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Global Earth Observation System of Systems (GEOSS): Achievements to date and challenges to 2025

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EXECUTIVE SUMMARY

This staff working document provides the state of play regarding the intergovernmental Group on Earth Observations (GEO) and the Global Earth Observation System of Systems (GEOSS) after almost 9 years of implementation. It identifies the main challenges which Europe is facing in view of accelerating the evolution of the GEOSS into a system of systems that could effectively contribute to EU policies, generate business opportunities for the EU industry and bring benefits to European society as a whole.

Two categories of challenges are described, accompanied by a number of issues identified so far through Commission consultations[1] or by GEO groups[2] involving European experts: (i) GEO-specific challenges which concern the whole GEO international community including its European members, and (ii) EU-specific challenges.

(i) GEO-specific challenges relate essentially to:

- the transition of the GEOSS towards an operational system of systems;
- fostering the GEO international initiatives and new partnerships;
- the optimisation of GEO capacity building activities, especially in developing countries;
- the revision of the GEO societal challenges with alignment to Sustainable Development Themes;
- the general GEO framework for engaging the private sector on a worldwide basis;
- GEO mechanisms for resource commitments to the GEOSS.

(ii) EU-specific challenges mainly concern:

- GEO-related coordination mechanisms at European and national levels;
- the role of the Horizon 2020 Framework Programme in support to the GEOSS and the evolution of the European Research Area in the field of Earth observation;
- possible synergies between the GEOSS and the EU Copernicus programme;
- the mobilisation of the European private sector to seize future GEOSS business opportunities in a growing global digital economy.

The challenges and issues identified so far are preliminary in nature and will require further analysis, assessment and refinement in case of follow-up action.

[1] Assessment of GEO achievements and benefits conducted by a pool of European experts during the second semester 2013 (annexe VI) and consultation of the representatives of the European GEO Member countries and Participating Organisations via the GEO High Level Working Group (annexe VII).

[2] GEO groups including the GEO Post-2015 Working Group, the Implementation Plan Working Group, the Boards for Infrastructure Implementation and for Institutions and Development, the Data Management Task Force, the Data Sharing Working Group and the GEO Ministerial Working Group.

1. INTRODUCTION

The urgent need for coordinated observations relating to the state of the Earth has been particularly highlighted since the World Summit on Sustainable Development in Johannesburg (South Africa) in 2002 and the meeting of the Heads of State of the Group of Eight Industrialized Countries (G8) in Evian (France) in 2003.

In 2005, several governments, and the European Commission, established the intergovernmental Group on Earth Observations (GEO) for a period of 10 years (2005-2015) with the vision "*to realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information*" and the objective of implementing the GEOSS, the Global Earth Observation System of Systems[3].

Recently, on 17 January 2014, the Ministers and other heads of delegations from the GEO Member governments have resolved to continue the GEO voluntary partnership. They have decided to renew GEO for another period of 10 years and requested to develop, by end of 2015, a plan for implementing the GEOSS through 2025[4].

At the same time, several major EU programmes expected to contribute specifically to the GEO and the GEOSS have been initiated for the period 2014-2020. This includes Horizon 2020[5], the Union's Framework Programme for Research and Innovation 2014–2020 established by Regulation (EU) No 1291/2013 of the European Parliament and of the Council, and Copernicus[6], the EU Earth observation flagship programme established by Regulation (EU) No 377/2014 of the European Parliament and of the Council.

This staff working document provides the state of play regarding the GEO initiative and the implementation of the GEOSS. It reflects the main challenges identified so far from Commission consultations and/or GEO reports, which Europe will be confronted with in the future, both at EU level and collectively with the other GEO Members.

Definition of "Earth Observations" (EO)

For the purpose of this document, the term "Earth observations" refers to measurements of variables related to the various components of the system Earth (e.g. oceans, land surface, solid Earth, biosphere, cryosphere, atmosphere and ionosphere) and their interactions. These measurements are obtained by individual or combined, fixed or mobile sensing elements, being instruments or human observers, either in situ or through remote sensing.

"*In situ* observations" are understood in the GEO context[7] as observations captured locally, i.e. within a few kilometres of the object or phenomenon being observed. These include measurements taken for instance at ground stations, by aircraft and probes, ships and buoys.

By contrast "remote sensing" encompasses observations made at a larger distance. In the GEO context, this refers typically to space-borne Earth observations.

[3] Resolution of the third Earth Observation Summit in Brussels of 16 February 2005 http://www.earthobservations.org/documents/eos_iii/Third%20Summit%20Resolution.pdf

[4] The Group on Earth Observations (GEO) Geneva Declaration of 17 January 2014 http://www.earthobservations.org/documents/ministerial/geneva/MS6_The_Geneva_Declaration.pdf

[5] Official Journal of the European Union, L 347/104, 20.12.2013, p. 104

[6] Official Journal of the European Union, L 122/44, 24.4.2014, p. 44

[7] GEOSS 10 Year-Plan Reference Document http://www.earthobservations.org/documents/10-Year%20Plan%20Reference%20Document.pdf

2. STATE OF PLAY

2.1 The GEO context

Observations of our planet are collected by a wide diversity of in situ and remote sensing instruments on-board various platforms whether space-borne, sea-borne, airborne or ground based. Such monitoring systems are managed by a plethora of public and private entities around the world. For decades, this situation has led to a high fragmentation of the global landscape for Earth system monitoring.

Several international coordination initiatives have been setup, notably in the 1980's, to address this fragmentation, such as the Committee on Earth Observation Satellites (CEOS[8]), the Integrated Global Observing Strategy (IGOS[9]), or other national or international initiatives often structured around a scientific domain, a monitoring technology or a component of the Earth system (e.g. oceans with the Global Ocean Observing System GOOS[10]). However, a global Earth observation coordination initiative having a comprehensive scope spanning through all scientific disciplines and monitoring technologies and linking governments directly with monitoring systems' operators and the EO user community did not exist before the creation of the GEO in 2005.

GEO's uniqueness consists of its intergovernmental and voluntary nature and its approach of implementing a system of distributed EO systems. GEO provides a legally non-binding framework, established outside the framework of the United Nations, within which the GEO Members develop EO activities and projects and implement the GEOSS. This is being performed in conformity with an agreed 10-year Implementation Plan covering the period 2005-2015 and via more specified multi-annual Work Plans. Background on these plans, the history of GEO, its current membership and governance are given in annexe II.

Central to GEOSS is the vision of making individual EO systems more interconnected and datasets easily accessible. This is accomplished through the promotion of common protocols and interoperability arrangements and the exchange of data, metadata and products in a full, open and unrestricted manner. The GEOSS supports the paradigm shift from disconnected EO programmes, infrastructures and datasets to an open, shared system of systems of discoverable, accessible and usable EO data and information. The GEOSS aims to provide a unique entry point, universally accessible, to access national, regional and global Earth observation capacities whilst respecting their mandates.

The success of the GEOSS largely depends on the expansion of its global network of content providers and users. The scope for resources to be contributed via the GEOSS ranges from raw data (in situ or remotely sensed observations) to EO-derived information and data management tools required to transform data into useful geo-products such as tools for data processing, computing and modelling, visualisation and analysis. While the GEO welcomes all data contributions to the GEOSS, data providers have to document - at registration stage - any restrictions applicable to the exchange of their data, metadata and products.

The GEOSS aims at facilitating access to global, regional and local data and ease the development of EO-derived products for uptake by a broad range of user communities, including managers and policy makers, scientific researchers, civil society, governmental and

[8] http://www.ceos.org/
[9] http://www.eohandbook.com/igosp/index.htm
[10] http://www.ioc-goos.org/

non-governmental organisations, international bodies, developing country users and the private sector. Doing so, the GEO aspires to provide and to deliver benefits in **nine societal challenges** related to disasters, health, energy, water, weather, ecosystems, agriculture, biodiversity and climate.

The nine GEO societal challenges

GEOSS aspires to encompass all areas of the world and to deliver benefits to society in the following nine societal challenges:

- *Reducing loss of life and property from natural and human-induced **disasters**;*
- *Understanding environmental factors affecting human **health** and well-being;*
- *Improving management of **energy** resources;*
- *Improving water-resource management through better understanding of the **water** cycle;*
- *Improving **weather** information, forecasting, and warning;*
- *Improving the management and protection of terrestrial, coastal, and marine **ecosystems**;*
- *Supporting sustainable **agriculture** and combating desertification;*
- *Understanding, monitoring, and conserving **biodiversity**;*
- *Understanding, assessing, predicting, mitigating and adapting to **climate** variability and change.*

2.2 Main GEO achievements

During its first nine years of existence, the GEO initiative has mainly been dedicated to building and consolidating its foundations. The GEO has organised itself, widened its partnership and articulated step by step its added value on the basis of voluntary contributions. The main GEO achievements to date can be grouped in the following categories:

- *Improved multilateral collaboration and coordination in Earth observation*
- *Full and open sharing of Earth observations*
- *Discovery of and access to a wide portfolio of EO datasets*
- *Capacity building including in developing countries*

2.2.1 Improved multilateral collaboration and coordination in Earth observation

Since its inception, the GEO has gradually doubled its **membership** to reach now 92 national governments plus the Commission and 77 Participating Organisations (see the full list in annexe II). The members of the GEO community recognise[11] that it has taken longer than expected to mobilise the full partnership towards the practical implementation of the GEOSS. However, the magnitude of the task to be performed by the GEO and the voluntary nature of the whole endeavour should be fully considered.

The GEO model could be seen as a good example of transnational cooperation, pooling efforts to address some of the grand challenges that we are facing globally. At the end of 2013, almost 850 contributors from more than 340 organisations were engaged in close to 60 individual GEO Work Plan activities. Especially during recent years, GEO has fostered substantial multilateral collaboration around various new **international initiatives** addressing most of the GEO societal challenges. Examples of such initiatives include the Blue Planet initiative, the GEO Biodiversity Observing Network (GEO BON), the Global Agricultural Monitoring initiative (GEOGLAM), the GEO Carbon Initiative, the Global Forest Observing Initiative (GFOI), the Global Mercury Observation System (GMOS) and the Geohazard Supersites initiative (more details in annexe II).

These initiatives involve GEO **communities of practice** that consist of self-organised groups of individuals and organisations who collaborate across geographic and political boundaries to

[11] GEO-X, 15-16 January 2014, Document 5, Preliminary Guidance for GEO 2025

foster EO applications in their fields of expertise. Eleven such communities[12] of practice have grown up over the past nine years. They are voluntary, informal, activity-based and results-oriented and share best practices in an evolving knowledge base. The GEO Integrated Global Water Cycle Observations (IGWCO) community of practice, for instance, has developed a GEOSS Water Strategy Report[13] which reviews the monitoring status for the main components of the global water cycle and provides recommendations to address EO monitoring gaps. This report forms the basis for a subsequent Water Implementation Plan to be proposed for support by GEO Members and Participating Organisations.

2.2.2 Full and open sharing of Earth observations

The GEO adopted its full and open GEOSS **Data Sharing Principles** back in 2005. Since then, the GEO has been instrumental in advocating full and open access to EO data worldwide. These principles are the cornerstones for expanding data reuse through the GEOSS. The GEO promotes broad open data across all its societal challenges and encourages governments and organisations with an EO mandate to adopt, as far as possible, open access policies for the data they own. Actually, all governments and organisations willing to join the GEO do commit to promoting the implementation of these principles.

A milestone has been achieved in 2010 when the **GEOSS Data-CORE label** was adopted. GEOSS Data-CORE datasets are "Data Collections of Open Resources for Everyone" which comply with the principles of full, open and unrestricted access at no more than the cost of reproduction and distribution. The GEOSS data CORE concept is becoming a key success story of the GEO. It allows users to discover and to know without ambiguity about the open conditions for reuse of the data. This makes the GEOSS distinctive from any other web-based infrastructure. The use of this very unique label by EO data owners has considerably increased since 2010 with 51 million individual GEOSS data-CORE resources in 2014.

The GEOSS Data Sharing Principles
"There will be full and open exchange of data, metadata and products shared within GEOSS, recognising relevant international instruments and national policies and legislation. All shared data, metadata and products will be made available with minimum time delay and at minimum cost. All shared data, metadata and products being free of charge or no more than cost of reproduction will be encouraged for research and education."

Examples of advances towards full and open sharing of space-borne EO data
During the period 2005-2013, many governments and organisations have adapted their EO data policies, leading to a significant increase of data and information becoming discoverable, accessible and openly re-usable. The Landsat free and open data policy announced in 2008 by the US Geological Survey (USGS) has revolutionised the use of four decades of Landsat data, spurring innovation and triggering new science and applications. As a result the increase of Landsat data use was dramatic with over 100 times more data downloaded in 2011 than in 2007. In 2010, the European Space Agency (ESA) has adopted a more open approach to its EO data policy for several space missions including the European Remote Sensing (ERS) satellites, Envisat and the Earth Explorer missions. Along the same lines, the Delegated Regulation (EU) No 1159/2013 on access to Copernicus data and information and the Regulation (EU) No 377/2014 establishing the Copernicus Programme represent major steps towards the free, full and open dissemination of Copernicus dedicated data, including data acquired by the series of Sentinel satellites, and the information delivered by the Copernicus services. Another decisive step was made by France who decided to provide open access to non-commercial use of 27 years of satellites images from the SPOT family.

[12] Air quality, atmospheric chemistry, biodiversity, Carbon, coastal zone, energy, forest, geohazards, global agriculture monitoring, health and environment, water cycle
[13] http://www.wmo.int/pages/prog/hwrp/chy/chy14/documents/ms/IGWCO.pdf

Trends towards open access to EO data are also observed in Asia and other parts of the world, such as the free access to data from the Chinese polar-orbiting meteorological satellite Fengyun-3, and the recent decision by Japan to guarantee free and unlimited access to low to medium resolution satellite data constellations operated by the Japan Aerospace Exploration Agency (JAXA).

2.2.3 Discovery of and access to a wide portfolio of Earth observation datasets

The GEOSS has recently reached the tipping point where users are beginning to reap the benefits of GEOSS data. Several Information Technology (IT) components have been progressively prototyped, deployed and interconnected by GEO experts to constitute the main IT architecture of the GEOSS information system referred to as **the GEOSS Common Infrastructure** (GCI).

The use of a broker technology, together with some user-support and interactions with more than 30 major data providers, have radically improved the GEOSS performance to provide access to distributed and heterogeneous EO data sources on the web. From only a few hundreds of thousands in 2012, the number of **GEOSS data resources** has increased up to 70 million in 2014. Those resources largely consist of satellite images plus other EO data records, documents or maps. More than two-thirds of these data resources are flagged as belonging to the GEOSS Data-CORE.

Current IT architecture of the GEOSS Common Infrastructure (GCI)

The main components of the GCI include:

- *The GEOSS Web Portal (GWP) developed by ESA which is the web interface allowing any user to search for and query GEOSS datasets;*
- *The Discovery and Access Broker (DAB), developed by the National Research Council of Italy (CNR), the Commission's Joint Research Centre and other partners of the FP7 EuroGEOSS and GEOWOW projects (annexe III), which provides harmonised access to heterogeneous datasets made available by different communities;*
- *A set of registries which allow monitoring the type of resources contributed to the GEOSS.*

2.2.4 Capacity building including in developing countries

The GEO vision aims to strengthen the capability of all countries to use EO data and products. This is particularly relevant to developing countries having less monitoring infrastructures, investments or capabilities to produce and process EO data. The GEO has been able to mobilise **resources for regional capacity building** networks in a number of developing countries notably in Africa, Asia, the Balkan, around the Black Sea and in South America. Typical actions included the identification of relevant stakeholders, building networks, providing training and e-training for local users.

In 2013, GEO has launched the **AfriGEOSS initiative**[14] to enhance Africa's participation in the GEO. Building on the current GEO membership of 22 African countries and five Participating Organisations, AfriGEOSS is helping to strengthen EO infrastructural capabilities at continental, sub-regional and national scales. It federates African efforts to bridge the digital divide on this continent and to build a knowledge-based economy using GEO networks and the GEOSS.

GEONETCast, the GEOSS global network for data broadcasting via telecommunication satellites, completes the web components of the GCI. It provides a user-friendly low-cost means to deliver GEOSS data in near real time in areas where users do not benefit from satisfactory internet connections. The GEONETCast system[15] results from the outstanding

[14] http://www.earthobservations.org/art_019_002.shtml
[15] http://www.earthobservations.org/geonetcast.shtml

collaboration between the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the China Meteorological Administration (CMA), the United States' National Oceanic and Atmospheric Administration (NOAA) and the World Meteorological Organisation (WMO). Thousands of receiving stations have already been deployed to allow nearly 6,000 users in 169 countries to receive GEOSS data, including in developing countries.

2.3 Current engagement of the EU towards the GEO and the GEOSS

2.3.1. Basis for EU action

Currently, 32 national governments from Europe (including 26 Member States) and the Commission participate in the GEO partnership in their own right (annexe II).

The Commission, in agreement with all European GEO Members and Participating Organisations, contributes to the GEO governance as one of the four GEO co-chairs together with the People's Republic of China, South Africa and the United States of America.

Each GEO Member belongs to one of the five regional GEO Caucus (Africa, Americas, Asia and Oceania, the Commonwealth of Independent States, and Europe). The Commission holds this position as co-chair for the European GEO Caucus: a group gathering the European GEO Members and Participating Organisations whose experts and representatives meet several times a year in the GEO High Level Working Group (HLWG) to develop some European convergence towards the GEO and the GEOSS.

Several GEO Ministerial Summits have been organised since 2005 (annexe II), leading to a series of declarations adopted by acclamation. While having no legally-binding implications, these declarations are consistent with and covered by policies, programmes and initiatives already agreed at EU level, such as:

- the Communication from the Commission of 3 March 2010 "Europe 2020: a strategy for smart, sustainable and inclusive growth"[16] and its flagship initiatives such as Innovation Union[17], the Digital Agenda for Europe[18] and the Resource-efficient Europe[19];
- Horizon 2020, the EU Framework Programme for Research and Innovation[20];
- the Communication from the Commission of 4 April 2011 "Towards a space strategy for the European Union that benefits its citizens"[21], the Commission Delegated Regulation on access to GMES data and information[22] and the Regulation (EU) No 377/2014 of the European Parliament and of the Council establishing the Copernicus Programme;
- the Directive 2007/2/EC[23] of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE);
- The Directive 2003/4/EC[24] of the European Parliament of the Council of 28 January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC;
- The Directive 2003/98/EC[25] of the European Parliament of the Council of 17 November 2003 on the re-use of public sector information, and the Directive 2013/37/EU[26] of the

[16] COM(2010) 2020 final
[17] COM(2010) 546 final
[18] COM(2010) 245 final
[19] COM(2011) 21 final
[20] Official Journal of the European Union, L 347/104, 20.12.2013, p. 104
[21] COM(2011) 152 final
[22] Commission Delegated Regulation (EU) No 1159/2013, 12.07.2013, p. 1
[23] Official Journal of the European Union, L 108, 25.04.2007, p.1
[24] Official Journal of the European Union, L 41/26, 14.02.2003, p. 26

European Parliament and of the Council of 26 June 2013 amending Directive 2003/98/EC on the re-use of public sector information;

- The Communication from the Commission of 01 February 2008 "Towards a Shared Environmental Information System (SEIS)"[27],
- the Communication from the Commission of 24 July 2009 “Mainstreaming sustainable development into EU policies: 2009 Review of the European Union Strategy for Sustainable Development”[28] and the Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 ‘Living well, within the limits of our planet’[29];
- the Communication from the Commission of 16 April 2013 on “An EU Strategy on adaptation to climate change[30];
- the Communication from the Commission of 12 December 2011 on “Open data, an engine for innovation, growth and transparent governance”[31];
- the Communication from the Commission of 4 November 2008 on “The raw materials initiative — meeting our critical needs for growth and jobs in Europe[32] and the Communication from the Commission of 2 February 2011 on “Tackling the challenges in commodity markets and on raw materials”[33];
- The Communication from the Commission of 8 September 2010 on “Marine Knowledge 2020: marine data and observation for smart and sustainable growth”[34] and the Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive)[35].

It is important to note that two EU programmes make explicit references to the GEO or the GEOSS: the Horizon 2020 Framework Programme and the Copernicus programme.

Basis for EU activities in support to GEO through the Horizon 2020 Framework Programme

The Horizon 2020 Specific Programme[36] refers to GEO as a multilateral initiative where international cooperation may be developed. In addition, the Horizon 2020 Framework Programme calls for activities that cannot be efficiently undertaken by Member States acting alone and where Union added value and impact shall be maximised. Commitments to GEO are evidenced, inter alia, by the following statements:

- *In the 3rd Part of the Horizon 2020 Framework Programme, the Societal Challenge on ‘Climate action, resource efficiency and raw materials’ states that “[European] Union level actions will also support relevant international efforts and initiatives, including....the **Group on Earth Observations (GEO)**”. This Societal Challenge includes an activity on “Developing comprehensive and sustained global environmental observation and information systems”;*
- *In the 2nd Part of the Horizon 2020 Framework Programme, the priority on ‘Leadership in enabling industrial technologies’ makes reference to activities aiming at enabling exploitation of space data. It is stated that “these activities can also contribute to tackling societal challenges, in particular if coordinated in a global effort such as through **the Global Earth Observation System of Systems (GEOSS)**, namely by fully exploiting the Copernicus programme as its main*

[25] Official Journal of the European Union, L 345/90, 31.12.2003, p. 90
[26] Official Journal of the European Union, L 175/1, 27.06.2013, p. 1
[27] COM(2008) 46 final
[28] COM(2009) 400 final
[29] Official Journal of the European Union, L 354/171, 28.12.2013, p. 171
[30] COM(2013) 216 final
[31] COM(2011) 882 final
[32] COM(2008) 699 final
[33] COM(2011) 25 final
[34] COM(2010) 461 final
[35] Official Journal of the European Union, L 164/19, 25.6.2008, p. 19
[36] Regulation (EU) No 1290/2013 of the European Parliament and of the Council of 11 December 2013 laying down the rules for participation and dissemination in "Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)" and repealing Regulation (EC) No 1906/2006
Official Journal of the European Union, L 347, 20.12.2013, p.81

European contribution (…)".

Basis for EU activities in support to GEO in relation to the EU Space Policy

- *The Communication from the Commission towards a Space Strategy for the European Union that benefits its citizens[37] states that: "As regards Earth observation, Europe is closely involved in developing* ***the Global Earth Observation System of Systems (GEOSS)*** *international initiative. The Commission will therefore continue to make the necessary efforts to implement mechanisms for sharing earth observation data in Europe, subject to the acceptance of such mechanisms by GEO Members".*
- *The Regulation (EU) No 377/2014 of 3 April 2014 establishing the Copernicus Programme restates that "Copernicus should be considered as a European contribution to building* ***the Global Earth Observation System of Systems (GEOSS)*** *developed within the framework of* ***the Group on Earth Observations (GEO)****".*

2.3.2. Cost implication

The renewed commitment for GEO through 2025 has no legally binding budgetary implication for the EU since GEO will continue to be based on voluntary contributions.

Most of the resources supporting the implementation of the GEO and the GEOSS continue to be provided through existing national and international mechanisms and voluntary contributions made on a best effort basis by the GEO Members and Participating Organisations. Experience has shown that GEOSS implementation relies significantly, though not exclusively, on in-kind contributions such as observing capacities, networks, expertise, staff time, interoperability arrangements and standards, datasets, information systems, services, projects and programmes.

Pursuant to the Regulation (EU) No 377/2014 of the European Parliament and of the Council of 3 April 2014 establishing the Copernicus programme and repealing Regulation (EU) No 911/2010[38], Copernicus should be considered as a European contribution to building the Global Earth Observation System of Systems (GEOSS) developed within the framework of the Group on Earth Observations (GEO). With an EU investment of up to 4.2 billion for Copernicus, the Multiannual Financial Framework of the EU sustains the operational phase of this programme for the period 2014-2020.

In addition, some mechanisms have been foreseen in the Horizon 2020 Framework Programme to support the GEO financially during the same period 2014-2020. These mechanisms are embedded within Horizon 2020 multi-annual work programmes and consist either of calls for proposals with expected impact on the European contribution to GEO and GEOSS, or of annual subscriptions to contribute to the activities of the GEO Secretariat. For instance, the Work Programme 2014-2015 of the Horizon 2020 Societal Challenge on Climate action, environment, resource efficiency and raw materials[39] foresees a total EU budget of about 48 Mio€ to be invested for activities directly related to GEO.

As a full GEO Member, the Commission has also foreseen to continue paying an annual subscription in 2014 and 2015 on behalf of the EU to the GEO Trust Fund. This Fund is the budgetary structure agreed by the GEO Members to fund baseline activities by the GEO Secretariat. Such subscriptions correspond to subscriptions to a body of which the Commission is a member, according to Article 121(2)(d) of the Financial Regulation applicable to the general budget of the European Communities. The indicative annual contribution by the Commission to the GEO Trust Fund in 2014 and 2015 is in the range of € 800,000.

[37] COM(2011) 152 final
[38] Official Journal of the European Union, L 122, 24.04.2014, p. 44
[39] http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-climate_en.pdf

2.3.3. Examples of European contributions

- Contribution towards a European leadership in GEO

The Commission has been amongst the early members of the '*ad-hoc* GEO' which has conceived the GEO in the period 2003-2004 before its formal inception. Since 2005, the Commission has been one of the four GEO co-chairs on behalf of the European GEO Caucus. The Commission is also co-chairing several GEO groups such as the Data Sharing Working Group, the Data Management Task Force and the Infrastructure Implementation Board. It has participated in other strategic GEO groups such as the Ministerial Working Group, the GEO Post-2015 Working Group and the Societal Benefits Implementation Board.

Over the last decade, the Commission has provided significant input into the development of official documents including the current 10-year Implementation Plan and the successive GEO Work Plans. The Commission is involved in several GEO tasks of the GEO Work Plan 2012-2015, either directly or through EU-funded European research consortia.

In the period 2012-2013, the Commission has been engaging with data providers of several GEO Members across the globe in order to facilitate the registration of datasets in the GEOSS and promote the GEOSS Data-CORE concept. The Commission is also actively working on legal interoperability issues, has been co-leading the development of the GEOSS Data Sharing Action Plan and is co-leading the ongoing revision of the GEOSS data sharing principles.

Through chairing and providing secretariat support to the HLWG European experts' group, the Commission is also easing a more coherent European contribution to the GEOSS.

- Contribution to the implementation of the GEOSS via FP7

More than € 200 Mio have been invested by the EU over the period 2007-2013 to GEOSS-related research and innovation activities within the Seventh Framework Programme for Community research (FP7). The biggest and most direct FP7 contribution to GEOSS came from the Environment Theme (including global change) under the Cooperation Programme. This investment has allowed funding about 50 FP7 collaborative projects that have directly supported the implementation of the GEOSS 10-year Implementation Plan via concrete contributions to several tasks of the GEO Work Plan, including key components of the GEOSS Common Infrastructure. This investment has had the effect of promoting the GEO vision within the European research community and to attract participation in this GEO undertaking by more than 400 organisations from 37 countries including the Member States and other countries associated to FP7. This FP7 investment has been presented as an example of good practice to other funding parties of the GEO community. It has given to the EU an influential role in the development of EO-based solutions to address global challenges.

- Contribution to the use of GEOSS in Africa via development cooperation

During the last decade several regional and national African institutions have acquired capacities for the exploitation of EO data thanks to European efforts in the EO field to support sustainable development in Africa. This was implemented in particular through African initiatives, actions of the European Development Fund such as the PUMA, AMESD and MESA[40] projects, as well as the ESA coordinated TIGER initiative[41] (since 2002) and several projects funded by the EU Framework Programmes for research and innovation. This build-up of capacity has also been facilitated by an increasing demand from the African decision makers

[40] MESA: Monitoring of Environment and Security in Africa programme, http://www.hd-mesa.org/
[41] http://www.tiger.esa.int/

for relevant information for climate and environmental monitoring as well as to ascertain human security and stability of livelihoods.

A partnership between African and European stakeholders and a framework in Africa for EO applications have been established through the GMES and Africa initiative launched in Lisbon (Portugal) during the 2nd EU-Africa Summit of December 2007. Doing so, GMES & Africa has allowed identifying priority thematic areas (marine and coastal areas, water, natural resources management) for an extension of the GMES/Copernicus initiative to Africa. This ongoing work contributes directly to several GEO societal challenges (climate, weather, water, agriculture and ecosystems) and the achievement of the AfriGEOSS objectives.

- Contribution to GEO secretariat operations via the GEO Trust Fund

Over the period 2005-2012, the EU has contributed about € 6,5 Million to the GEO Trust Fund, thus bringing essential support to the functioning of the GEO Secretariat and related activities. This represents more than 30 % of total cash contributions given by the GEO community to the Trust Fund over that period[42]. This figure however does not include in-kind contributions provided by China, South Africa, and the USA in the form of staff secondments or organisation of Plenary and Ministerial events. Nor does it include financial support (about € 150,000) provided by the Commission for developing country participants in GEO related meetings since 2005.

2.4 Towards a renewed GEOSS Implementation Plan for 2016-2025

With the approaching term (in 2015) of the current 10-year GEO mandate, governments from all GEO Member countries and leaders from the GEO Participating Organisations have been invited early this year to extend their support to GEO through 2025.

On 17 January 2014, the ministers and other heads of delegations assembled at the GEO Summit in Geneva (CH) renewed the GEO mandate for the period 2016 till 2025. This decision to renew, formalised in the Geneva Ministerial Declaration[43], is accompanied by the request to develop a new 10-year Implementation Plan (2016-2025) to improve the effectiveness of the GEO action and ensure that the aims and ambitions of the declaration become a reality.

The process leading to the development of such a Plan was initiated in March 2014 with the establishment of the GEOSS Implementation Plan Working Group (IPWG), a group of experts nominated by the various GEO caucuses. The IPWG has undertaken the preparation of a draft Implementation Plan for acceptance by the GEO Plenary at the end of 2015 and for subsequent endorsement at the next GEO Ministerial Summit currently foreseen for the period November 2015 - January 2016.

The new Implementation Plan is likely to build upon the options and scenarios for the next phase of GEOSS implementation reported in 2013 by the Post-2015 working group and upon the outputs of the 2014 GEO Ministerial Summit. The IPWG is engaging with the various GEO Boards, Groups and Task Forces for specific elements of the Implementation Plan, as well as with the broad stakeholder community.

[42] Group of experts' Report "Assessment of the Achievements of the Group on Earth Observations (GEO): A European Union Perspective", under assignment by the European Commission, May 2014

[43] The Group on Earth Observations (GEO) Geneva Declaration of 17 January 2014 http://www.earthobservations.org/documents/ministerial/geneva/MS6_The_Geneva_Declaration.pdf

2.5 Consultation results

As part of the Commission approach to investigate the future of the GEO and the GEOSS, a consultation of the European GEO Member countries and Participating Organisations has been conducted by the Commission via a questionnaire in the period May to September 2013 (annexe VII). The Commission has also convened a group of external European experts in the second semester of 2013 to assess and report on the achievements and benefits that have accrued to Europe and the EU from the Commission involvement in GEO since 2005 (annexe VI). The main strengths weaknesses, opportunities and threats related to the GEO and the GEOSS that came out of these consultations and external experts' analysis are summarised in the figure below and further described in annexe VI.

Set of factors characterising today's GEO and the GEOSS
(arising from external consultations)

Strengths	Weaknesses
Unique intergovernmental and voluntary nature of the GEO partnership: linking directly the scientific and technical levels to the political level while preserving flexibility, adaptability and reactivity	**GEO voluntary approach**: risk of softened levels of resource commitments, especially in this period of pressures on public budgets; general lack of alternative funding schemes and in cash contributions
GEO vision and GEO international initiatives: federating communities and EO activities and fostering multilateral and multidisciplinary collaborations across global societal challenges	**GEO impact**: difficulty to assess impact due to delays in implementation and historical focus on data supply rather than data use; too few examples of trans-disciplinary products used for improved decision-making
GEOSS data sharing principles: promoting full and open data sharing and inspiring GEO Members	**Communication on the GEO added value**: GEO is still perceived as co-opting pre-existing EO-related initiatives
GEO as a driver for research and innovation: is a unique discussion forum for the whole environmental observations community	**GEO and the private sector**: to date, the private sector has benefitted very little from the GEOSS; consultation have been too limited; an overall framework for engaging the private sector on a level playing field is missing
The system of systems GEOSS: provides access to distributed EO portals while respecting their mandate and autonomy; unique attempt to provide access to all kinds (multi-disciplinary, remote sensing and in-situ) of EO data	**GEO synergies with UN programmes and agencies**: not sufficiently developed
Visibility and leverage effect at global stage through the GEO: GEO is a lever to existing EO-related infrastructures, programmes, projects, and activities, it reinforces international standing of its major contributors	
Opportunities	**Threats**
The renewed GEO mandate 2016-2025: existing political momentum **The next GEOSS 10-Year Implementation Plan**: possibility for GEO adaptation and evolution in the light of new raising political, institutional, scientific, and technical challenges **Future GEO Work Plans**: provide opportunities for influencing EO global agendas	**Future commitments by GEO Member countries and Participating Organisations**: might be impacted by the general pressure on public budgets worldwide
GEO communities of practice and international initiatives: provide opportunities for consolidating user requirements fat the global scale and for producing or benchmarking reference EO data sets of global reference	**GEOSS core-functionalities in the long-term** (a pre-requisite for attracting the business sector): will require a transition from prototyping to operations, as well as secured long-term commitments for which a voluntary approach might be less adapted
GEOSS data sharing and management principles: bring opportunities for innovation an growth, stimulating a global EO market place and to contributing to the digital economy of tomorrow	**Consensus building on the next 10-year Implementation Plan**: will have to accommodate more conservative and more innovative views circulating amongst the GEO community
Digital revolution and the internet of things: bring huge potential for innovative uses of EO data and products	**GEO positioning on the international landscape of EO initiatives**: need to communicate on the complementarity and to build partnerships with an increasing number of other initiatives related to environmental data
The Copernicus programme: provides a key opportunity to consolidate the EU contribution to the GEOSS and to position the European EO industry on the global stage **The Horizon2020 programme**: foresees specific research and innovation contributions to the GEO and the GEOSS	

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3. CHALLENGES AHEAD

3.1. Timeliness for a debate in Europe

Considering the GEO state of play presented in the previous section and the ongoing process towards the future implementation of the GEOSS through 2025, the period 2014-2015 represents a unique window of opportunity for the EU to assess and review its position regarding GEO.

The EU could possibly address the issue of its contribution during the next GEO decade and reflect on a renewed approach to the future evolution of the GEOSS. Such an approach would require answering key questions such as the following. Does the EU wish to maintain or reinforce its position as a driving force in global Earth observation? Should the EU profile in the renewed GEO be raised or not? How should European GEO Members and Participating Organizations enhance GEOSS benefits to European society through 2025? Answering these questions would require taking full consideration of the strengths, weaknesses, threats and opportunities described in section 2.5.

Such a debate could be particularly timely now that the Copernicus programme (2014-2020), has entered in operations and that the Horizon 2020 Framework Programme (2014-2020) brings new instruments and opportunities for developing comprehensive and sustained global environmental observation and information systems.

3.2 GEO prospects of interest to the EU

Consultations in annexes VI and VII demonstrate the initial motivations by the Commission and the other European GEO Members to join the GEO continue to be valid. They point toward four main GEO prospects of interest to the EU. They also indicate that the GEO could deliver more to the EU during the next decade if GEO succeeds in implementing a more robust and user-oriented GEOSS.

3.2.1 EU's international standing to collaborate on EO and tackle global challenges

Many of the major societal challenges that confront Europe today are global in nature such as climate change, pressure on natural resources, food security, interactions between the environment and human health, the reduction in greenhouse gas emissions and the increased share of renewable energies. The Europe 2020 Strategy[44] recognises that these global challenges do intensify and calls for the EU to act jointly in order to influence global policy decisions related to such long-term challenges.

The World Summit on Sustainable Development in Johannesburg (South Africa) highlighted already in 2002, the urgent need for coordinated observations to provide information relating to the state of the Earth. The report[45] of the United Nations Conference on Sustainable Development of June 2012 in Rio de Janeiro (Brazil) explicitly recognizes the GEO efforts in developing global environmental observing systems. In addition to investing in and taking advantage of its world-class EO operational programmes, organisations, and research infrastructures (annexes IV and V), Europe has established and continues to develop strategic partnerships with key players on the global stage in order to address global data gaps jointly.

[44] COM(2010) 2020 final
[45] http://www.uncsd2012.org/content/documents/814UNCSD%20REPORT%20final%20revs.pdf

Consulted European experts confirm in their report (annexe VI) that "*EU's increasing contribution to, and role in, the international EO arena is largely configured within the context of its active involvement in GEO*". Furthermore, they stress on the link existing between the Commission commitment to GEO and the improved visibility and influence that the EU can gain on the international scene regarding the development of solutions to address global challenges.

When consulting the HLWG (annexe VII), the Commission has collected evidence that European GEO Members, as well as several European Participating Organisations, have already benefited from the GEO to reinforce their influence and reputation at global level. It is not surprising then that European organisations such as the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Centre for Medium-Range Weather Forecasts (ECMWF), the European Environment Agency (EEA) or the Geological Surveys of Europe (EuroGeoSurveys) have all become active GEO Participating Organisations.

3.2.2 Achieving EU policy goals with the GEOSS

The GEOSS is progressively removing barriers to the discovery and access of Earth observations which, when processed and combined with other data, could be very complementary to the classical European data streams currently used for EU policy making.

In their assessment report (annexe VI), the consulted European experts affirm that a continued EU engagement in the GEO initiative - most specifically via the Commission - will continue to result in benefits for the Europe 2020 Strategy and to the implementation of various EU policies. Making an exhaustive review of possible GEO benefits for each and any policy of the EU would go beyond the scope of this document. Instead, the following cases are given as illustrations of the potential GEO value to EU policies.

- *EU Research and Innovation Policy*

The GEO has promoted and will continue to facilitate international research collaboration, networking and projects. GEO will continue triggering cross-cutting research activities across disciplines and societal challenges and bridging the gap between science and applications. As reflected in the GEO Work Plan 2012-2015[46], typical research and innovation activities driven by the GEOSS implementation include improved monitoring strategies and technologies, improved data management practices and information systems, the provision of essential variables, the exploitation of GEOSS data to improve scientific understanding, modelling, prediction and forecasting, to perform risk assessments or contribute to environmental indicators, the development of pre-operational EO-based services and applications. The consultations also reveal some GEO-induced opportunities for a better alignment of research and innovation agendas at national and regional levels, notably along sustainable development objectives.

- *EU Space Policy*

Earth observation from space, has become an area of EU competence since the Lisbon Treaty. The Copernicus programme, which is a pillar of the EU Space Policy, has entered in operation with the recent adoption of the Copernicus Regulation 377/2014 by the EU Parliament and Council. This Regulation notably states that Copernicus will be supporting and contributing to European policies and fostering global initiatives, including GEOSS. While Copernicus represents a major European contribution to the GEOSS, GEO represents a unique platform to develop the international dimension of Copernicus, notably with regards to the open exchange of EO data and information, as well as the access to other observation

[46] http://www.earthobservations.org/geoss_imp.php

infrastructures. In order to promote their use and to strengthen businesses in the field of Earth observation, Copernicus data and information will be made available on a free, full, and open basis, subject to appropriate conditions and limitations defined in the Commission Delegated Regulation (EU) No 1159/2013. With the Copernicus Regulation adopted, its two first operational Copernicus services operational (the Emergency Management and the Land Monitoring Services) and the first satellite of the series of Sentinels launched in April 2014, the EU contribution to the GEOSS is going to expand significantly over the next decade. As reported by the consulted experts (annexe VI), the full and timely implementation of the Copernicus Programme will contribute considerably to the successful implementation of the GEOSS, while GEO provides an international co-ordinating platform through which the EU Copernicus programme can be leveraged. All consultations confirm the importance of enhancing links and collaboration between Copernicus and GEO.

- EU Climate and Energy Policies

GEO can support the EU Climate Policy through sustaining the Global Climate Observing System (GCOS[47]) and delivering more comprehensive and reliable measurements of the Essential Climate Variables[48] needed by several international climate initiatives such as the World Climate Research Programme (WCRP[49]), the Intergovernmental Panel on Climate change (IPCC[50]) and the United Nations Framework Convention on Climate Change (UNFCCC[51]). Scientific assessments of the climate evolution resulting from such initiatives help EU and other international efforts towards reducing emissions, in line with the agreed global objective to keep global temperature increase below 2°C.

GEO can support the EU adaptation policy through filling knowledge gaps on climate change impacts and vulnerability. With a better understanding of the changing climate, policy-makers at EU, national and even local level could get better prepared and reduce impact of climate change. GEO could also help comparing the effects of climate change in the EU with those observed in other regions of the world and support adaptation efforts by the EU conducted abroad.

In the context of its societal challenge on climate, GEO could help in the coordination and foster various initiatives aiming at developing climate services including the EU Copernicus Climate Change Service[52] or the UN Global Framework for Climate Services (GFCS[53]). GEO could become a major source of global reference data and information in support to the development of an EU market for Climate Services. Such data and information could trigger the development of new customised information and applications for end users communities such as farmers for example. The European climate adaptation platform[54] (Climate-ADAPT), hosted by the European Environment Agency, could then play a role in disseminating such information to its final users.

The GEO CARBON international initiative (annexes II and III) might produce additional information on carbon pools and fluxes, ranging from global to regional scales, with increased resolution and accuracy and reduced uncertainty. The Global Forest Observation Initiative (GFOI) (annexe II) is expected to continue promoting the wider deployment of a monitoring capability to estimate changes in carbon stocks and report on forest areas and greenhouse gas emissions.

[47] http://www.wmo.int/pages/prog/gcos/index.php?name=AboutGCOS
[48] http://www.wmo.int/pages/prog/gcos/index.php?name=EssentialClimateVariables
[49] http://www.wcrp-climate.org/
[50] http://www.ipcc.ch/
[51] http://unfccc.int/
[52] http://www.copernicus.eu/pages-principales/services/climate-change/
[53] http://www.gfcs-climate.org/
[54] http://climate-adapt.eea.europa.eu/

GEO could also help moving further towards a low carbon economy by promoting the use of Earth observations by the energy sectors for improved prediction of potential hazards to energy infrastructures and better mapping of renewable energy potentials (see the example of EnerGEO in annexe III). As part of the Strategic Energy Technology Plan (SET-Plan), the Commission has launched six European Industrial Initiatives (EIIs) on wind, solar, carbon capture and storage, electricity grids, bioenergy and nuclear fission. Better synergies between the roadmaps of these EIIs and future GEO tasks could be very useful for the EU.

- EU Environmental and Sustainable Development Policies

The EU Strategy on Biodiversity is expected to continue benefiting over the long term from the GEOBON international initiative (annexes II.5 and III). GEOBON is a successful example of governmental, inter-governmental and non-governmental organisations joining forces to help implementing the international Convention on Biological Diversity. They collaborate to improve terrestrial, freshwater and marine biodiversity observations globally and make their essential data and forecasts more readily accessible. GEO plays a pivotal role in the implementation of a global standardised ecosystem classification system and map that could serve as a basis for more detailed inventories of major ecosystems and the protected areas. GEO has also the objective to support in the future a wide-ranging EO capability to monitor ecosystems and the human impacts on them, to improve the assessment, protection and sustainable management of terrestrial, coastal and marine resources and the delivery of associated ecosystem services.

The implementation of the Directive 2000/60/EC[55] of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy could benefit from future GEO activities to improve access to in situ and space observations to be used to derive added-value information about the water cycle on multiple scales, the assessment of floods and droughts risks and a more integrated management of world's water resources.

The role that GEOSS could play in sustainable development policy-making was specifically recognised in the Rio+20 Declaration[56] entitled 'the future we want'. The GEOSS could provide the geospatially referenced environmental and socio-economic data necessary to analyse the complex interactions between human activities and the Earth system. The GEO could provide stable, reliable and long-term operations of the EO networks and systems required to fulfil international environmental treaty obligations and achieve the Sustainable Development Goals.

The GEO and the GEOSS could also bring added value by improving environmental spatial data infrastructures and information systems in Europe. In the context of the implementation of the Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)[57], Europe has accumulated a huge experience in facilitating 'system of systems' in a multilingual context which is highly relevant to the GEOSS implementation. Data harmonisation through interoperable transformation services can become a major INSPIRE contribution to the evolution of the GEOSS. Vice versa, GEO, which is currently elaborating common GEOSS Data Management Principles on data preservation, distribution and data quality documentation, could bring to the international stage some recommendations resulting from the INSPIRE context.

[55] Official Journal of the European Union, L 327, 22 .12. 2000, p. 1

[56] http://www.un.org/disabilities/documents/rio20_outcome_document_complete.pdf

[57] Official Journal of the European Union, L 108/1, 25.04.2007, p. 1

- EU Marine and Maritime Policy

The EU policy initiative called "Marine Knowledge 2020"[58] is coordinating efforts made in Europe to monitor the most significant marine parameters in European seas. Central to this initiative are the European Marine Observation and Data Network (EMODnet)[59] which assemble marine data, data products and metadata from diverse sources and the Copernicus Marine Service (annexe IV). Currently, this initiative provides a limited number of gateways to provide web access to the most significant collected parameters. GEOSS could facilitate an international dimension for the Marine Knowledge 2020 initiative by enabling interoperability with global Earth observation systems such as the Global Ocean Observing system (GOOS[60]). This could bring benefits to Europe through the provision of non-European data that may impact on forecasts or the health of European seas. This was reflected in a public consultation[61] on the Marine Knowledge 2020 initiative conducted by the Commission in 2012.

The GEO Blue Planet international Initiative could facilitate the EU Integrated Maritime Policy[62] and the European Marine Strategy Framework Directive[63] through establishing better synergies with ocean observation programmes existing worldwide. GEO promotes the full and open discovery and access to ocean observations and facilitates interoperable exchange of ocean observations. These aspects are driving forthcoming research and innovation activities to deploy an Integrated Atlantic Ocean Observing System (IAOOS) building on existing capacities on both side of the Atlantic[64].

- EU Development Policy

GEO facilitates the development of enhanced capacities for the use of EO datasets in a number of developing countries. In their assessment of the GEO (annexe VI), the experts note that the EU is already strongly engaged in capacity building globally, notably in relation to achieving the Sustainable Development Goals (SDGs). They stress how well positioned is the EU to possibly develop further capacity building initiatives in relation to the GEO, with a continuous focus on Africa and the Mediterranean region.

On the occasion of the recent EU-Africa Summit 2014, EU and African leaders have adopted a roadmap to frame EU-Africa relations for 2014-2017[65]. Under the Priority area on Global and emerging issues of this roadmap, the need to establish a coherent framework for the development of EO activities in Africa is pointed out. EU-African cooperation is foreseen in line with the priorities of the Africa Space Policy and Strategy and the AfriGEOSS initiative, in order to deliver services in priority domains for Africa such as food security and health. As part of Africa's contribution to GEO, the roadmap further specifies a strengthened African capacity to monitor environment and security in Africa especially regarding marine and coastal areas, water resources and natural resources management. In the margins of the 4th EU-Africa Summit, the African Union Commission and the Commission have signed a Cooperative Arrangement on GMES and Africa related to the implementation of the above

[58] http://ec.europa.eu/maritimeaffairs/policy/marine_knowledge_2020/index_en.htm
[59] http://www.emodnet.eu/
[60] http://www.ioc-goos.org/
[61] http://ec.europa.eu/dgs/maritimeaffairs_fisheries/consultations/marine-knowledge-2020/outcome_en.pdf
[62] http://ec.europa.eu/maritimeaffairs/policy/index_en.htm
[63] Official Journal of the European Union, L 164/19, 25.6.2008, p. 19
[64] Horizon 2020 'Blue Growth' call 2014, topic BG 8: Developing in-situ Atlantic Ocean Observations for a better management and exploitation of the maritime resources
[65] http://www.european-council.europa.eu/eu-africa-summit-2014?lang=en

three priority thematic areas. A study is ongoing for the identification and formulation of the GMES & Africa project to be funded by the Pan African Program[66].

- EU Humanitarian and civil protection policies

The GEOSS could further contribute to EU humanitarian policy and help civil protection agencies by providing timely access to EO data of relevance to the full cycle of disaster management. This would help building the resilience of nations and communities to natural disasters, crises situations and catastrophic events. Some achievements have already been reported by the GEO during the GEO Ministerial Summit early this year. The Advanced Fire Information System (AFIS), for instance is the first near-real time satellite fire monitoring system developed for Southern African countries. The Caribbean Satellite Disaster Pilot has provided a range of image maps during the 2010 to 2013 hurricane seasons in affected regions before, during and after disasters. The International Charter 'Space & Major Disasters' has been further promoted by the GEO and provides rapid access to satellite data to aid civil protection agencies and humanitarian organisations responding to natural and human-induced disasters. Working closely with the latter Charter, the Copernicus Emergency Management Service has also played an important role, especially with its components of rapid risk and recovery mapping and early warning systems for floods and forest fires, in providing timely and relevant information in disaster management contexts from risk reduction and preparedness to response and recovery. Another key asset for GEO is the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER)[67] of the United Nations Office for Outer Space Affairs (UNOOSA) which ensures since 2006 a global coordination of space-based information for emergency response and disaster risk reduction. In the future, a more operational and expanded GEOSS (including for instance more real-time data, in-situ data and socio-economic data) could contribute a lot more to the global capacity to respond natural disasters and crisis situations.

Taking food security as another field of humanitarian aid, the GEO is investigating how to combine operational weather and climate forecasts with improved agricultural risk assessment based on crop monitoring? This could lead in the future to better early warnings and help reducing impact of future food crises.

3.2.3 Coordination of EO public sector initiatives in the EU

GEO has initiated a catalytic effect for more EO coordination of public sector initiatives in Europe, both at European and national levels. At European level, the GEO HLWG managed by the Commission and involving all European GEO Members and Participating Organisations oversees the GEOSS implementation from a European perspective and helps shaping common European view on GEO. At national level, several European GEO Members, such as Germany, Greece, and Spain have developed or are intending setting-up national management structures to coordinate their GEO contributions, as well as their EO strategies, investments, activities and programmes. These are good examples of early structuring effects for the coordination of EO public sector initiatives in Europe.

In addition, the consultations so far emphasize how useful and necessary it would be to strengthen and make national coordination mechanisms more widespread, to strengthen the European coordination at the various levels of the GEOSS implementation, and to reinforce the role of the current HLWG.

[66] Commission implementing Decision of 30.7.2014 adopting a Multiannual Indicative Programme for the Pan-African programme for the period 2014-2017; C(2014) 5375 final

[67] http://www.un-spider.org

3.2.4 Growth and economic return from exploiting the GEOSS in the EU

A study[68] in 2012 by the European Association of Remote Sensing Companies highlights that restrictions on the availability of EO data have negative consequences on the development of downstream services and general user take-up. During the last few years, free, full and open access to EO data is becoming more and more accepted and implemented as good practice by European countries and organisations. Open data policies are increasingly perceived as drivers for the development of new products and added-value services, which in turn do stimulate the service sector and contribute to jobs creation.

The open data trend for Earth observation which is developing in Europe is buttressed by the wider open movement which affects Public Sector Information (PSI) in general, as well as open research data and publications. This movement is facilitated by continuously evolving ICT technologies, the progressive move of public agencies towards the so-called 'Information Age' and the growing reliance on electronic media to store records, data and information. It is also accelerated through the progressive implementation in Europe of the INSPIRE Directive[69].

The economic value of Earth observation is not first in the data itself but in what is done with the data downstream. The European business sector (annexe VIII) could strongly benefit from increased full and open data sharing leading to lower market entry barriers. Although difficult to assess in quantitative terms, new market places and opportunities for the EO downstream service industry could emerge in Europe.

The increasing GEO potential for businesses to use open and free data for added value services is well recognised in the consultations conducted by the Commission in 2013 (annexes VI and VII). The GEOSS distinguishes itself from other EO portals by the fact that it aims to provide a universal entry point and comprehensive access to EO data with a priority given to GEOSS data-CORE datasets for reuse at minimum cost by any users for any purpose.

3.3. Issues for consensus by the whole GEO community

Via the Geneva declaration, the GEO Members have decided to retain the current nature of the GEO partnership, the general governance structure and the resourcing mechanism based on voluntary contributions. However, at the same time, they have asked for "*exploring modifications*", leaving room for adaptation in order to better address the political, institutional, scientific and technical challenges that GEO will be facing in the coming years.

Six new elements for the next GEO decade have already been identified in the Vision document for GEO 2025[70] and have been adopted by the GEO-X plenary. These new elements will require consensus amongst the whole GEO community on their detailed interpretation and the way they should be reflected in the next 10-Year Implementation Plan. The following sub-sections outline these new elements and present in the form of "related questions" a set of issues that are currently being discussed by the GEO community and examined in detail by the IPWG (see the report of July 2014 by the IPWG[71]). These issues

[68] "About GMES and data: Geese and golden eggs - A study on the economic benefits of a free and open data policy for Sentinel satellite data", Final Report European Association of Remote Sensing Companies, Brussels, 2012 (under an assignment from the European Space Agency).
[69] Official Journal of the European Union, L 108, 25.04.2007, p.1
[70] GEO Plenary X, 15-16 January 2014, Document MS2: Vision for GEO 2025
[71] GEO EXCOM 31, 8-9 July 2014, Document 5: Interim Report of the Implementation Working Group : Towards the 10-Year Implementation Plan 2016-2025

would deserve further consideration by the EU for their possible impact on the GEO as a whole and on the EU in particular.

3.3.1 "*Sustaining the GEOSS information system that provides access to the data and products of the GEO Member governments and Participating Organisations*"

- Related question: How to sustain GEOSS operation, maintenance and evolution?

The GEO Board on Infrastructure Implementation acknowledges that the GEOSS Common Infrastructure, which falls under the direct responsibility of GEO, is still at an intermediary stage of development. Moving from an ad-hoc, mainly S&T-oriented prototyped GEOSS to a wider, operational and sustained GEOSS information system is considered essential by the GEO Plenary. The GEO capacity to evolve the GEOSS towards a permanent infrastructure with long term maintenance and operation commitments will be challenged in the next decade, notably in the perspective of attracting more users and engaging the private sector. In its report 2014, the IPWG evokes that, in order to develop and operate a more robust GCI that meets the users' expectation, sustainable funding arrangements will have to be found. This could for instance allow to streamline the components of the GCI, make it more user-friendly, modular, robust, flexible and maintained over time. Moreover, the system of systems approach retained for the GEOSS makes it strongly dependant on the distributed components harvested by the GCI. Therefore, additional attention might have to be paid on the operational relationships with the managers of those distributed components.

- Related question: How to make the GEOSS more user-friendly?

The GEOSS has two general categories of users: data providers and data users. The pace of the GEOSS data expansion and use is expected to grow as a function of the GEOSS maturity and user acceptance. Therefore, it might be essential pursuing current efforts or ideas circulating amongst the GEO community to streamline and simplify as much as possible the procedures for the registration of new GEOSS datasets, to adapt interfaces according to the main user profiles targeted by the GEOSS and to develop functionalities allowing users' feedback on registration and data reuse.
As pointed out in the interim report of the IPWG, it would also be important to develop and implement GEOSS Data Management Principles, including on data documentation and quality control, to provide GEOSS users with sufficient information to judge fitness for use. For instance, it could be useful verifying if a GEO consensus could be reached on how far to go with respect to a possible implementation of a GEO label[72] on data quality or the promotion of reference datasets of global interest.
Beyond the issue of data management, it is also the issue of interoperability of models, tools and services which could become more acute in the future. The IPWG recalls in its interim report 2014 that modelling is an integral part of GEOSS and that the integration of observation-based models within GEOSS should be enhanced in order to serve user needs for spatial, temporal and variable coverage. This would depend on the set of data users that GEO will want to target, the main requirements by these users and the type of GEOSS resources (data, models, tools, applications, services) upon which GEO would agree to focus on when implementing the GEOSS through 2025. To date, many members of the GEO community acknowledge that the GEOSS has been driven by a data-provider perspective and that the current GCI is mainly adapted for "expert" users. Not much has happened yet to serve "non-expert" users such as individuals who might wish querying the GEOSS more occasionally for simpler straightforward applications, for instance about their local living environment. Policy users, who often do not have the capacity to ingest increasing volumes of different kinds of data, would require advanced products generated by added value services. Researchers represent still another category of users who are often interested in getting large amounts of raw data on a frequent basis. Thus, requirements in terms of spatial,

[72] http://www.geolabel.info/

temporal, spectral resolutions, the levels of data pre-processing and delivery times, frequencies of data requests, types of user interface and support services might differ significantly. A pre-requisite for rendering GEOSS more user-friendly will thus require the establishment of, as repeated by the IPWG, a more concise and clearer understanding of the targeted GEOSS users.

3.3.2 "*Fostering global initiatives that address identified gaps in Earth observation information including, where appropriate, facilitating the development of partnerships to identify relevant stakeholders (end-users), as well as development of associated services and arranging for their subsequent uptake by relevant entities*"

- Related question: How to enable a more widespread uptake and use of the GEOSS?

The importance of strengthening of the user dimension across all GEO societal challenges has been underlined in the latest GEO assessment report[73] as well as in the Commission consultations referenced in annexes VI and VII. How the GEO should broaden the global initiatives approach conducted so far by GEO in order to better meet the demand from users is a subject for further investigation also reported by the IPWG. The GEO international initiatives have maximum few years of gestation. Sustaining them and the services they start providing, as well as strengthening the associated communities of practice over the long term, are issues that are likely to become more pressing as these initiatives mature over time.
Developing new strategic working partnerships when GEO reaches out to other organisations is another area being considered by the GEO community for possible investigation. The aim would be to better contribute to the goals of those organisations through developing a better match between user demand and GEOSS supply.

- Related question: How to better 'brand' the GEO added value on the international scene?

The topic of sharing and managing geospatial environmental data via digital infrastructures is getting more attention on the international scene. As underlined in the GEO assessment report, there is a need for the GEOSS to keep pace with a fast-moving digital landscape and the growing number of data infrastructure initiatives. The GEO would probably gain to better position itself and showcase its specific added value in an increasingly complex global landscape of new environmental e-infrastructure initiatives (such as the Future Earth[74], Earthcube[75], the Shared Environmental Information System - SEIS[76], the Global Framework for Climate Services - GFCS[77], or the UN initiative on Global Geospatial Information Management - UNGGIM[78], just to mention a few).

3.3.3 "*Mobilising appropriate resources for EO capacity building with a specific emphasis on developing countries*"

- Related question: How shall GEO strengthen engagement with developing countries and foster regional cooperation?

The need for Earth observations might significantly differ from one part of the world to another, including those by citizens in developing or developed nations. The need to strengthen engagement with developing countries, as well as foster regional cooperation is clearly mentioned in the Geneva Declaration[79]. Following the example of the AfriGEOSS

[73] GEO EXCOM 31, 8-9 July 2014, Document 11: Target and task assessment
[74] http://www.icsu.org/future-earth/
[75] http://www.earthcube.org/
[76] http://ec.europa.eu/environment/archives/seis/index.htm
[77] http://www.gfcs-climate.org/
[78] http://ggim.un.org/
[79] http://www.earthobservations.org/documents/ministerial/geneva/MS6_The_Geneva_Declaration.pdf

initiative, GEO could consider establishing new regional initiatives and partnerships to accelerate capacity building and GEOSS penetration at regional to local scales. Such an approach could have implications for all caucuses and trigger possible modifications of governance as envisaged in the Vision document for GEO 2025. Some equilibrium would have to be found between global and regional, centralised and decentralised approaches so as to allow for multi-scale GEOSS penetration while avoiding break-out. The latest assessment of GEO progress[80] reports that engagement of developing countries remains a challenge. In the case that partnerships would be established with a group of developing countries, additional care should be taken of their real involvement and steering, as well as to collaborate with the relevant development programs existing in the different caucus.

3.3.4 "*Allowing for the possibility of modifications to GEO's current Societal Benefit Area structure, exploring linkages to sustainable development themes*"

- Related question: What revised concept for future GEO societal challenges and what implications on future GEO strategic targets?

Several challenges are not specifically covered by the current nine GEO Societal challenges. For instance, the management of geo-resources is not included. However, the major contribution that minerals and metals make to the world economy and modern societies is well recognised, as well as the need to address the environmental and social impacts of mining activities. This was notably pointed out in the outcome document 'The future we want' of the United Nations Rio+20 conference on Sustainable Development[81]. Taking geo-resources as an example, GEO could reconsider the scope of its societal challenges and related strategic targets for the next decade. The Vision document for GEO 2025 and more recently the interim report by the IPWG recommend that: "*GEO should seek to become the point of reference for Earth observations and information in the area of the Sustainable Development Goals (SDGs)*" and that "*GEO should align its agenda with that of the SDGs*".

3.3.5 "*Making a renewed effort, where possible, to collaborate with the private sector while remaining an intergovernmental partnership*"

There is consensus amongst the GEO members that GEO should remain driven by a partnership of governments. This was highlighted in the Vision document for GEO 2025 and confirmed in the Commission consultation of the HLWG (annexe VII). The public-good nature of Earth observation and its contribution to long-term public policy-making largely explain this requirement to maintain public control of the GEO and the GEOSS. At the same time, the essential role of the private sector in contributing to the innovation cycle, incubating new EO-derived services and connecting to the end users is fully recognised by the GEO community. In the Geneva declaration, the GEO Ministers resolved "to broaden and strengthen engagement with non-governmental organisations, non-profit organisations (…), foundations, and the private sector".

- Related questions: What business cases could be developed to attract the private sector? What functions could industry carry out when supporting and/or benefiting from GEOSS? Should the door be opened to private investment in GEO-GEOSS? Is there a role for the private sector in the GEO governance?

New models could be developed to better match public- and private-sector interests in the medium to long terms, while also preserving transparency, fairness and equal access to GEOSS for companies of all countries. This could be done considering the evolving nature of a private sector which is not monolithic and taking stock of possible GEO values for the

[80] GEO Plenary X, 15-16 January 2014, Document 7: Assessment of Progress – Target and Task
[81] http://www.un.org/en/sustainablefuture/

private sector: from developing new market segments to understanding global requirements, triggering new business models or providing a new platform for marketing and advertising. In this context, GEO might give a new push to its intention of developing a general framework for private sector engagement. The Vision document for GEO 2025 briefly mentions models such as public-private fora and other platforms for dialogue. New aspects of the GEO mode of functioning might have to be considered, especially if GEO would decide to invite the private sector to contribute towards the costs of upgrading the GCI to better serve the private sector's needs. As reported by the IPWG, this is one of the new perspectives currently discussed amongst the GEO community.

- Related questions: How far shall GEOSS expand accessibility beyond EO data? What about giving access to processing tools for big data, interfaces for computing on the cloud, Earth system models, new data streams such as crowdsourcing data? How shall GEO succeed in improving access to and use of cultural, social and economic data?

Currently, the GEOSS infrastructure provides access to millions of data, files, images and catalogues in various forms. The range of resources made available to users via the GEOSS could well expand to take into account of new monitoring trends such as crowdsourcing, unmanned airborne observing platforms, sensor web, data made available through social networks or those big data that are so large and complex that they cannot be processed anymore using on-hand database management tools or traditional data processing applications. According to the Vision document for GEO 2025, facilitating access to big data should be amongst the strategic objectives of the GEOSS through 2025. In various workshops, experts of the GEO Infrastructure Implementation Board have suggested that the GEO could decide to take more advantage of the Internet of Things, to share services and tools for information processing such as web mapping and visualisation tools, web modelling, high computation technologies or grid computing. This could possibly lead to a more hybrid approach where not only data are brought to the users but also where users are brought to the data. GEO might also wish to clarify the extent to which the future GEOSS would share processed datasets, derived analytical products and more sophisticated information products. In the context of the future expansion of the GEOSS offer, the Commission consultations in annexes VI and VII have pointed out the importance of seizing future opportunities for the private sector while at the same time ensuring a global level playing field.

3.3.6 "*Developing a specific and strengthened framework or mechanism for steady resource commitments to GEOSS, from both public and non-public sources, while relying on the principle of voluntary contributions*"

- Related question: How to balance / increase expectations and commitments? What revised resourcing mechanisms for GEO?

Expectations for GEO through 2025 should ideally be commensurate with the scale of commitments by the GEO Members. Large expectations would require large commitments; lower commitments might erode the level of ambition. The IPWG unambiguously reflects the general opinion in the GEO community that "*GEO needs more resources and stronger commitments*" and that "*there is dysfunctional management at [GEO] task level, with a lack of resources permeating every aspect of implementation*". However, it remains to be defined what the intended framework for sustained resource commitments, as resolved by the Ministers during the GEO Summit in Geneva, could consist of and if this mechanism will be sufficiently attractive considering the maintained voluntary approach of the GEO. As referred to in section 2.5, this voluntary approach brings a lot of flexibility, agility, inclusiveness and reactivity potential in the GEO process. It also sometimes lessens the level of commitment by some GEO Members or Participating Organisations which in turn sometimes might jeopardise the ability of the GEO Work Plan to reach the intended strategic targets completely and on time. Whilst there is a widespread consensus on the need for more

resources for the GEOSS implementation, the GEO Members will have to find a common position on how this can be achieved considering both public and non-public sources, both in-kind and in cash.

3.4. EU-specific issues for possible consideration

Lessons learnt from nine years of European involvement in implementing the GEOSS, show that Europe would gain from addressing the following additional EU-specific issues if it wishes to reinforce the contribution from and benefit to the EU in the renewed GEO. These issues for possible consideration have been compiled from the results of the consultations made in 2013 of the members of the HLWG and additional external European experts (annexes VI and VII). They are outlined as a basis for possible deeper analyses that could help identifying optional actions and alternatives and assessing their respective impacts.

3.4.1 GEO-related coordination mechanisms in Europe

- EU dimension and long-term strategy of the GEO European regional node

In the last GEO Summit in Geneva, the Ministers and other heads of delegations have resolved to reinforce the regional component of the GEOSS. There is a general agreement that establishing stronger regional nodes of the GEOSS can be an effective means to coordinate and catalyse GEOSS activities.

The coordination of the European Caucus is based on the HLWG which involves experts nominated by the Member States and whose meetings remain driven by Plenary and EXCOM agendas. The coordination is essentially *ad hoc* and informal. Each European GEO Member country and the Commission participate in their own right. In GEO Plenary meetings, the European Caucus speaks with 33 voices (32 national governments located in Europe - including 26 EU Member States - plus the Commission).

The Member States delegates generally acknowledged the fundamental success of the GEO HLWG in developing common European positions with respect to GEO. However, some delegates have recommended that this group could be strengthened and formalised with a view to getting stronger engagement not only by few but by all its members. Furthermore, they have also underlined that, while the EU support via FP7 has been essential to help the GEOSS implementation since 2007, this has not lead to a proportional level of EU influence on the management and execution of the GEO.

Furthermore, the panel of experts consulted in 2013 (annexe VI) advised the Commission to explore ways and means with the European GEO Members to evolve the organisation of the European GEO Caucus so that the current European participation in GEO becomes a more formal EU participation. The panel of experts noted that "*effective intra-European coordination at an implementation level is not yet sufficiently in place. To allow effective and coordinated participation of a European network of representatives in all areas of GEOSS implementation, management and coordination, consideration should be given to designating European coordinators for each of the GEO strategic targets, and linking them with the GEO HLWG. These coordinators would also act as points of contact both within Europe and towards GEO*"[82].

To provide a more coherent and sustained EU leadership throughout the GEO initiative during the period 2016-2025, there might be a need to explore and detail with the Member States the best mechanisms towards a renewed coordination framework with a possible

[82] Group of experts' Report "Assessment of the Achievements of the Group on Earth Observations (GEO): A European Union Perspective", commissioned by the European Commission, May 2014

widened strategic character for the European GEO Caucus. At the same time, such a framework could foresee the most adapted interfaces with the European downstream industry at large, with national EO management structures and other sub-national initiatives in Europe to facilitate GEO-inspired innovation. Experience could be gained from other Commission Expert Groups such as steering boards of existing European Innovation Partnerships. Synergies could also be sought with groups of experts and committees involving Member States representatives such as the INSPIRE Committee, the Copernicus Committee or the Europe Regional Committee of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM: Europe). The European caucus might investigate further how to reinforce its direct links to the various boards, groups and committees involved in the governance of the GEO.

- National GEO management structures

During the GEO Summit in Geneva, several GEO delegations have pointed out that efforts should be continued to develop or consolidate national-level management structures for the GEO and the GEOSS. This was further emphasised by several members of the GEO HLWG during the consultation conducted in 2013 (annexe VII). In Europe, several European Member States, such as Germany, Greece, Austria and Spain, have developed to various extents such national structures also called 'national GEO Offices of GEO Secretariats'. In general, the prime aims of such structures are to inform and coordinate EO players in those countries and to represent them in meetings of the GEO HLWG and other GEO events. Some Member States have already expressed the wish that experiences on existing national GEO management structures shall be exchanged in the frame of the GEO HLWG. Synergies could be explored with the national coordinating structures that are foreseen in the legal provisions of the INSPIRE Directive.

- Collaboration with ESA and other major EO public organisations in Europe

There could be a high leverage potential to be gained from even greater synergies with major European organisations of relevance to the GEOSS, in particular with ESA taking into account of the forthcoming evolution of EU-ESA functioning relationship.

The Council in its conclusions of 18 February 2013[83] recognised that there may be a need to "*review and enhance the functioning of the relationship between the EU and ESA in view of the changed political context, the increasing role of the EU in the space domain, competitiveness challenges faced by the space sector and the growing importance of space activities for society*". The Commission has outlined various options in its progress report on establishing appropriate relations between the European Union and the European Space Agency (ESA)[84]. ESA is currently discussing these options in view of a decision expected by the end of this year. Whatever the selected option could be, there is a clear trend towards greater operational efficiency, political coordination and accountability.

ESA has a leading role in the space component of the EU Copernicus programme and in the GEOSS implementation. This role includes delivering and managing the GEOSS portal, providing satellite-based EO assets for various GEO societal challenges (such as disaster and climate) and GEO initiatives (such as AfriGEOSS and GFOI). Furthermore, as recognised in the experts report in annexe VII, ESA is conducting research and innovation programmes in the field of Earth observation to support European and Canadian geo-spatial information industry, develop and grow the prospects of EO services being used in business and

[83] ST6571/13
[84] COM(2014) 56 final

organisations for their operations (e.g. the ESA Value Adding Element[85], a programme component of the ESA Living Planet Programme[86]).

Existing collaboration with other European organisations which already participate in the GEO could also be reinforced such as with EUMETSAT, ECMWF, the EEA, the EU Satellite Centre and EuroGeoSurveys. Advantage could be taken from the fact that most of these organisations are also strongly involved in the EU Copernicus programme (annexe IV).

- EU consensus building on the next 10-year Implementation Plan

Ministers and other heads of delegations representing various EU Member States or other European countries during the GEO Summit in Geneva have expressed their opinions and perspectives on the renewed GEO for the period 2016-2025. The Commission, as GEO co-chair, called on that occasion for an accelerated and more robust evolution of the GEOSS and invited for more commitment by the GEO Members. The Commission has also underlined the potential benefits that the GEOSS could bring to the global economy and its possible role to help achieving the Sustainable Development Goals.

The Commission and the other members the HLWG are already supporting the work of the IPWG for the drafting of the next 10-Year Implementation Plan. However, true consensus within the GEO European caucus has not yet been reached on future modifications that could be introduced to the GEO functioning (new elements detailed in section 3.3). The experts' report (annexe VI) suggests that the HLWG should provide its own input to the IPWG to provide European views on the GEO governance for the period 2016-2025.

3.4.2 Coordination of European research and innovation in the field of Earth observation

When conceptualised in 2003, the GEOSS was first introduced as a comprehensive system of systems to take the pulse of the Planet and as a means of building the next level of Earth observation to allow an 'Earth Science Renaissance': a true revolution in our understanding of the Earth as a complex and interconnected system[87]. A GEO report[88] prepared in 2008 by the GEO Science and Technology Committee has emphasised the high dependency of the GEOSS implementation on advances in science, technology, and research, and how GEOSS itself could be a driver for such advances. The main relationships between science and GEOSS do articulate along the following five main functions:

- Linking observations across Societal Benefit Areas
- Identifying gaps in observations, research and development
- Provision of long time series of observations
- Improve access and harmonization of in-situ data
- Bridging the gap between science and application

- Earth observation focus across the Horizon 2020 Framework Programme

The Horizon 2020 Framework Programme is overwhelmingly recognised by the Member States delegates of the HLWG and by the group of experts convened by the Commission as essential for progressing on the GEOSS implementation and providing added value to national contributions (annexes VI and VII).

The Horizon 2020 Framework Programme offers a great potential to achieve research and innovation breakthroughs in the field of Earth observation through 2025. This potential relies

[85] http://www.eomd.esa.int/
[86] http://www.esa.int/Our_Activities/Observing_the_Earth/The_Living_Planet_Programme
[87] Intervention of Vice-Admiral Conrad C. Lautenbacher, Jr. at the 14th WMO Congress (May 2003)
[88] GEO report 'The role of science and technology in GEOSS' © European Communities, 2008

partly on the new instruments of the Horizon 2020 Framework Programme made available to address the full innovation chain and the general objective to encourage and facilitate the transition from research to operations in partnership with operational actors from the public and private sectors. It also relies on the focus given to Earth observation in each of the three main Parts of the Horizon 2020 Framework Programme.

- Part I on 'Excellent Science' of the Horizon 2020 Framework Programme aims to ensure that Europe has world-class research infrastructures accessible to all European researchers and beyond. This includes support of essential monitoring infrastructures in various scientific domains including environment (annexe V). Depending on their scope and maturity, some of them could represent interesting EO capabilities with open data management strategies that could be brought by GEO to the global stage. Research infrastructures under 'Excellent science' also include e-infrastructures activities and the continued support to transversal, crosscutting interoperable solutions, for all research domains (including geo-sciences). Typical e-Infrastructure areas of research and innovation of high relevance to GEOSS include: infrastructure for open access, long term preservation, management of extremely large research datasets, persistence and trust, as well as community-driven data infrastructures, computational infrastructure such as High Processing Computing (HPC) services or cloud computing, GÉANT, virtual Research Communities, and virtual research environments and virtual labs.

- Part II on 'Industrial Leadership' of the Horizon 2020 Framework Programme aims at strengthening industrial leadership and competitiveness. A prime area of interest under Part II relates to satellite-based Earth observation including their validation, processing, and exploitation to develop new information products and services. This would contribute to make Copernicus the main European contribution to the GEOSS. Another interesting area with relevance to GEO relates to Information and Communication Technologies (ICT) activities for 'digital content and creativity'. This area looks at new tools to create, exploit and preserve all form of digital content in any language and to model, analyse, and visualise vast amounts of data. ICT focussing on 'big data' processing is also a subject being treated under Part II which is getting increasing interest by the GEO community.

- Under Part III of the Horizon 2020 Framework Programme, the Societal Challenge on Climate action, Environment, Resource Efficiency and Raw materials foresees research and innovation activities to support relevant international efforts and initiatives, through the development of comprehensive and sustained global environmental observation and information systems, including in the context of GEO.

- As part of the Horizon 2020 Framework Programme, the Commission's Joint Research Centre (JRC) is expected to continue providing independent customer-driven scientific and technical support for the formulation, development, implementation and monitoring of EU policies. Typical JRC domains of contribution include EO data availability, modelling and advanced processing capabilities to transform data into information, as well as interoperability between information systems.

In their assessment report (annexe VI), the group of experts recommends an increased coordination to streamline EO activities within the various services of the Commission. In the field of research and innovation, a strong leverage effect could possibly be achieved from an increased coordination across Horizon 2020 priorities of EO relevance.

- ERA coordination in the field of Earth observation

Many European countries and pan-European organisations are conducting EO research and innovation programmes but many of these activities remain too fragmented. They could be more coordinated to reach the critical mass that would enable the EU to be better positioned with regard to its main competitors.

As identified in the Commission consultations (annexes VI and VII), a strengthened European Research Area (ERA) in the domain of Earth observation would reduce fragmentation, align agendas, pool resources towards more transnational activities, and leverage impact of public funded research and innovation conducted by (inter)national and regional programmes in Europe. Such coordination would not only bring improved coherence of the overall EU contribution to the GEO, but also consolidate the research and innovation component to the EU Copernicus programme.

The ERA-NET Cofund instrument proposed in the Work Programme 2014-2015 under Societal Challenge on Climate Action, Environment, Resource Efficiency and Raw materials could be considered as a milestone for such coordination. This ERA-NET, if implemented, foresees a joint call for proposals with EU co-funding on observing and monitoring changes affecting the Earth's atmosphere, oceans, cryosphere and landscapes.

- Data relationship between the Horizon 2020 Framework Programme and the GEOSS

To date, the number of EO resources (data, information, images, services, standards and best practices) that can be searched, discovered and accessed via the GEOSS Web Portal is close to 70 million. Of these resources, about 51 million can be accessed for reuse without restriction either free-of-charge or at the cost of reproduction.

There would be benefit for beneficiaries of the Horizon 2020 Framework Programme to exploit for their research and innovation activities the data made accessible openly via the GEOSS, and also to register in GEOSS the geospatial data that they have produced as foreground of their project. The latter could be done as a contribution to the Open Research Data Pilot currently experimented with various parts of the Horizon 2020 Framework Programme.

3.4.3 Synergies between the GEOSS and Copernicus

- GEOSS discovery and access to Copernicus data and services

Copernicus, the EU flagship programme for Earth observation, is gradually becoming operational, component-by-component and service-by-service (annexe IV). In view of the dissemination of the wealth of Copernicus data and services, the various partners involved in the Copernicus programme are now considering how to upgrade and up-scale the current distributed infrastructure shared between the various Copernicus stakeholders including the Commission, EEA, ESA, EUMETSAT, other national space agencies and the Member States. This is a major issue in order to meet the demand while accommodating the expected large volume of Copernicus data and products.

Previous consultations indicate that GEO helps reaching out beyond the EU through bringing an international context to the Copernicus data and products (e.g. from the Emergency Management and the Land Monitoring Services). Copernicus is expected to provide operational GEO services that will represent a significant European contribution to the GEOSS. However, a clear recommendation resulting from these consultations is the need to "*enhance links and collaboration between Copernicus and GEO*".

For instance, until recently, access from the GEOSS Web Portal to existing Copernicus services was limited and sub-optimal. Increased attention is now being given to make new Copernicus data and services more easily accessible through the GEOSS, and registered, as far as possible, as GEOSS Data-CORE resources. It might be useful to further explore how to widen and systematise these efforts if the EU wants to effectively allow the GEO community of use and feedback on Copernicus data and products.

- *Interconnection between Copernicus services, GEO international initiatives and communities of practice*

As the individual Copernicus services fit generally very well with the scope of one or more of the GEO societal challenges, it could be beneficial to reflect on how to better interconnect these services with the relevant GEO international initiatives and communities of practice that are addressing them. For instance, the GEO being a global and multi-disciplinary partnership, it could very well enrich Copernicus with a wide international feedback on the definition and validation of the Copernicus service requirements.

- *In situ data for the GEOSS and Copernicus*

Long-term and continuous provision of airborne, seaborne and ground-based in-situ data play a crucial role in both the GEOSS and the Copernicus programme. In-situ data are not only required for calibration and validation purposes of satellite products, but also as a parallel data stream to derive products of higher value to the user.

However, in-situ data are repeatedly reported amongst the GEO community as underplayed in the GEOSS. As reported in the latest GEO assessment report, several valuable, high quality sources of in-situ data have not yet been properly integrated within the GEOSS. This particularly concerns:

- Environmental research infrastructures (see annexe V), including those listed in the roadmap of the European Strategy Forum on Research Infrastructures (ESFRI)[89]. They represent a strategic source of in situ data to monitor essential variables of the Earth system;
- Citizen science, crowdsourcing, social networks, sensor web, unmanned airborne vehicles and georeferenced big data. These developments represent promising in situ monitoring opportunities that could complement, to some extent, the more classical and institutional environmental observation networks;
- Official statistical information on socio-economic and environmental phenomena. There might be an opportunity in the future to strengthen a GEO partnership with UN-GGIM and statistical institutes in general. The European Statistical System, for instance, has recently reaffirmed its commitment to engage in the integration of geospatial information with statistical information with the aim of supporting sustainable development. Statistical offices are also increasingly investing into research on geo-referenced big data.

A wide experience regarding in-situ data coordination has been accumulated in Europe, particularly by the EEA in the contexts of Copernicus, the FP7 project on GMES In-Situ Coordination (GISC[90]), the GEO Task to “develop, maintain and coordinate in situ and airborne observing networks”, and Eionet[91], the European environment information and observation network. The EU could possibly gain from better connecting its multiple efforts related to the harmonisation, provision and sharing of in-situ data, for example through the implementation of the INSPIRE Directive, exploiting further this experience and using GEO more intensively to bring it at global scale to consolidate the in-situ component of both Copernicus and the GEOSS.

[89] http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri
[90] http://gisc.ew.eea.europa.eu/
[91] http://www.eea.europa.eu/about-us/countries-and-eionet

3.4.4 Avenues for engaging the European private sector in GEO for possible consideration

- Mobilization of the European business sector to benefit from the GEOSS

The global trend towards more full and open EO data sharing to which GEO is contributing actively lays down the foundations for a more competitive and innovative EO-related global market place that downstream industries from any region of the world might wish to exploit.

While it was premature in 2005 to open a discussion with the European private sector on how to benefit from GEOSS opportunities, the progressive implementation of the GEOSS, the achievements in terms of discovery and access to EO datasets, and the expansion of the GEOSS Data-CORE bring into light the growing issue of the optimal take-up of the GEOSS data opportunities by the European private sector. More generally, this issue could also be linked to the degree of preparedness of the whole European private sector to embrace the ongoing digital data revolution and to participate in the global digital economy.

Increasing awareness about GEOSS-related market opportunities and dialoguing with the business sector in Europe are pre-requisites in order to raise interest, collect views, and ultimately transform the GEOSS into a lever to support the EU industry. A detailed description of this EO industry in Europe and related markets is given in annexe VIII. This description provides a general categorization of the Earth observation private sector, figures and trends concerning the European EO service industry over the period 2006-2012 and considerations about global markets for remote sensing and geo-services.

- Consolidation of the EO-based service sector in Europe

A better positioning of the EU service industry on the global stage, including on markets outside Europe, implies accelerating the emergence of the service sector in Europe, giving a special attention to new innovative SMEs. Building upon the Communication from the Commission of 28 February 2013 on the "EU space industrial policy: releasing the potential for economic growth in the space sector"[92], it might be useful to examine whether complementary actions would reinforce the emergence of a European service sector. For instance, the case of businesses essentially based on in-situ Earth observation data could be further explored. Prospects for new innovative products and applications using EO data as one amongst several other sources of information might lead to new profiles of private providers and new market niches to be explored.

- Stimulating innovative services for non expert users

Several market indicators point towards the strategic role of local markets for the service industry. Recent studies[93] confirm the importance of micro-enterprises in developing products optimised for local needs, as well as the trend towards the very high resolution for many commercial applications and the importance of land applications for local planners. A special Eurobarometer conducted in May-June 2013 on Europeans' attitudes to space activities[94] revealed that more than half of Europeans would be interested in using information derived from space-borne observations to help plan their travel and outdoor activities. This survey shows also a growing trend towards some democratisation of the use of EO data, beyond the more classical institutional use of Earth observations to inform policies. Therefore, more demonstration of simple GEO-based applications for local needs by non-expert users could raise awareness on the GEOSS potential to stimulate such a kind of market in Europe.

[92] COM(2013) 108 final
[93] EO Services industry, EARSC survey under assignment by ESA, September 2013, http://earsc.org/news/a-survey-into-the-state-and-health-of-the-european-services-industry
[94] Special Eurobarometer 403 / Wave EB79.4 – TNS opinion & Social

- European public private partnerships to help realising the GEO vision

Public-private Partnerships (PPPs) in general are increasingly being used by policy makers across the world as a tool to deliver on their growth agendas. To be successful, previous experiences have shown that such 'organised relationships' between public and private organisations should build upon a balanced sharing of skills and assets, risks and rewards. It could be useful to investigate the 'pros and cons' of such multi-stakeholders' models if applied to the EO private sector in Europe in the GEOSS context. Such an investigation could typically target the objectives to facilitate the strongest GEOSS take-up by the European EO downstream industry, and the direct engagement of the European business sector in the development of the next GEOSS. Indeed, the European business sector could most probably contribute on various grounds such as providing EO data from privately owned (space or non-space) complementary observing capacities, delivering interoperability solutions for universal access to distributed information systems, or giving access to tools and processing capabilities for the transformation of EO data.

A major form of PPP implementation in FP7 has been the Joint Technology Initiative (JTI), whereby the Union and industry jointly fund and implement certain areas of the Community 7th Framework Programme. As noted in the Communication from the Commission of 10 July 2013 on "Public-private partnerships in Horizon 2020: a powerful tool to deliver on innovation and growth in Europe[95], "*JTIs in particular represent an innovative way of implementing the Union's research and innovation policy. They bring together the frontrunners in terms of research and innovation in the industrial sectors concerned and allow them to focus and align their efforts around strategic research and innovation agendas*". Lighter schemes could also be envisaged such as European Technology Platforms (ETPs) consisting of industry-led stakeholder forums that develop short to long-term research and innovation agendas and roadmaps for possible action at EU and national levels, possibly supported by private and public funding.

- Addressing the full value chain from EO research to innovation and market deployment

The strong focus of the Horizon 2020 Framework Programme on innovation, the inclusion of calls for innovation activities that aim to be closer to the market and the availability of SME-targeted calls and instruments could bring opportunities to involve EO adding value SMEs and to maximise economic impact of EO-related research and innovation activities.

[95] COM(2013) 494 final

4. CONCLUSION

Since its inception in 2005, the GEO initiative has gradually articulated its added value and matured over time. The GEOSS has progressively evolved from concept to action and implementation. It has now reached the step where users could start benefiting from a range of EO datasets, a majority of them being made accessible for reuse on a free and open basis.

The Commission has been amongst the key players in the GEO, acting as one of the four GEO co-chairs on behalf of the European GEO Caucus, providing major guidance for the evolution of the initiative, and supporting the GEOSS implementation through significant research and innovation investments during the 7th Framework Programme.

The next GEO decade (period 2016-2025) will be crucial in bringing more benefits to users and intensifying use and exploitation of a more diversified GEOSS offer in terms of EO data, products, models, toolkits and applications. The GEO mandate, renewed for ten years on the occasion of the GEO Summit in Geneva, represents a remarkable opportunity to enhance the benefits that the GEO and the GEOSS could bring to European society.

Europe might build upon significant assets to implement the GEOSS through 2025, most importantly the Horizon 2020 Framework Programme, the new Copernicus programme and various EU policy initiatives and legislations related notably to environment, space and the digital agenda of the EU.

Consultations by the Commission in 2013 have confirmed that many challenges lie ahead including GEO tasks and projects to be completed, monitoring networks to be coordinated, observation gaps to be filled, GEO international initiatives to be sustained and a GEOSS to be brought into operation over the long term. They have also emphasized that the EU and the GEO would both benefit from a continued enhancement of a strong EU component in the implementation of the GEOSS and from an enhanced coordination at European and national levels. Before embarking in this direction, the various issues outlined in the 3rd section of this Staff Working Document would require further analysis to help identifying possible actions and alternatives and assessing their respective impacts.

ANNEXE I – List of acronyms

Acronym	Definition
DAB	Discovery and Access Broker
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environment Agency
EO	Earth Observations
ERA	European Research Area
ESA	European Space Agency
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EXCOM	(GEO) Executive Committee
G8	France, Germany, Italy, Japan, United Kingdom, United States of America, Canada, Russia[96], European Union
GCI	GEOSS Common Infrastructure
GCOS	Global Climate Observing System
GEO BON	GEO Biodiversity Observing Network
GEO	Group on Earth Observations
GeoCarbon	Global Carbon Observing System
GEOGLAM	Global Agricultural Monitoring initiative
GEONETCast	GEOSS global network for data broadcasting
GEOSS	Global Earth Observation System of Systems
GEOSS Data-CORE	GEOSS Data Collection of Open Resources for Everyone
GFOI	Global Forest Observing Initiative
GMES	Global Monitoring for Environment and Security
GOOS	Global Ocean Observing System
GTOS	Global Terrestrial Observing System
GWP	GEOSS Web Portal
HLWG	GEO High Level Working Group
ICT	Information and Communication Technologies
JRC	Joint Research Centre of the European Commission
INSPIRE	Infrastructure for Spatial Information in the European Community
IT	Information technology
IPWG	Implementation Plan Working Group
PPP	Public-private partnerships
SBAs	(GEO) Societal Benefit Areas (also referred to as societal challenges)
SDG	Sustainable Development Goals
SMEs	Small and Medium-sized Enterprises
SPOT	Satellite Pour l'Observation de la Terre (Satellite for observation of Earth)
UN	United Nations
UNGGIM	UN initiative on Global Geospatial Information Management

[96] Till March 2014

ANNEXE II – GEO background

II.1 GEO history in a nutshell

The urgent need for coordinated observations relating to the state of the Earth was strongly highlighted in 2002 at the World Summit on Sustainable Development in Johannesburg (South Africa) and in June 2003 at the meeting of the Heads of State of the Group of Eight Industrialized Countries (G8) in Evian (France).

As a follow-up, the initial concept for the future Group on Earth Observations (GEO) was proposed at the First Earth Observation Summit in Washington (USA) in July 2003. This happened via a first Declaration establishing the ad hoc intergovernmental Group on Earth Observations ('ad hoc GEO') with the mandate to draft a first 10-Year Implementation Plan.

The concept for GEO was further advanced at the Second Earth Observation Summit in Tokyo (Japan) in April 2004, where the 'ad hoc GEO' adopted a Framework Document defining the scope and intent of a Global Earth Observation System of Systems (GEOSS).

The Third Earth Observation Summit, held in Brussels in February 2005 endorsed the GEOSS 10-Year Implementation Plan and established the intergovernmental Group on Earth Observations (GEO). At this Summit nearly 60 governments were hosted by the Commission which was represented by Commissioner Dimas and Commissioner Potočnik.

Since its establishment, the G8 Heads of State have given direct support to GEO-GEOSS notably in Gleneagles (UK) in 2005, Heiligendamm (DE) in 2007, Hokkaido (JP) in 2008, L'Aquila (IT) in 2009.

Early GEO achievements were welcomed on the occasion of the Fourth GEO Ministerial Summit in Capetown (South Africa) in November 2007. The progressive evolution of GEOSS from concept to action and implementation was noted and a mechanism was called for to reach a consensus on the implementation of future GEOSS Data Sharing Principles.

Ministers and Heads of Delegations who participated in the Fifth GEO Ministerial Summit in Beijing (China) in November 2010 noted with particular satisfaction the refined GEOSS Strategic Targets for 2015, the GEOSS Data Sharing Implementation Guidelines and Action Plan, and the establishment of the initial GEOSS Common Infrastructure (GCI). They committed to maximize the number of datasets made available on the basis of full and open access, to create a distributed pool of documented datasets with full, open and unrestricted access at no more than the cost of reproduction and distribution (the GEOSS Data CORE), and to develop policy frameworks promoting the sharing of more open data.

In June 2012, at the 'Rio+20' Summit on sustainable development, Heads of State and Governments adopted the Declaration "The future we want" which recognises the "*importance of space-technology-based data, in situ monitoring, and reliable geospatial information for sustainable development policy-making, programming and project operations*". It also refers to "*the efforts in developing global environmental observing systems (…) including through the Global Earth Observation System of Systems*".

On 17 January 2014, during the sixth GEO Ministerial Summit in Geneva, Ministers and Heads of Delegations agreed to continue building on the GEO voluntary partnership to unleash the power of open Earth observation data for another decade. They decided to renew GEO for the period 2016-2025 and approved a procedure for developing a new 10 Year Implementation Plan. This is reflected in the main output of the Summit: the so-called 'Geneva Declaration'.

II.2 GEO plans for the implementation of the GEOSS

- The 10-Year Implementation Plan (2005-2015)

The current GEOSS 10 Year Implementation Plan covers the period 2005-2015. It summarizes the essential steps (defined in 2005) to be undertaken by the global GEO community of nations and organisations to advance the GEOSS till 2015. The 10 Year Implementation Plan also defines the main mechanisms for coordinating and strengthening existing EO systems of global interest.

- The GEO Work Plan (2012-2015)

The GEO Work Plans provide the more detailed task-oriented frameworks for implementing the GEOSS 10-Year Implementation Plan. These plans are living documents that cover periods of three years and which are updated annually. The current Work Plan covers the period 2012-2015; it allows voluntary contributors to team up around 26 dedicated GEO tasks. Leads and contributors to the Work Plan assume their roles on a best-effort basis, voluntarily, in the spirit of advancing GEOSS. The tasks being performed currently are categorised as follows:

a) "Infrastructure tasks" featuring the physical cross-cutting components of an operational and sustainable GEOSS Common Infrastructure (GCI);
b) "Institutions and Development tasks" focussing on reinforcing data sharing, mobilising resources, developing capacity, engaging users;
c) "Information for Societal Benefits tasks" with an emphasis on information, tools, and end-to-end systems to support decision-making across the nine Societal Benefit Areas defined at the early stage of GEO.

II.3 GEO membership

The GEO membership is organised into five regional caucuses – Europe, Africa, Asia-Oceania, the Americas and the Commonwealth of Independent States (CIS). It is open to all Member States of the United Nations and to the Commission. In addition, GEO welcomes, as Participating Organisations, intergovernmental, international, and regional organisations with a mandate in Earth observation or related activities, subject to approval by the GEO Members. The current partnership includes key international scientific programmes (such as the international programme on biodiversity science - Diversitas[97], the International Geosphere-Biosphere Programme - IGBP[98] and the World Climate Research Programme - WCRP[99]), global observing systems (such as the Global Ocean Observing System - GOOS[100], the Global Climate Observing System - GCOS[101] and the Global Terrestrial Observing System - GTOS[102]), UN conventions (such as the United Nations Convention on Biodiversity –- UNCBD[103], the United Nations Convention to Combat Desertification - UNCCD[104] and the United Nations Framework Convention on Climate Change - UNFCCC[105]) and other committees involved in international coordination activities such as the CEOS. Membership and participation are contingent on formal endorsement of the GEO Implementation Plan including the GEOSS data sharing principles.

[97] http://www.diversitas-international.org/
[98] http://www.igbp.net/
[99] http://www.wcrp-climate.org/
[100] http://www.ioc-goos.org/
[101] http://www.wmo.int/pages/prog/gcos/index.php?name=AboutGCOS
[102] http://www.fao.org/gtos/
[103] http://www.cbd.int/
[104] http://www.unccd.int/
[105] http://unfccc.int/

GEO's current Members include 92 countries and the Commission:

Africa	Americas	Asia and Oceania	CIS	Europe
Algeria Burkina Faso Cameroon Central African Republic Congo Republic of the Cote d'Ivoire Egypt Ethiopia Gabon Ghana Guinea-Bissau Guinea Republic of Madagascar Mali Mauritius Morocco Niger Nigeria Senegal Seychelles Republic of **South Africa (GEO Co-Chair)** Sudan Tunisia Uganda	Argentina Bahamas Belize Brazil Canada Chile Colombia Costa Rica Honduras Mexico Panama Paraguay Peru **United States (GEO Co-Chair)**	Australia Bahrain Bangladesh **China (GEO Co-Chair)** India Indonesia Iran Israel Japan Korea Republic of Malaysia Nepal New Zealand Pakistan Philippines Thailand	Kazakhstan Moldova Russian Federation Tajikistan Ukraine Uzbekistan	Austria Belgium Bulgaria Croatia Cyprus Czech Republic Denmark Estonia **European Commission (GEO Co-Chair)** Finland France Georgia Germany Greece Hungary Iceland Ireland Italy Latvia Luxembourg Malta Netherlands Norway Portugal Romania Serbia Slovakia Slovenia Spain Sweden Switzerland Turkey United Kingdom

There are currently 77 Participating Organisations in GEO. The full list is available from: http://www.earthobservations.org/pos.php

II.4 GEO governance

The GEO governance structure consists of a Plenary, an Executive Committee (EXCOM), a GEO Secretariat (hosted by WMO), as well as Implementation Boards and Working Groups. The GEO Plenary and the GEO Executive Committee are currently co-chaired by The Commission, South Africa, The United States and China. The Plenary meets at least once per year to adopt the annual GEO Work Plan, the coming year's budget and to receive reports from the Executive Committee. The latter committee consists of 13 members from across the five caucuses. In addition to the Commission, the two other European members of EXCOM are currently, Estonia and Italy. European EXCOM members (apart from the Commission) serve for a period of two years.

II.5 Examples of international initiatives initiated by the GEO

The **Blue Planet initiative** launched in November 2012 seeks to raise public awareness of the role of the oceans in the Earth system and their impacts on humankind. This initiative seeks to coordinate the various marine activities within GEO, to advocate and advance the

establishment and maintenance of a global observing network for the oceans. A first Horizon 2020 call in 2014 is concentrating on supporting this initiative with the aim of strengthening in-situ Atlantic ocean observations for a better management and sustainable exploitation of the maritime resources.

The **GEO Biodiversity Observing Network** (GEO BON) launched in 2008 has the objective of improving terrestrial, freshwater and marine biodiversity observations globally and make their biodiversity data, information and forecasts more readily accessible to policymakers, managers, experts and other users. GEO BON (supported by the FP7 project EUBON) has been recognised by the Parties to the Convention on Biological Diversity (CBD) and has submitted a report entitled "Adequacy of Biodiversity Observation Systems to support the CBD 2020 Targets" to the CBD.

The **Global Agricultural Monitoring initiative** (GEOGLAM) was called for by the Group of Twenty (G20) Agriculture Ministers in June 2011. The initiative forms part of the G20 Action Plan on Food Price Volatility and is designed to enhance worldwide agricultural production estimates. Beginning in August 2013, GEOGLAM (supported by the FP7 project SIGMA) started delivering monthly global crop outlooks to the Agriculture Market Information System's (AMIS) Market Monitor publication, hosted by the Food Agriculture Organisation of the United Nations (FAO).

The **GEO Carbon Initiative** (supported by the FP7 project GEOCarbon) is a global effort to develop and make available integrated data and information about the impact of human activities and natural processes on the carbon cycle at the national, regional and global level.

The **Global Forest Observing Initiative** (GFOI). This GEO Initiative helps nations to monitor their forests and forest carbon stocks. This initiative fosters sustained use of satellite and ground observations for national forest monitoring, and for measuring, reporting and verification of forest areas, carbon stocks and greenhouse gas emissions.

The **Global Mercury Observation System** (GMOS) launched in 2010 does monitor mercury and its compounds in air, precipitation, surface water, soil, sediments, vegetation and biota. Sharing data through this network helps scientists and decision makers to understand mercury transport and deposition to, and fluxes from, terrestrial and aquatic ecosystems. The GMOS monitoring network (supported by the FP7 project GMOS) has now been fully established. GMOS is expected to directly support the implementation of the Minamata Convention (adopted by 140 nations in October 2013).

The **Geohazard Supersites initiative** aims at fulfilling geospatial information needs for the prediction and monitoring of geological hazards, such as earthquakes, volcanoes and land instability. This initiative (supported by the FP7 projects MEDSUV, MARsite and FUTUREVOLC) conducts long-term observation experiments to access and retrieve data and integrated data products notably for improved estimates of volcanic and seismic unrest; better response during periods of activity; improved forecasts of ash dispersion; and more accurate, reliable hazard assessments.

ANNEXE III – Examples of FP7 contributions to GEO and GEOSS

The following examples of FP7 projects have been selected to illustrate the European support given to various GEO societal challenges, international initiatives, and the development of the GCI. They represent a limited sample of the 50 FP7 projects funded by the Theme Environment (including global change) under the Cooperation Programme.

Contribution to the GEO Societal Benefit Area on climate change

FP7 project GEOCARBON: Operational Global Carbon Observing System (www.geocarbon.net/)

Scope: GEOCARBON aims to integrate and analyse a higher quantity and quality of CO2 and CH4 data from in situ and remote sensing observations encompassing atmosphere, land and oceans in order to establish an operational integrated Global Carbon Observation and Analysis System. A global integration of the current carbon monitoring efforts and their datasets is pursued in order to build an operational GEOSS for carbon. It is envisaged that an even denser operational monitoring systems is needed for the future.

Results: new global maps of Forest Change, Wood Harvest, Forest Age and Forest Biomass have been produced. The research findings on the CH4 budget resulted in the publication (Nature Geoscience Magazine 2013) of a synthesis of the global methane sources and sinks over the past three decades. A forthcoming outcome is the provision of an aggregated and harmonized set of data and information on carbon pools and fluxes, ranging from global to regional scale, with an increased resolution and accuracy, and a reduced uncertainty. This will improve the global understanding of carbon cycle and its role in the climate change system, both from a scientific as well as from a policy perspective. A variety of innovative tools for visualizing and downloading climate and carbon related information have been developed (i.e. www.globallometree.org and http://biomass.geo-wiki.org).

Policy Relevance: GEOCARBON contributes to the implementation of the GEO 2012-2015 Work Plan and to the achievements of GEO's Strategic Targets on Climate, toward building an operational GEOSS for carbon. GEOCARBON fulfils the requirement for an uninterrupted provision of accurate and reliable data and information on environmental issues to users in charge of policy making in relation to the carbon cycle and climate change. The GEO-Carbon Office is providing advice and coordination to the GEO Task CL-02 on "Global Carbon Observations and Analysis".
The GEOCARBON results have direct policy-relevant implications, including: (i) identifying feasible and effective emission reduction targets (to be included in international treaties) to keep the temperature increase below acceptable levels; (ii) verifying the efficacy of mitigation policies (necessary to meet the objectives of the international treaties); (iii) creating the baseline of carbon pools and fluxes (against which those policies can be verified); (iv) improving the ability to predict future changes (including those due to the implementation of the GHG management strategies); and (iv)develop the most timely and appropriate mitigation and adaptation actions (according to the previsions based on the analysis of the observations).

Contribution to the GEO Societal Benefit Area on health

FP7 project EO2HEAVEN: Earth Observation and Environmental Modelling for the Mitigation of Health Risks (www.eo2heaven.org/)

Scope: to enhance understanding of the relationship between environmental changes and their impact on human health through monitoring changes induced by human activities, with emphasis on atmospheric pollution and water-borne diseases. EO2HEAVEN involves public health stakeholders with technology and service providers in both the Earth observation and in situ environmental monitoring domains. The project addresses three case studies, using health, remote sensing (satellite), and in situ data: (i) The Dresden (Germany) case study investigated cardiovascular and respiratory diseases caused by air pollution, as did the (ii) Durban (South Africa) case study. (iii) The Mozambique case study addressed the gap in current understanding of the dynamics of cholera and used observation data of both air quality and water quality to study cholera outbreaks and spread.

Results: EO2HEAVEN designed and developed methods and tools to correlate environmental data with exposure and health data, to support the collection and integration of data, and to visualise results in their geographical context. EO2HEAVEN developed methodologies, correlation models, spatial data services (using Standards of the Open Geospatial Consortium) and applications supporting:

- *Discovery and acquisition of environmental data*
- *Integration of heterogeneous Earth observations (satellite, in-situ and field data)*
- *Extraction of time series and visualization of graphs and maps*
- *Development of models of health effects*
- *Development of risk maps*
- *Development of predictions for early warning systems*

EO2HEAVEN specified and implemented a Spatial Information Infrastructure (SII) and developed a software platform for: (i) scientists to find, access, process and explore environmental and health data and (ii) decision makers to visualize summarized information. This open architecture is based on international standards and geospatial web services supporting the large-scale initiative GEOSS of GEO. Special emphasis was placed on achieving sustainability through capacity building in stakeholder and user training workshops in Uganda, South Africa and Germany.

Policy Relevance: EO2HEAVEN contributed to the provision of timely data, information and expertise for assessing the state of the environment and the impact on health. This enabled policy-makers to decide on appropriate measures for protecting the environment and health and to monitor the effectiveness of policies and measures implemented. These processes involved many players at all levels of government, within the Commission, the EEA, the WHO, WMO, ESA, GEO, and national, regional and local authorities. EO2HEAVEN contributed best practices and proof of concept implementations to GEOSS pilot activities. EO2HEAVEN had strong interactions with the GEO Community of Practice "Health and Environment" and led the GEO SBA health activities in the GEO Architecture Implementation Pilot phase 5 (AIP-5).

The main engagement of EO2HEAVEN was facilitated through active participation in the GEOSS Architecture Implementation Pilot (AIP) and Community of Practice (CoP) activities. EO2HEAVEN has contributed results to HE-01-C1 Air-borne Diseases, Air Quality and Aeroallergens and HE-01-C2 Water-borne Diseases, Water Quality and Risk from its respective case studies. EO2HEAVEN placed a special focus on community and capacity building as a contribution to Task ID-02.

Contribution to the GEO Societal Benefit Area on disasters

FP7 project FUTUREVOLC: A European volcanological supersite in Iceland: a monitoring system and network for the future (http://futurevolc.hi.is/)

Scope: FUTUREVOLC forms part of the GEO Supersites clustering initiative which fosters the integration of, and open access to space based and in-situ observations for improved monitoring and evaluation of geologically active regions of Europe prone to natural hazards. FUTUREVOLC is establishing an innovative volcano monitoring system in Iceland and developing new EO methods towards best practice in early warnings preparation for future global eruption responses.

Results: The project delivers monitoring of the most active volcanoes in Iceland located under ice caps such as Mýrdalsjökull and Vatnajökull. Close monitoring of these subglacial volcanoes will increase preparedness level and enable tracking of magma movements through migration of microseismicity and through detailed analysis of earthquake source mechanisms. The emphasis is on real-time processing of detected signals for early warning of volcanic eruptions. The project cooperates closely with MARsite, another FP7 Supersites project, which develops seismic instruments suitable for deployment in the ice.

Policy Relevance: FUTUREVOLC contributes to building the resilience of nations and communities to disasters. It contributes to the GEO 2012-2015 Work Plan by providing easy access to data from space, air and ground-based monitoring before, during or after a volcanic eruption. The project has agreed to an Open Data access policy contributing thus to GEOSS in terms of European preparedness for volcanic eruptions. The project develops in particular technical and data standards to facilitate data sharing in GEOSS. At an international level, the project collaborates with other

Supersites projects directly and through EPOS. The project has strong collaboration with many international projects, and has submitted a proposal to CEOS, the Committee on Earth Observing Satellites, for establishing Iceland Volcanoes permanent supersite under the GEO Geohazard Supersites and Natural Laboratory initiative.

FUTUREVOLC involves close collaboration between academics, public institutions and SMEs in the delivery of volcano monitoring methods. The SMEs in the FUTUREVOLC consortium contribute to the development of the relevant European industrial sector, by developing and delivering infra-red cameras and remote sensing solutions to detect and measure hazardous ash particles in the air; new instruments to measure particle size for ash fall measurements from eruption plumes, new operational algorithms to extract ash information from radar observations and new seismometers and techniques to operate on ice caps that can be applied at other ice-covered volcanoes and on ice sheets worldwide.

Contribution to the GEO Societal Benefit Area on biodiversity

FP7 project EU BON: Assessing global biological resources: the European contribution to GEO BON, the Global Earth Observation Network (www.eubon.eu/)

Scope: EU BON aims is to deliver a comprehensive "European Biodiversity Portal" for all stakeholder communities and strategies for a global implementation of GEO BON and supporting the new Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES). EU BON will strengthen European capacities and infrastructures for environmental information management overall.

Results: A system that facilitates open access to taxonomic data is being developed to allow a sustainable provision of high quality data to partners and users, including e-science infrastructure projects as well as international initiatives on biodiversity informatics. EU BON is working on an innovative approach in terms of integration of biodiversity information system from on-ground to remote sensing data, for addressing policy and information needs in a timely and customized way. The project is ensuring integration between social networks of science and policy and technological networks of interoperating IT infrastructures. This will enable a stable new open-access platform for sharing biodiversity data and tools to be created. EU BON's 30 partners from 18 countries are members of networks of biodiversity data-holders, monitoring organisations, and leading scientific institutions. EU BON is building on existing components, in particular GBIF, LifeWatch infrastructures, and national biodiversity data centres.

Policy Relevance: Sustainable governance of our biological resources demands reliable scientific knowledge to be accessible and applicable to the needs of society. The fact that current biodiversity observation systems and environmental datasets are unbalanced in coverage and not well integrated brings the need of a new system which will facilitate access to this knowledge and will effectively improve the work in the field of biodiversity observation in general. In light of the Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES), such a network and approach are imperative for attaining efficient processes of data collation, analysis and provisioning to stakeholders.

Contribution to the GEO Societal Benefit Area on energy

FP7 project EnerGEO: Earth Observation for Monitoring and Assessment of the Environmental Impact of Energy Use (www.energeo-project.eu/)

Scope: to provide a versatile modelling platform to enable planners, environmental scientists and governments to calculate, forecast and monitor the environmental impact of changes in the energy mix on local, regional and global scales. The integration of Earth observation data with different state-of-the-art modelling tools and packages will allow socio-economic impact and environmental cost to be calculated.

Results: In the areas of solar, wind, biomass and fossil fuels, EnerGEO has created an online portal allowing users access to the latest spatial information with which to make informed decisions. EnerGEO delivered for the first time a continuous 10 year time series of bioenergy potential for Europe and the Globe starting in 2000 and ending in 2050. It demonstrated a state-of-the-art modelling system which quantifies the contribution of fossil fuel to air pollution. EnerGEO made available a solar site ranking service through a web-based decision support tool for locating suitable regions for solar power plants. The EnerGEO wind pilot allows decision makers to compare cost of various types of energy production but also their impact on the environment.

Policy Relevance: The project is relevant to the development of energy strategies in the EU as it has defined four scenarios to illustrate the capability of the modelling cluster to assess the impact of contrasting energy mixes:

1. *Baseline: continuation of current European policies with regard to limitation of CO2*
2. *Open Europe: Solar import to Europe from North Africa, high biomass share, nuclear phase-out*
3. *Island Europe: no electricity imports from outside Europe, renewable energy use like in Open Europe or higher, nuclear energy use continued / extended*
4. *Maximum Renewable Energy: renewable energy penetration close to 100%*

The EnerGEO consortium includes active participation of the Energy-Community of Practice of GEO within its consortium, and delivers a significant contribution to the GEO-Energy tasks, giving EU a strong leadership in this GEO Societal Challenge.

Contribution to implementing the GEOSS Common Infrastructure

FP7 project EUROGEOSS: A European approach to GEOSS (www.eurogeoss.eu/)

Objectives: The EuroGEOSS FP7 project aimed to better connect within GEOSS existing Earth science information systems already developed by different scientific communities across the globe. Ultimately, the project was targeting an increased capacity for scientists from different disciplines to work together sharing data, models, and processes, to develop better understanding and predictions of environmental phenomena and social impacts. The emphasis of the project was placed on systems addressing forests management, droughts, and biodiversity. The modular approach deployed in the project to connect systems and disciplinary domains was conceived so as to make it possible to extend the process to other applications and societal benefit areas. To achieve this objective, an essential task of EuroGEOSS consisted in engaging further the related scientific communities in the construction and use of GEOSS.

Results: A three-stage approach was followed by the consortium starting by (i) better connecting to each other the relevant systems at local, national, and global levels, then (ii) achieving horizontal, multi-disciplinary interoperability, and finally (iii) sustaining capacity building effort. In the end, EuroGEOSS has been a very successful project, which has demonstrated the added value of multi-disciplinary research and multi-scale analysis in each of the three thematic areas of forestry, droughts and biodiversity. The new scientific insights achieved, and new web services developed to process data and models are a true contribution to the scientific community and GEOSS. The Brokering framework developed by the project that has underpinned this effort has been used by the GEO to enhance the capability of the GEOSS. The success of this approach was recognised at the GEO Plenary in November 2011, resulting in the adoption of the EuroGEOSS Data and Access Broker (DAB) as a key new technology powering the GEOSS Common Infrastructure.

Policy Relevance: Results from this project will have a lasting impact on future research in the three thematic areas and in the technology field of spatial data infrastructures. The research undertaken in EuroGEOSS has had a direct impact on the revision of the GEOSS architecture, hence supporting the GEO vision supported at Ministerial level in several GEO summits since 2003 in response to the call for greater Earth observation coordination expressed by ministers at the World Summit on Sustainable Development in 2002 and subsequent declarations of the G8 Group of the eight leading industrialised countries.

Contribution to implementing the GEOSS Common Infrastructure

FP7 project GEOWOW: GEOSS Interoperability for Weather, Ocean and Water (www.geowow.eu/)

Objectives: The GEOWOW FP7 project aims to bring new discovery, access and use functionalities to the GEOSS Common Infrastructure (GCI) which constitutes the architectural framework of the global GEOSS system of systems. GEOWOW should improve significantly the GCI interoperability, standardisation, performance and operability, especially through bringing (i) new developments in the field of distributed architectural model federating Earth observation and other Earth Science data, (ii) methods for semantic discovery and harmonised access to distributed heterogeneous data, services, and models, and (iii) generic services for data dissemination, access, use and processing. The project will also consolidate the GEOSS Data CORE through promoting the contribution of data sets to be shared as full and open resources.

Results: After 18 months of activities, the GEOWOW consortium has completed its survey of infrastructure and data requirements across the weather, ocean and water communities. In collaboration with the GEO community, they have also produced a "GEOWOW Vision" document providing a long-term strategy for an evolution of the GCI. The current GCI brokering framework (developed in the context of the previous FP7 project EUROGEOSS) has been enhanced. Semantic discovery is being progressively implemented based on aligned controlled vocabularies. Several data use scenarios are being implemented to test new GEOSS functionalities, address interoperability issues related to data access from different providers, multi-model combinations, and use of processing tools. They include track forecasting of Tropical cyclones and storms, river discharge and vulnerability of ocean ecosystems to global temperature and ocean acidification changes. In the future, the project will focus on new tools including a Data Cleansing Tool, a Developer Cloud Sandbox, a Cloud Controller and a resource registration Widget.

Policy Relevance: The research undertaken in GEOWOW will have a direct impact on the revision of the GEOSS architecture, hence supporting the GEO vision supported at Ministerial level in several GEO summits since 2003 in response to the call for greater Earth observation coordination expressed by ministers at the World Summit on Sustainable Development in 2002 and subsequent declarations of the G8 Group of the eight leading industrialised countries. In addition, the project will make significant contributions to international standards related to geospatial information and support innovation and the creation of research-led jobs in SMEs.

ANNEXE IV – Background information on the EU Copernicus programme

Interest in space-enabled Earth observation has been growing substantially over the last two decades. The precursor of the Copernicus programme was the GMES initiative for Global Monitoring for Environment and Security. GMES was initiated in 1998, one year after the signature of the Kyoto protocol, as a result of the 'Baveno Manifesto'. This Manifesto which originated with strong Commission (JRC) leadership, was stressing on the need for a European strategy in the field of environmental monitoring to allow Europe playing a major role at the international level in tackling global environmental issues. This declaration was calling for a long-term European commitment to developing environmental monitoring services, making use of European skills and technologies including space technologies. GMES was then intended to become a pillar of the EU space strategy. GEO was conceived at the first Earth Observation Summit in Washington in 2003, and established at the Earth Observation Summit of Brussels in 2005 as a major step forward in promoting intergovernmental coordination and cooperation of Earth observations (in situ and space data) at global level.

Entering progressively into operations from 2014 onwards, the EU Copernicus programme is the most ambitious civil Earth observation programme in existence. Its main objectives are the following:

(a) monitoring the Earth to support the protection of the environment and the efforts of civil protection and civil security;

(b) maximising socio-economic benefits, thereby supporting the Europe 2020 Strategy and its objectives of smart, sustainable and inclusive growth by promoting the use of Earth observation in applications and services;

(c) fostering the development of a competitive European space and services industry and maximising opportunities for European enterprises to develop and provide innovative Earth observation systems and services;

(d) ensuring autonomous access to environmental knowledge and key technologies for Earth observation and geoinformation services, thereby enabling Europe to achieve independent decision-making and action;

(e) supporting and contributing to European policies and fostering global initiatives, such as GEOSS.

Copernicus provides a system through which vast amounts of data, acquired from European space missions and other remote sensing and in situ sensors, are fed into six thematic information services related respectively to: land management, marine environment, atmosphere, emergency response, security, and climate change. The Copernicus infrastructure helps to guarantee continuity over the medium term, to ensure European independence regarding strategic Earth observation data flows, and to provide greater certainty on data availability for the users, which is also an enabler for growth in the downstream sector.

The first satellite of the Sentinel series (Sentinel-1A) has been launched in April 2014 and should be followed (a year later) by the launches of Sentinel-2A and Sentinel-3A, and (later on) by the recurrent units Sentinel-1B, -2B and -3B (annexe V). With the progressive deployment of the Copernicus space components, the continuous stream of user products will continue to increase over time. In parallel, two out of the six Copernicus services (the Emergency Response and Land Monitoring Services) are already delivering operational

products. The four other services (Marine Environment Monitoring, Atmosphere Monitoring, Climate Change and security) are expected to become operational in the next few years.

The EU has made important steps to ensure firm and long-term legal basis for the Copernicus programme. The European Parliament and the Council have recently reached an agreement on the Copernicus Programme, and the Copernicus Regulation (Regulation (EU) No 377/2104)[106] entered into force on 25 April 2014. This regulation extended the requirement for dedicated mission data and Copernicus information to be made available on a full, open and free-of-charge basis. As part of the Multiannual Financial Framework (MFF), the EU is devoting EUR 4.2 billion to the Copernicus programme over the next seven-year period.

The Commission, acting on behalf of the EU, is responsible for the overall Copernicus programme, setting requirements and managing the services.

The European Space Agency (ESA)[107] has the responsibility of the overall coordination of the Copernicus Space Component (CSC) and is in charge of the operation of Sentinel-1 (radar), Sentinel-2 (high-resolution optical mission), Sentinel-3 (medium resolution imaging of land) and the Sentinel-5 (low Earth orbit atmospheric chemistry precursor mission), as well as of the monitoring of the evolution of the user requirements of the overall system.

The European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)[108] has the mandate to supply weather and climate-related satellite data, images and products 24 hours a day, 365 days a year to the National Meteorological Services of our Member and Cooperating States in Europe, and other users worldwide. As part of Copernicus, EUMETSAT will be responsible for the operation of Sentinel-3 (ocean altimetry part), Sentinel-4 (geostationary atmospheric chemistry mission), Sentinel-5 (low Earth orbit atmospheric chemistry precursor mission) and Sentinel-6 (Jason-CS altimetry mission).

The European Environment Agency (EEA)[109] in partnership with its member and cooperating countries operates Eionet[110], the European environment information and observation network, to provide timely and quality-assured data, information and expertise for assessing the state of the environment in Europe and the pressures acting upon it. In Copernicus, the EEA is responsible for the coordination of the demand for in situ data by the various services and the establishment of agreements with the data suppliers. The EEA, together with the Joint Research Centre (JRC), is also involved in the management of the Copernicus service for Land monitoring.

The European Centre for Medium-Range Weather Forecasts (ECMWF)[111] is particularly renowned for its operational capacity to provide operational medium-range weather forecasts and extended-range seasonal forecast, as well as unique super-computing facility for scientific research. In Copernicus, ECMWF has expressed its interest in getting involved in the management of the Copernicus services on Climate change and atmosphere monitoring.

Copernicus provides a critical framework for the achievement of a strong and visible European contribution to GEOSS. This is not only true considering satellite-based observations, but also for in-situ networks. "*Copernicus should be considered as a European contribution to building the Global Earth Observation System of Systems (GEOSS)*

[106] Official Journal of the European Union, L 122, 24.04.2014, p. 44
[107] http://www.esa.int/
[108] http://www.eumetsat.int/website/home/index.html
[109] http://www.eea.europa.eu/
[110] https://www.eionet.europa.eu/about
[111] http://www.ecmwf.int/

developed within the framework of the Group on Earth Observations (GEO)" (recital 8 of the Copernicus Regulation[112]).

The Copernicus Climate Change Service (CCS) will provide a significant contribution to the aims of the GEO Societal challenge on climate. Specifically, the Copernicus Climate Change Service will contribute to the harmonisation and quality control of climate data records available through the envisaged Climate Indicator Data Store, as well as the development of concrete and dedicated services for policy through the Sectorial Information System. The Copernicus Climate Change Service would benefit from a broad requirement definition process which is accessible through the GEO stakeholder community.

The Copernicus Land Monitoring Service (LMS) has already established many links to GEO. The Land service supports notably the GEOGLAM initiative on food security with the provision of low to medium resolution products and provides information to the Joint Experiment for Crop Assessment and Monitoring (JECAM)[113] validation sites. The Copernicus Land service is also contributing to the GEOBON initiative on biodiversity via support to the Digital Observatory for Protected Areas (DOPA)[114] managed by the Commission (JRC), and the provision of low to medium resolution Global Land products. The European Environment Agency (EEA) is ensuring the co-leadership of activities on land cover products validation. The Pan-EU component of the Copernicus Land Service could be mainstreamed at global level as a good practice example via the GEO land cover initiative. The EEA is also leading the development of the In situ component of GEOSS which builds upon results of the FP7 GISC project for coordination and open access to in-situ data.

The Copernicus Emergency Management Service (EMS) has been developed in the last decade through a series of RTD projects and international collaborations. The Commission, through the JRC, is responsible for the technical coordination of the EMS, ensuring emergency mapping notably at the service of the Commission and the EU Member States. In collaboration with GEO and UNISDR, use cases of EMS products can be developed to demonstrate the use of EO products to inform policy and practice in disaster risk reduction. The European mapping service of the EMS, for instance, provides civil protection authorities and humanitarian aid agencies with timely and relevant information based on satellite imagery and other data in disaster management contexts from risk reduction and preparedness to response and recovery.

The Copernicus Atmosphere Monitoring Service (AMS) will be operational during the GEO post-2015 period. The service will provide information for societal benefits in the domains of health (air pollution and dust), climate (greenhouse gases and aerosol), energy (aerosol and radiance information for solar energy planning).

The Copernicus Marine Service (CMS) could contribute information products in direct support to several GEO societal challenges: climate through links established with the GOOS, weather through monitoring essential variables of oceanic ecosystems (e.g. water temperature, salinity, pH and pCO2, phytoplankton species composition and productivity and marine resource stocks), biodiversity through additional information on marine species and habitats.

By aggregating both space and in-situ data based on observations with global reach over land and seas, the Copernicus Security Services (CSS) can make an important contribution to serve EU security needs. This has been demonstrated through a series of EU and national R&D projects, in particular in the domains of border and maritime surveillance, humanitarian

[112] Official Journal of the European Union, L 122, 24.04.2014, p. 44
[113] http://www.jecam.org/
[114] http://dopa.jrc.ec.europa.eu/

aid missions, conflict early warning and prevention, and others. Application support to the EU External Actions are presently been developed. In this field, there is also potential for additional cooperation on a global level including through GEO.

With Copernicus and its Space, In-Situ and Service Components, Europe is currently putting in place an unprecedented world-class Earth observation infrastructure. The European EO service industry should be able to benefit from the system through wider opportunities to create new downstream services focussing on Europe. Through an involvement in GEOSS, the service industry would be enabled to put their services on a global stage by adapting them to other regional needs and by enhancing these services through wider combination with additional data streams. This development will be facilitated by the objectives stated in the Copernicus Regulation.

ANNEXE V – Examples of European research infrastructures related to the monitoring of the environment

Examples of European research infrastructures related to the monitoring of the environment

- ***EISCAT_3D***[115] *will be a three-dimensional imaging radar for atmospheric and geo-space research, which constitutes an upgrade to EISCAT, an existing international infrastructure based in Europe and devoted to the study of the upper atmosphere, ionosphere and geospace. This new large-scale European Research Infrastructure will have applications in a wide range of European research areas including Earth environment monitoring and technology solutions supporting sustainable development, well beyond atmospheric and space sciences. EISCAT_3D will contribute to Environmental sciences through studies of space weather and global change, as well as addressing atmospheric science and plasma physics.*

- ***EMSO***[116] *is the European Multidisciplinary Seafloor Observatory, a research infrastructure for long term permanent monitoring of the ocean margin environment around Europe. It is considered critical by the European Science Foundation marine board. EMSO is an essential tool for deep sea research including geosciences and geo-hazards, physical oceanography, biology and non-living resources. Cabled sea-floor observatories are needed to collect simultaneously long time series of data identifying temporal evolutions, cyclic changes and capturing episodic events related to oceanic circulation, deep-sea processes and ecosystems evolution. In addition, long-term monitoring will allow the capture of episodic events such as earthquakes, submarine slides, tsunamis, benthic storms, bio-diversity changes, pollution and other events that cannot be detected and monitored by conventional oceanographic sea-going campaigns.*

- ***Euro-Argo***[117] *is a European research infrastructure contributing to the Argo international programme through the procurement, deployment, monitoring of a wide number of profiling floats and through the delivery of processed data both in real-time and delayed-mode to monitor the temperature, salinity, and velocity of the upper ocean. Euro-Argo plans to deploy about 250 floats per year necessary to maintain an array of about 800 floats in operation at any given time (one quarter of the ARGO global array). Argo is endorsed by several GEO Participating Organisations and programme such as the Climate Research Programme of the World Meteorological Organisation (WMO), the Global Ocean Observing System (GOOS), and the Intergovernmental Oceanographic Commission (IOC). Euro-Argo is an essential in situ component used today for the Copernicus Marine Core Service.*

- ***IAGOS***[118] *aims notably to operate a fleet of long range in-service aircraft of internationally operating airlines equipped with fully automatic instruments for the continuous monitoring of the important reactive gases and greenhouse gases like ozone, carbon monoxide, nitrogen oxide, together with dust (aerosol) and cloud particles. This infrastructure in the making can contribute to a global observational network for long term observations of atmospheric composition, aerosol and cloud particles on a global scale. In the future, IAGOS could potentially provide near real time data to the "Atmospheric Monitoring Service" of the European Copernicus programme and to GEOSS.*

- ***ICOS***[119] *aims at tracking carbon fluxes in Europe and adjacent regions by monitoring the ecosystems, the atmosphere and the oceans through a network of in situ stations. With 95 stations expected in 2014, ICOS is expected to become fully operational in 2015. The network includes (i) atmospheric stations measuring continuously the greenhouse gas (CO2, CH4, N2O)*

[115] https://www.eiscat.se/
[116] http://www.emso-eu.org/
[117] http://www.euro-argo.eu/
[118] http://www.iagos.org/
[119] http://www.icos-infrastructure.eu/

concentration variability, (ii) ecosystem stations monitoring the functioning of land ecosystems and the exchange of energy and greenhouse gases between the ecosystems and the atmosphere, and (ii) a network of ships and fixed stations to monitor carbon exchange between the surface ocean and the atmosphere, acidification of oceans, surface temperature, salinity and other variables. Resulting measurements should allow daily determination of sources and sinks at scales down to about 100 km^2.

- ***EPOS***[120] *is the European Plate Observing System (EPOS) which coordinates, collects and archives high-quality data from a range of Solid Earth science disciplines across Europe including from seismological and geodetic networks, local geomagnetic and volcano observatories, experimental laboratories in Europe and other integrated satellite data and geological information. This European Research infrastructure is making rapid progress to enter into operations from 2015.*

[120] http://www.epos-eu.org/

ANNEXE VI - Assessment of GEO achievements by external experts

The Commission convened a group of 5 external European experts in the second semester 2013 to assess and report on the achievements and benefits that have accrued to Europe and the EU from the Commission involvement in GEO since 2005. The executive summary of this report is presented below. The assessment restates the unique GEO configuration on the global scene to facilitate full and open access to important EO datasets that address global societal challenges. It also provides 11 recommendations to the Commission.

Executive summary of the report

The report presented here was commissioned by the European Commission (EC) to assess the achievements and benefits that have accrued to the European Union (EU), and more widely to Europe, from the Commission's investment in, and work with, the Group on Earth Observations (GEO)[121], since 2005. The report is structured to identify existing gaps and includes recommendations on opportunities for improvement with regard to any future engagement of the European Commission in the GEO-Post 2015 framework of activities. For the purposes of this report the term "Earth observations" refers to data, information and products derived from space-based and *in-situ* airborne, terrestrial, freshwater and ocean-based platforms, for civil purposes.

This review of GEO-related achievements, outputs and impacts of relevance to the EU is based on information available from sources including GEO itself, the EC, pan-European organisations such as ESA, GEO member countries in Europe, and existing literature.

The assessment presented here demonstrates the range and extent of benefits derived from GEO which are of relevance to the EU, and resultant from the European Commission's participation in GEO. Such benefits include: the opening up of access to essential global, regional and national datasets and the associated adoption of compatible data policies in EU Member States and pan-European organisations (supported by GEO's Data Sharing Principles); the direct and indirect contribution of GEO to the Europe 2020 Strategy and related policies including capacity building in developing countries and mobilisation of the research community. As far as Europe 2020 is concerned the release of GEO rich data source, along with the increasing amount of datasets from the public sector, demonstrated the GEO potential to foster and stimulate growth and innovation for industry, as well as providing new opportunities for SMEs, in particular through EU efforts (with international cooperation) on global challenges such as climate change, energy and food security, and health.

GEO's Data Sharing Principles have resulted particularly in positive impacts for the EU; examples include their influence on ESA's data policy (ERS, ENVISAT and Earth Explorer) and ESA's Sentinel data policy principles, which in turn led to the recently adopted Delegated Act by the European Parliament confirming the principle of a free, full and open Copernicus data and information policy. As evidenced by the steady increase in the number of exploitation projects using Earth observations data that are openly and freely available (e.g. Landsat, ENVISAT, Earth Explorer missions), an open data policy is necessary to increase the potential for the development of new products and added-value services, which in turn stimulate research and innovation and contribute to job creation throughout the EU. Quantification studies on the benefits of using GEO-enabled data estimate the return to be, on average, four times that of the initial investment. The outcomes of investment also include reduction in uncertainty in environmental assessments at both EU and national levels; these can also be quantified through tools for benefit assessment, some of which have been developed within the context of GEO.

Data sourced from diverse and dense Earth observations networks are essential to enable the EU to address those global challenges that EU policies identify as a priority. From the assessment presented here, it is evident that, without GEO, the ability to facilitate access to important datasets that address global challenges including climate change, energy security, urbanization, pollution, biodiversity and ocean acidification, while progressing towards achieving the United Nations Millennium Development Goals, would not otherwise be achieved as efficiently or effectively as they are within the context of

[121] "GEO: The intergovernmental Group on Earth Observations, established by the Resolution of the Third Earth Observation Summit in February of 2005, consisting of a Plenary, an Executive Committee, a Secretariat, and Implementation Boards and Working Groups as appropriate"

GEO.

There are several activities in the EU that are of direct importance to GEO, most notably the European Commission's Copernicus (formerly GMES) Programme, and the Seventh Framework Programme for Research and Technological Development 2007-2013 (EU FP7). The EU FP7 provides a major contribution (within the Environment theme of the Cooperation Programme), in terms of R&D effort, providing support to GEO by initiating and funding research constituents necessary to develop GEOSS (Global Earth Observation System of Systems). GEOSS combines local, national, regional and global Earth observations data and infrastructures to build global datasets necessary to understand and predict the functioning of the Earth's systems. Through FP7, the European Commission has invested more than €200M to develop research within the context of GEOSS.

One of the FP7 promising initiatives regarding GEO is the development of new-in-situ observatories based on citizens' own devices (e.g. smart phones, tablets laptops and other social media) that have the potential on the mid-terms to fill out environmental observational gaps at relatively low cost.

The European Commission's contributions to GEO include as well, since 2005, annual subscription to the GEO Trust Fund[122], providing essential support to the GEO Secretariat and related activities. This direct involvement of the European Commission ensures that the EU is positioned with a leadership role within GEO. With its undisputed strengths and capacities in Earth observations, the EU will benefit further from continuing its role as a leading partner in GEO and related international Earth observations programmes.

The private sector is also a source of Earth observations data and information which are derived from privately owned and operated systems, as well as providing value-added and downstream products and services. A trusted relationship between the public and private sector is a pre-condition to achieving sustained engagement and benefits for all parties. The scope and potential to develop public-private-partnerships in the context of EU-based Earth observations private sector and the EC deserves further attention.

Recommendations by the panel of experts to the Commission:

1. *The Commission should continue to support the implementation of GEOSS in particular through HORIZON 2020, and its participation in the corresponding GEO bodies, in particular as Co-Chair of the Executive Committee/Plenary, the Data Sharing Working Group, and the working group that will draft the next 10-year GEO implementation plan;*
2. *The Commission should intensify the collaboration between GEO and Copernicus, including enhancing synergy and complementarity with relevant ESA programmes within this domain;*
3. *The Commission should increase further inter-DG coordination regarding the GEO file for the benefit of the relevant policies of the EU;*
4. *The Commission should explore ways and means with the European Members of GEO to evolve the organisation of the European GEO Caucus (GEO High-Level Working Group), so that the current European participation in GEO becomes a formal EU participation.*
5. *The Commission should, together with the HLWG, provide input for the development of a GEO-governance beyond 2015 including the necessary arrangement for the role of the GEO secretariat.*
6. *The interests, needs and contributions of the private sector should be reflected within GEO; the Commission should promote further the participation of the private sector within GEO. The Commission should foster and support private and public-private partnership initiatives within GEO.*
7. *The Commission should continue working with the European GEO Members and Participating Organisations to make data and services freely available through GEOSS.*
8. *The success of the involvement of the users' perspective in GEO requires regular evaluation by independent bodies in order to monitor progress. The Commission should support the development of key performance indicators, defined in advance, for the continuous monitoring of GEO's progress.*
9. *The Commission and the EU GEO Members should develop further capacity building initiatives towards GEOSS. Particular effort should be made to cooperation and capacity building to the*

[122] "GEO Trust Fund : the budgetary structure agreed by the GEO members to fund the GEO secretariat"

developing world, with a continued focus on Africa and the Mediterranean regions.

10. *European contribution to GEOSS research activities are largely dependent on the EU research funding Framework Programmes, which are of fixed duration. It will be necessary to embed responsibilities to develop GEOSS-related research within national agencies and programmes, to ensure long-term sustainability of relevant Research and Innovation programmes: Horizon 2020 instruments such as ERA-NET and/or Joint Programming Initiative should be used to achieve this goal.*
11. *The Commission should pursue its dissemination effort regarding GEO in order to comprehensively inform the public, the EO community and the private sector about GEO activities of relevance to EU.*

ANNEXE VII – Consultation of European GEO Member countries and Participating Organisations

As part of the Commission approach to investigate the future of GEO and GEOSS, a consultation of the European GEO member countries and Participating Organisations has been conducted via a questionnaire in the period May to September 2013.

Responses to this survey confirm that GEO has enabled European countries to become aware of the vast amount of information available on the global scene, of the benefits of accessing and exchanging information, and also of the advantages in tackling common problems on a wider scale. A strong motivation for being a GEO Member is the opportunity to reinforce national Earth observation cooperation strategy and to focus on common targets. GEO is perceived as the unique forum where Earth observation initiatives of global, continental, regional and national nature should interface and collaborate.

On the other hand, there is a concern that GEO has not been as effective as it could have been, with sometimes a relative lack of effective commitment, resources and management on the part of some GEO member countries.

Some worries were also expressed concerning the future coordination between Copernicus and GEO activities. Copernicus having been acknowledged as a main European contribution to GEOSS, more clarification is required about how this is going to happen, especially now that Copernicus is entering its operational phase.

A clear support was expressed towards the continuation of the Commission commitment to GEO beyond 2015. The prominent role of the Framework Programme for Research and Innovation was advocated with the wish to see continued support in the Horizon 2020 Framework Programme. The idea was suggested to further explore common strategies and enhanced coordination among relevant nationally funded Earth observation activities and programmes, for instance through an ERA-NET type of activity.

The role of the GEO High Level Working Group was praised. This group is considered as having been instrumental in promoting the European role and influence in GEO. It has functioned as a forum for exchange of information and has allowed the European GEO Members to have a say in GEO discussions, especially those held at the GEO Executive Committee. In general, the respondents to the questionnaire recommend that the GEO High Level Working Group should be strengthened or formalised, after having further addressed the relative lack of engagement by some of its Members.

With regard to the renewed GEO, some European countries of the High Level Working Group would have preferred more innovative and ambitious proposals than what had been recommended by the GEO Post-2015 working Group in its GEO Vision 2025 document. This observation particularly concerns the future governance and resourcing of the GEO.

The following aspects of strengths, weaknesses, opportunities and threats of GEO and GEOSS are taken from a compilation of the results of this consultation of the European GEO member countries and Participating Organisations and those provided by the European experts mandated by the Commission to assess GEO challenges and benefits (annexe VI).

Strengths

The GEO represents a wide multilateral effort for EO coordination. The inter-governmental nature of the GEO also involving Participating Organisations allows linking of scientific and technical levels, as well as some users, directly to the political level. As such, the GEO is unique on the international scene to speak about Earth observation on a global scale.

The GEO reinforces this uniqueness by having opted for a voluntary approach (not-legally binding and conducted on a best effort basis) to implement the GEOSS. This brings flexibility, adaptability and reactivity compared to other more formal international coordination mechanisms.

The GEO vision is long-term and multi-disciplinary. It is federating EO communities and EO activities from all over the world. It helps re-thinking EO with the view of bringing real societal benefits. GEO has demonstrated the capability to stimulate networking and foster new initiatives, projects and collaborations (e.g. with national agencies, academia, private sector, NGOs, etc.) within and across the GEO societal challenges.

The GEO has gained political momentum during its first nine years of implementation. It has enabled many countries, including in Europe, to take conscience of the vast amount of EO datasets available on the global scene, of the benefits of sharing data and of tackling common societal problems on a wider scale. Some national agencies have crafted their data policies taking the GEOSS data sharing principles as guiding principles.

The GEO is inclusive in the sense that it provides the only discussion forum for the whole environmental observations community. It is a driver for new research and innovation. The EU framework programmes for Research and Innovation is recurrently presented as a best practice example to other funding parties in the GEO.

GEO provides a strong platform to promote EO best practices (e.g. common protocols, interoperability arrangements, reference data sets of global interest) and GEOSS principles (e.g. in relation to full and open data sharing or to data management) at the global scale.

The current version of the GCI already connects expert users to major EO systems distributed globally while respecting their respective mandate and leaving them autonomous. While increasing numbers of EO portals are being developed, none so far are attempting, like the GEOSS, to provide comprehensive access to EO data.

The GEO provides international visibility and a leverage effect for existing infrastructures and other resources invested at local, national and regional scales to increase the knowledge base within and across the various GEO societal challenges. For instance, some GEO international initiatives have amplified the exploitation of ESA missions, hence enhancing the international impact of ESA programmes. The deployment of the GEONetCast infrastructure has leveraged the EUMETCast system[123], enhanced EUMETSAT collaboration with international partners and accelerated EO capacity building activities within Africa.

The GEO initiative has raised the visibility of the EO expertise and capacities of the EU on the international scene. It has initiated a process towards stronger coordination between national and European EO programmes and activities.

The active coordination of the European caucus by the Commission through the HLWG is acknowledged as a determinant for the influential role played by Europe in GEO Plenary and EXCOM meetings.

Weaknesses

The voluntary approach of GEO is also sometimes seen as a weakness in the sense that it brings the risk of softened levels of resource commitment and involvement by some GEO Members or Participating Organisations. Lack of functional commitment by several GEO Member countries or Participating Organisations towards carrying out the GEO Work Plan has sometimes jeopardised the timely or full delivery of intended GEO outcomes.

[123] http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast/index.html

Quantifying the impact the GEO is not yet straightforward. This is partly due to the fact that the GEO took some time to articulate its added value, but also partly because the GEO, which has an upstream positioning in the value chain, has only recently started to deliver demonstrable outcomes to end users.

GEO has had a strong focus on data supply, discovery and access mainly for expert users. While good achievements can be reported in this domain, the added value in terms of using the data for decision-making, innovation and growth and for developing trans-disciplinary products based on EO data sets has not yet been sufficiently demonstrated. While access to space-borne data sets has been rather well addressed, the offer in terms of in-situ data, real-time data and models is too limited to date. Moreover, the existence and value of a pool of full and open access data resources (the GEOSS Data CORE) has not been sufficiently promoted.

GEO does not own the information systems harvested by the GCI. It is not directly managing the data to which it is providing access. Its impact with respect to EO data sharing and management is subject to the data providers' willingness to adopt and implement the common principles, guidance and best practices provided by the GEO.

The communication on the added value of the GEO and the GEOSS has been sub-optimal. GEO is still sometimes perceived as co-opting pre-existing EO-related initiatives at local, national, regional levels or activities conducted by pre-existing communities. In those cases, GEO is sometimes perceived as a competitor for resources.

There could be scope (beyond the EU FP7 R&D programme) for alternative funding schemes and in cash contribution in order to sustain the GEOSS implementation.

The consultation of the private sector has been too limited; progress for developing an overall framework stimulating private sector engagement has been too slow. To date, the private sector has benefitted very little from the actions of the GEO.

Synergies with UN programmes and agencies have not yet been sufficiently developed.

The level of engagement by the European members of the HLWG can vary significantly. While several delegations are very collaborative and proactive, others show less involvement in the European caucus coordination process.

Opportunities

The renewed GEO mandate for the period 2016-2025 is a positive political signal. Adaptation possibilities exist for the next 10-year Implementation Plan in order to better address the political, institutional, scientific, and technical challenges that GEO will be facing in the coming years.

The GEO provides opportunities to further influence EO global agendas in the future. The design and execution of the next GEO Work Plans through 2025 constitute opportunities in this respect.

The digital revolution of our society and the outcome of the Internet of Things bring potential for innovative uses of EO data and products, including for/by the citizens.

The continued effort towards promoting open and free data policies amongst the GEO community is not only instrumental for tackling global problems but also for stimulating a global EO market place and contributing to the digital economy of tomorrow. This could bring opportunities for innovation and growth, including for European SMEs.

The GEOSS potential to promote the use of EO, enlarge the user base, consolidate user requirements at the global scale, benchmark reference data sets of global interest, and stimulate the global market for geo-services is substantial.

The strong EU contribution represented by Copernicus provides a key opportunity for Europe to position its EO services industry on the global stage. The GEO provides an international co-ordinating platform through which the EU contribution can be leveraged.

With its SME instrument and the renewed focus given innovation activities (closer to the market), the Horizon 2020 Framework Programme provides new opportunities for SMEs to stimulate innovation and growth.

Threats

It is questionable whether the sole voluntary approach would be fully suited to providing the stability and long-term commitments required for the core functionalities of the GEOSS, as well as for attracting the industry.

Pressure on public budgets worldwide might impact the level of resource commitment by the GEO Members and Participating Organisations for the GEOSS implementation.

In relation to resource commitment, GEO has not proven yet its capacity to sustain over time the global initiatives which have been launched in the recent years.

In general, making the transition from an ad hoc prototype to a reliable operational system or exploitable product is known to be difficult. This also applies to the GEOSS operations.

The rather loose organisation of the management of the Work Plan tasks has to be addressed in order to achieve new, realistic and measurable targets for the progressive implementation of the GEOSS.

Different views (more conservative versus more innovative) will have to be reconciled when drafting the new GEOSS 10-Year Implementation Plan. Consensus building amongst GEO Members will be crucial.
The international landscape for initiatives related to EO, environmental data and e-Infrastructures is increasingly complex.

ANNEXE VIII – The Earth observation service industry and related markets

The Earth observation sector is traditionally composed of upstream and downstream infrastructure and service components. It may happen that for some EO data streams (e.g. meteorological data and information), these components are vertically integrated vertically to some extent; however, for most other EO market niches, they are separated. They can be privately or publicly owned, or operated under joint public private agreements. In all case, the sector as a whole is often exposed to the level of interactions existing between the public and the private sectors. The definition of clear roles and boundaries is known to have a strong influence in investments decisions. The public sector plays an important role not only through influencing the regulatory framework of the sector, but also affecting the market demand for Earth observation services.

- The upstream Earth observation sector

While the upstream space sector is rather capital-intensive and therefore often concentrated within a small number of mainly industrial providers specialised in satellite manufacturing, launchers and ground segment operations, the upstream in situ infrastructure is very heterogeneous and primarily owned by the Member States who operate and maintain a variety of EO systems deployed at various scales.

- The downstream Earth observation sector

The downstream industry is composed of Earth observation value-adding companies which turn Earth observation data into information and insights for commercial and governmental organisations. They provide products and services customisation according to specific user needs. Process automation remains often limited; manual processing by skilled Geo-experts allows addressing specific market niches.

- Categorization of Earth observation providers

The Private Sector is all but monolithic and includes at least the following broad categories:

- Providers of data: private operators giving access to complementary observing capacities such as satellite manufacturers and operators or companies developing in situ sensors and systems, or hosting instruments on board the platform they operate such as trucks, ships of opportunity, airplanes on unmanned drone vehicles, etc.);
- Providers of infrastructure and data: this ranges from companies involved in standardisation and interoperability and providing solutions for universal access to distributed information systems, to companies supplying tools and processing capabilities for the transformation of Earth observation data,
- Providers of end-to-end services: companies exploiting GEOSS data, especially the full and open GEOSS Data-CORE, to develop tools for decision support and other added-value services;
- Private sector customers of Earth observation in the nine GEO Societal Benefit Areas: agriculture (e.g. commodities traders, processed-foods companies), biodiversity (e.g. pharmaceutical companies), weather and climate (e.g. construction companies, energy companies, insurance companies).

- Facts and figures concerning the European Earth observation service industry

A recent study by the European Association of Remote Sensing Companies (EARSC)[124] estimates that the European Earth observation service industry is composed of about 300 companies employing more than 5000 employees of very high level of qualification. About 90 % of the work-force is composed of university graduates or people holding a higher degree. The total sector revenues are estimated at € 757 Mio in 2012 of which 79 % of the revenues come from the large to medium companies. The information segment represent 43 % of the market by value, while data selling activities and software selling activities represent respectively 40 % and 17 % of the market. With more than 50 % of the total share of revenues, the public market (which includes R&D grants) slightly overtakes the private market estimated at 43 %. Looking at revenues from sales of data and information, the first three ranked market sectors are security and defence, followed by local and regional planners and then the oil and gas commercial market. "Security products represent the largest thematic area of interest, but land products (e.g. land use / land cover change, forest and agriculture) in general are of interest for most companies. Land products are often driven by EU policy and are often associated with local needs". The R&D intensity, estimated at 7%, is higher than the average in the aerospace or automobiles industries, but lower than the software and computer industry or the pharmaceuticals and biology industry.

The comparison of these figures with those collected in earlier studies[125,126] allows extracting the following major trends for the Earth observation service industry over the period 2006-2012:

- Although still in the early stages of development, the European Earth observation service industry is progressively moving from an activity essentially driven by R&D grants, to one that is becoming more operational.
- The share of commercial or private sector sales has grown significantly (almost 4 fold increase in absolute terms) and further growth in commercial markets is expected.
- There has been a steady increase (8% p.a.) in the number of companies offering Earth observation services. This growth in small and especially micro enterprises (less than 10 employees) confirms the dynamic nature of the sector. Employment has grown at an annual rate of 10%.
- Revenues for the sector have grown at an annual rate of 10.7 %. This growth is mainly attributed to companies which were created in the last 6 years with new business models. "For companies that existed in 2006, the growth in revenues faltered with the economic crisis".
- There has been a small increase in the share of sales to public operational customers, while the shares of sales to NGO's and academia have fallen significantly, probably due to the trend towards free data access to public data (see next section).
- The value adding industry does not contribute a lot to data sales revenues; small and micro enterprises in particular seem to increasingly base their business on free data.
- The announced growth (doubling) in the number of civil and commercial EO satellites globally forecasted for the period 2010-2019[127] is progressively happening. The data trend is towards a mix of optical sensors and radars. Optical imagery makes up about 80% of the data sales (compared to radar data sales reaching 20%), with Very High Resolution (< 2,5 m) set to become the most important part.

[124] EO Services industry, EARSC survey under assignment by ESA, September 2013, http://earsc.org/news/a-survey-into-the-state-and-health-of-the-european-services-industry
[125] ECORYS study for the Commission on the "Competitiveness of the GMES Downstream Sector", 2008
[126] Booz & Company study for the Commission on the "Cost-Benefit Analysis for GMES", 2011
[127] Euroconsult study "Satellite-based Earth Observation, Market Prospects to 2019", 2010

- With only 14% of revenues coming from markets outside Europe and North America, there is a potential for growth in export. Looking at the future, the industry remains cautious but optimist.

- Global markets for remote sensing and geo-services

Based on data acquired in 2012, the global market for remote sensing products has been estimated to grow from $8,1 billion in 2014 (more than EUR 5,5 billion) to $12,1 billion in 2019 (about EUR 8,9 billion), with an annual growth rate of 8,2 % over the five year period from 2014 to 2019[128]. These figures relates to remote sensing in a wide sense, thus including products acquired from sensors on-board satellites but also airborne sensors including from pilotless "drone" aircraft.

The geo-services sector is estimated to generate $150-$270 billion (approximately €110-200 billion) of revenue globally and to expand at an annual rate of 30%[129].

Although difficult to quantify, the Earth observation-based services deliver efficiency gains in the economy that can be many times the size of the sector itself. For instance, a study by BCG in 2012 has estimated an impact of geospatial services on the US economy to be 15 to 20 times the size of the geospatial industry[130].

- Comparison with the US Earth observation service industry

Compared to the US situation, the European Earth observation downstream sector is also affected by the budget austerity characterising the public sector in general. Still, US companies can take advantage of a larger domestic defence and security market accessible. Moreover, attention is paid in the US on preserving downstream opportunities for the private sector.

[128] BCC Research report on "Remote Sensing Technologies and Global Markets", 2013
[129] Oxera Consulting Ltd study prepared for Google on "What is the economic impact of Geo services?", 2013
[130] BCG study commissioned by Google on « Putting the U.S. Geospatial Services Industry on the Map", 2012