity through which particular services generate impacts and create benefits.

(2) In all cases, peer reviewed and accepted standard indicators were used to assign economic value to an impact generated as a result of information provided by GMES. Key assumptions and calculation processes inherent in generating these indicators were reviewed for consistency with the assumptions underlying the analysis of GMES benefits (in particular, the time frames over which benefits were being assessed and the geographic coverage of the services were considered with respect to the assumptions supporting the generation of each indicator);

(3) The discount rate applied to express projected benefits in present value terms is taken to be 4% real. This is coherent with the Impact Assessment Guidelines;

(4) The timeframe over which the projected annual benefits are appraised is 25 years and these are brought together and expressed in present value terms. Terminal Values (the continued economic value of a benefit stream beyond the core appraisal period of 25 years) were also used to supplement the analysis and capture perpetual benefits.

3. PRESENTATION OF THE RESULTS

The main body of the PWC study is structured around policy areas (global environment, security, natural resources, European environmental protection, risk and civil protection, sustainable growth).

However, different levels of effort are inherent in realising particular impacts by GMES and the subsequent benefits. For example, a forest change monitoring service impacts on the formulation of new agreements where states subject to heavy illegal deforestation implement effective control measures to reduce the level of forest loss, while maritime surveillance integrating satellite and conventional techniques improves the cost efficiencies for current oil spill monitoring practices within an existing well defined legal framework.

Clearly it is significantly more straightforward to realise benefits in the second. To better represent the substantial variation over different benefit areas in the effort implied for successful implementation of the underlying policies, benefits realised under individual policy areas were aggregated into three higher level categories. This categorisation is based on the inherent difficulty in effectively implementing the underlying policies including the extent to which an appropriate legal and operational framework already exists, the degree of institutional reform required, the difficulty in securing agreement on new European environmental legislation, the agreement of states to implement effective policies etc. The three categories are summarised below:

- **Category 1: (Efficiency benefits)** – these benefits relate to improved cost effectiveness in responding to the implementation or enforcement of policies currently in place. In these cases, access to GMES information readily available from precursor GMES services or

from services that are planned in the near future directly generates the benefits cited. These benefits are analogous to the benefits of data continuity that GMES will bring. Category One benefits are assumed to be delivered through existing institutional and policy channels, and as a result these benefits could be achieved in a more timely manner;

- **Category 2: (European policy formulation benefits)** – these benefits relate to improved definition, structuring and implementation of European policies as a result of GMES information being available during the policy formulation process. Their realisation depends upon policy developments at European level, or significant changes in the working practices of target user institutions with a view to making operational use of GMES information. In these cases the benefits will be realised once the policies begin to achieve their objectives. Implementing such policies usually requires investment on the part of Member States while the benefits take longer to accrue. These considerations imply that the benefits stream will begin later in the appraisal period, to reflect the extent of policy and institutional change required for the benefits to be realised;

- **Category 3: (Global action benefits)** – these relate to the use of GMES information in setting up or improving the implementation of global agreements (e.g. for climate change, desertification, deforestation). In these cases, realisation of the benefits is critically dependent on international agreements and cooperative actions, which are successfully implemented and lead to behavioural changes. Such international agreements take considerable time to set up and to make an impact. Implementing these agreements also implies considerable investment by the signatory states (e.g. in transfer payments, income foregone or investing in alternative technologies). Given these issues, it was assumed that these benefits are realised from 2025.

On this basis, the table below summarises the phasing of each benefit category and shows that whilst Category One benefits are assumed to accrue in the near-term, Category Three benefits are assumed to arise only in the period from 2025.

Table 2-3: Phasing of projected GMES benefits, by benefit category

Category	Modelling year: benefits commence (year)	Corresponding calendar year (year ending)
1	Year 3	31/12/2008
2	Year 6	31/12/2011
3	Year 20	31/12/2025

Source: PwC, ESYS assumption. Discussed and agreed with ESA

4. LIMITATIONS OF THE PWC BENEFITS ASSESSMENT

The assessment of GMES benefits in specific policy areas was limited by access to stakeholders within the time constraints of the study period. In particular, many of the stakeholders consulted were working within European or international organisations or in research and policy development institutes in order to ensure as wide an overview as possible. Although more than 120 stakeholders were contacted (approximately double the number usually considered for an assessment of this type), there were gaps in the contributions received. These included:

- Stakeholders from southern Europe working at national and regional level in sectors where GMES may impact;

- Stakeholders from industry sectors where GMES may be expected to impact;

- Stakeholders working in policy sectors where there is low level of policy focus or limited experience within the European Union (e.g. polar issues, security issues).

Throughout the study stakeholders provided valuable input but often the diversity of interests represented (for example during the climate change workshop there was representation from specialists in forests, urban planning, emissions trading) limited the ease with which consensus could be achieved on the magnitude of potential benefits. Where appropriate, the consultants filtered information provided by the stakeholders in order to reach a consensus in their views.

Other inherent limitations existed in relation to the level of understanding and hence availability of information on the value of potential benefits, and in the ability to assess the benefits of GMES information in the context of other dependencies for benefit realisation. In particular:

- Where prototype services exist (e.g. under the ESA GMES Services Element) and stakeholders had experience in using the information provided, the impact and benefit characterisation was significantly easier and more explicit than for stakeholders who as yet have had no direct exposure to the products and services presently being provided.

- For areas where new policies are about to be implemented or updated (e.g. air pollution, marine environment) or where the full impact is yet to be seen (e.g. water framework directive, soils thematic strategy), stakeholders were less certain about impacts and benefits due to ambiguity with respect to the precise content of the baseline "*Without GMES*" situation.

The baseline scenario does not include any radical change in stakeholder responsibilities or organisational structure over the time period being considered (2005-2030). The benefits and impacts are estimated by stakeholders on the assumption that their operational roles and responsibilities will evolve gradually over the next 25 years and that the impacts made by GMES will be a gradual part of this evolution process.

Moreover, it is important to note that the understanding of what is included in GMES has evolved since the study (and even during the course of it). However, it is fair to say that assumptions documented in Annex 4 to the PWC study on the definition of the different scenarios used are still largely valid today.

Finally, it is important to reiterate that the value of the information provided by GMES and the value of the benefits identified does not materialise unless the information is actually used. It has been assumed throughout the PWC study that this effective utilisation would occur. In some cases, the resulting economic benefits can be considerable. In general, for the benefits assessed in the PWC report, benefits that can be realised in a straightforward manner are much smaller in magnitude (i.e. below € 5bn discounted over the total 25 year timeframe under consideration) while benefits that relate to the implementation of new policies arise only when these policies begin to achieve their objectives. Clearly this is a more complex process and requires significant additional investment, political commitment and time for the benefit realisation. However these benefits are much larger in magnitude (of the order of tens of billion of Euros).

These processes leading to Category two and Category Three benefits will result in costs being incurred by the signatory states (e.g. consider the implementation of the Montreal or Kyoto Protocols). However, the resulting benefits are very large. In these cases, the impact estimated by the stakeholders refers to the total impact of GMES on the process to set these

agreements up while the estimates of the benefits refer to the benefits from the successful implementation of the resulting policy or international agreement. This means that the benefit assessment assumed that the required investments necessary for these benefits to be realised would be effectively be made.

An alternative approach, more related to the contingent valuation (willingness to pay) methodology, would address only the value represented by the information and not count the total value of the resulting benefits. After extensive consultation, this approach was not adopted in the PWC study.

ANNEX V
LIST OF ABBREVIATIONS

AR:	Acceptance Review
CDR:	Critical Design Review
DAP:	Data Access Portfolio
DRS:	Data Relay System
ECSS:	European Cooperation for Space Standardisation
EGNOS:	European Geostationary Navigation overlay System
EM:	Engineering Model
EPS:	Eumetsat Polar System
ESA:	European Space Agency
EUMETSAT:	European Organisation for the Exploitation of Meteorological Satellites
EUTELSAT:	European Telecommunications Satellite Organization
FAR:	Flight Acceptance Review
FM:	Flight Model
FOS:	Flight Operations Segment
FP6:	6th Framework Programme for Research, research, technological development and demonstration activities
FP7:	7th Framework Programme for Research, research, technological development and demonstration activities
GEO:	Group on Earth observation
GEOSS:	Global Earth Observation System of Systems
GMES:	Global Monitoring for Environment and Security
GNSS:	Global Navigation Satellite System
GSC:	GMES Space Component
INSPIRE:	Infrastructure for Spatial Information in the European Community
IOCR:	In-Orbit Commissioning Review
IOV:	In-Orbit Validation
IR:	Implementation Review
LEOP:	Launch and Early Orbit Phase
LTDN:	Local time at descending node
LTS:	ESA Long term Scenario
MTG:	Meteosat Third Generation
NPV:	Net Present Value
OLCI:	Ocean Land Colour Instrument

PDGS:	Payload Data Ground Segment
PDR:	Preliminary Design Review
PPP:	Public-private partnership
PRR:	Preliminary Requirements Review
QR:	Qualification Review
R&D:	Research and development
ROM:	Rough Order of Magnitude
RR:	Requirements Review (for Data Access)
SEIS:	Shared Environmental Information System
SRR:	System Requirement Review or (for Data Access) System Readiness Review
SLST:	Sea and Land Surface Temperature
SME:	Small and medium-sized enterprise
TT&C:	Telemetry, Tracking & Command
UVNS:	UV/VIS/NIR/SWIR (Ultraviolet/Visible/Near Infrared/Short Wave Infrared)