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This version of ESA/PB-EO(2010)56 replaces the version issued on  
10 May 2010, which did not show figure 1 properly.

**EUROPEAN SPACE AGENCY**

**EARTH OBSERVATION PROGRAMME BOARD**

**GMES Space Component - Draft GSC Operations Concept**

**Summary**

This document is presenting the GSC Operation Concept. It builds on the presentation made in the 134<sup>th</sup> PB-EO meeting in February 2010 and the bilateral and comments from Member States and the EC.

**Required action**

Delegations are invited to take note and to comment on this document.

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## 1 INTRODUCTION

The scope of the GMES Space Component (GSC) operations concept is to set a technical target to which the current development contracts and the later GIO phase and Operations phase shall result in.

The GMES Space Component (GSC) Operations Concept describes:

- The perimeter of the GSC operations phase from 2014 onwards, including the assumptions made for the start up of this operations phase.
- The architecture of the GMES Space Component Ground Segment and its implementation at high level. It includes:
  1. the technical architecture and its contractual implementation,
  2. Interface with the GMES Core, Downstream and national Member States Services in response to their needs in terms of EO data including data quality and data access performance.
  3. the process for the evolution of data demand and supply through gap analysis
  4. The expected reporting interfaces.

The GSC Operations Concept refers to period from 2014 onwards, by when 'operational budgets' from the EC are expected to be available and following the GIO phase during which Sentinel operations have gradually started.

The GSC Operations Concept, as of today, has to rely on a set of assumptions (technical, programmatic, financial and schedule) to be managed on top of the GSC intrinsic challenge. Any deviations from these assumptions will be reported in the GSC QSRs and other programmatic documents as relevant and may lead to adjustments of this Operations Concept.

The GSC Operations Concept:

- builds upon:
  - a series of requirements (Sentinels Mission Requirement Documents - MRDs-, GSC Data Access Portfolio –DAP and DAP-R -, the current Data warehouse requirements, all combined in a GSC System Requirements Document),
  - the GSC Programme Declaration, the ESA GSC Long Term Scenario the EC-ESA Delegation Agreement, and
  - the Sentinel Data Policy Principles,
- is aligned with today's technical architecture and its contractual plan for the GSC development.
- will have to handle unprecedented volume and rate of data within its ground segment and finally at the user end

The figure below describes the overall GSC architecture consisting of Sentinels and contributing Missions and the Coordinated Data Access System.

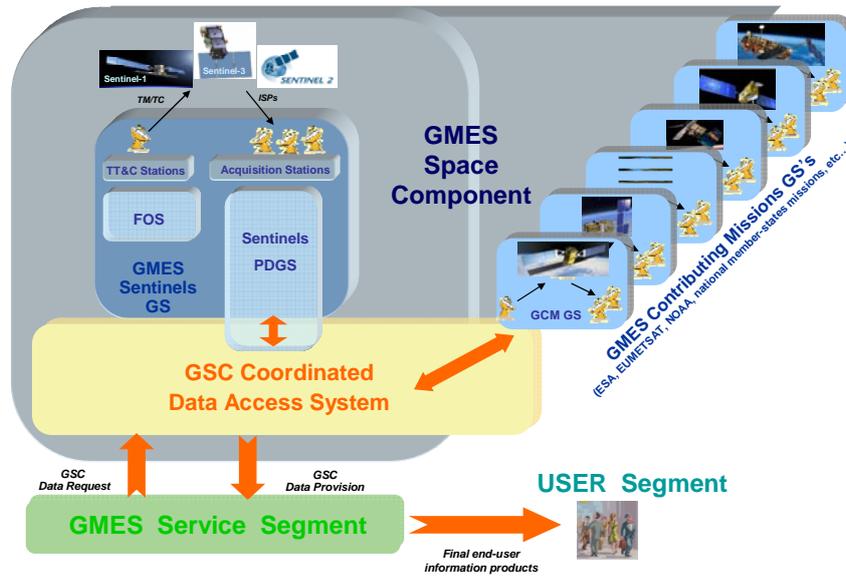


Figure 1 GSC Space Component architecture and data flow to GMES Services <sup>1</sup>

## 2 TECHNICAL AND PROGRAMMATIC ASSUMPTIONS AND CONSTRAINTS

### 2.1 Technical assumptions

It is assumed that by the start of the GSC operations phase, i.e. beginning of 2014:

- the three A-units of Sentinel-1, 2 and 3 have been launched and commissioned and already operated based upon approved Sentinel High Level Operations Plan (HLOP) before this phase using GMES Initial Operations (GIO) funding;
- Sentinel-5 Precursor is launched by Q3 2014 and will be integrated in the overall GSC operations by beginning of 2015;
- Data Relay (EDRS) laser communication terminals have been installed on Sentinel-1A and Sentinel-2A, EDRS ground receiving stations have been installed, tested and are linked to the high speed GSC ground data network and EDRS has been successfully launched and tested (launch of 1<sup>st</sup> spacecraft is currently scheduled for 2012). This will complement an acquisition strategy which has to ensure acquisition of all Sentinel data, also in absence of EDRS.
- Independent from the ‘ownership’ of the Sentinels, ESA with its known procurement and management procedures in 2014 until decided otherwise, is responsible for the implementation of the GSC operations through contracts and agreements, as defined on the current governance papers and discussions with EU; Any later ‘handover’ to another entity will require:
  - Several years to complete the technical and programmatic handover after the organisation is identified and legally mandated,

<sup>1</sup> Data flow to other users (e.g. national) may be added later once the perimeter of ‘GMES’ has been settled.

- Hand-over of GSC Services-type contract management to the new entity; the concept relies on re-use and sharing of distributed facilities and operational centers and does not set-up a 'stand-alone infrastructure'. Such development is not covered by the current GSC Built-up Phase budgets. Constraints might apply if the selected entity is an industrial private entity (e.g. IPR, subcontracting to public organization, neutrality in the data access and agreements with collaborative Ground Segment entities)
- the GSC technical architecture (the data flow, user interfaces, acquisition and processing facilities) remains unchanged as from the build-up and GIO phases;
- GSC operations shall not technically rely on the GMES in-situ component. Sentinels instruments Calibration and Validation will use the traditional Earth Observation calibration and validation sites and procedures;
- the Envisat mission is operational and providing large quantities of free of charge data to the GMES Services until January 2014;
- historical data from the ERS-1, ERS-2, Envisat and other ESA missions continue to be easily accessible;
- agreements and contracts with all GMES Contributing Missions (GCMs) have been established, the operational interfaces with the respective mission operations have been agreed and successfully tested during Build-Up and GIO phases;
- all data from GCMs, purchased or obtained otherwise during Build-Up and GIO phases is still easily accessible during the operations phase under similar license conditions.

## 2.2 Programmatic assumptions

This GSC Operations Concept refers to a programmatic phasing *of the future GMES Operations programme*, namely the availability of 'operational budgets' for the GMES Space Component. This concept of phasing differs from the classical ESA technical definition of Phase E i.e. the operations of a single satellite.

The financial framework for the GSC Operations Phase, described in the GSC Long Term Scenario document, is the basis for this GSC Operations Concept. Any financial reduction would lead to a reduction in the operational services below the current draft operations concept. Depending on the level of such underfunding the operations concept would be reduced in: timeliness of the end to end system, timeliness of the data dataflow (less NRT stations, no EDRS), less overall GSC end to end management and reporting (less interfaces/support to collaborative GS), less 'cross-mission-coverage' i.e. less cross-mission planning with contributing missions and in the extreme case to the pure operations of the spacecraft.

The financial and programmatic envelope of the GMES Initial Operations phase will determine the pace of the gradual increase of the Sentinels data services, their performance and processing capabilities from the commissioning set up towards the final concept and performance of the GSC operations phase.

The GSC operations concept relies on a overall management and reporting of the GSC operations through ESA, to ensure a fair and independent operational setup and procurement process in the data access management including:

- a GSC implementation according to the GMES governance model and an end to end performance management and monitoring
- a certain well known industrial- and procurement policy according to the ESA and EC's procurement rules
- Interfacing to the collaborative ground segment not funded through the EC.

In addition, the GSC Operations Concept is also driven by the following programmatic milestones to be completed during the period 2010-2013 with the European Commission:

- the implementation of three main streams of data policy:
  - the Sentinel Data Policy Principles, approved by PB-EO in 2009 (ESA/PB-EO(2009)98, rev. 1) and to be approved by EC/EU in 2010, and the Sentinel High Level Operations Plan (HLOP), defining priorities in case of constraints and conflicts for the Sentinel operations,
  - the overall GMES Information Policy, led by the EC/EU, including the data and information flow,
  - the individual data policies of the GMES Contributing Missions (i.e. up to 20 different data policies and related data Terms and Conditions).
- the definition of the GMES Services Operations concept describing the selection, management and funding of such services during the Operations phase and therefore defining the 'GMES use' perimeter. It should also address the expected amount of Services, pace of growth over time and their expected data requirements. The process for managing the GMES Services requirements should also be formalised.
- The implementation of a reporting structure towards PB-EO/DOSTAG, ESA Council, GMES Joint Monitoring Board and the EC Boards/Committees.
- the approval within 2010 of the GMES Initial Operations (GIO) phase programmatic agreement at the full amount requested of the GIO operations budget to allow issuing the Sentinels facilities service tender.
- the confirmation that contracts placed through the build-up phase can be easily extended through CCNs into the GIO phase and later into the Operations phase.

This current concept refers to 'ESA taking care and custody of the Sentinels'. The discussion on the Sentinel ownership may alter this operations concept.

During GSC Built-Up phase cooperation agreements has been set-up with CNES, DLR, Eumetsat, NIVR. It is assumed that any other future agreement with partners like USGS for Landsat Data Continuity Mission, Canadian Space Agency for Radarsat Constellation mission, other GMES Contributing Missions, GEOSS will not affect this operations concept nor its financial planning.

### **3 USER REQUIREMENTS FOR EO DATA**

The goals and user driven approach of the GMES Programme have been described in a series of EC communications and programmatic ESA documents.

Requirements towards the Space Component have been consolidated through two processes, which take into account the compromise to be made between the stability of mission requirements necessary to develop space systems and the equally important necessity to adapt the mission operations to the evolving operational users needs:

- the Mission requirements process leading to the suite of Sentinel Mission Requirements Documents (MRD) with a first version endorsed in 2006/2007 by the core service Implementation Groups and the EC. The Sentinel MRD, which capture the user requirements as known at time of their elaboration in 2005/2006, were used for subsequent derivation of each Sentinel system requirements, specifying in detail the system requirements for all engineering aspects.
- the Data Access Portfolio requirement (DAP-R) process, operated since 2008 in 18 month intervals first via the EC Grant agreement, then via the ESA/EC Delegation Agreement through a data warehouse concept (DWH) from end 2010 to end 2013 and to be continued during the GSC Operations Phase. The Data Access Portfolio requirements (DAP-R) provides the most recent knowledge of the operational EO data needs with respect to the required data from the multitude of missions contributing to the Space Component, and therefore also from the Sentinel missions.

Both the short term requirements collected through the DAP, as well as the long-term requirements collected via the MRD mechanism will evolve over the years.

The suite of data being made available via Contributing Missions will equally evolve.

For the Sentinel missions, in the requirements evolution process, should conflicting requirements arise between users, they will be handled through the priorities defined in the Sentinels' High Level Operations Plan (HLOP).

A systematic, regular gap analysis at 18 months intervals should be maintained also during the GSC Operations phase with respective requirements, management and mission simulation tools to provide the basis for decisions:

- concerning Contributing Missions in the short term
- concerning the evolution of Sentinels beyond their C units in the long term

### **4 GSC OPERATIONS CONCEPT**

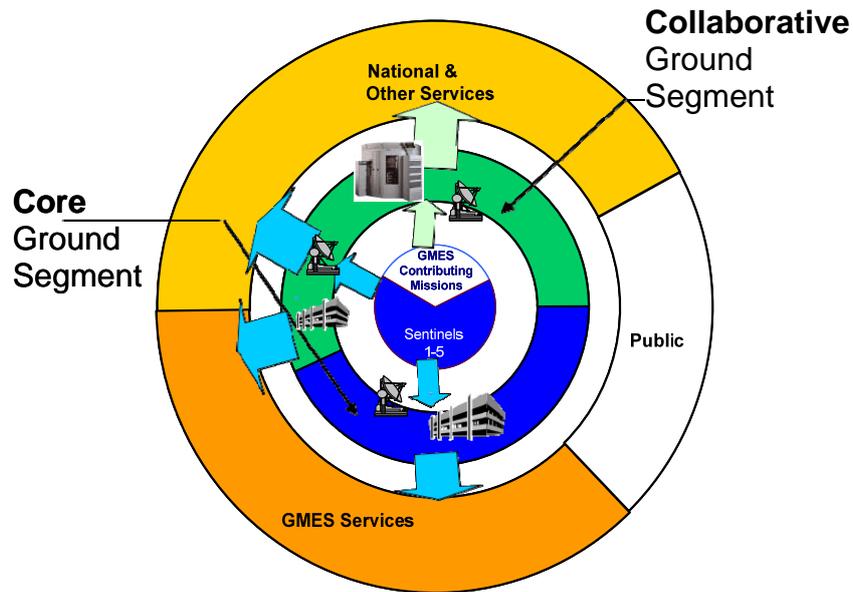
The GMES Space Component Operations Concept responds to an overall set of requirements as above and includes GSC end to end coordination and management, with elements delegated to other partners (e.g. Sentinel-3 partly and Sentinel-4 and Sentinel-5 to Eumetsat).

It shall ensure access for:

|   |                |   |
|---|----------------|---|
| <p><b><u>GSC Data Sets</u></b><br/>Composed of Sentinel data and of data from GMES Contributing Missions (GCMs)</p> | <p>To</p>      | <p>Eligible GMES Services (Criteria defined through the governance process), in short “GMES use”</p>                            |
| <p><b><u>Sentinel Data</u></b></p>  | <p>Also to</p> | <p>Other user communities according to the data policy and in line with the GSC programme declaration, in short “other use”</p> |

The GSC Operations Concept will rely on a GSC Ground Segment consisting of:

- a GSC Core Ground Segment, with GMES-funded Functions and Elements, providing the primary access to Sentinel Missions data as well as coordinating access to Contributing Missions data,
- a GSC Collaborative Ground Segment, with non GMES-funded Functions and Elements, providing a supplementary functions to Sentinel Missions data, e.g. either through specific data acquisition, processing, dissemination, or specific data products.
- the access to GMES Contributing Missions.



**Figure 2 Core and collaborative ground segment concept <sup>2</sup>**

The Core ground segment will allow

- the data access to GCMs and all coordination and management of the GSC overall,
- the systematic data acquisition and processing and distribution of all Sentinel data for GMES and other use as described in the GSC Programme (Declaration).

<sup>2</sup> The Core Ground Segment, through the CDS functions (Chapter 4.1.3) provides data also from Contributing Missions to GMES Services

The detailed mechanism will be finalised once the exact perimeter of GMES use has been defined by the EC.

The GSC Operations Concept, once fully implemented in a first version, will evolve progressively, with each new Sentinel satellite (Sentinel-5 Precursor, B-units, Sentinel-4 & 5) being launched, complemented with new GMES Contributing Missions becoming available for data access.

During the GMES Initial Operations phase (GIO), the Sentinels operations will be gradually integrated in the GSC overall system (not yet at their full operational performance) and the data services for individual Sentinels will seek a gradual evolution and improvement in the performance like increasing the number of facilities, in the data throughput and timeliness, deployment of level 2 products, in the services to users, in the availability of the system for planning/replanning etc. The amount and type of funding available for the GIO phase will determine pace of upgrading from a 'launch-commissioning configuration' to the target configuration and target performance as of this 2014-GSC operations concept.

Standards discussed and agreed within international bodies (GEO, CEOS, GSCB, OGC), e.g. for the definition of products, interfaces and procedures, will be applied across all elements and for the GSC development and evolution. This includes the Inspire technical definitions (Implementing rules), the HMA interface definitions, the Long Term Data Preservation guidelines, and the Quality Assurance Framework for Earth Observation data guidelines (QA4EO) being promoted under GEO.

#### **4.1 GSC Core Ground Segment**

The GSC Core Ground Segment will ensure coherent EO data supply (end-to-end data access management and monitoring and control) for GMES data use. In the specific case of the Sentinel missions, the GSC Core Ground Segment will also ensure the primary data supply of system corrected products for non-GMES use.

The GSC Core Ground Segment includes tools and systems for:

- GSC EO data requirements analysis based upon EC and other requirements and subsequent data gap analysis,
- GSC data flow end-to-end monitoring and control,
- generic data access (multi-mission mission planning, catalogues, servers, archives, networks interface specifications, GSC datasets quality control, etc) as needed for handling data from Sentinel missions and from GMES Contributing Missions,
- Sentinel missions specific functions (e.g. Sentinel data acquisition, front end and data processing, Sentinels telecommand and telecontrol, mission planning, quality control),
- an architectural and technical ground segment evolution strategy to cope with evolving user and performance requirements and new technologies.
- the related contractual management.

The GSC data flow is represented in Figure 1. Data from the Sentinels and the GMES Contributing Missions flows directly from the related facilities to the GMES Services after being authorised by the GSC Coordinated Data Access except if 'coverages' have to be composed by combining multiple satellite sources.

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

- will assume the overall technical coordination, including the management of the GMES Contributing Missions data access and the coordination of ground segment interface/standard developments;
- will manage through contracts and agreements the operations of the Core Ground Segment for the Sentinel-1 missions, for the Sentinel-2 missions and for Sentinel-3 missions (for the land user community) and the operations of the Coordinated Data Access System. Operations will be performed by facilities or operational industry under contract with ESA;
- will ensure the technical integration of new missions and the technical evolution of the Core Ground Segment, while maintaining its operational services.

Eumetsat will operate the FOS and the Core Ground Segment for the Sentinel-3 mission for the ocean user community, for the Sentinel-4 and Sentinel-5 missions in line with the overall GSC operations concept.

#### **4.1.1 GSC Data products**

The GSC Core Ground Segment will provide:

- Sentinel missions products generally up to Level 1B or 1C, occasionally up to Level 2 in a timeliness, quality and format as specified in Sentinel Products Documents as documented in Annex 1,
- Data products from the Contributing Missions (a priori according to the standard procedures already existing for these missions)
- coverages<sup>3</sup> or ‘time series’ composed of products from multiple satellites and instruments as specified in the DAP-R, all with the respective metadata for access and processing.

The list of Sentinel missions’ products is being further consolidated throughout 2010 involving PB-EO through DOSTAG, and the current EC GMES Services Projects. Budget plans in the development, GIO and later Operations Phase focus on systematic level 1 production and reducing the level 2 products out of the Core Ground Segment as described in the Annex. An extension of this list may incur additional cost.

The Collaborative Ground Segment, not funded through GSC, will therefore be encouraged to deliver complementary (higher level and/or regional) Sentinel products.

Sentinel missions’ products are subject to the Sentinels’ Data policy, while access rights to collaborative products will be defined in the bilateral agreement.

The mechanism to capture new proposed product types for the Collaborative scheme e.g. through an Announcement of Opportunity will be defined later.

The list of Sentinel products, in Annex 1, covers

- products provided by the Core Ground Segment and
- some products recommended today to be offered by the Collaborative Ground Segment.

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<sup>3</sup> Collection of products. It excludes mosaics.

This list will be updated to reflect the Collaborative offer. The GSC Core products specifications will include parameters such as: distribution mechanisms, coverage, timeliness and quality.

The Core ground segment also provides access to products from Contributing missions. It is expected that every mission owner/operator manages the quality of its products. The data flow for these products will be managed and tracked, but GCM products will not be 'certified' by the core ground segment data access function. User Complaints in case of GCM quality issues would be forwarded by the GSC held desk to the responsible mission for resolution.

The GSC Core Ground Segment products list and details might be adjusted in response to the evolving user requirements as described in Section 3 and according to the progress in information technology (e.g. processing power).

The GSC Core Ground Segment products list will be maintained and published to users and services via the GSC Data Access portal (<http://gmesdata.esa.int>).

Products generated by the collaborative ground segment will be also advertised through the Portal.

The approval process for the GSC data products list and its evolution will be described once the governance scheme and funding is finalised.

#### **4.1.2 Sentinels Facilities**

The GSC Core Ground Segment infrastructure relies on the re-use of existing facilities and their sharing with the operations of other EO missions.

Most of the GSC Core Ground Segment elements are de-centralised and distributed in particular the facilities such as receiving stations, processing centres, archive centres.

The data flow is direct from the space segment to these facilities and to the users. The data is acquired in the Sentinel Acquisition Stations where data is also processed and distributed in Near Real Time to the users. The data is transferred to the Sentinels Processing and Archiving Facilities (PACs) where it is preserved, re-processed when needed, and accessible to the users. Also the long term data preservation in this concept will be handled through the PACs. Auxiliary data (including calibration) will be also collected and distributed to all processing centers (Stations and PACs).

Standardised interfaces procedures and protocols are used. Other decentralised elements are the support for Sentinel products algorithm maintenance and evolution. The operations of these elements will be implemented as service contracts.

Centralised infrastructure elements are the data flow management, monitoring and control. Also, the user interface (registration, help-order desk functions, catalogues for the distributed data), the mission planning (for Sentinel Missions and towards Contributing Missions) will be implemented centrally, and operated through industrial contracts. These functions are detailed in chapter 4.1.3.

The main Sentinels Facilities are:

- Sentinel Flight Operations Segment (FOS)
- Sentinel Data Acquisition and Near Real Time Product Generation
- Sentinel Data Access and Preservation and Reprocessing
- Sentinels Precise Orbit Determination (POD).

### **a. Sentinel Flight Operations Segment (FOS)**

The Mission Flight Operations Segment performs the Sentinel satellites commanding & control including the uplink and downlink of tele-command and telemetry (S-band link) as well as the Sentinel satellites maintenance support, e.g. on-board software maintenance. The FOS and/or the Sentinels PDGS mission planning will have to handle and schedule the EDRS for Sentinel-1 and Sentinel-2, pending the EDRS schedule and programme is aligned to that of the Sentinels.

These functions are handled by:

- ESA D/OPS at ESOC for Sentinel-1, Sentinel-2 and Sentinel-5 Precursor (if not defined differently during phase A)
- EUMETSAT for Sentinel-3 (ESA D/OPS at ESOC ensuring the Commissioning Phase) and later for Sentinel-4 and Sentinel-5.

### **b. Sentinel Data Acquisition and Near Real Time Product Generation**

The Sentinel-1, -2 and -3 data acquisition provides the X-Band and Ka-Band (for data acquisition via data relay satellite system) data downlink and ingestion services and it is achieved via a Sentinel Missions core receiving stations network.

The Payload Data Ground Segment architecture foresees a number of core X-band receiving stations necessary to ensure acquisition and systematic processing of all data from Sentinel-1, Sentinel-2 and Sentinel-3. Furthermore, Near Real Time (NRT) data delivery in less than 3h from sensing can be provided for the whole Sentinel-3 data and for pre-planned regions for Sentinel-1 and Sentinel-2. Some Sentinel-1 and Sentinel-2 products can also be available with improved scalable performance (typically in less than 1h from sensing) according to HLOP conditions, stations network layout and deployed hardware sizing. Further details on timeliness limits will be confirmed after core stations selection.

In order to allow the possibility to develop quasi-near-real time services (e.g. around 10 minutes from sensing) using the direct downlink capabilities at regional collaborative stations or core stations, the core dump scenario and receiving stations need to be selected such as to allow direct downlink capabilities over a set of real-time zones to be defined in the HLOP. In any case, ultimately if conflict arises, the core ground segment ensuring the overall data flow will be given priority.

The scenario of receiving stations is - at this stage - the same, independently on whether EDRS will be available or not. The network of X-band receiving stations is needed to allow full data dump in case of EDRS unavailability, just with a delay on quasi-real-time delivery.

The X-band data downlink scenario for Sentinel-1 and Sentinel-2 missions will be complemented by a downlink via EDRS. This capability will increase the flexibility of having direct data downlink and recorded data simultaneously and thus increase the availability of Sentinel data.

Two EDRS core receiving stations will be selected competitively and will provide Near-Real-Time services. They can be collocated with X-band receiving stations (advantage: sharing of the processing systems) or located elsewhere (advantage: no constraints/conflicts in processing and dissemination). Once the EDRS acquisition scenario

is operated, a lower amount of data will need to be acquired via the X-band stations reducing their workload, not the need for their availability however.

Concerning Sentinel-5 Precursor, this chapter will be updated after completion of the Phase A/B1.

### **c. Sentinel Data Access, Preservation and Reprocessing**

All Sentinel data products are kept archived for online access by users. The online archives and data access will be based on an architecture combining dedicated servers at decentralised facilities and online archiving services.

Long-term data preservation, in particular of Level 0 data, will follow the Long Term Data Preservation guidelines (<http://earth.esa.int/ldp>). In particular, all Sentinel data will be kept at two independent archiving systems and facilities.

The Sentinel data will need to be re-processed following processing algorithms or calibration parameters upgrades. The re-processing architecture is based on an efficient combination and concept of dedicated processing systems at core facilities and external cloud computing elements absorbing peak processing loads and processing campaigns. The Initial GIO system will be sized to cover commissioning reprocessing needs and to demonstrate scalability approach.

It is assumed that Sentinel-1, 2 and 3 will share some Processing and Archiving Centres (PACs). The applicable sizing assumption for these centres is currently considering a maximum of 7 facilities covering the needs for on-line data access and long term preservation that can be collocated.

Above assumption is built considering the following scenario:

- for Sentinel-1 mission: a layout of 2 PACs,
- for Sentinel-2 mission: a layout of 2 PACs,
- for Sentinel-3 mission: a layout of 2 or 3 PACs for the 3 instruments, plus the EUMETSAT Processing and Archiving Centres dedicated to the marine applications users.

Concerning the Sentinel-5 Precursor, this chapter will be updated after completion of the Phase A/B1.

### **d. Sentinels Precise Orbit Determination (POD)**

The Sentinels-1, 2 and 3 Precise Orbit Determination (POD) Service makes use of the data provided by the same embarked GNSS-receiver in a common approach to deliver the orbital information needed for the generation of the mission products.

The POD Service will be tailored to consider the mission specific requirements for accuracy, timeliness and data coverage. In the case of Sentinel-3, with the presence of DORIS instrument on-board, the CNES specific service is integrated as a complementary data flow.

The POD Service also guaranties the long-term monitoring of the GNSS-receiver performances, the long term maintenance of the orbit data set, as well as the generation of the auxiliary information necessary to the PDGS ground processing.

### 4.1.3 GSC Coordinated Data Access

The Coordinated Data Access (CDS) functions are part of the core ground segment and include the data access management not only of the Sentinels but also from the GMES Contributing Missions (GCM). It ensures all functions and systems necessary for:

- Gap and EO data requirements analysis
- GSC Multi-Mission Mission Planning in order to achieve:
  - multi-mission ‘coverages’ such as multi-mission cloud-free datasets over defined zones
  - time-series of dataset across several missions
  - multiple, frequent acquisitions from as many relevant missions as possible in case of emergencies (coordinated with the scheduling of Charter participating missions)
- User Registration and Management:
- Coherent User Services for GMES Services including data catalogues of Sentinel and GCM datasets, coherent data description (as described in the GEO/CEOS QA4EO guidelines), single sign-on for all datasets, advertisement of Core and Collaborative Ground Segment services (including product list)
- Centralised Infrastructure for Data-Set assembly: Storage of and online access to multi-mission datasets
- End to End Monitoring and Control, including data product quality
- Network Infrastructure Management: Data Flow Networks across facilities for Sentinel and GCM data
- Security Management.

These functions are planned to be managed through D/EOP in ESRIN

#### a. Gap and EO data requirements analysis

Since both the GMES data requirements and the available data sources (Sentinel missions and different Contributing Missions) will continuously evolve, a demand-supply crosscheck is being performed in regular intervals. As compliant with the available budget and the technical constraints, the GSC operations will react to new requirements stemming from the evolution of user needs identified by the EC.

The result will be:

- 1) the definition and implementation of a ‘baseline observation plan’ for Sentinel-1 & Sentinel-2 missions, i.e. the exact area definition – with regular adjustments – of instrument operations. This shall include the definition of real-time zones for direct downlink to be complemented via the regional stations of the Collaborative Ground Segment.

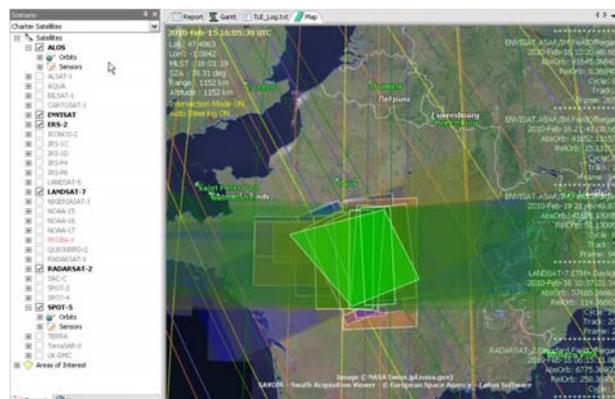
- 2) the list of data requirements to categories of Contributing Missions based on EC and GMES Services requirements; this is the input for the contractual requirements to Contributing Missions in subsequent slices.
- 3) the identification and confirmation of long-term data gaps, i.e. when data observation capacities are insufficient or not planned for in the near future; this information is relevant for Member States and industry when developing plans for future EO missions.

The output of this activity will also be required for the broader concept and the discussions at the High Level Space Policy Group about future Earth Observation missions.

## b. GSC Multi-Mission Mission Planning

The GSC Multi-Mission Mission Planning function includes:

- Generation of baseline observation plans for the Sentinel missions and their acquisition schedules for the core, collaborative and EDRS receiving station.
- Generation of multi-mission emergency request; including the acquisition schedules for Sentinel-1 mission and acquisition requests to all GCMs supporting emergency services
- Generation of acquisition requests for all Contributing Missions if not operating on a default basis
- Generation of acquisition plan and operational monitoring of ‘coverage datasets’ and time series both with Sentinels and GCMs data.



**Figure 3 Example of generation of multi-mission emergency request**

**c. User Registration and Management:**

- a) Users will self-register for all freely available data. Once registered, the user has access to the data through a single unique User Account.
- b) GMES Services and other users requiring access to EO data restricted by technical or licensing constraints will go through an approval process – always through web supported forms. Technical constraints (e.g. data acquisition or data processing constraints) are ruled by the HLOP including a priority scheme.
- c) Access to all data will be logged and the information safely stored in a dedicated Reporting Infrastructure.

**d. Coherent User Service:**

The GSC User Services function covers the operations of the front-end interface to the above set of users and for all GSC data requests from Sentinel and Contributing Missions, and includes:

- GSC advertisement for publication of available information about existing and planned collections and for a cooperative information exchange environment,
- Coordination of Sentinel multi-mission satellite tasking requests,
- GMES Services support, including user registration and service desk, in coordination with the GCMs and Sentinels service desks as applicable,
- Data and catalogue coordinated access interface integrating in a user interface both mission products selection and data access functions.

**e. Centralised Infrastructure for Data-Set assembly**

GMES Services today also rely on the usage of large quantity of accumulated products (e.g. coverage or stack data-sets). The GSC Core Ground Segment offers the possibility to store, consolidate, make an inventory of and retrieve such datasets. All GSC datasets (e.g. coverages) are kept archived for online access by users within this Coordinated Data Access function.

**f. End to End Monitoring and Control:**

The end-to-end performance of the GSC Core Ground Segment will be monitored, with operational objectives to be achieved in terms of data products quality and in terms of availability of delivered data products.

This function includes:

- Customer satisfaction monitoring
- Monitoring of Sentinel data products quality and instrument performance evolution, including calibration and validation
- Monitoring of product quality from Contribution Missions delegated and reported through a Service Level Agreement
- Monitoring of end-to-end data flow, including timeliness from instrument operations to product delivery to the user, both for Sentinels and contributing Missions

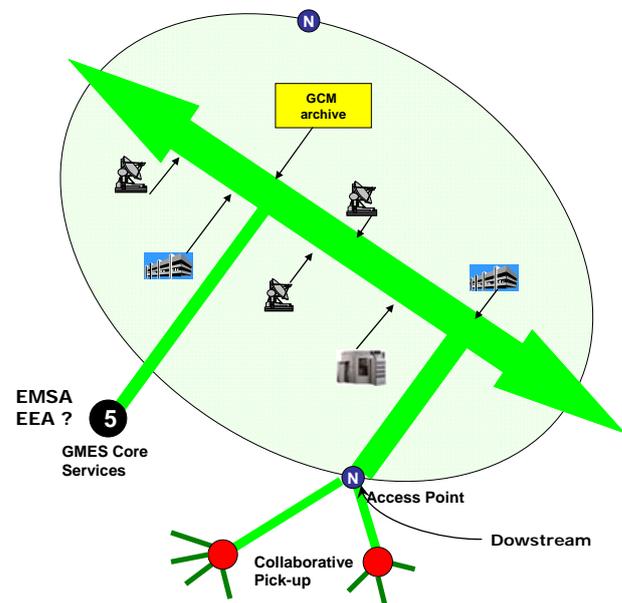
- GSC system performance monitoring and reporting

These functions particularly address the specific case of the Sentinels Mission performances monitoring. The Sentinels space and Core ground segment will be monitored constantly in order to ensure an optimal quality of the GSC and Sentinels data products and their provision services versus the allocated resources. This includes the regular reporting on measured Sentinel operations performances, the verification that those performances match the operational user needs, the product upgrades following e.g. an improved characterisation or calibration of the instruments or as a result of a validation campaign, and any other identification of change needed for a better appropriateness of the Sentinel missions to the operational user needs.

### g. Network Infrastructure Management

Network infrastructure will support the on-line data access, the data circulation among Acquisition Stations and Processing and Archiving Centres as well as the on-line user interface and overall ground segment monitoring and control. Its performance and capacity are essential to support this operations concept.

Ground network infrastructure design is under consolidation: dedicated links, high-speed Internet access as well as Content Data networks and cloud computing is being considered through a centralised management. The satellite multicast cost-effectiveness to handle the GMES and Sentinels data products is also being assessed



### h. Security Management

The GSC Operations Concept takes into account:

- the Sentinel full and open data policy
- the ESA security directives.

Currently end-to-end security aims primarily at preserving the integrity of the data and of the user information, as well as preserving availability and integrity of the data access services at the required level of performance. Furthermore the security concept in order to allow access to the data from the GMES Contributing Missions complies with their security requirements and regulations, when existing.

#### 4.1.4 Core Ground Segment Evolution and Maintenance

- **Integration of S-5 Precursor**

[Details will be provided following completion of Phase A/B1]

- **Continuous Integration/De-Integration of new Contributing Missions**

As new missions are launched, and others will reach the end of the lifetime, the suite of GMES Contributing Missions constraints will evolve over time. Therefore integration activities will be ongoing continuously for those new Contributing Missions. Others will have to be removed either because reaching end-of-life or following the gap analysis with updated GMES services requirements; and new acquisition scenarios will have to be built up.

- **Continuous Integration of new Collaborative Ground Segment Functions**

Dependent on the function, the technical interface and the dataflow from Core to Collaborative Ground Segment, different types of formal arrangements -all without exchange of funds- may be established. They will cover the formal interfaces such as signature of Terms & Conditions or another type of arrangement and will also include technical functions such as:

- The advertisement process to all GMES Services of the additional collaborative function,
- The particular technical interface being mutually developed and operated for data flow,
- The particular contribution to the GMES programme overall, e.g. a particular regional service,
- The technical support by the Core- to the Collaborative Ground Segment, e.g. in integration testing, processor or system maintenance, etc.

- **GMES Service Evolution**

GMES Services will evolve over time, maturing their service portfolio and performances, and new services will be created. The Core ground segment should continuously integrate the new GMES services and support, to the extent of the operational budget, allowing the evolution to the new requirements from the Services.

#### 4.2 GSC Collaborative Ground Segment

The GSC Core Ground segment will not be able to satisfy all and especially not the customized requirements in data and data access services. However the Core Ground segment shall allow and support the set-up and operations of such complementary ground segment functions.

Examples of such GSC Collaborative Ground Segment are:

##### a. Sentinels Mission Data Acquisition and RT production

It can provide a regional (within the station coverage) quasi real-time (10-15 min from sensing) data service via Sentinels Regional Stations. As far as no conflicts arise with the systematic space- and ground segment operations, ESA will support operations in terms of

mission planning (acquisition scheduling including all auxiliary information) over the local geographical area of interest and provision of satellite-to-ground interface information.

Only a limited number of regional stations can be supported for Sentinel-1 and Sentinel-2, as the systematic downlink scenario to Core stations may exclude certain real time downlinks. It is envisaged that few regional stations outside Europe (Asia, South East Asia, Southern parts of North America and South America) a priori not in overlap with core receiving stations can be supported. There is no limitation on the number of collaborative ground stations with similar visibility as the core stations. EDRS receiving stations as part of the Core Ground Segment will ease the dump scenario and potential conflicts between core dump and direct downlink stations.

#### **b. Sentinels Mission Collaborative data products**

Collaborative systems may offer product types or product formats in addition to those offered by the GSC core functions. Potential products of interest for collaboration may be:

- product algorithms tailored to a particular coverage or region,
- product algorithms tailored to specific services, like the Essential Climate Variables extraction,
- generation of local/ regional data sets with correction, projection, calibration, merging etc different to the standardized one offered by the GSC Core Ground Segment.

National Entities, EU agencies or even GMES core services, may, at their own funds, provide such products.

Operational generation of collaborative products may be supported by implementation and operation of specific data flow interfaces with the Core Ground Segment. In some cases, according to available operational resources and budget, processing capability through hosting processing in the Core Ground Segment may be provided (e.g. such Collaborative mode will be particularly encouraged wherever decrease of dissemination data volume will be demonstrated).

#### **c. GSC data product dissemination and access**

Particular regional or thematic data access nodes and mechanism may be offered, such as,

- a satellite multicast capability for Africa or Eumetcast for the Meteorology community
- Regional online data servers and data pick-up points for regional users e.g. in the US, Asia etc
- Redistribution services of Sentinels products, systematically received from the Core Ground segment, becoming additional pick-up points.

#### **d. Dedicated Products and Services by EUMETSAT**

Eumetsat may wish to offer special product formats or access mechanisms or higher level products for Sentinel 3 data to the Meteorology- or Oceanography- Community.

EUMETSAT may offer too 'collaborative' ground segment functionalities beyond the Core ground segment functions in systematic processing and archiving.

Such collaborative Ground Segment functions, as defined in the above four areas, can be supported by the Core Ground Segment through:

- provision of standard processors for Sentinel data or Sentinels specific front end processors and their maintenance
- development of specialized interfaces
- sharing of the GSC network and data dissemination infrastructure
- cross calibration support
- advertisement of the collaborative services through the Data Access Portal

The extent of the support depends on the financial envelope allocated to GSC operations.

### **4.3 GMES Contributing Missions operations**

The GMES Contributing Missions (GCMs) will continue to supply their data towards the GSC Data Access (GSC-DA), also at the time when the Sentinel Missions are fully operational. Data from GCMs will be required to either:

- provide data that the Sentinel Missions cannot supply (e.g. VHR optical or SAR data), or
- increase data density, revisit times or
- complete coverage in shorter time frames.

The data flow and interfaces by which the GCMs will contribute will be very similar to the mechanism in place today. Based on the known EO data requirements collected in short loops of around 18 months (see Section 3 on user requirements), ESA will issue competitive tenders among all available mission owners/operators, for the supply of their data into the GSC-DA or place agreements, to complement the Sentinels. This will include both data delivery under a Service Level Agreement and the evolution of technical interfaces towards the Coordinated Data Access system (CDS).

As these GCMs will continue to have their own data policy, business model and user community to be served alongside GMES, the mission owners will through the tender process offer their capabilities towards GSC-DA, and the related cost for operations, licences and performance of data supply. The legal conditions, under which those data can be used, will continue to be laid down in the Terms and Conditions document, with mission-specific Annexes, as already in place today. On top of the commercial missions, it is expected that public missions will remain available at no cost to GSC-DA (e.g. Eumetsat missions, CNES Research missions)<sup>4</sup>.

The mission responsibility of those GCMs remains fully with the owners and operators of the GMES Contributing Mission Entities (GCMs). ESA will remain in charge of the overall technical and programmatic management and coordination of this data access.

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<sup>4</sup> This item is being discussed as part of the on-going EC-ESA dialogues with Member States owning space infrastructure

#### 4.4 Procurement Approach

During the build-up phase, PDGS Systems and Elements developed will follow the traditional building block architecture, furthermore the operational services will reuse existing facilities. The procurement principles are described in "EO Payload Data Ground Segment: Approach and Activities Information Note" (ESA/IPC(2006)66, Sept 2006). This building block and facilities re-use approach for the GSC operations concept allows efficient evolution and replacement of particular ground segment elements and services, through an open ITT whenever necessary.

The contracts, both to support the system development and the later operations, will be released during the build-up phase and therefore will constrain the operations phase procurement approach, and in particular the procurement of the operational services as well as of the systems maintenance and evolution.

The types of contracts needed to support the GSC operations concept are:

a) **System Development and Integration Contracts** aiming at procuring and integrating the hardware and software of the Core ground segment. As for example for Sentinel specific PDGS elements such as front-end processors, data processors, mission planning systems. The Sentinels Payload Data Ground Segment procurement plan is further detailed in the ESA IPC document ESA/IPC(2009)45. During the operations phase, and once these systems are installed for operational use at any of the facilities, they will have to be maintained. Therefore software and hardware 'maintenance contracts' will have to be in place initially with the developer and eventually with other industries. Whenever feasible operational software is requested such to allow competition in the software maintenance.

b) **Facility Services Contracts** aiming mainly at providing basic PDGS operational services such as acquisition and archiving of Sentinel data, controlled through Service Level Agreements and at hosting and operating the systems developed under a). Procurement of the networking services and the EDRS services will be managed similarly.

During the build-up phase, the service contracts for the Sentinels facilities (4.1.2) only cover the support to the deployment in the operational facilities of the systems developed and the ground segment operational services supporting the Sentinels commissioning phase. The competitive tenders for their selection will request options for the extension of the operational services during GIO and later operations. Major risk for these tenders is the substantial upfront investment the bidder might need to owe, but only commits to the short period of integration and commissioning. ESA will raise this issue with the EC.

The service procurement approach allows the decentralisation of the operational services and the outsourcing of these activities to industry/operators. These contracts shall be issued, however, such that a smooth transition into the operations phase is assured. They will include contractual breakpoints for the transition into the GMES Initial Operations and later the Operations Phase.

c) **Operations contracts with the GMES Contributing Missions** aiming at providing access to their data for the GMES Services according to a specified level of performances and through standard interfaces, as already in place today.

- d) Operations and maintenance contracts for the CDS (Coordinated Data Access System) functionality ITTs according to EC rules will be issued for these contracts
- e) Sentinel 1&2 FOS operations will take place in ESOC through internal SLAs.
- f) Sentinel 3 FOS operations will be delegated to Eumetsat through SLAs, also covering its part of the S3 Core ground segment operations. This scheme is open for Eumetsat to extend its operations of the S3 mission towards the Meteorological community through the collaborative ground segment and an own co-funding scheme.

Since the GSC ground segment in general and the Sentinel facilities are already validated and established prior to launch to support the commissioning phase, it is expected that the basic ground segment architecture remains unchanged for GIO and during the operations phase. During the GIO phase, the limited system performances required to support the Sentinels commissioning will be gradually enhanced at pace and final target determined by the amount and type of funding available during this phase. Simple contract extensions are expected to support both GIO and Operations phase. The EC has been requested to confirm this approach with the pre-requisite that previous contracts have been placed during built-up phase via competitive tender as described in the delegation agreement for joint ESA EC funding elements.

The procurement approach will aim at maintaining a certain level of involvement of SMEs.

#### **4.5 Cooperation**

The GSC Operations concept supports both technically and programmatically a number of cooperation and contribution schemes such as:

- GMES Contributing Mission, this means contribution of satellite operations and data products under (data access) either under a contractual scheme or an arrangement
- contribution of ground segment elements, systems, facilities or a contribution of expertise either for Sentinels and/or for the coordinated data access under
  - a contract as part of the GSC Core Ground segment or under
  - another arrangement (Terms and Conditions and Interface agreement) as collaborative ground segment element.

All elements of contribution to the overall GSC will be subject to reporting.

The GSC Operations concept allows for cooperation with international partners, which can be implemented through various means, including regional (re-)distribution of Sentinel data, set up of ground station facilities for regional services (e.g. for Sentinel-1, within mission operations constraints), etc.

This GSC Operations concept, will, in its further versions, also cover mission-cooperation schemes e.g. between the Landsat Data Continuity Mission and Sentinel -2 and between Radarsat Constellation Mission and Sentinel-1; the High Level Operations Plan will contain further details.

## **5 SCHEDULE**

The GSC 'operational' data provision started in 2008 when the GSC Core Services started to request data from the existing GMES Contributing missions. The GSC operations are gradually improving through:

- the addition of new Contributing Missions
- increase of amount of data and improved data services of the GCMs, including ESA and Eumetsat missions
- the gradual development, and transfer into operations of the Coordinated Data Access System (CDS)

In parallel, following activities are progressing, each of them with their own schedule:

- the Sentinels are being developed
- the Sentinel FOS and PDGSs are being developed and will be validated and integrated according to their respective project plans as described in the QSRs
- the EDRS is being approved and developed stepwise
- Sentinel-5 precursor is in phase A/B1; once this phase is completed the mission will have to be included in the operations concept.

## **6 NEXT STEPS**

This document provides an updated draft of the GSC Operations concept after the consultation process with delegations and the EC during March and April 2010.

It follows up from the endorsement of the Sentinel data policy principles and the GMES Space Component Long Term Scenario. It is aligned with the 2 documents on ESA's role within the GMES governance and on the GSC System requirements and objectives.

The compliance of this GSC operations concept will have to be reconfirmed, once the GIO and GSC operations funds have been confirmed and the GMES data requirements can be extrapolated at a sufficiently reliable level based upon a GMES Services Operations Concept. This may then lead to updates of this operations concept.

Further updates are foreseen for the inclusion of Sentinel 5 Precursor and later for Sentinel 4 and Sentinel 5 and when any other of the assumptions are defined and changed.

The uncertainties and assumptions are critically high at this point. ESA and EC need to settle them as fast as possible. Progress and financial impact will be reported to PB-EO. The next steps are implemented through a series of consultation opportunities both with the EC and ESA Member States. The following set of further milestones is foreseen:

- May 2010: First Blue Paper for PBEO for formal consultation (this document)
- Presentation to GAC (date tbc)
- May 2010: First presentation on Sentinels HLOP with PBEO
- September 2010: Presentation of Sentinel HLOP to Dostag
- September 2010: Oral Presentation of Sentinel missions' products list to Dostag
- September 2010: PBEO endorsement of the GSC Operations Concept V1.

- September 2010: First Blue paper of HLOP for PBEO for formal discussion
- November 2010 (tbc): Issue of GSC Facility ITTs
- (tbd) Decision on EDRS
- (tbd) Integration of Sentinel-5 Precursor in this operations concept.

This schedule will be further amended following coordination with EC.

All lower level detailed technical documentation in ESA will be kept aligned with this evolution and Member States will be kept informed and consulted for any major changes on the GSC operations concept and changes in external project plans such as EDRS.

**ANNEX: SENTINEL PRODUCTS**

| <b>Product Level</b>       | <b>Product Type</b>          | <b>Processing concept</b>   | <b>Data Access</b> | <b>Timeliness<br/>(availability after downlink)</b>                                       |
|----------------------------|------------------------------|---|--------------------|---|
| L0                         | SAR L0                       | Systematic Local  | On-line            | < 10 min (for NRT areas defined through HLOP)   |
|                            |                              | Systematic Global   |                    | < 1 h (for NRT areas defined through HLOP)  |
|                            |                              |   |                    | > 24 h (all acquired data)  |
| L1                         | SAR L1 SLC                   | Systematic Regional (For regional areas of interest defined through HLOP)                 | On-line            | < 1 h (for NRT areas defined through HLOP)  |
|                            |                              |   |                    | > 24 h (all acquired data)  |
|                            | SAR L1 GRD                   | Systematic Global   |                    | < 1 h (for NRT areas defined through HLOP)  |
|                            | MSI L1B, L1C                 |   |                    | > 24 h (all acquired data)  |
| OLCI L1, SLSTR L1, SRAL L1 | < 1.5 h (all acquired data)  |   |                    |   |
|                            |                              | < 1 h for all acquired data<br>< 1 month for consolidated production (e.g. updated orbit) |                    |   |
| L2                         | SAR L2 OCN                   | Systematic Global   | On-line            | < 1 h For WV mode data acquired over ocean and HBR areas defined through HLOP             |
|                            | SRAL L2 products             |   |                    | < 1 h<br>< 2 days<br>< 1 month  |
|                            | OLCI L2 products<br>SLSTR L2 |   |                    | < 1 h for all acquired data<br>< 1 month for consolidated production (e.g. updated orbit) |
|                            | Vegetation L2                |   |                    | < 1 month for consolidated production   |

**Table 1 Sentinel-1, Sentinel-2 and Sentinel-3 Products list from the GSC Core Ground Segment**

| Sentinel-1                                    |   | Sentinel-2                                    |   | Sentinel-3 (***)                              |   |
|---|---|---|---|---|---|
| Core PDGS<br>(committed quality & timeliness) | Collaborative PDGS<br>(non-exhaustive list)   | Core PDGS<br>(committed quality & timeliness) | Collaborative PDGS<br>(non-exhaustive list) | Core PDGS<br>(committed quality & timeliness) | Collaborative PDGS<br>(non-exhaustive list) |
| SAR L0  | see timeliness table on regional availability |   |   |   |   |
| SAR L1 SLC                                    | see timeliness table on regional availability | MSI L1B                                       |   | OLCI L1                                       |   |
| SAR L1 GRD                                    |   | MSI L1C                                       |   | SLSTR L1                                      |   |
|   | SAR L1 Orthorectified                         |   |   | SRAL L1                                       |   |
| SAR L2 OCN<br>(wind,wave,currents)            | Soil moisture                                 |   | MSI L2(*), L3                               | OLCI Water Color L2                           | [OLCI Water Color L2]                       |
|   | Swell propagation                             |   |   | OLCI Land L2                                  | [OLCI Land L2]                              |
|   | PS Cal products (**)                          |   |   | SLSTR Water L2                                | [SLSTR Water L2]                            |
|   | Sigma0 Mosaic (**)                            |   |   | SLSTR Land L2                                 | [SLSTR Land L2]                             |
|   |   |   |   | SRAL L2                                       | [SRAL L2]                                   |
|   |   |   |   | Vegetation L2                                 | [Vegetation L2]                             |

**Table 2: Sentinels products: examples of collaborative products**

[ ] ESA ensures processor development. Collaboration is being considered for S3 L2 Production

(\*) The necessary MSI atmospheric corrections will be available through Sentinel-2 toolbox

(\*\*) ESA supports implementation and operation for PDGS core calibration purposes only

(\*\*\*) Level 2 final product list is subject to financial scrutiny and consolidation of the specifications during 2010.

Level 2 product availability as from Operations Phase onwards ( 2014)