Sentinel High Level Operations Plan
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1. **Introduction**

1.1. **Scope**

The Sentinel High Level Operations Plan (HLOP) provides the top level operations plan of the Sentinel missions, including space and ground segment. The HLOP will be applicable to all operational entities of Sentinels and Sentinel facilities.

The HLOP is based upon the Declaration on the GMES Space Component (GSC) Programme [RD1], the Sentinel Data Policy [RD2] and the GMES Space Component Operations Concept [RD3] as illustrated in Figure 1.

The HLOP is applicable to the Sentinel missions for the routine phase, i.e. after completion of respective satellite commissioning phases.

The aim of the HLOP is:
- to identify the main constraints, limitations and potential conflicts related to the high level operations of the Sentinel missions
- to define the rules for resource allocation and for resolving conflicts, with the definition of a priority scheme
- to describe the measures and the strategy to cope with these constraints, reducing to the maximum the potential conflicts during operations.

The HLOP is implemented through a set of detailed rules and operational directives defined in the detailed operations plans of the respective Sentinel missions.

1.2. **Validity, approval and procedure for future revisions**

The HLOP will become applicable after its approval by ESA’s Programme Board for Earth Observation (PB-EO). The European Commission (EC) will be asked, as Programme Manager of GMES, to endorse the priority setting (Chapter 6) and the process for establishing the observation scenarios (Chapter 8) and to approve the later version of this document covering the Full Operations Capacity.

The current version of the Sentinel HLOP addresses the Sentinel-1, Sentinel-2 and Sentinel-3 missions with high level operations principles and technical constraints, as well as the rules and strategy for resource allocation with the related priority scheme.

Future revisions of the Sentinel HLOP will include additional details related to:
- the observation scenarios of Sentinel-1, -2 and -3 missions covering the ramp-up phase up to full operational capacity
- the use of the European Data Relay System (EDRS)
- the Sentinel-5 Precursor operations
- the Sentinel-4 and Sentinel-5 operations
- the Jason-CS operations.

In view of the launch of the first Sentinel spacecraft, PB-EO is invited to approve the Sentinel HLOP in its current form. The Sentinel HLOP will routinely be updated to make reference to
the evolution of the operational scenarios. It is proposed to regularly consult ESA’s Data Operations, Science and Technical Advisory Group (DOSTAG) and the GMES User Forum (typically once a year) on the Sentinels observation scenarios, elaborated based on the process described in the present version of this document.

Furthermore, it is proposed that the update of the HLOP to reflect the completion of the Full Operational Capacity (i.e. constellation of the Sentinel-1, -2,- 3 A and B-models as well as Sentinel-5P) will be re-submitted to PBEO for approval.

The high level definition of the observation plan relevant to the first part of the Sentinel operations ramp-up phase is provided for complementary information as attachment to this document. Based on the current Sentinels launch schedule, this phase corresponds to the first 6 months of routine operations for Sentinel-1A that will follow the satellite in-orbit commissioning review. This observation scenario is to be considered indicative as it is based on a number of assumptions including the availability of the related operations funding and on some GMES services and national requirements not yet fully consolidated.
## 2. Reference Documents

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<td>ESA/PB-EO/CXI/Dec. 1, rev. 6 (Final) attached to ESA/C(2012)217</td>
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<td>RD6</td>
<td>Sentinel-1 Mission Requirement Document</td>
<td>ES-RS-ESA-SY-0007, issue 1 rev.4</td>
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3. **Sentinel Missions Background**

3.1. **Sentinel missions Overview**

The GMES Space Component currently comprises the following series of Sentinel missions.

The Sentinel series, in complement to relevant National, EUMETSAT and other Third Party Missions, have been designed in order to satisfy the user requirements for the implementation of GMES and National services. These services expressed the need for observation continuity and seamless access to data, redundancy in the context of an operational system and increased frequency of observations.

The Sentinel missions consist of:

- Sentinel-1: High-resolution radar imaging
- Sentinel-2: High-resolution multispectral imaging
- Sentinel-3: Medium-resolution multispectral imaging and altimetry
- Sentinel-4: Atmospheric composition monitoring from geostationary orbit
- Sentinel-5: Atmospheric composition monitoring from low-Earth orbit
- Jason-CS: High precision radar altimeter mission

This space observation infrastructure will ensure the continuity of observations enabling the gradual implementation of services in the area of land monitoring, operational oceanography, atmospheric composition monitoring, emergency response, security and climate change monitoring.
3.2. Sentinel missions objectives overview

3.2.1. Sentinel-1

The Sentinel-1 mission is based on a constellation of two satellites (A and B units). Sentinel-1 carries a C-band Synthetic Aperture Radar (SAR), and provides continuity of ERS and ENVISAT SAR types of missions. It allows all-weather and day/night imaging capability. SAR observations are key for operational applications over ocean, seas and polar areas (oil slick monitoring, sea-ice monitoring, ship traffic monitoring, ship routing, etc.). SAR observations are also used for land applications and provide data for emergency response and security, in particular under adverse weather conditions. SAR interferometry has proven scientific and operational value for terrain motion monitoring.

3.2.2. Sentinel-2

The Sentinel-2 mission is based on a constellation of two satellites (A and B units). Sentinel-2 provides continuity of Landsat and SPOT types of missions for GMES operational land services. Sentinel-2 is used for land applications such as land cover, usage and change-detection maps, and to derive geophysical variable maps (leaf chlorophyll content, leaf water content, leaf area index, etc.). It also provides data for emergency response and security.

3.2.3. Sentinel-3

The Sentinel-3 mission is based on a constellation of two satellites (A and B units). Sentinel-3 provides continuity of MERIS (ENVISAT), ATSR/AATSR (ERS/ENVISAT) and radar altimetry (ERS/ENVISAT) missions. Sentinel-3 is used for global land, ocean colour, sea/land surface temperature monitoring and sea-surface and land-ice topography.

3.2.4. Sentinel-4

The Sentinel-4 mission is based on a payload to be embarked on EUMETSAT Meteosat Third Generation (MTG) satellites. Sentinel-4 instruments will be accommodated on board the two MTG-S satellites (sounding mission satellites). Sentinel-4 is used for atmospheric composition monitoring from the geostationary orbit.

3.2.5. Sentinel-5 and Sentinel-5 Precursor

The Sentinel-5 mission is based on a payload to be embarked on the EUMETSAT Polar System Second Generation (EPS-SG) satellites. Sentinel-5 is used for atmospheric composition monitoring from a low-Earth polar orbit.

A Sentinel-5 Precursor satellite has the objective to limit the gap between the ESA ENVISAT mission and the Sentinel-5 mission.
3.2.6. Jason-CS

Jason-CS and Sentinel-3 form a complementary pair in which both are needed to provide the necessary accuracy for GMES. The Jason-CS spacecraft will be based on a platform derived from CryoSat-2 adjusted to the specific requirements of the mission, including the much higher orbit. The instrument suite will comprise a radar altimeter based on Sentinel-3 SRAL, a Microwave Radiometer (recurrent from Sentinel-3 but adapted to the higher orbit), a GPS device (recurrent from Sentinel-3), a DORIS receiver (recurrent from CryoSat-2) and a Laser Reflector (recurrent from CryoSat-2).

3.3. Data Policy

The main objective of the Sentinel Data Policy, as described in [RD2], is to establish full and open access to Sentinel data of the currently defined Sentinel missions, with free of charge license for the Sentinel data itself.

Such an approach aims at maximising the beneficial use of Sentinel data for the widest range of applications and intends to stimulate the uptake of information based on Earth Observation data for end users.

The principles of the Sentinel Data Policy have a substantial impact on the Sentinel overall operation strategy, as described in the following chapters.

The European Commission is preparing a “Commission Delegated Regulation on the access to GMES dedicated data and GMES service information”. A future version of the HLOP will make reference to this regulation and, if required, amend its content accordingly.

4. Operations Strategy

4.1. Scope

This chapter describes the Sentinel’s operations strategy and the measures taken to cope with the main constraints, limitations and potential conflicts related to the Sentinel missions, which have an impact on the operations.

Technical constraints, limitations and conflicts for Sentinel operations may occur due to:

- spacecraft design, e.g. instrument modes, on-board data management, downlink design
- ground segment design, e.g. related to facilities for data acquisition, product generation, product distribution
- operations conflicts across the Sentinels
- governance and funding approach, e.g. change of technical operations concept, budget limitation.

For each of the main relevant areas, including instrument observation/planning, acquisition, processing and dissemination, the following chapters (from 4.3 to 4.6) describe first the technical constraints and potential conflicts and second, the operations strategy.
Further operational constraints may arise in case of a reduced funding scenario leading to a reduction of operational availability.

4.2. **Overall Sentinel operations strategy**

The main objectives of the Sentinel operations strategy, which is based on the Sentinel Data Policy and the GSC Operations Concept, and for the various set of HLOP relevant activities (including planning, acquisition, production, dissemination) are:

- to provide data to GMES and National services according to their specified requirements
- to ensure systematic and routine operational activities with a high level of automation and with pre-defined operations to the maximum extent possible
- to minimize the number of potential conflicts during operations, therefore to solve anticipated conflicts a priori, in particular in the elaboration of the mission observation scenarios.

The Operations phase of Sentinel-1, -2 and -3 is based on a ramp-up approach in terms of exploitation capacity that will gradually increase over time. The ramp-up phase starts at completion of the first spacecraft launch and commissioning, and continues until the the Full Operational Capacity (FOC) is reached, with the constellation of the Sentinel-1, -2, -3 A and B-models as well as Sentinel-5P.

4.3. **Observation and instrument planning**

4.3.1. **General**

a) **Sentinel instrument operations constraints**

The main instrument constraints that have an impact on the operations, and require the elaboration of a planning strategy, are typically the exclusivity of instrument modes (Sentinel-1) and the instrument operations time limitations or sensing constraints.

b) **Sentinel observation and instrument planning strategy**

A robust and pre-defined Sentinel’s observation strategy is the tool to ensure predictable repetitive coverage and continuous data flow required by the GMES services. While by nature the instruments on board Sentinel-3, Sentinel-4 and Sentinel-5 (incl. Sentinel-5 Precursor) are continuously operated and feature relatively low to medium data rates, the implementation of a pre-defined observation strategy for the Sentinel-1 and Sentinel-2 missions requires careful analysis of the user needs and optimisation of the related space and ground resources. This is necessary due to the various constraints related to these missions, in particular the high data rates and volume generated, the instrument duty cycle, and other constraints and conflicts as identified below (SAR modes exclusivity, limitations in number of X-band switches, available
core ground stations network for data downlink, etc.), as well as requirements in terms of timeliness between sensing and downlink (real time, near real time, etc.).

A major objective in the operations of the Sentinel-1 and Sentinel-2 missions is therefore to implement, to the maximum feasible extent, a conflict-free instrument observation and planning scenario, aiming at fulfilling the observation requirements from the GMES and National services. These observations and planning scenarios are based on the latest status of requirements as derived from the mission MRDs, and complemented by the recurrent versions of the Data Access Portfolio Requirements (DAP-R) document [RD9] responding to the GMES Data Access Data Warehouse requirements [RD11], which develops in more detail the observation requirements as expressed by the individual GMES services. The process for collecting Sentinel observation requirements and for elaborating the observation scenarios is further detailed in Chapter 8.

Emergency observation requests in support to related GMES and National services are foreseen to be accommodated via data supplied by the better tailored GMES Contributing Missions. Furthermore, it is expected that such requests will also be satisfied by data already foreseen to be acquired as part of the pre-defined Sentinels observation scenario (see chapter 6.3). As a consequence it is not foreseen to alter the Sentinels-stable observation scenario in support of such emergency requests (this may occur in exceptional cases only).

4.3.2. Sentinel-1

a) Sentinel-1 instrument operation constraints

Mode exclusivity
The Sentinel-1 SAR features four exclusive imaging modes of operations:
- Interferometric Wide Swath (IW)
- Extra Wide Swath (EW)
- Strip Map (SM), with 6 possible incidence angles
- Wave (WV).

The first three modes can be operated in 4 different schemes of polarisation (2 in single and 2 in double): HH, VV, HH+HV or VV+VH. The Wave mode can operate only in single polarisation, either in HH or VV. Overall this represents 34 possible sub-modes of operations.

Mode transition time
A transition time, currently estimated in the order of 2.4 seconds (corresponding to roughly 17 km), is necessary to switch from a SAR measurement mode to another measurement mode, or to perform a change of polarisation. No data are acquired during this time interval.

Duty cycle
The Sentinel-1 SAR is capable of operating up to a total of 25 min per orbit in any combination of the IW, EW or SM modes, and up to the rest of the orbit in Wave mode.

Due to the above constraints, conflicts may therefore take place if different modes are required over the same (or adjacent) geographical area, or if the duty cycle limitation does not allow accommodating instrument mode (IW, EW or SM) over a geographical area. The transition
time constraint to switch from one measurement mode to another measurement mode may result in some imaging gaps of geographical areas.

b) Sentinel-1 observation and planning strategy

Based on the above constraints, the elaboration of a pre-defined Sentinel-1 mission observation scenario requires solving, a priori and systematically, the identified conflicts between the observations requirements.

This scenario shall make optimum use of SAR duty cycle, taking into account its limitation, as well as potential limitation in the number of X-band switches (see chap 4.4.2) and the constraint of transition times between measurement modes.

The Sentinel-1 mission observation scenario during full operations capacity is based on the following principles for each satellite:

- Wave Mode continuously operated over ocean, with lower priority w.r.t. the other modes
- IW or EW modes operated (for a total duration of up to 25 min per orbit) over pre-defined geographical areas:
  - Over land: the pre-defined mode is IW
  - Over oceans, seas and polar areas: the pre-defined mode is either IW or EW
  - If possible, use of single polarisation is adopted in order to give priority to the coverage extent and, if relevant, to facilitate the data acquisition strategy. Note: it is recognised that the use of dual polarisation improves some applications such as sea-ice monitoring or ship detection, however using dual polarisation in real time (which require the use of both RF channels – see chap 4.4.2.a) has a strong impact on the overall acquisition scenario.

The observation scenario shall take into account the preliminary status of the mission with the Sentinel-1A in orbit, and the Full Operational Capacity (FOC) with both Sentinel-1A and Sentinel-1B in orbit.

During FOC operations, in order to optimise the average revisiting and coverage frequency, the two satellites are placed in the same orbit but with a mean anomaly delta of 180 deg. This results in a repeat cycle of 6 days for the 2-satellite constellation. This phasing is of particular benefit for InSAR applications (interferometric pairs every 6 days) and for maritime surveillance and sea-ice monitoring applications (increased average revisit time).

A high level description of the Sentinel-1A observation scenario covering the first 6 months of the ramp-up phase (which starts at completion of the satellite commissioning phase) is provided in the Attachment of the current version of this HLOP.
4.3.3. Sentinel-2

a) Sentinel-2 instrument operation constraints

There is only a simple relevant constraint on the operations of the MSI instrument, related to the normal functioning of the sensor: MSI data are systematically acquired during daylight portions of the orbit where the target surface has a Sun Zenith Angle below a certain threshold (currently being specified at 83 deg.). Different illumination conditions will hence derive seasonal patterns and lead to varying acquisition scenarios according to summer solstice, winter solstice and autumn/spring equinoxes.

b) Sentinel-2 observation and planning strategy

The Sentinel-2 instrument has been designed based on a pre-defined observation scenario as required in the MRD [RD7], to cover all land surfaces between 56° South latitude (Cape Horn in South America) and 84° North latitude (north of Greenland) including major islands (greater than 100 km2 size), EU islands and all the other small islands located at less than 20 km from the coastline, the whole Mediterranean Sea as well as all inland water bodies and closed seas. The actual Sentinel-2 observation scenario during full operations capacity for each satellite is elaborated from these requirements, and will be defined in more detail based on further requirements from the GMES and National services, to derive associated continental to regional observation areas and priorities, coverage repetitiveness (e.g. systematic or with a specific mapping frequency), seasonal variations, as well as timeliness for various areas etc.

This scenario accounts for the limitation in the number of X-band switches (see 4.4.3).

The observation scenario shall take into account the preliminary status of the mission with the Sentinel-2A in orbit, and the FOC with both Sentinel-2A and Sentinel-2B in orbit.

During FOC operations, in order to optimise the average revisiting and coverage frequency, the two Sentinel-2 satellites are placed in the same orbit but with a mean anomaly delta of 180 deg. This results in a repeat cycle of 5 days for the 2-satellite constellation.

A high level description of the Sentinel-2 observation scenario, both during the ramp-up phase and the full operations will be attached to a future version of this document.

4.3.4. Sentinel-3

a) Sentinel-3 instruments operation constraints

There are no major relevant constraints on the operations of the Sentinel-3 instruments, other than operating the OLCI and the visible channels of the SLSTR based on specific solar illumination conditions:

- OLCI operates during daylight, therefore during the descending part of the orbits, with a Sun Zenith Angle of the sub-satellite point of less than 80 deg. (and taking into account the seasonal variations), representing 44% of the time
- The SLSTR visible channels acquired data out of eclipse only (all infrared and SWIR channel acquired data permanently).
b) Sentinel-3 observation and planning strategy

The spacecraft routine operation is highly autonomous in the sense that no frequent space to
ground dialogue is required by the nominal missions of Sentinel-3. The Sentinel-3 instruments
provide the sensing of the data autonomously on-board the spacecraft on the basis of
predefined geographic data and selection of observation mode depending on the surface over
which the spacecraft is flying. This mode of operation does not require any specific request
from users, and ground-based routine operations planning of the spacecraft is extremely
simple. The Sentinel-3 instruments autonomously perform systematic and continuous sensing
as follows:

- The OLCI instrument acquires data over daylight part of the orbit (i.e. for a Sun Zenith
  Angle below 80 deg)
- The SLSTR instrument operates the infra-red and SWIR channels over the whole orbit,
  and the visible channels out of eclipse only
- The SRAL instrument acquires data over the whole orbit with a pre-defined split
  between Low Resolution Mode (LRM) and SAR mode. Mode switching between LRM
  and SAR is made automatically along the orbit, and ensures optimum observation of
  the different target surfaces (coverage needs will be provided in a next release of the
  document). Upon formal request from the EC, an operations concept based on an
  increased use of the SRAL SAR mode over the oceans may be implemented. This
  aspect is under analysis at the time of writing the present version of this document.
- The MWR instrument operates over the whole orbit.

These autonomous operations are based on on-board mechanisms controlling the various
instrument mode transitions as a function of the satellite orbital position.

4.4. Data acquisition

4.4.1. General

a) Data acquisition constraints

The main constraints related to acquisition and on-board data management system are:

- Volume of data generated on-board and to be downlinked and acquired, especially in
  the case of Sentinel-1 and Sentinel-2, and to some extent in the case of Sentinel-3
- Possible conflict between parallel downlink of real time data and of on-board recorded
  data
- Limitation of the number of X-band downlink switches, maximum downlink time per
  orbit and maximum consecutive downlink time
- Number and geographic location of ground stations, concurrent use of the stations by
  the Sentinel satellites and possible downlink frequency interferences between the
  Sentinel satellites
- Capacity and availability of the EDRS system, concurrent use of the EDRS system by the Sentinel-1A, -1B, -2A and -2B satellites, simultaneous downlink via EDRS and X-band.

b) Data acquisition strategy

The data acquisition for each of the Sentinel missions relies on a network of X-band core ground stations and, regarding Sentinel-1 and Sentinel-2, on the use of the EDRS system. The EDRS system will complement the data acquisition scenario for the Sentinel-1 and Sentinel-2 missions. The network of core stations for Sentinel-1, -2 and -3 includes Matera (e-GEOS), Maspalomas (INTA), Svalbard (KSAT) and Alaska - Prudhoe Bay (KSAT).

For the Sentinel-1 and Sentinel-2 missions, the data acquisition strategy heavily depends on the respective mission observation scenarios, and reversely, constraints related to the data acquisition capacity may affect and require refinement of the observation scenarios.

The sizing of data acquisition and downlink will take into account the available operations funding resources, impacting the deployment and use of the core stations network and the overall downlink capacity, which, in turn, will affect the affordable observation scenario.

4.4.2. Sentinel-1

a) Sentinel-1 data acquisition constraints

Data volume
The potential operation of up to 25 min of SAR data per orbit among IW, EW or SM modes, with instant average data rate in the order of 430 Mbps (i.e. for IW mode with the use of dual polarisation), leads to a very large amount of data to be recovered on ground (corresponding to about 2.4 TBytes of compressed raw data per day in FOC with both Sentinel-1A and Sentinel-1B operating in parallel at the maximum duty cycle). The use of single polarisation and/or EW mode leads to a decrease in the overall data volume.

Data rate versus X-band downlink capacity
The spacecraft X-band downlink system comprises two X-band channels at 260 Mbps (each) of useful data. The FDBAQ (Flexible Dynamic Block Adaptative Quantisation) on-board data compression allows reducing the SAR data rates from all modes. Swath 1 of the SM mode features however, in dual polarisation, a data rate greater than the total X-band channel capacity. This constraint requires buffering the data in the on-board memory. The SM mode Swath 1 is however not planned to be normally used as part of the pre-defined observation scenario (see 4.3.2. b)) and will be commanded only in specific exceptional cases.

Downlink conflict
Conflict may occur between real time downlink and downlink of recorded data, in case of real time downlink of dual polarisation data (requiring the use of both X-band RF channels, i.e. one assigned to each polarisation).
On-board data management
The on-board data management allows prioritising data downlink. However it does not provide a precise ground control of data to be downlinked at each ground station, due to the necessary use of the FDBAQ compression.

On-board memory sizing
The total available on-board memory size (1410 Gbits) allows the storage of more than all SAR data that could be acquired within one orbit (considering a total of 25 min of SAR operations per orbit from IW, EW or SM modes and the rest of the orbit in Wave mode). This sizing requires, as a general rule, to avoid accumulating recorded data over several orbits, i.e. the dumping strategy should permit the dump of all recorded data of an orbit during the following orbit.

X-band duty cycle
As per the current baseline, the spacecraft thermal and power/energy accommodation of the X-Band System allows a maximum downlink time per orbit of 30 min, with a maximum of 20 consecutive minutes.

Limited number of X-band downlink switches
The X-Band system is specified for an overall number of operation cycles (from standby to operation and back) equal to 150,000 for the mission lifetime. This constraint results in an average number of maximum 4 switches per orbit considering 7 years lifetime (and maximum average of 2.4 switches per orbit considering the extended lifetime of 12 years). This constraint has an impact on the number of non-overlapping downlink passes per orbit and on the detailed definition of the observation scenario, i.e. on an orbit basis. In addition, specific real time downlink requests over local stations might not be satisfied due to this constraint.

Network of ground stations
The network of selected ground stations and their effective use may constrain the final achievable downlink capacity, thus the maximum effective instrument duty cycle operations, resulting in an impact on the observation scenario. The capability to ensure real time or near real time timeliness also depends from the ground station network.

b) Sentinel-1 data acquisition strategy
The Sentinel-1 data acquisition strategy during full operations will be described, at high level, in a future version of the HLOP. It is closely linked to the systematic and pre-defined observation scenario (chapter 4.3.2.b), and, naturally, to the network of core ground stations. During the first 6 months of the ramp-up operations phase of Sentinel-1A, the Svalbard and Matera core stations will be used to acquire the data (as per high level observation scenario described in the Attachment to the current version of the HLOP).

The data acquisition scenario also requires taking into account the real-time transmission of data to stations part of the collaborative ground segment, i.e. beyond the core ground segment downlink facilities.
4.4.3. Sentinel-2

a) Sentinel-2 data acquisition constraints

Data volume
The combination of the large swath (290km), spectral range (13 bands from the visible to the short-wave infrared), spatial resolution (10/20/60m), coupled with the global and continuous acquisition requirement with high-revisit frequency, leads to the daily generation of 1.6 TBytes of compressed raw image data from the 2-satellite constellation. This corresponds to an average continuously sustained raw-data supply rate of 160Mbps.

Downlink conflict
The observation and downlink strategy for Sentinel-2 needs to be able to consider 3 types of data downlink:

- A Real-Time (RT) downlink may be commanded so as to forward the MSI real-time 490 Mbps data stream directly to the transmission system
- The MSI data may be buffered on-board at the same time to allow for a repeated downlink by playback at a later stage.
- The MSI data recorded on-board may be prioritised as Near-Real-Time (NRT) data into the playback queue so as to ensure it is downlinked as early as possible, rather than following the regular First-In First-Out (FIFO) nominal approach.

Conflict may occur between (near-)real time downlink and downlink of recorded data, as all modes make use of the 2 X-band RF channels at 260 Mbps in parallel.

X-band duty cycle
As per the current baseline, the satellite thermal and power/energy accommodation of the X-Band System is capable of at least 24 minutes of continuous downlink per orbit. (This limit will be better qualified at a later stage and it is already expected that 30 minutes should be achievable after characterisation and tuning of system parameters).

Limited number of X-band downlink switches
The constraint is the same as for Sentinel-1 (see previous chapter).

Network of ground stations
This constraint is similar as in the case of Sentinel-1 (see previous chapter).

b) Sentinel-2 data acquisition strategy

The Sentinel-2 data acquisition strategy during ramp-up and full operations will be described, at high level, in a future version of the HLOP. It is closely linked to the systematic and pre-defined observation scenario (chapter 4.3.3.b), and, naturally, to the network of core ground stations.

The data acquisition scenario also requires taking into account the real-time transmission of data to stations part of the collaborative ground segment, i.e. beyond the core ground segment downlink facilities.
4.4.4. Sentinel-3

a) Sentinel-3 data acquisition constraints

There are no major relevant constraints for Sentinel-3 data acquisition, apart from the appropriate selection of the X-band core stations in order to support the required contact time for data download. The X-band system used for Sentinel-3 is identical as for Sentinel-1 and Sentinel-2; the simple downlink strategy to the core ground segment implemented for Sentinel-3 is not affected by the limited number of X-band downlink switches like in the case of Sentinel-1 and -2.

b) Sentinel-3 data acquisition strategy

The data acquisition and recovery strategy is based on recording the instrument data over a complete orbit and dumping the recorded data to one or several core ground stations, without making use of the real time transmission of the data. First estimate, considering the X-band RF channel capacity, leads to a need for about 6 minutes station contact time per orbit to download the recorded data from all instruments. This figure may be increased depending on the decision to adopt an operations concept based on an extended use of the SRAL SAR mode over oceans (see chapter 4.3.4).

The set of core ground stations to support the downlink scenario during ramp-up and full operations will be described in a future version of the HLOP. The current constraints allow for the use of a single core ground station at high latitude.

Local ground stations, part of the collaborative ground segment, are able to receive Sentinel-3 data, typically to fulfil local needs for NRT data access. The baseline operations concept foresees that all data downlinked at the local ground stations are also downlinked to the core ground station network, avoiding the need for data repatriation. The limited number of X-band downlink switches may constrain the direct downlink capability to collaborative ground stations.

4.4.5. Sentinel concurrent access to X-Band stations

a) Downlink conflicts between Sentinels

Potential conflicts among Sentinels are anticipated for the share of X-Band resources considering that the GSC operations concept aims at maximising common and interoperable usage of ground segment resources. This particularly applies to the common use of X-Band ground stations among the Sentinels, as the data rates introduced by the Sentinel missions and the dual spacecraft approach for each mission require, overall, a large number of X-Band station contacts to recover the data on-ground.

b) Strategy

The Sentinel ground segment shall plan the X-band downlinks taking into account the above described potential conflicts. Considering these conflicts are fully deterministic (for a given station network) and the conflict pattern repeats after a given number of cycles, it is assumed
that this conflict-free coordination among Sentinels will be static to a large extent (e.g. on a six months basis).

4.4.6. EDRS

a) Operations constraints for EDRS use

The high level operation constraints related to the use of the EDRS system by the Sentinel-1 and Sentinel-2 missions will be described in a future version of the HLOP. They will cover, among others:

- number and location of EDRS satellites
- available data rates / channels / time slots, relevant for potentially both real-time transmission and downlink of recorded data
- on-board conflict of memory data downlink through X-band with memory data downlink through EDRS
- conflicts related to concurrent access between Sentinel-1 and Sentinel-2 satellites
- time to establish the link between a Sentinel-1 or Sentinel-2 satellite and an EDRS satellite.

b) Strategy for EDRS use

The use of EDRS for data downlink for the Sentinel-1 and Sentinel-2 missions represents an important complementary capacity with respect to the X-band stations network. It brings flexibility in the elaboration of the downlink scenarios and in order to support real-time services (in particular for Sentinel-1).

Further close coordination with the EDRS system management is required to establish the use of the EDRS service for the Sentinel-1 and Sentinel-2 missions. This will result in the agreement on pre-defined available EDRS time slots at static times along the orbits of the Sentinel-1 and -2 satellites. The resulting strategy will be described in a future version of the HLOP.

4.5. Data production

4.5.1. General

a) Data production constraints

The main constraint on data production is related to the requirement to systematically generate and make available products from all acquired data within specific timeliness. A subset of data products is to be made available within 3 hours from sensing, or less in very specific cases.

b) Data production strategy

All acquired Sentinel data will be systematically processed to a pre-determined product level for each sensor type (typically Level 1), and archived. The sizing and the timeliness of the production as well as the online retention time will take into account the available operations
budget. The systematic character of the production allows achieving a stable and deterministic production scenario.

The exceptions to this pre-defined scenario are:
- for Sentinel-1, the handling of specific, on-demand and urgent production request related to an rush emergency situation
- campaigns of data re-processing, necessary following major updates of processing algorithms or auxiliary data for all Sentinel missions.

4.5.2. Sentinel-1

a) Sentinel-1 data production constraints

Sentinel-1 data production constraints include:
- High volume of data to be processed and large processing resources needs
- Systematic and short processing timeliness
- Need for reprocessing campaigns.

b) Sentinel-1 data production strategy

The systematic processing approach allows the systematic generation of a pre-defined set of Level-1 and Level-2 products after acquisition (either in NRT or within 24h), with no ordering required for each product to be generated. The set of products to be systematically generated respond to the different requirements of the GMES services and allows generating several products with different characteristics for the same data take. This systematic processing approach is also used in case of a reprocessing campaign, to update the Level-1 and Level-2 products archive, after major processing algorithm changes to ensure a long-term harmonised data set quality (note: reprocessing resources will be sized according to the operational budget during the ramp-up and FOC phases). On-demand production capability from historical Level 0 products (greater than 24 h) for product different than those systematically generated (e.g. level 1 SLC products are generated over regional areas of interest only) will be available and sized (in terms of resources and users having access to them) according to the operational budget and evolving requirements.

Systematic product generation is based on the following types of processing:

- systematic NRT 10 min. processing to Level 0 (in practise, such timeliness is implemented by collaborative ground segment stations)

- systematic NRT 1h/3h processing for a subset of the acquired data

- systematic 24h processing for all data acquired to a pre-defined Level-1/2 products (note: SLC products are generated over regional areas of interest only).

In a next release of the document, the HLOP will define:

- the areas related to systematic regional production of level 1 SLC products, to support interferometric applications in particular
- the regional areas for NRT 1h/3h product generation.

For the first 6 months of the ramp-up phase a preliminary indication of the above information is provided at high level in the Attachment to the current HLOP version.

4.5.3. Sentinel-2

a) Sentinel-2 data production constraints

Similarly to Sentinel-1, the main Sentinel-2 data production constraints include:
- High volume of data to be processed and large processing resources needs
- Systematic and short processing timeliness
- Need for reprocessing campaigns.

b) Sentinel-2 data production strategy

The production strategy is similar as for Sentinel-1 apart from the on-demand production (for the specific case of Sentinel-1 level 1 SLC). Differences may occur for reprocessing in the case of Sentinel-2 with regard to orthorectified products in cases where e.g. new auxiliary data (e.g. Reference maps or Digital Elevation Models) become available.

Generally all data acquired by the MSI from the Sentinel-2 constellation will be systematically processed up to level-1C.

In next releases of the document, the HLOP will define during ramp-up and full operations the regional areas for NRT 1h/3h product generation.

4.5.4. Sentinel-3

a) Sentinel-3 data production constraints

The Sentinel-3 main data production constraints include:
- Flow of data from 4 different instruments and requirements related to production timeliness
- Need for reprocessing campaigns.

b) Sentinel-3 data production strategy

The systematic processing approach allows the systematic generation of Level-0 products and of a pre-defined set of Level-1 products after acquisition. No ordering from users is required for each product to be generated.

The set of products to be systematically generated responds to the different requirements of the GMES services and allows generating land and marine Level-2 products with different geophysical parameters from the same Level-1 input data. This systematic processing approach
is also used in case of a reprocessing campaign, to update the Level-1 or higher level products archive, after major processing algorithm changes to ensure a long-term harmonised data set.

4.6. **Data dissemination**

a) **Data dissemination constraints**

The main constraint related to data dissemination is related to the huge volume of processed Sentinel data, to be widely accessible on-line by the users (see data policy, chapter 3.3). Measures must be taken to avoid conflicts and network congestions in downloading the products.

b) **Data dissemination strategy**

All acquired Sentinel data will be systematically disseminated with on-line access by users, according to the principles of the Sentinel data policy. Sentinel data will be made available for GMES and National use and, in line with the Sentinel data policy and within available operational budget, for other use (e.g. scientific, international, etc.).

The distributed implementation of the product dissemination during FOC, involving several core centres, allows decentralising the dissemination function. Regular review of the dissemination performance is a pre-requisite for the evolution of the network of centres in charge of dissemination, avoiding problem of network bottleneck in particular.

Enhanced data dissemination, including e.g. Centralised Data Pick Up Points, mirror sites, additional distribution nodes as part of the collaborative ground segment, could further ease the access to data by end users. This concept, to be further addressed in a future version of the HLOP, is planned to be implemented, starting during the ramp-up phase and particularly during the FOC phase, with the support of partners for:

- National or regional re-distribution by partners within Member States
- regional re-distribution (e.g. one main entity to serve US users)
- specific user community or large research projects
- etc.

5. **Cooperation**

Specific cooperation is planned with missions having similar mission characteristics and data policy compared to the Sentinels, as well as a similar way to operate (e.g. pre-defined observation scenario). A high level description of the relevant cooperation is the object of the following three sub-chapters regarding Sentinel-1, Sentinel-2 and Sentinel-3.

Note: such cooperation comes on top of the involvement of GMES contributing missions (from Member States in particular e.g. Terrasar-X, Tandem-X, Cosmo-Skymed, Paz, Radarsat-2, Rapideye, Spot-4/5/6/7, DMC, Deimos, Ingenio, Pleiades, etc) for which data access contracts are placed.
5.1. Cooperation on the Sentinel-1 mission

The basic description of the envisaged cooperation between the Sentinel-1 mission and the future Radarsat Constellation Mission will be provided in a future version of the HLOP. The main objective is to define and implement complementary observation scenarios between Sentinel-1 and RCM for the respective benefits of the Canadian and European users in particular.

5.2. Cooperation on the Sentinel-2 mission

Cooperation is planned between the Sentinel-2 mission and the Landsat Data Continuity Mission, in particular regarding product harmonisation between both missions. Further details on the envisaged cooperation will be provided in a future version of the HLOP.

5.3. Cooperation on the Sentinel-3 mission

The basic description of the envisaged cooperation between the Sentinel-3 mission and other relevant missions (such as potentially PROBA-V) will be provided in a future version of the HLOP.

6. Priorities for accessing Sentinel resources

6.1. Scope

The extent of the Sentinel data access is constrained by:

- the technical constraints of the space and ground segments (see chapter 4 for high level constraints)
- the limitations in financial resources during the development and operations phase.

The access to Sentinel data will be complemented by the contributions by collaborative centres or stations, including national ground segment functionalities, and by GMES services.

One main objective of the Sentinel operations strategy is to ensure systematic and routine operational activities with pre-defined operations to the maximum extent possible, anticipating and avoiding conflicts during operations through the Sentinel observation scenarios. Priorities are used for the definition of the observation scenario and for the implementation of exceptional emergency requests in the case of Sentinel-1.

6.2. Priority scheme

The priority scheme relies on the GSC Programme Declaration [RD1] and would be used for managing conflicting user requirements for accessing Sentinel missions' resources. Today it is expected that most of the potential conflicts can be solved by appropriate planning of shared resources among the 2-spacecraft Sentinels constellation.

The following Sentinel data use is foreseen:
- **GMES use**: this data use is related to GMES service providers, responding to the GMES governance. It consists of all “GMES services” approved by the EC.

- **National utilisation** by ESA Participating States in accordance with the GMES Space Component Programme Declaration [RD1]

- **Other use**:
  1. Cooperation agreements with international collaborative ground segment partners, responding to present and future data requirements.
  2. Use by the scientific community
  3. Other use.

Cooperation agreements, such as the ones envisaged under “other use” i), are subject to the applicable ESA approval procedures.

The following priorities, in descending order, are assigned:

<table>
<thead>
<tr>
<th>Priority</th>
<th>Data use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (first priority)</td>
<td>GMES use and National utilisation by Participating States in accordance with the GMES Space Component Programme Declaration [RD1]</td>
</tr>
<tr>
<td>2</td>
<td>Other</td>
</tr>
</tbody>
</table>

In all cases, the Sentinel data are available free of charge and following acceptance of the Terms and Conditions for the use of the data.

### 6.3. Handling of Sentinel-1 emergency observations

In the case of the Sentinel-1 mission only, emergency observations may have to be handled. The Sentinel-1 observation strategy is based on a pre-defined observation scenario, fulfilling the GMES and national user needs known and agreed in advance, based on the priority scheme described in chapter 6.2.

The Sentinel-1 pre-defined observation scenario is set-up anticipating observations on a systematic basis for the main types of disasters over land, i.e. earthquakes, volcanoes and flooding. As part of the overall GSC operations, it is indeed assumed that on-demand ad-hoc requirements for emergency and security purpose, user requests will be fulfilled by very high resolution observation (typically less than 5 meters) from optical and SAR (X-band in particular) GMES contributing missions.

Whereas the Sentinel-1 operations can technically cope with specific user emergency requests, support of such requests by the Sentinel-1 mission will be made in exceptional cases only following the provisions defined below.
Users entitled to submit Sentinel-1 emergency / security requests are:
- the GMES emergency core service
- the GMES security services.

In addition, in the event of urgent observation requirements arising in association with a disaster and in case this event is neither supported by the pre-defined observation scenario nor by the data acquired via GCMs, the Sentinel-1 Mission Manager may allocate specific requests for SAR operation and product generation. This may include specific requests from Member States or National services, EMSA or from the International Charter for Space and Major Disasters.

The following criteria shall be met and assessed by the Mission Manager for deciding that a particular event should be supported by specific Sentinel-1 observation, if not yet in the pre-defined observation scenario:

1. The event is recognised as a disaster (e.g. may induce danger on human life, may have important environmental or security consequences, etc.)

2. The satellite data are of help during the crisis phase of the event

3. The satellite data are required by disaster management authorities with short response time with respect to the event.

4. The satellite data is not foreseen to be acquired by the Sentinel-1 pre-defined observation scenario and can not be provided by one of the GMES Contributing Missions.

In these cases, the required Sentinel operations will have priority over the standard and pre-defined observation scenario.

Effort shall be made to minimize these observations to the strict necessary duration and to avoid overriding the pre-defined observation scenario.

The following priorities, in descending order, are assigned for the Sentinel-1 mission operations:

<table>
<thead>
<tr>
<th>Priority</th>
<th>Originator/category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (first priority)</td>
<td>Spacecraft safety</td>
</tr>
</tbody>
</table>
| 2        | Emergency Observations (no specific priority is applied among the items of the list below):  
                   - GMES emergency core service  
                   - GMES security services  
                   - Other cases as defined above, handled through the mission management. |
| 3        | Pre-defined observation scenario                        |
7. **Mission management**

The following principles apply for the management of the Sentinel mission operations:

- The HLOP provides the ground rules for the allocation of Sentinel resources, within the mission operations constraints. The detailed definition of these activities and therefore the detailed planning of spacecraft and ground segment operations will be implemented accordingly.

- Problems of interpretation of the HLOP documentation, appearing in the day to day planning of the mission, will be solved by the relevant Mission Managers as required, and confirmation sought at the first following DOSTAG meeting, or any other body according to the GMES governance rules.

- If deviations are required with respect to HLOP rules and dispositions, two cases should be considered:
  - occasional deviations, which do not imply a revision of the HLOP: the Mission Managers can authorise such deviations
  - deviations which require a (permanent) revision of the HLOP. If required, as a matter of urgency, the Mission Managers can authorise the implementation of such deviations, establishing a temporary rule to be applied.

The reporting and consultation mechanism with the EC will be included in a future version of the HLOP, based on the EU-ESA agreement covering the GSC operations.

8. **Process for defining the Sentinel observation scenarios**

8.1. **Scope**

The process for collecting Sentinel observation requirements and for elaborating the observation scenarios is established in accordance with the Declaration of the GMES Space Component Programme (RD1) and the Joint Principles for a GMES Sentinel Data Policy (RD2). Based on the operations guidelines and constraints described in Chapter 4, the elaboration of observation scenarios is required for the Sentinel-1 and -2 missions. Considering the nature of the mission and instruments operations, the definition of the Sentinel-3 observation scenario is straightforward and therefore this process can be simplified.

8.2. **Collection of observation requirements**

The objective of this exercise is to discuss and collect with a good level of details the observation requirements from the various user groups, starting with the GMES and National services. This allows further detailing the requirements as derived from the Mission Requirements Documents (MRDs).

Five main groups of requirements are identified as follows:

- GMES services and “GMES use” as defined by the European Commission
- National services and use by ESA and EU Member States in accordance with the GSC Programme Declaration
- Scientific use, e.g. on-going ESA projects, continuity of ERS/ENVISAT (Sentinel-1)
- Contribution to international initiatives, bi-lateral international cooperation
- Other use including use for commercial value-adding.

Table 1 below summarises these categories and indicates the mechanisms and forum for collecting the requirements.

<table>
<thead>
<tr>
<th>Group</th>
<th>Source of Requirements</th>
</tr>
</thead>
</table>
| GMES services and GMES use                              | - Extrapolation of GMES Data Access Data Warehouse requirements  
- Direct discussions with GMES services and EU Agencies (e.g. EMSA)                                                                                     |
| National services and use by ESA and EU Member States   | - Discussions with Member States Delegations  
- Reply to Collaborative Ground Segment questionnaire (in the framework of the GOCG)                                                                         |
| Scientific use, on-going projects, continuity of ERS/ENVISAT | - Recommendations from scientists at key SAR workshops (FRINGE, SEASAR), Sentinel-2 and -3 workshops, SEN4SCI, etc.  
- ESA GSE Projects (e.g. Polar View, MARISS, Terrafirma, GMFS, etc.)  
- Glob-series projects, CCI, SEOM, etc.  
- Extrapolation of ERS/ENVISAT projects                      |
| International Initiatives, International cooperation    | - GEO, CEOS, IGOS, FAO, FCT, GFOI, REDD, PSTG, IICWG, GCOS, CliC, TIGER, DRAGON, Geo-hazard Supersites, etc.  
- Requests from international partners (e.g. US (NOAA / NASA / USGS), Australia, China, etc.)       |
| Other use including use for commercial value-adding     | - EARSC, etc.                                                                                                                                                |

Table 1 – Source of Sentinel observation requirements

### 8.3. Elaboration of the observation scenarios

Based on the collected observation requirements, a series of simulations are performed to elaborate the Sentinels observation scenarios, taking into account the priority scheme as defined in Chapter 6.2. In addition to the instrument planning and coverage maps, the simulations also cover the elaboration of the data downlink scenarios within both the technical constraints described in Chapter 4 (satellite, instrument, ground segment, EDRS) and the
potential budget constraints that translate into technical constraints (e.g. potential reduction of the station operations).

8.4. Evolution of the Sentinel observation scenarios

It is planned to define and implement a stable observation plan for the benefit of the (operational) users. Nevertheless, regular revisions and adaptations of the observation scenarios will be necessary, both within the ramp-up phase and during the full operations phase, as follows:

From Space Segment Commissioning phase to full routine operations capacity of the first A satellites:

- an observation / operations scenario allowing to carry out the satellite commissioning activities will support the phase E1
- ramp-up phase: the scenario will gradually evolve in line with the ground segment operational capacity and incorporating the priority user requirements (GMES, National) to reach the routine exploitation of the first satellite.

Evolution during GSC operational phase, to cope in particular with:

The main system capacity scenarios, including:

- the inclusion of the second Sentinel satellite leading to the Full Operational Capacity of the missions with the 2-satellite constellation
- for Sentinel-1 and -2, the gradual use of the European Data Relay System (EDRS) to improve the data download capacity

- The evolution of the requirements from the GMES services, the evolution of the “perimeter” of the GMES services as defined by the European Commission
- The evolution of national requirements from ESA/EU Member States, to satisfy in particular the collaborative ground segment activities
- The evolution of the requirements from the other sources
- The constraints on the use of the space and ground segment resources (e.g. core and collaborative ground station networks)
- At a later stage, regarding Sentinel-1, the contribution of (and interoperability with) the Radarsat Constellation Mission (RCM) from the Canadian Space Agency.
ANNEX

Indicative Sentinel observation scenario for the first 6 months of the Sentinel-1 exploitation phase

For information

1. **Scope**

The scope of this note is to provide for information a description of the Sentinel observation scenario planned to be gradually implemented during the first 6 months of the Sentinel exploitation phase (phE2). Based on the current Sentinels launch schedule, this phase corresponds to the first 6 months of ramp-up phase operations for Sentinel-1A that will follow the satellite In-Orbit Commissioning Review (IOCR).

Important: the presented scenario is based on a number of assumptions including the availability of the related operations funding. Furthermore, it is based on the current best knowledge of the GMES and national requirements, and is therefore to be considered preliminary and indicative. It may be refined up to the effective start of the exploitation phase at IOCR.

2. **Assumptions and constraints**

The preliminary observation scenario to be gradually implemented during the first 6 months of the ramp-up phase is based on the following assumptions and constraints:

- The availability of the Matera and Svalbard core ground stations (the Maspalomas and Alaska stations will be included during the ramp-up phase)

- An average downlink capacity of 6 min/orbit of data download. This constraint leads to a number of possible durations of average SAR duty cycle in the high rate modes, depending on the selected mode (IWS, EW, SM), the polarisation option (single or dual) and the timeliness requirements (real-time transmission or on-board recording): e.g. 8 min of IW in dual polarisation, or 16 min of IW in single polarisation, or 25 min of EW in single polarisation, etc.

- A clear priority given to GMES services / projects and GMES use, as well as to National services and use by ESA and EU Member States, as stipulated in the Sentinel HLOP.

- This observation scenario starts at the end of the satellite commissioning phase (IOCR), typically 3 months after launch, and assumes a Payload Data Ground Segment (PDGS) still under commissioning with, in parallel, on-going activity of operational user products
quality verification, calibration and validation. This latter activity is foreseen to last about 6 months after the end of the satellite commissioning phase.

- A basic set of observations supporting future operational services (e.g. oil spill monitoring) is implemented from the beginning of the ramp-up phase for testing and validation purpose, including related core PDGS operations.

- A gradual increase of the PDGS capacity, regarding the production in particular.

3. High level description of the Sentinel-1A preliminary observation scenario

3.1 Observations

Coverage of Europe, European waters, and North Pole

- A full coverage of European land and seas is performed at each repeat cycle to support many GMES (core and downstream) and national activities. A careful selection of the passes is made to ensure an optimisation of the coverage reducing the overlaps between passes. A full coverage is ensured every repeat cycle both in ascending and descending passes. The selected mode and polarisation is IWS VV (initially single polarisation), with long segments acquired over Europe and the Mediterranean Sea / western waters without mode switch to avoid data gap either on the coasts or on the water coastal areas (some exceptions with the Baltic Sea, see below). The polarisation VV is chosen as better suited for oil spill monitoring and wind / wave monitoring, while for land key applications based on InSAR, the difference is minor between vertical and horizontal polarisation.

- On the western European waters observed by orbits not crossing the European coasts, and outside the sea-ice monitoring areas, the background selected mode is EWS VV+VH to allow oil spill monitoring and wind-wave monitoring. Some exceptions may occur along some particular areas (e.g. western and northern Norwegian waters, waters around UK and Ireland), for which the IWS (VV or VV+VH) is selected for some passes.

- For sea-ice monitoring (MyOcean and national services) the best mode is EWS HH+HV (GRD product in medium resolution at 90 m), systematically used for all passes in both ascending and descending to get the maximum revisit time (with an optimisation in the far North where overlaps are very frequent). In the particular case of the Baltic Sea for sea-ice monitoring requiring EWS HH+HV as well (activities performed in winter for typically 7-8 months in the Northern part and 2-3 months in the southern part), all the passes in descending are assumed, and half the passes in ascending orbits; the other half of the ascending passes are made in IWS VV (which is the default mode over land) to avoid switching between land and sea. It should be noted that the scenario takes into account the variations of the sea-ice monitoring areas of interest during the year.

- A specific strategy is also adopted regarding Greenland waters and Greenland ice sheets: e.g. the requirement to have a monthly coverage of Greenland ice sheet in IWS HH is implemented with the selection of some passes concentrated during few days only which are also used – without mode switch to avoid data gap – for sea-ice and iceberg monitoring (IWS medium resolution GRD product).
Note: like for the Antarctica case (see later), the monitoring of fast moving glaciers of the Greenland ice sheet may rather require less regular mapping (3 to 4 times a year) but concentrated during short periods of time (3 to 4 consecutive cycles). The availability of the 2-satellite constellation will ease the implementation of the related observation requirements.

The above observation plan is illustrated on the following figures.

Europe and European waters – EWS mode, ascending orbits over a 12-day repeat cycle (January)

Europe and European waters – EWS mode, descending orbits over a 12-day repeat cycle (January)
Europe and European waters – IWS mode, ascending orbits over a 12-day repeat cycle (January)
(coverage of Greenland ice sheet every 2 or 3 repeat cycles)

Europe and European waters – IWS mode, descending orbits over a 12-day repeat cycle (January)
(coverage of Greenland ice sheet every 2 or 3 repeat cycles)
North Pole – EWS (in red) and IWS (in green) modes, ascending orbits over a 12-day repeat cycle

North Pole – EWS (in red) and IWS (in green) modes, descending orbits over a 12-day repeat cycle
Observations outside Europe

With the capacity of 6 min/orbit of data download, resources are available to complement the European observations to support some GMES services activities outside Europe, some national services / use on national territories outside Europe (e.g. Canada or French overseas territories / departments) and some national services / use outside national territories (e.g. Antarctica, western Arctic, etc.). Additional observations are performed to support key activities only possible with SAR data (e.g. InSAR related applications for geo-hazard). Regarding the operational services requiring data in quasi or near real time, the detailed observations will be adjusted depending on the readiness of the relevant users to acquire and process the data.

The following observations during this 6-month ramp-up phase are planned to be gradually implemented in terms of volume, associated production and timeliness:

- MyOcean sea-ice / iceberg operational service in Southern Ocean around Antarctica (EWS HH, NRT 3 hours), also covering national requirements on the subject areas. The revisit frequency is expected to be similar to Envisat past regular activities, as starting point.

- Background observations to provide reference map for GMES Emergency Response Service and GMES Security Service (IWS VV+VH or IWS HH+HV depending on the area) (areas are still be consolidated, but represent limited SAR resources as 1 or 2 reference product is to be provided per year).

- Regular observations to support Volcano monitoring at global level, starting with EVOSS selected volcanoes (IWS VV).

- Regular observations to support Canadian operational services, in particular sea-ice monitoring services (EWS HH+HV ideally) and the sea-state monitoring activities (EWS VV+VH), outside of / in complement to Radarsat-2 observations.

- Regular observations to support French overseas territories / dept. operational services (maritime surveillance) with local collaborative stations starting with Kerguelen (IWS HH)

- Seasonal observations to support national activities over Antarctica (IWS HH or SM HH implemented as campaigns during 3 to 4 consecutive repeat cycles) and in the western Arctic (EWS HH+HV).

- Systematic observation (every repeat cycle) both in ascending and descending passes to support InSAR on major tectonic areas and geo-hazard supersites worldwide (IWS VV or HH)

- One campaign to support forest monitoring international activities (IWS VV+VH), starting with some observations over REDD participating countries. Note: some of the relevant passes including tectonic areas are imaged in VV+VH (instead of only VV for InSAR)

- Campaigns for testing / validation purpose mainly, to support agriculture / crop monitoring outside Europe (e.g. rice monitoring).

- Reference data for support to flood monitoring, in some high risk areas worldwide.
Selected examples of the above observations are illustrated on the following figures.

South Pole – EWS (in red) and IWS (in green) modes, ascending orbits over a 12-day repeat cycle

South Pole – EWS (in red) and IWS (in green) modes, descending orbits over a 12-day repeat cycle
Americas – EWS (in red) and IWS (in green) modes, ascending orbits over a 12-day repeat cycle

Americas – EWS (in red) and IWS (in green) modes, descending orbits over a 12-day repeat cycle
Asia – IWS mode, ascending orbits over a 12-day repeat cycle

Asia – IWS mode, descending orbits over a 12-day repeat cycle
Africa – IWS mode, ascending orbits over a 12-day repeat cycle

Africa – IWS mode, descending orbits over a 12-day repeat cycle
Pacific – IWS mode, ascending orbits over a 12-day repeat cycle

Pacific – IWS mode, descending orbits over a 12-day repeat cycle
3.2 Production

The production scheme, to be gradually implemented during the first 6-months of the ramp-up phase, is established in accordance with the production strategy as described in chapter 4.5.2 of the Sentinel HLOP.

The following processing approach is planned:

- NRT acquisition and processing timeliness will be gradually put in operations during the ramp up phase, in line with available operations resources

- The most demanding timeliness provided by the core ground segment is the 1h-from-sensing requirement for generating level 1 GRD products for the MyOcean sea-ice monitoring services in Europe. More stringent timeliness, not part of the mission MRD, in support of specific user needs (e.g. 10 min from sensing for e.g. EMSA or national maritime surveillance services) are implemented through collaborative stations

- The provision in NRT 1h/3h of level 1 GRD products over land in Europe is limited to the few services requiring data in near-real time, like snow monitoring. The areas of interest for which NRT will be provided will depend on the capacity of the related users to ingest and make use of the data for related NRT value-adding services

- For all other areas of interest, systematic processing to level 1 GRD products for all data acquired is available within 24h from sensing (at the exception of SLC products generated over regional areas of interest only – see below)

- Systematic generation of SLC products, relevant to InSAR applications, is planned to be provided only over relevant tectonic areas in Europe. SLC products are in any case available through on-demand production from the PDGS archives

- Provision of level 0 data, available within 1 day typically

- Gradual increase of systematic wave mode data processing into Level-2 products for geophysical validation only (Level 2 products may be gradually made available once validated)

- Gradual increase of high rate mode data processing over selected ocean areas into Level-2 products (Level 2 products may be gradually made available once validated).

It should be noted that during the ramp-up phase, the activities of operational user products quality verification, calibration and validation will be pursued, aiming at ensuring delivery of fully calibrated and validated products for the routine operations.
4. Remarks

- SAR Polarisation
  Over land, it is planned to systematically make use of the same SAR polarisation scheme over a given area, to guarantee data in the same conditions for routine operational services and to allow frequent InSAR. Depending on the area, the selection is either vertical or horizontal, the choice being made according to the main application behind. The reason for selecting the VV polarisation over Europe is explained in chapter 3.1 above. Conflicts may occur during winter season with snow monitoring activities (though these services are less developed) for which the horizontal polarisation is preferred. Over large ice sheets (Greenland and Antarctica), the HH polarisation is more suitable.

- SAR Mode
  The default mode over land is the IW mode. Specific requirements (some of them part of national requirements) ask for the use of the SM mode over some particular areas (e.g. volcanoes or zones of special interest in Antarctica like the Peninsula or the other Antarctica ice shields) or even at global level (e.g. one mapping per year of all land areas in SM). It should be noted that while some exceptional campaigns may be performed in SM mode, the Sentinel-1 observation plan is established with the goal to ensure systematic and routine provision of data allowing operational services to run on a routine basis. As a general principle, the use of the SM mode in the standard observation plan will be limited to the specific cases where there is no other use in competition (e.g. a volcano in the middle of the Pacific ocean). In full operational capacity, an increase in utilisation of the SM mode is envisaged taking into account the share of resources of the 2 spacecraft constellation. Users will otherwise be invited to make use of data from other missions if a higher resolution than the one provided by the IWS mode is required.

- Limitations with one Sentinel-1 satellite
  The Sentinel-1 mission relies on a 2-satellite constellation which permits to reach the Full Operations Capacity (FOC). The availability of the 2-satellite constellation is a prerequisite to solve the vast majority of conflicts which arise with one satellite only, and to fulfil the necessary revisiting requirements of the key operational services. It will also allow to perform InSAR every 6 days over extended areas, resulting in great progress expected in the operational application, operational science and the scientific domains in general.

  As indicated above, the availability of the second satellite will also permit to make use of the SM mode for regular campaigns to respond to user expectations.
Appendix to Annex:

Overview of preliminary Sentinel-1 requirements collection to be considered for the Full Operations Capacity phase

The following tables provide an overview of the various Sentinel-1 observation requirements collected so far. Detailed additional information, not reported below, is available for some of them (shape files, period of the year, etc.) while for others, a process of clarification or consolidation is currently in-progress. These requirements will be considered for the evolution of the observation scenario leading to the Full Operations Capacity phase.

### OVER OCEANS & SEAS, SEA-ICE

<table>
<thead>
<tr>
<th>Source of requirements</th>
<th>Indicative Geographic Area</th>
<th>Latency - Availability of (level 1) product</th>
<th>Mode / Polarisation</th>
<th>Temporal coverage, revisit frequency</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea-ice and iceberg monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GMES services / projects and GMES use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MyOcean, MONARCH-A, SIDARUS</td>
<td>Baltic Sea, Euratic Waters, Greenland waters (incl. South), Davis Strait, Labrador Sea, Baffin Bay, Antarctica (Southern Ocean)</td>
<td>1 hour to 3 hours, depending on the areas</td>
<td>EWS HHHV or IWS HHHV (iceberg)</td>
<td>Every Opportunity or Daily coverage, in some cases sample strategy. Seasonal acquisition scheme. Coverage around Antarctica at least 1 every 3 days</td>
<td>Single polarisation (HH) is acceptable for ice drift monitoring in the Arctic Ocean and Antarctica winter season. Seasonal variation of extent.</td>
</tr>
</tbody>
</table>

### National services and use by ESA and EU Member States

| National requirements from Canada, Denmark, Finland, France, Norway, UK | Baltic Sea, Northwest Atlantic, Barents Sea, High Arctic, Davis Strait, Labrador Sea, Great Lakes, Baffin Bay, Hudson Strait, Eastern Canadian Coast, Kara Sea, North East Passage, Bering Strait, Gulf of St. Laurence, Antarctica (around Antarctica and between -45 and -55 deg. latitude in Southern Ocean) | 1 hour to 3 hours, depending on the areas | EWS HHHV or IWS HHHV depending on coverage requirement / areas | Every opportunity or daily coverage, in some cases sample strategy. Seasonal acquisition scheme. Coverage around Antarctica at least 1 every 3 days | Single polarisation (HH) is acceptable for ice drift monitoring in the Arctic Ocean and Antarctica winter season. Seasonal variation of extent. |
### Scientific use, on-going ESA projects, continuity of ERS/ENVISAT

<table>
<thead>
<tr>
<th>Project</th>
<th>Area of Interest</th>
<th>Temporal</th>
<th>Polarimetry</th>
<th>Coverage Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar View</td>
<td>Davis Strait, Labrador Sea, Baffin Bay, Eastern Canadian Coast</td>
<td>NRT</td>
<td>EWS HHHV or IWS HHHV (iceberg)</td>
<td>Every opportunity or daily coverage, in some cases sample strategy. Seasonal acquisition scheme. Coverage around Antarctica at least 1 every 3 days</td>
</tr>
<tr>
<td>Science Requirement</td>
<td>Beaufort Sea and Arctic Waters</td>
<td>not NRT</td>
<td>EWS HHHV</td>
<td>Regular mapping at daily to weekly frequency</td>
</tr>
</tbody>
</table>

### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Areas of Interest</th>
<th>Temporal</th>
<th>Polarimetry</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOAA (US coordinated requirements)</td>
<td>Ice concentration, ice type, ice depth, ice motion, ice extent, All ice covered regions of world, including the Great Lakes</td>
<td>NRT</td>
<td>EWS or IWS or SM</td>
<td>Daily to weekly</td>
</tr>
</tbody>
</table>

### Other use including commercial use

<table>
<thead>
<tr>
<th>Sector</th>
<th>Areas of Interest</th>
<th>Temporal</th>
<th>Polarimetry</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support to oil and gas industry</td>
<td>Barents Sea, Greenland Sea, Norwegian Sea</td>
<td>NRT</td>
<td>EWS HHHV</td>
<td>Daily to weekly coverage During relevant seasons only</td>
</tr>
</tbody>
</table>
## Oil spill monitoring and polluter identification

### GMES services / projects and GMES use - EMSA

<table>
<thead>
<tr>
<th>EMSA, SeaU</th>
<th>Large coverage of European waters</th>
<th>10 min</th>
<th>EWS VVVH or HHHV - or IWS VVVH or HHHV</th>
<th>Frequent observations but not necessarily every opportunity (sampling concept)</th>
<th>CleanSeaNet station network (part of collaborative GS), today: Matera, Brest, Azores, Grimstad, Tromsø, Svalbard</th>
</tr>
</thead>
</table>

### National services and use by ESA and EU Member States

<table>
<thead>
<tr>
<th>National requirements from Denmark, Finland, France, Germany, Italy, Norway, Portugal, Romania, UK, Canada</th>
<th>National / European waters (incl. Back Sea), Atlantic NE Region, Greenland waters, Canadian waters, French overseas territories / dept.</th>
<th>10 to 60 min (depending on areas)</th>
<th>EWS VVVH or HHHV - or IWS VVVH or HHHV</th>
<th>Frequent observations but not necessarily every opportunity (sampling concept)</th>
<th>Coordination with EMSA wherever relevant. Potential collaborative stations: Brest, Matera, Neustrelitz, Tromsoe/ Svalbard (TBC), Kiruna, Sodankylä, Romania (TBC), Azores, Kerguelen, La Reunion, French Guyana, Gatineau, Prince-Albert, Inuvik.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>National requirements from Canada</th>
<th>Canadian Waters</th>
<th>60-120 min</th>
<th>EWS VVVH</th>
<th>Every opportunity, all year</th>
<th>Use of Canadian collaborative stations: Gatineau, Prince-Albert, Inuvik</th>
</tr>
</thead>
</table>
## Scientific use, on-going ESA projects, continuity of ERS/ENVISAT

<table>
<thead>
<tr>
<th>Science Requirement</th>
<th>Global shipping and drilling areas</th>
<th>Not NRT</th>
<th>EWS VVVH or HHHV</th>
<th>TBD</th>
<th>former Envisat SDS BRM</th>
</tr>
</thead>
</table>

## International Initiatives, International cooperation

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>INPE</td>
<td>Brazilian Coast</td>
<td>Quasi-real time</td>
<td>TBD</td>
<td>former Envisat SDS BRM</td>
<td></td>
</tr>
<tr>
<td>NOAA (US coordinated requirements)</td>
<td>EEZ US, Gulf of Mexico north of 25 deg. N, and occasionally other regions globally</td>
<td>Quasi-real time</td>
<td>IWS, EWS or SM</td>
<td>Daily to 3-days</td>
<td>Receiving capabilities to be clarified</td>
</tr>
<tr>
<td>Former Cat 2 Envisat</td>
<td>Caspian Sea</td>
<td>TBD</td>
<td>TBD</td>
<td>Regular sampling</td>
<td>Potentially Moscow Scanex receiving station</td>
</tr>
</tbody>
</table>

## Maritime surveillance, maritime security information services (incl. ship detection)

### GMES services / projects and GMES use + EMSA and EU bodies

<table>
<thead>
<tr>
<th>EMSA, SeaU, DOLPHIN, NEREIDS</th>
<th>Large coverage of European waters</th>
<th>10 min</th>
<th>EWS VVVH or HHHV, or IWS VVVH or HHHV</th>
<th>Frequent observations but not necessarily every opportunity (sampling concept)</th>
<th>CleanSeaNet station network (part of collaborative GS), today: Matera, Brest, Azores, Grimstadt, Tromsø, Svalbard</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMSA</td>
<td>East African Coast (Somalia Coast, Gulf of Aden, etc.)</td>
<td>60 min</td>
<td>EWS VVVH or HHHV, or IWS VVVH or HHHV</td>
<td>Frequent observations but not necessarily every opportunity (sampling concept)</td>
<td>Receiving capabilities to be clarified</td>
</tr>
</tbody>
</table>
## National services and use by ESA and EU Member States

| National requirements from Denmark, Finland, France, Germany, Italy, Norway, Portugal, Romania, UK, Canada | Atlantic Approaches (Biscay, UK & Ireland), European waters (up to 1000 NM from national coasts), Mediterranean Sea, Black Sea, Greenland waters, French overseas territories / dept (Indian Ocean, Northern part of South American Coast), Eastern and Western African coasts. | 10 to 30 min | EWS VVV or HHHV, or IWS | Very frequent observations, sampling strategy | Potential collaborative stations: Brest, Matera, Neustrelitz, Tromsø/ Svalbard (TBC), Kiruna, Sodankylä, Romania (TBC), Azores, Maspalomas, Kerguelen, La Réunion, French Guyana, Gatineau, Prince-Albert, Inuvik |
| National requirements from Finland, France, Germany, Italy, Norway, Spain, UK, Canada | Activities with international partners and/or outside Europe & National territories: East and West African coastal areas, NE-passage / Siberia, North Polar Ocean/ NW-passage, Canadian waters, Caribbean, Antarctic Peninsula polar ocean, western coasts of South America | 10 min to 3 hours | EWS VVV or HHHV – or IWS VVV or HHHV depending on the areas | Very frequent observations, sampling strategy | Collaborative stations: O’Higgins, Inuvik, Chetumal, Malindi, others in South America (west coast). EDRS Ka-Band collaborative stations: Oberpfaffenhofen /Weilheim, Neustrelitz, Harwell |

### (Scientific use,) on-going ESA projects, continuity of ERS/ENVISAT

| MARISS | Mediterranean, North Sea, Baltic Sea, Open Atlantic, Portugal, Black Sea, Canaries/West Africa, Red Sea, East Africa, Caribbean | 10 to 60 min | IWS HHHV or VVVH | Very frequent observations, sampling strategy | Strong overlaps / coordination with National activities (see above). Use of collaborative stations is assumed |

### International Initiatives, International cooperation

| NOAA (US coordinated requirements) | Approaches to major U.S. ports, major fishing grounds, U.S./Russia Maritime Border in Bering Sea, south of western Aleutian islands (illegal drift nets), Northwest Hawaiian Islands. Secondary - North Atlantic and Pacific | Quasi to near real time | SM, IWS | Hourly to 3 days | Receiving capabilities to be clarified |
| Former Cat 2 Envisat | Caspian Sea | TBD | TBD | Regular sampling | Potentially Moscow Scanex receiving station |
### Sea-state monitoring (wind, wave, current)

#### National services and use by ESA and EU Member States

<table>
<thead>
<tr>
<th>National requirements from</th>
<th>North and Baltic Seas, all free of ice European waters</th>
<th>10 min to 3 hours</th>
<th>EWS VV VH</th>
<th>If possible every opportunity, all year</th>
<th>Note: quasi-real time requirements assumed to be implemented by collaborative GS</th>
</tr>
</thead>
<tbody>
<tr>
<td>National requirements from</td>
<td>Canadian East and West coasts, Hudson Bay, Great Lakes, Northern Lakes and Southern Lakes</td>
<td>60 min</td>
<td>EWS VVVH or HHHV</td>
<td>Acquisition window according to AOI</td>
<td>Canadian collaborative stations assumed</td>
</tr>
<tr>
<td>National requirements from</td>
<td>All coastal waters worldwide, Supersites (Gulf Stream and Aghulas currents), Malakka Strait</td>
<td>3 hours</td>
<td>EWS VV</td>
<td>Routinely operated</td>
<td></td>
</tr>
</tbody>
</table>

#### Scientific use, on-going ESA projects, continuity of ERS/ENVISAT

<table>
<thead>
<tr>
<th>Science Requirement</th>
<th>Global Open Ocean monitoring (incl. Sea State ECV)</th>
<th>not NRT</th>
<th>Wave mode and possibly high rate modes</th>
<th>Routine observations</th>
</tr>
</thead>
</table>

#### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>NOAA (US coordinated requirements)</th>
<th>All ocean products from ESA - Global Ocean, especially US EEZ, North Atlantic, entire Pacific, and global coastal. Top Priority: Gulf of Alaska, Gulf of Maine, Northwest US, Bering Sea, Tropical cyclone areas. Second Priority: The rest of the US EEZ, extra tropical cyclone areas, North Atlantic and Pacific</th>
<th>Quasi or near real time</th>
<th>Wave mode and high rate modes</th>
<th>Hourly to 3 days</th>
</tr>
</thead>
</table>
### Glacier and Snow monitoring

#### National services and use by ESA and EU Member States

<table>
<thead>
<tr>
<th>Source of requirements</th>
<th>Indicative Geographic Area</th>
<th>Latency - Availability of (level 1) product</th>
<th>Mode / Polarisation</th>
<th>Temporal coverage, revisit frequency</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>National requirements from Austria, Finland, Germany, Italy, Norway, Romania</td>
<td>Snow monitoring: Central/Eastern Europe, Alpine Arc, Northern Europe / Scandinavia, Baltic Sea (drainage)</td>
<td>3 hours</td>
<td>IWS HHHV</td>
<td>Frequent coverage during snow season</td>
<td>Ascending &amp; descending passes</td>
</tr>
<tr>
<td>National requirements from Finland and UK</td>
<td>Snow cover: Northern Hemisphere and Global (Finland requirement)</td>
<td>NRT (Northern Hemisphere), not NRT (global)</td>
<td>EWS VVH</td>
<td>Daily (Northern Hemisphere), weekly (global)</td>
<td></td>
</tr>
<tr>
<td>National requirements from Denmark, Germany, UK</td>
<td>Greenland and Antarctica Coast selected outlet glaciers, Global Glacier Areas (UK)</td>
<td>not NRT</td>
<td>IWS HH or SM HH</td>
<td>Dense time series during relevant seasons, monthly coverage for Greenland, at least twice a year as a minimum</td>
<td>Ascending &amp; descending passes</td>
</tr>
<tr>
<td>National requirements from Canada</td>
<td>Glaciology: about 10 northern latitude glaciers</td>
<td>Not NRT</td>
<td>SM HHHV</td>
<td>Once a year</td>
<td></td>
</tr>
</tbody>
</table>

#### Scientific use, on-going ESA projects, continuity of ERS/ENVISAT

<table>
<thead>
<tr>
<th>Source of requirements</th>
<th>Indicative Geographic Area</th>
<th>Latency - Availability of (level 1) product</th>
<th>Mode / Polarisation</th>
<th>Temporal coverage, revisit frequency</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar View</td>
<td>Snow monitoring: Central Europe, Alpine Arc, Scandinavia, Baltic Sea area</td>
<td>NRT or not NRT depending on area</td>
<td>IWS HH TBC</td>
<td>Frequent coverage during snow season</td>
<td></td>
</tr>
<tr>
<td>Science Requirement (climate change monitoring)</td>
<td>Global Glacier Areas</td>
<td>not NRT</td>
<td>IWS HH or SM HH</td>
<td>Typically twice a year</td>
<td></td>
</tr>
<tr>
<td>Ice Supersites (PSTG)</td>
<td>Fast moving glaciers in Arctic and Antarctica</td>
<td>not NRT</td>
<td>IWS HH</td>
<td>TBD</td>
<td>Modes and revisit requirements to be consolidated (action of PSTG SAR Coordination Group)</td>
</tr>
<tr>
<td><strong>International Initiatives, International cooperation</strong></td>
<td></td>
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<td>------------------------------------------------------</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NOAA (US coordinated requirements)</td>
<td>Snow cover, depth, state: Global Land, priority for North America</td>
<td>NRT</td>
<td>EWS or IWS</td>
<td>3 to 120 h</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Ice sheets / shelves monitoring</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>GMES services / projects and GMES use</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>MONARCH-A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>National services and use by ESA and EU Member States</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>National requirements from Denmark, Germany, Norway, Italy, UK</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Scientific use, on-going ESA projects, continuity of ERS/ENVISAT</strong></th>
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<td>CCI</td>
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<table>
<thead>
<tr>
<th><strong>International Initiatives, International cooperation</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>PSTG SAR Coordination Group</td>
</tr>
</tbody>
</table>
### River and Lake Ice monitoring

<table>
<thead>
<tr>
<th>National services and use by ESA and EU Member States</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>National requirements</strong></td>
</tr>
</tbody>
</table>

**International Initiatives, International cooperation**

<table>
<thead>
<tr>
<th><strong>NOAA (US coordinated requirements)</strong></th>
<th><strong>Service</strong></th>
<th><strong>ESA</strong></th>
<th><strong>Member States</strong></th>
<th><strong>Frequency</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern North America rivers (especially Yellowstone River and Alaska rivers), especially in spring.</td>
<td>NRT</td>
<td>EW, IWS or SM</td>
<td>Daily</td>
<td></td>
</tr>
</tbody>
</table>
### Scientific use, on-going ESA projects, continuity of ERS/ENVISAT

<table>
<thead>
<tr>
<th>Science Requirement</th>
<th>Global Subsidence background monitoring, focus on large urban areas</th>
<th>not NRT</th>
<th>IWS HH</th>
<th>Monthly, yearly</th>
<th>Details TBD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESPOND</td>
<td>Africa, Latin America, South-East and Central Asia, Middle East</td>
<td>normal</td>
<td>TBD (IWS assumed)</td>
<td>Yearly</td>
<td>EGSE_036-Thematic mapping Medium Scale</td>
</tr>
<tr>
<td>Terrafirma</td>
<td>Covered by national requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>Former Cat 2 Envisat</th>
<th>East Asia: Flooding / Typhoon monitoring</th>
<th>NRT</th>
<th>Mode TBD, dual pol</th>
<th>During flooding / typhoon season</th>
<th>Potential international collaborative stations: Beijing, Hongkong, Hanoi, Taiwan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former Cat 2 Envisat</td>
<td>US East Coast, Caribbean, Gulf of Mexico (Miami station coverage): Hurricane monitoring</td>
<td>NRT</td>
<td>Mode TBD, dual pol</td>
<td>During hurricane season</td>
<td>Miami as potential international collaborative station</td>
</tr>
</tbody>
</table>

### Tectonic Areas and Volcano Monitoring

#### GMES services/ projects and GMES use

| EVOSS, GMES EMS (incl. former SAFER) | Subset of volcanoes worldwide. EVOSS test sites: Jebel Zubair, El Hierro, Nabro, Grimsvötn, Eyjafjallajokull, Dalaffilla, Dabbahu, Erta’Ale, Manda Hararo, Ol’Doinyo Lengai, Jebel-al-Tair, Stromboli, Mt. Etna, Nyiragongo, Piton de la Fournaise, Karthala, Soufriere Hills, Nyamuragira. | NRT 1h or not NRT depending on volcano | IWS HH or VV | Every repeat cycle | Ascending and descending |

#### National services and use by ESA and EU Member States

| National requirements from Italy, Germany, Greece, France, Norway, Romania, UK | Tectonic areas and volcanoes in Europe, South East Europe and Middle East - Global tectonic areas. | NRT or not NRT depending on areas | IWS VV or HH | Max. revisit, every opportunity | Ascending & Descending, no land/sea discontinuities. |

### Scientific use, on-going ESA projects, continuity of ERS/ENVISAT

<table>
<thead>
<tr>
<th>Science Requirement</th>
<th>Tectonic areas and volcanoes in Europe – Global tectonic areas and (subset of) worldwide volcanoes</th>
<th>Not NRT</th>
<th>IWS VV or HH</th>
<th>Every opportunity or every second cycle</th>
<th>Ascending &amp; Descending</th>
</tr>
</thead>
</table>
### International Initiatives, International cooperation

| GEO Geohazard Supersites | Supersites worldwide: Los Angeles, Vancouver/Seattle, Hawaii, Istanbul, Tokyo-Mt Fuji, Mt Etna, Vesuvius, Haiti, Chile, Tohoku-oki, Wenchuan | Not NRT | SM or IWS | Frequent revisit | Ascending and descending |

### Specific GMES Security Services, Critical Assets Monitoring, Illegal Mining

#### GMES services and GMES use

| Former G-MOSAIC | Africa: DR Kongo (Kinshasa, Great Lakes Area, North and South Kivu province), Somalia, Chad, Sudan, Angola, Nigeria (Niger Delta), Algeria, Tanzania-Congo-Burundi borders Asia: Iraq, Kuwait, Odessa Port, Ukraina, Georgia, Baku-Tiflis-ceyhan pipeline Eastern Europe: Sofia region South America: Colombia (lower Magdlena river) | Not NRT | IWS HHHV or VVVH | 3 times a year | SEC_002 – Crisis Indicators: Exploitation of natural resources. Note: these were test sites and should be reconsidered. |

| New GMES security service | Requirements TBD |

#### National services and use by ESA and EU Member States

| TBD |

### Forest monitoring, Agriculture monitoring, Crop Mapping

#### GMES services / projects and GMES use

| Geoland-2 EUFODOS REDDAF ReCover REDD-FLAME ISAC | Geoland-2: priority for Europe, potentially outside Europe, at global level. Focus on generally cloudy areas (Northern Europe, Equatorial regions for forest monitoring) Other EU projects related to REDD / Deforestation: focus on tropical and sub-tropical forests ISAC: agriculture and the agro-environment in Europe and Africa | not NRT | IWS VVVH | Regular coverage | In complement to optical data. Requirements outside Europe are TBD. Acquisition window depending on AOI |
### National services and use by ESA and EU Member States

| National requirement from France, Germany, Italy, Norway, Romania, Spain, Switzerland, UK, Canada | Agriculture and forestry in Europe and Canada. Involvement in international partnership / projects at global level. Monitoring deforestation (special focus in South America). | not NRT | IWS VVVH or HHHV | Regular coverage, depending on growing season for agriculture / crop monitoring | Details TBD |

### Scientific use, on-going ESA projects, continuity of ERS/ENVISAT

| GMFS | African territories involved in GMFS | not NRT | IWS VVVH or HHHV | Regular coverage, depending on season | Details TBD |

### International Initiatives, International cooperation

| REDD, FCT, GFOI | Participating Countries, potentially all forests worldwide | not NRT | IWS VVVH or HHHV | 4 coverage per year typically | Details to be consolidated |

### Land Use, Hydrology, Soil Moisture

#### GMES services and GMES use

| Geoland-2 HELM | Land use in Europe – Potentially Soil Moisture worldwide. Selected areas in Asia. | NRT | IWS HH | Systematic / very frequent coverage |

### National services and use by ESA and EU Member States

| National requirements from Austria, France, Germany, Greece, Italy, Romania, UK, Canada | Land use and land cover changes at national and regional level, integrated water management, internal waters, etc. Regions in North Africa and Central Asia (for integrated water management). Sparsely vegetated regions (for soil moisture). Regional and global land areas (for soil moisture / hydrology) | Not NRT | IWS HH or IWS HHHV | 1 coverage during dry season for North Africa and Central Asia water management - Systematic / very frequent coverage for soil moisture / hydrology. |
## International Initiatives, International cooperation

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<th>Initiative</th>
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<th>Data Availability</th>
<th>One coverage / year</th>
<th>Details TBD</th>
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<td>GEO, UN, EEA, etc.</td>
<td>Global land areas</td>
<td>Not NRT</td>
<td>SM or IWS</td>
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<td>NOAA (US coordinated requirements)</td>
<td>Land topography, land cover, land use classes, burnt areas: Targeted Global, Coastal US, North America + US Territories</td>
<td>NRT, not NRT depending on activities</td>
<td>IWS, SM</td>
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<td>Soil moisture / water surface: Global Land, North America, U.S. territories</td>
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