Sentinel High Level Operations Plan (HLOP)
## APPROVAL

**Title**  Sentinels High Level Operations Plan  

<table>
<thead>
<tr>
<th>Issue</th>
<th>Revision</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Author**  
CSC Mission Management Team  
**Date**  27.01.2017

**Approved by**  
P. Potin  
Sentinel-1 Mission Manager  
**Date**  27/1/2017

B. Hoersch  
Sentinel-2 Mission Manager  
**Date**  27/1/2017

S. Mecklenburg  
Sentinel-3 Mission Manager  
**Date**  27/1/2017

C. Zehner  
Sentinel-5P/4/5 Mission Manager  
**Date**  27/01/17

**Authorised by**  
P. Bargellini  
Head CSC Mission Management  
**Date**  27/1/2017

## CHANGE LOG

<table>
<thead>
<tr>
<th>Reason for change</th>
<th>Issue</th>
<th>Revision</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Approved version by PBEO (document reference ESA/PB-EO(2013)), rev.1</td>
<td>1</td>
<td>0</td>
<td>6.02.2013</td>
</tr>
<tr>
<td>Formal revision to reflect end of Sentinel-1A ramp-up phase</td>
<td>2</td>
<td>0</td>
<td>8.10.2015</td>
</tr>
<tr>
<td>Formal revision</td>
<td>2</td>
<td>1</td>
<td>27.01.2017</td>
</tr>
</tbody>
</table>
## CHANGE RECORD

<table>
<thead>
<tr>
<th>Issue  2</th>
<th>Revision 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason for change</td>
<td>Date</td>
</tr>
<tr>
<td>First revision (draft for Commission review)</td>
<td>15.06.2015</td>
</tr>
<tr>
<td>Second update following comments from Commission</td>
<td>15.08.2015</td>
</tr>
<tr>
<td>Third and final update following final comments from Commission</td>
<td>8.10.2015</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Issue  2</th>
<th>Revision 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reason for change</td>
<td>Date</td>
</tr>
<tr>
<td>Formal revision (draft for Commission review)</td>
<td>7.11.2016</td>
</tr>
<tr>
<td>Formal revision</td>
<td>27.01.2017</td>
</tr>
</tbody>
</table>
Table of contents:

1 INTRODUCTION 0
  1.1 SCOPE 0
  1.2 VALIDITY, APPROVAL AND PROCEDURE FOR FUTURE REVISIONS 0
  1.3 STRUCTURE OF THE DOCUMENT 1

2 REFERENCE DOCUMENTS 2

3 SENTINEL MISSIONS BACKGROUND 3
  3.1 SENTINEL MISSIONS OVERVIEW 3
  3.2 SENTINEL MISSIONS OBJECTIVES OVERVIEW 3
  3.2.1 SENTINEL-1 3
  3.2.2 SENTINEL-2 4
  3.2.3 SENTINEL-3 4
  3.2.4 SENTINEL-4 4
  3.2.5 SENTINEL-5 AND SENTINEL-5 PRECURSOR 4
  3.2.6 SENTINEL-6 (JASON-CS) 4
  3.3 DATA POLICY 5

4 OPERATIONS STRATEGY 5
  4.1 SCOPE 5
  4.2 OVERALL SENTINEL OPERATIONS STRATEGY 5
  4.3 OBSERVATION AND INSTRUMENT PLANNING 6
    4.3.1 GENERAL 6
    4.3.2 SENTINEL-1 7
    4.3.3 SENTINEL-2 8
    4.3.4 SENTINEL-3 9
    4.3.5 SENTINEL-5 PRECURSOR 10
  4.4 DATA ACQUISITION 11
    4.4.1 GENERAL 11
    4.4.2 SENTINEL-1 12
    4.4.3 SENTINEL-2 14
    4.4.4 SENTINEL-3 15
    4.4.5 SENTINEL-5P 16
    4.4.6 SENTINEL CONCURRENT ACCESS TO X-BAND STATIONS 16
    4.4.7 EDRS SERVICE 17
  4.5 DATA PRODUCTION 20
    4.5.1 GENERAL 20
    4.5.2 SENTINEL-1 20
    4.5.3 SENTINEL-2 22
    4.5.4 SENTINEL-3 22
    4.5.5 SENTINEL-5P 23
  4.6 DATA DISSEMINATION 23
5 INTERNATIONAL TECHNICAL COOPERATION 24

5.1 ROLES AND RESPONSIBILITIES 25
5.2 COOPERATION ON THE SENTINEL-1 MISSION 25
5.3 COOPERATION ON THE SENTINEL-2 MISSION 25
5.4 COOPERATION ON THE SENTINEL-3 MISSION 25
5.5 COOPERATION ON THE SENTINEL-5 PRECURSOR MISSION 25

6 PRIORITIES FOR ACCESSING SENTINEL RESOURCES 26

6.1 SCOPE 26
6.2 PRIORITY SCHEME 26
6.3 HANDLING OF SENTINEL-1 EMERGENCY OBSERVATIONS 27

7 MISSION MANAGEMENT 29

8 PROCESS FOR DEFINING, REVISING AND APPROVING THE SENTINEL OBSERVATION SCENARIOS 30

8.1 SCOPE 30
8.2 COLLECTION OF OBSERVATION REQUIREMENTS 30
8.3 ELABORATION OF THE OBSERVATION SCENARIOS 31
8.4 CONSULTATION AND APPROVAL MECHANISM 32
8.5 EVOLUTION OF THE SENTINEL OBSERVATION SCENARIOS 32
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 is applicable to all operational entities of Sentinels and Sentinel facilities.

The HLOP is part of the Copernicus Space Component system technical baseline as defined in the EU-ESA Copernicus Agreement [RD14]. It is based upon a number of documents as listed in Chapter 2, and in particular on the CSC System Requirements Document (SRD) [RD15], the Declaration on the Copernicus Space Component (GSC) Programme [RD1], the Sentinel Data Policy as defined in [RD2], the Copernicus Space Component Operations Concept [RD3], the Data Warehouse Requirements (Version 2.0) [RD12] as well as the Sentinel Mission Requirements Documents.

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 first version of the HLOP (ESA/PB-EO(2013)1, rev. 1) became applicable after approval by ESA Member States (PB-EO) in February 2013.

The European Commission (EC), as Programme Manager of Copernicus and owner of the Sentinels, endorses the Sentinel HLOP and its revisions, including the Sentinel observation scenarios, based on the process described in Chapter 8.

The current version of the Sentinel HLOP addresses the Sentinel-1, Sentinel-2, Sentinel-3 and Sentinel-5 Precursor missions with high level operations principles and technical constraints, as well as the rules and strategy for resource allocation with the related priority scheme, where relevant. Following the release of HLOP Issue 2 in October 2015, this revised version (Issue 2 Rev 1) provides minor updates to the document, mainly related to the observation scenarios of Sentinel-1 and Sentinel-2.
Future revisions of the Sentinel HLOP will include additional details related to:
- the Sentinel-4 and Sentinel-5 operations.
- the Sentinel-6 (Jason-CS) operations.
- potential amendments which might be required in case of an evolution of the CSC requirements as concerns data security

The Sentinel HLOP will routinely be updated to make reference to the evolution of the operational scenarios. It is proposed to regularly consult the EC, DOSTAG and the Copernicus User Forum and/or Copernicus Committee (typically once a year or as needed in case of major changes) on the Sentinels observation scenarios, elaborated based on the process described in this document (chapter 8).

Furthermore, it is envisaged 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 on-going Sentinels operations ramp-up phase towards the Full Operational Capacity is provided for complementary information in the Annexes of this document. The observation scenarios are to be considered indicative as they are based on a number of Copernicus services and national requirements which are evolving.

1.3 Structure of the document

Following a high-level overview of the Sentinel missions (chapter 3), the document addresses the key elements that drive the operations baseline and related strategy.

For each Sentinel, common and mission specific strategies are described in terms of observation and instrument planning, data acquisition, data production and data dissemination.

In each of these areas, the document provides a description of the relevant constraints and of the adopted high-level strategy (chapter 4) that, taking into account the priorities for resource allocation (described in chapter 6) and based on the observation needs, result in the baseline operations scenario.

It should be noted that for Sentinel-1, as well as for Sentinel-2 during the ramp-up phase, the resulting baseline mission operations plans are defined taking into account the payload observation strategies and the data acquisition strategies.
## 2 REFERENCE DOCUMENTS

<table>
<thead>
<tr>
<th>RD</th>
<th>Description</th>
<th>Reference/Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD1</td>
<td>Declaration on the GMES Space Component (GSC) Programme</td>
<td>ESA/PB-EO/CXI/Dec. 1, rev. 9 (Final) attached to ESA/C(2015)33</td>
</tr>
<tr>
<td>RD3</td>
<td>CSC Operations Concept Document</td>
<td>GMES-GSEG-EOPG-PD-12-0056, iss. 1, rev. 1, 19 August 2013</td>
</tr>
<tr>
<td>RD4</td>
<td>Agreement between the European Union, represented by the European Commission and the European Space Agency on the Implementation of the Copernicus Programme including the transfer of ownership of Sentinels (Copernicus Agreement)</td>
<td>Signed on 28 October 2014</td>
</tr>
<tr>
<td>RD6</td>
<td>Sentinel-1 Mission Requirement Document</td>
<td>ES-RS-ESA-SY-0007, issue 1 rev.4</td>
</tr>
<tr>
<td>RD7</td>
<td>Sentinel-2 Mission Requirement Document</td>
<td>EOP-SM/1163/MR-dr, issue 2 rev.0</td>
</tr>
<tr>
<td>RD8</td>
<td>Sentinel-3 Mission Requirement Document</td>
<td>EOP-SMO/1151/MD-md, issue 2 rev.0</td>
</tr>
<tr>
<td>RD11</td>
<td>Data Warehouse Requirements – Version 2.0: Copernicus Data Access Specifications of the space-based Earth Observation needs for the period 2014-2020&quot;</td>
<td></td>
</tr>
<tr>
<td>RD13</td>
<td>Copernicus Space Component System Requirements Document</td>
<td>EOP-E/GSC-SRD-01 Issue 1 Rev. 9</td>
</tr>
<tr>
<td>RD14</td>
<td>GMES Sentinel 4 and 5 Mission Requirement Document</td>
<td>EOP-SMA/1507/JL-dr, iss. 1, rev. 0, 2 April 2007</td>
</tr>
<tr>
<td>RD15</td>
<td>The Copernicus Space Component: Sentinel Data Products List</td>
<td>COPE-GSEG-EOPG-PD-14-0017 Issue 1 Rev.1</td>
</tr>
</tbody>
</table>
3  SENTINEL MISSIONS BACKGROUND

3.1  Sentinel missions overview

The Copernicus 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 Copernicus 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, and Sentinel-5 Precursor: Atmospheric composition monitoring from low-Earth orbit
- Sentinel-6 (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 Copernicus operational services such as e.g. Copernicus 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 (based on the pre-defined observation plan), and may contribute also to coastal zone and inland water monitoring.

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/Cryosat) 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.

The Sentinel-5 Precursor satellite will extend data sets as provided by the SCIAMACHY/Envisat and NASA's OMI/Aura instruments, and will be followed by the Sentinel-5 mission.

3.2.6 Sentinel-6 (Jason-CS)

Sentinel-6 and Sentinel-3 form a complementary pair in which both are needed to provide the necessary accuracy for Copernicus. The Sentinel-6 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 comprises 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 the Commission Delegated Regulation [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.

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.

4.2 Overall Sentinel operations strategy

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

- to provide data to Copernicus 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, -3 and -5P 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 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 baseline Sentinel’s observation strategy is the tool to ensure predictable repetitive coverage and continuous data flow required by the Copernicus services. While by nature the instruments on board Sentinel-3, Sentinel-5P and Sentinel-6, as well as the Sentinel-4 and Sentinel-5 instruments hosted on MTG-S and MetOP-SG, are continuously operated and feature relatively low to medium data rates, the implementation of a baseline 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 Copernicus and National services. These observations and planning scenarios are based on the requirements as derived from the mission MRDs, and complemented by the recurrent versions of the Data Access Portfolio (DAP) document [RD12] responding to the Copernicus Data Access Data Warehouse requirements [RD11], which develops in more detail the observation requirements as expressed by the individual Copernicus 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 Copernicus and National services are foreseen to mainly be accommodated via data supplied by the better tailored Copernicus Contributing Missions providing specifically developed functions with high agility of the satellite to address this kind of needs. Furthermore, it is expected that such requests will also be satisfied by data already foreseen to be acquired as part of the baseline Sentinels observation scenario (see chapter 6.3). As a consequence it is not foreseen to frequently alter the Sentinels stable observation scenario in support of such emergency requests (this may occur in exceptional cases only). This approach allows to implement an efficient use of the available Copernicus Space Component infrastructure resources.

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, 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 (within a moving window of a 100 min. orbit period duration) 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 baseline 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 baseline mode is IW
  - Over oceans, seas and polar areas: the baseline mode is either IW or EW. The EW mode (featuring a 400 km swath) is the preferred mode for services providing monitoring activities over large areas with frequent revisiting requirements and not having specific needs for high resolution products (such as the sea-ice monitoring operations performed by the Copernicus Marine Environment Monitoring Service)
  - 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-1 observation scenario is provided in the Annex of the current version of this document.

### 4.3.3 Sentinel-2

**a) Sentinel-2 instrument operation constraints**

Once the mission is in operations at the end of ramp-up phase and full downlink capacity is available, 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 82 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 baseline observation scenario as required in the MRD [RD7], to cover all land surfaces (starting 20 km from the coastlines) 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 Copernicus 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 at any given stage takes into account the status of the mission with currently only the Sentinel-2A in operations, 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 at the equator, and 2-3 days in mid-latitudes.

A high level description of the Sentinel-2 observation scenario is provided in Annex 2 of the current 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 Sentinel-3 mission is based on the simultaneous operation of a pair of identical 3-axis stabilised satellites phased by 140 degrees (note: amended from the original phasing of 180 degrees), following a change request from the Commission. The 140 degrees phasing allows to optimise the topography mission for CMEMS with a minor impact on the optical and temperature mission, in a common orbital plane, with a polar, sun-synchronous orbit at an altitude of 814.5 km, an inclination of 98.65°, an orbital cycle of 27 days (14+7/27 orbits per day, 385 orbits per cycle) and a mean local solar time at descending node of 10:00 hours.

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 in the SRAL SAR mode.
- 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.

4.3.5 Sentinel-5 Precursor

a) Sentinel-5 Precursor instruments operation constraints

There are no major relevant constraints on the operations of the Sentinel-5 Precursor instrument TROPOMI. The autonomous operations are based on a stable orbit scenario and a periodic execution of the TROPOMI instrument calibration and atmospheric target measurements in line with the instrument specific repeat cycle.

b) Sentinel-5 Precursor observation and planning strategy
The operations of the Sentinel-5 Precursor payload TROPOMI are performed in accordance with a set of pre-defined planning rules and constraints based on an instrument specific planning repeat cycle of 360 orbits. The following observation strategy is followed:

- Radiance measurements will be taken on the whole day-side part of each orbit plus some few additional minutes at both ends of the day side part to cover the terminator crossing.
- Background measurements will be taken on the eclipse part of each orbit.
- Solar irradiance measurements will be performed approximately every 15 orbits.
- Calibration (e.g. radiometric and spectral lamp) measurements will be taken outside the South Atlantic Anomaly before spacecraft midnight.

The Sentinel-5 Precursor satellite will be operated in a so-called loose formation with the NOAA Suomi-NPP satellite. Loose formation means that the overpass time between Sentinel-5 Precursor and Suomi-NPP will be less than 5 minutes. The main driver for the formation flying is the cloud clearing for the Sentinel-5 Precursor Methane product using the high spatial resolution data from the Visible/Infrared Imager Radiometer Suite aboard Suomi-NPP. The technical coordination will be through the exchange of planning files (e.g. orbits) between ESA and NOAA.

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 (which features a lower generated data volume than Sentinel-1 and -2 and therefore a less complex data download strategy – see chapter 4.4.4. b))
- 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 (and potentially with other satellites making use of the same X-band frequencies for data downlink)
- 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 the Sentinel-1 and Sentinel-2 missions, is complemented by the use of the EDRS system. The network of core stations for Sentinel-1, -2 and -3 includes Matera (e-GEOS), Maspalomas (INTA) and Svalbard (KSAT). A fourth station (KSAT) located in Inuvik, Canada, is being set up. The core stations in support of Sentinel-5P routine operations are Svalbard and Inuvik.

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 takes 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 3 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 baseline observation scenario (see 4.3.2. b)) and will be commanded only in specific exceptional cases (e.g. emergency situation, specific campaigns potentially).

**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 is performed in accordance with the general Sentinel data acquisition strategy (chapter 4.4.1) tailored to take into account the specific Sentinel-1 constraints listed above. It is closely linked to the systematic and baseline observation scenario (chapter 4.3.2.b), and, naturally, to the network of core ground stations.

The current data download strategy to X-band core stations takes into account the timeliness of the core product, i.e. NRT or Fast-24h.

On-board memory packet-stores containing NRT data are allocated a high priority for download to X-band core stations, and are therefore sent in the next X-band station visibility opportunity. Download of packet-stores containing Fast-24h data are performed chronologically to the next visibility opportunities of the core stations, some of them may be retained on-board during several orbits. The adopted approach depends on various parameters such as the size of the data in the packet-store (which in turn varies according to the sensing segment duration and the SAR mode), the available downlink resource time of the next X-band visibilities, etc. For Fast-24h data, since all data products must be made available at the latest
within 24 hours (this includes download, production and dissemination), a maximum retention time in the on-board memory of a few hours is configured in the ground segment mission planning system as a configuration parameter used to define the downlink plan.

For data to be transmitted in real-time, the so-called “pass-through” concept is followed, i.e. the data transit through the on-board memory and are immediately transmitted to the ground, with the possibility for ground to perform “data retain”, i.e. the same data can be kept in the on-board memory for later download.

The data acquisition scenario also requires taking into account the real-time transmission of data to the EMSA CleanSeaNet stations and other collaborative local ground segment, i.e. beyond the core ground segment downlink facilities. To this end the current CSC operations concept baseline assumes that local stations are only allowed to listen-in to downlinks from the Sentinels to the X-band core ground stations. As such the local stations activities have no impact on the spacecraft resources and lifetime, the downlink plan or operations. In this respect, the operations concept baseline makes no distinction between local station within or outside Europe, as long as they can listen-in to data downlinks to core stations.

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 1.7 TBytes of orthorectified top-of-atmosphere reflectance products (L1C) per each of 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 (nominal First-In First-Out (FIFO) mode)
- 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 FIFO nominal approach.

1 Currently on Sentinel-2A the RT/NRT mode is not operated, and would require a software change on the Mass Memory and Formatting Unit (MMFU). The respective software will be validated as part of the S2B IOC Phase. S2A is until then operating in First-in-First-Out (FIFO) nominal mode.
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**
The satellite thermal and power/energy accommodation of the X-Band System shall not exceed operations of 25 mins per orbit in a sliding window of 10 orbits.

**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 is closely linked to the systematic and baseline observation scenario (chapter 4.3.3.b), and, naturally, to the network of core ground stations, as well as to the existence of cloud cover, and the need to compile a cloud-free global image database for the creation of the Global Reference Image (GRI).

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. The sole use of the SRAL SAR mode over requires a slight adjustment to the data download operations, which will be consolidated during the commissioning phase.

The current constraints allow for the use of a single core ground station at high latitude to download routinely all instrument data. The Svalbard station will be used for this function.
4.4.5 Sentinel-5P

a) Sentinel-5P data acquisition constraints

There are no major relevant constraints for Sentinel-5P data acquisition, apart from the appropriate selection of the X-band core stations in order to support the required contact time for data download. In order to guarantee NRT data delivery, the baseline network during the commissioning phase comprises the S-/X-band acquisition stations in Svalbard and Inuvik which are used for the downlink of up to 139 Gbit per orbit. Both stations are located at high latitudes thus ensuring that at least one downlink opportunity of sufficient visibility duration exists for each orbit.

The Svalbard and Inuvik stations will also be used during the routine phase.

b) Sentinel-5P data acquisition strategy

The X-band data acquisition and recovery strategy is based on a ‘resume/dump’ concept, ensuring that science data contained in a given dump will cover the sensing time interval from the start of the previous dump up to the start of the actual dump. The spacecraft will automatically switch off the X-band transmission when all measurement data acquired up to the start of the actual dump have been transmitted. The required dump time is approx. 520 s, exceeding the visibility time of mid latitude stations.

This is based on recording the instrument data over a complete orbit and dumping the recorded data to the ground stations. Note that Sentinel-5 Precursor has no direct downlink capabilities, i.e. no pass-through mode.

4.4.6 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 CSC 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).
4.4.7 EDRS service

a) System and data flow overview

The baseline service required by the Sentinels from EDRS is the data relay service, linking the Sentinels satellites via one or several EDRS geostationary satellites (or embarked payload) to the ground. This service is planned to be provided for Sentinel-1 and -2 models.

Sentinel-1 and -2 satellites host an OCP (Optical Communication Payload), including a Laser Communication Terminal (LCT), an LCT Adaptation Unit (LIAU) and a radiator. Sentinel-1 and -2 communicate with the EDRS GEO satellite(s) via an optical link, Sentinel data are then relayed from the Geostationary satellites through a Ka-Band RF downlink to a set of Ka-band ground stations. See Figure 1.

Figure 1 – EDRS – Sentinel service interfaces

OCP operations on-board the Sentinels are under CSC Mission Management responsibility. Interfaces between the EDRS Mission and Operation Centre and the Sentinels Ground Segment are required to exchange necessary management data, including exchange of orbit data, mission plans and reporting.

Sentinel data can be encrypted by the EDRS satellites before downlink to the ground. On the ground, the Ka-band Ground Stations perform reception, demodulation, decoding, and decrypting functions.
An overview of the overall architecture is illustrated on Figure 2.

The Sentinel data acquired by the Ka-band ground stations are transferred to the Sentinel-1 and Sentinel-2 Payload Data Ground Segment, through the high capacity Copernicus ground network.

![Diagram of EDRS - Sentinel System Architecture](image)

**Figure 2 – EDRS – Sentinel System Architecture overview**

**b) Operations constraints for EDRS service use**

The high level operation constraints related to the use of the EDRS service by the Sentinel-1 and Sentinel-2 missions takes into account among others:

- number and location of EDRS GEO terminals (currently including EDRS-A and EDRS-C)
- available data rates / channels / time slots provided by the EDRS service, as defined in the applicable SLA.
- on-board memory data downlink through either X-band or through EDRS service, refer to section 4.4
- coordination related to concurrent access between Sentinel-1 and Sentinel-2 satellites, which are managed by the Sentinels ground segment as part of the service requests sent to the EDRS provider
- time to establish the link between a Sentinel-1 or Sentinel-2 satellite and an EDRS terminal, which typically required less than one and a half minutes.
c) Operations strategy for EDRS service use

The use of the EDRS service 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). A detailed cost-benefit analysis related to the EDRS service in support to the Sentinel-1 and Sentinel-2 missions was provided as part of the service contract award proposal to the Copernicus Procurement Board.

In particular, the use of the EDRS service for the Sentinel-1 and -2 missions observations will be managed according to the following observation strategy:

- inclusion of acquisition and downlink capacity in support of Copernicus operational services outside Europe (within EDRS coverage) making use of Sentinel-1 data in near real time (NRT) and quasi real time (QRT), i.e. defined as data being made available in less than 1 hour from sensing.

Note: European initiatives are taking shape to organise maritime surveillance activities outside EU waters, e.g. over African coasts. EDRS represents a major asset for such services as it will on one hand avoid to set up direct receiving X-band stations over the related critical areas and on the other hand allows to get the data immediately in Europe. In such scenario, the related responsible entities (e.g. EMSA) will be able to receive the Sentinel data via an own Ka-band local receiving station, via a Ka-band local receiving station operated by own service provider, data provided by ESA via terrestrial network, or Level-1 core product retrieval.

- Considering the fact that some operational services require the pass-through mode to be used over Europe for data transmission in quasi real-time via the two X-band channels, the EDRS service will be used to download to Europe the recorded data (sensed elsewhere in the world) outside X-band core stations visibilities.

Note: Sentinel-1 orbital segments in visibility of EDRS over the southern hemisphere (within EDRS visibility from the geostationary orbit) can in particular be used for this purpose. For Sentinel-2, transmission can take place over non-relevant areas (e.g. over oceans) or during ascending orbits (night).

- increase of the overall Sentinel-1 and -2 downlink capacity and provision of flexibility and redundancy for the mission data download scenarios, being complementary to the X-band core station network.

Note: in particular for Sentinel-1, the use of EDRS is planned to support the data acquisition associated to the full SAR duty cycle capacity, considering in particular the potential constraints in Europe with respect to X-band stations (see above).

Note: for Sentinel-2, in addition to providing additional downlink capacity, the use of EDRS also allows to improve the overall data timeliness performance.
- enhancement of the Sentinel-1 data availability timeliness outside Europe (within EDRS coverage), in case of emergency or crisis situation, to support the Copernicus Emergency Management or Security services

- Download of data in encrypted mode from the EDRS GEO terminals to the Ka-band receiving station for subsequent decryption.

Note: encryption of sensitive data is considered useful in the framework of the above mentioned security-related services.

The resulting operational coordination with the EDRS service provider will be used to establish the detailed planning of the EDRS service for the Sentinel-1 and Sentinel-2 missions. This results in pre-defined available EDRS time slots at static times along the orbits of the Sentinel-1 and -2 satellites. In addition, technical procedures for short term allocation of EDRS slots to support emergency activities are also available as part of the service (please refer also to the ‘EDRS-Sentinels service high level description document, reference ESA-EOPGS-0018, for further details).

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, corresponding to specific geographical areas, is to be made available within 3 hours from sensing, or less in very specific cases, as defined in [RD15].

b) Data production strategy

All acquired Sentinel data are systematically processed to a pre-determined product level (see [RD15]) 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 baseline scenario are:
- for Sentinel-1, the handling of specific, on-demand and urgent production request related to a 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 set of Level-1 and Level-2 products (see RD[15]) 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 Copernicus 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 generated from past level 0, before the systematic SLC product generation was generalised – see below) is available and has been sized (in terms of resources and users having access to them) according to the evolving requirements.

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

- systematic NRT 10 min. processing to Level 0. Currently such timeliness is implemented by collaborative ground segment local stations operating in support of EMSA. As part of a future evolution this will be achieved within the CSC ground segment via use of the EDRS service outside Europe in particular, and by relevant core ground stations, for provision of the resulting QRT data stream.

- systematic NRT 1h/3h processing for a subset of the acquired data, based on geographical areas

- systematic 24h processing for all data acquired to a pre-defined Level-1 and -2 products. 24h processing, performed at the processing and archiving centres, makes use of more accurate orbit information than the NRT processing performed at the stations, providing in particular more precise geolocation. This is especially relevant to specific applications, including the ones based on interferometry.

The areas related to systematic regional production of level 1 SLC products, to support interferometric applications in particular, are published online at: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/production-scenario

The Sentinel-1 operations concept initially foresaw the generation of SLC over a limited set of areas over land. Since 21 July 2015, 100% of the IW and SM data over land are systematically produced to level 1 SLC. SLC IW production has also been subsequently extended to all data
at global level, i.e. acquired over seas and sea-ice areas as well. This represents a major enhancement of the initial processing and dissemination concept, with an associated increase in the overall ground segment processing load and core products volumes. Such SLC production increase is expected to foster the exploitation of Sentinel-1 data for an increasing number of applications and over an increasing number of areas worldwide.

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, driven by improvements of the processor baseline.

b) Sentinel-2 data production strategy

The production strategy is similar as for Sentinel-1. 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 or where improvements were done in the processing baseline or format changes (e.g. short filenames, pixel co-registration etc.).

Generally all data acquired by the MSI from the Sentinel-2 constellation are systematically processed up to level-1C (see RD[15]). The possibility of a systematic global generation of Level-2A products is being explored as part of a related feasibility study.

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 (see RD[15]). No ordering from users is required for each product to be generated.

The production is split between the land part operated by ESA and the marine part operated by EUMETSAT.
The set of products to be systematically generated responds to the different requirements of the Copernicus 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.

4.5.5 Sentinel-5P

a) Sentinel-5P data production constraints

The 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-5P data production strategy

The data acquired at the ground stations will be provided to the Processing and Archiving Center for systematic Level 0 processing. The following higher-level data production will be generated at the PAC:

- systematic Level 1b/Level 2 NRT production with delivery of the Level 2 within 3 hours (all Level 2 except Methane and tropospheric ozone)
- systematic Level 1b/Level 2 production based on consolidated calibration and auxiliary data (including Level 2 Methane and tropospheric ozone products) within 3 days
- systematic full mission reprocessing upon major processing baseline changes

Similarly than the other Sentinels, no ordering from users is required for core products to be generated.

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-1, -2, -3 (land) and -5P data are systematically disseminated by ESA with on-line access by users, according to the principles of the Sentinel data policy. Sentinel-3 (marine) data are disseminated by EUMETSAT. Sentinel data are made available for Copernicus and National use and, in line with the Sentinel data policy and within available
operational budget, for other use (e.g. scientific, international, etc.). More information is available at: https://sentinels.copernicus.eu/web/sentinel/sentinel-data-access

The Copernicus Space Component Ground Segment data access implements an open and free data policy ensuring that all Sentinels products are accessible to all users online.

Access to Sentinel-1, -2, -3 (land) and -5P latest products is made available via dedicated data hubs:

- User can self register to the data hubs
- Data provision via rolling archives
- Data download via terrestrial network (connectivity to internet at e.g. 10 Gbps)

In addition, access to full Sentinels long-term archive will be made available to all users online.

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 infrastructure 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 e.g. the collaborative ground segment, further ease the access to data by end users. This concept is being implemented during the CSC ramp-up phase and will be consolidated 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. by partners with whom international cooperation agreements have been established by the EU)
- specific user community or large research projects
- Copernicus Data Access and Information service platform(s).

5 INTERNATIONAL TECHNICAL COOPERATION

Specific international technical 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. baseline observation scenario). A high level description of the relevant cooperation is the object of the following sub-chapters regarding Sentinel-1, Sentinel-2, Sentinel-3 and Sentinel-5P.

Note: such cooperation is in addition to the involvement of Copernicus 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 Roles and responsibilities

In accordance with the EU-ESA Copernicus Agreement [RD4], the EU shall represent Copernicus and manage relationships with third countries and international organisations, ensuring the coordination of Copernicus with activities at national, Union and international levels.

ESA shall provide support to the EU for the matters concerning the international technical cooperation of the Copernicus Programme. In particular, ESA shall assess the impact of international technical cooperation requests and shall implement and be responsible for technical actions with international partners subject to prior consultation with the Commission.

To date, four technical arrangements have been established with NASA, NOAA, USGS and Geoscience Australia. The content of these agreements is available at: https://sentinels.copernicus.eu/web/sentinel/missions/international-cooperation/partners

5.2 Cooperation on the Sentinel-1 mission

The detailed 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.

5.3 Cooperation on the Sentinel-2 mission

Cooperation is on-going between the Sentinel-2 mission and Landsat-8, in particular regarding product harmonisation between both missions.
Co-operation items include geometric alignment of Sentinel-2 and Landsat-8 (incl. geometric references, Digital Elevation Model) and radiometric cross-comparison.

5.4 Cooperation on the Sentinel-3 mission

The long-term time-series comparability from SPOT VGT, PROBA-V and Sentinel-2 to Sentinel-3 products for vegetation needs is under consideration.

5.5 Cooperation on the Sentinel-5 Precursor mission

The basic description of the envisaged cooperation between the Sentinel-5 Precursor mission and other relevant missions, in particular with Suomi-NPP, will be provided in a future version of the HLOP.
6 PRIORITY 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 is complemented by the contributions by collaborative centres or local stations, including national ground segment functionalities, and by Copernicus 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 Copernicus Regulation [RD16], the GSC Programme Declaration [RD1] and the EU-ESA Copernicus Agreement [RD4] and is 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:

- Copernicus service use: this data use is related to Copernicus service providers, responding to the Copernicus governance. It consists of all “Copernicus services” approved by the EC.

- National utilisation by Copernicus Participating States and ESA Participating States in accordance with the Copernicus Regulation [RD16] and the GMES Space Component Programme Declaration [RD1], and utilisation by the following EU institutions: European Parliament, European Council, Council of European Union, European Commission, European External Action Service (EEAS)

- Other use:
  i. Cooperation agreements between EU and international partners, responding to present and future data requirements.
  ii. Scientific use
  iii. Other use.

Cooperation agreements, such as the ones envisaged under “other use” i), are subject to the applicable EU and 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>Copernicus service use</td>
</tr>
<tr>
<td>2</td>
<td>National utilisation by Participating States in accordance with the Copernicus Regulation [RD16] and the GMES Space Component Programme Declaration [RD1] and utilisation by the following EU institutions: European Parliament, European Council, Council of European Union, European Commission, European External Action Service (EEAS)</td>
</tr>
<tr>
<td>3</td>
<td>Other</td>
</tr>
</tbody>
</table>

The process to solve any remaining conflict is based on the adoption of the above priority scheme, defined in line with the provisions of the EU-ESA Copernicus Agreement. Therefore, a simple procedure is applied to solve these cases, whereby the requirement from the use typology with higher priority takes precedence. It is not expected that the priority scheme will vary over the course of the mission, thus allowing adoption of such straightforward and robust approach. In case a conflict cannot be unequivocally resolved based on the above priority scheme (e.g. a conflict within a single priority group) the mission manager will decide on a case-by-case basis, in consultation with the European Commission.

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 baseline observation scenario, fulfilling the Copernicus and national user needs known and agreed in advance, based on the priority scheme described in chapter 6.2. The concept of planning specific observations for emergency support is not applicable to the other Sentinels.

The Sentinel-1 baseline 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 CSC 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) Copernicus contributing missions.
Whereas the Sentinel-1 operations can technically cope with specific user emergency requests, support of such requests by the Sentinel-1 mission is made in exceptional cases only following the provisions defined below.

Users entitled to submit Sentinel-1 emergency / security requests are:
- the Copernicus Emergency Management Service
- the Copernicus 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 baseline observation scenario nor by the data acquired via CCMs, the Sentinel-1 Mission Manager may allocate specific requests for SAR operation and product generation. This may include specific requests from ESA/EU Member States or National services, the Commission via its formal point of contact to ESA (as defined in the EU-ESA Copernicus Agreement), 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 in an exceptional basis by specific Sentinel-1 observation, if not yet in the baseline observation scenario:

1. The satellite data is not foreseen to be acquired by the Sentinel-1 baseline observation scenario and equivalent data can not be provided by one of the Copernicus Contributing Missions.
2. The satellite data are required by disaster management authorities with short response time with respect to the event.
3. The event is recognised as a disaster (e.g. may induce danger on human life, may have important environmental or security consequences, etc.)
4. The satellite data are of help during the crisis phase of the event.

In these cases, the required Sentinel operations will have priority over the baseline observation scenario.

Effort shall be made to minimize these observations to the strict necessary duration and to avoid overriding the baseline 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>
The Mission Manager will decide in case of such exceptional cases and inform the Commission (via the standard reporting mechanism). In addition, in case the exceptional tasking affects the baseline scenario, the user community at large is informed through the release of resulting detailed planned acquisitions segments.

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 are 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 from the Commission or any other body (e.g. Copernicus User Forum, Copernicus Committee) according to the Copernicus 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.

Once the full operations capacity of the mission is reached, the Mission Managers will inform the Commission in case of exceptional or occasional deviations of the Observation Scenario prior to their implementation.

The reporting and consultation mechanism with the Commission is based on the provisions defined in the EU-ESA Copernicus agreement covering the CSC operations. The consultation
mechanism related to the Sentinel observation scenarios is defined in this document under chapter 1.2 and chapter 8.

Whenever deviations are implemented, be it occasional or a (permanent) revision of the observation scenario, the user community at large is informed through the release of resulting detailed planned acquisitions segments and through a dedicated news item.

8 PROCESS FOR DEFINING, REVISIONING AND APPROVING 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 Copernicus Regulation [RD16], the Declaration of the GMES Space Component Programme [RD1], the Sentinel Data Policy as defined in [RD2], the Copernicus Space Component Operations Concept [RD3], the Data Warehouse Requirements [RD12] as well as the Sentinel Mission Requirements Documents. 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 and Sentinel-5P 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 the observation requirements from the various user groups, starting with the Copernicus services, National requirements and relevant EU institutions. This allows further detailing the requirements as derived from the Mission Requirements Documents (MRDs).

Five main groups of requirements are identified as follows:

- Copernicus services use
- National services and use by ESA and EU Member States in accordance with the Copernicus Regulation and GSC Programme Declaration, and by the following EU institutions: European Parliament, European Council, Council of European Union, European Commission, European External Action Service (EEAS)
- Other use, including:
  - International public use based on international agreements, contribution to international initiatives
  - Scientific use
  - Other use including use for commercial value-adding.

Table 1 below summarises these categories and indicates the mechanisms and main forum for collecting the requirements.
Table 1 – Source of Sentinel observation requirements

<table>
<thead>
<tr>
<th>Group</th>
<th>Source of Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copernicus services</td>
<td>- Copernicus Data Access Data Warehouse requirements</td>
</tr>
<tr>
<td></td>
<td>- Direct discussions, operational progress meetings with Copernicus services and user questionnaires in the frame of CSCDA operations</td>
</tr>
<tr>
<td>National services and use by Participating States in accordance with the Copernicus Regulation [RD16] and the GMES Space Component Programme Declaration [RD1] and by the following EU institutions: European Parliament, European Council, Council of European Union, European Commission, European External Action Service (EEAS)</td>
<td>- Discussions with Member States Delegations, European Commission, Copernicus User Forum and Copernicus Integrated Ground Segment Task Force Members</td>
</tr>
<tr>
<td></td>
<td>- Interactions in the frame of the Sentinel Collaborative Ground Segment</td>
</tr>
<tr>
<td>International public use based on international agreements, contribution to international initiatives</td>
<td>- EU agreements with international partners</td>
</tr>
<tr>
<td></td>
<td>- GEO/CEOS (e.g. FCT, GFOI, Geo-hazard Supersites), IGOS, FAO, REDD, PSTG, IICWG, GCOS, IRRI, CliC, TIGER, DRAGON, etc.</td>
</tr>
<tr>
<td>Scientific use</td>
<td>- Recommendations from scientists at key SAR workshops (FRINGE, SEASAR), Sentinels workshops, SEN4SCI, etc.</td>
</tr>
<tr>
<td></td>
<td>- Extrapolation of ESA GSE Projects (e.g. Polar View, MARISS, Terrafirma, GMFS, etc.)</td>
</tr>
<tr>
<td></td>
<td>- Glob-series projects, CCI, SEOM, etc.</td>
</tr>
<tr>
<td></td>
<td>- Extrapolation of ERS/ENVISAT projects</td>
</tr>
<tr>
<td>Other use</td>
<td>- Any other use, including use for commercial value-adding</td>
</tr>
</tbody>
</table>

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 the technical constraints described in Chapter 4 (satellite, instrument, ground segment, EDRS). Detailed optimisations are performed with the operational mission planning systems with the resulting observation plans published online at sentinels.copernicus.eu.
8.4 Consultation and approval mechanism

The consultation of the European Commission and ESA/EU Member States on both the collection of observation requirements and the resulting observation plans is planned to take place once a year typically, or as needed in case of major changes. A time interval of 3 to 6 months indicatively is necessary between the submission of requirements and the effective definition of the observation plans, in order to perform the necessary analyses, simulations and optimisation in the use of mission resources.

The approval mechanism with the Commission is based on the following principles:

- before issuing a new version of the HLOP and/or a baseline observation scenario update (see Annexes), ESA will submit the draft of the document to the Commission for review and endorsement, indicating the reasons for the suggested updates and allowing sufficient time to review the proposal
- on request by the Commission, ESA will support the presentation of HLOP updates to the relevant Copernicus boards (e.g. User Forum, Committee, Integrated Ground Segment Task Force)
- the gradual extension of the observation scenario during the ramp-up phase (in line with the increasing operational capacity), as well as day-to-day routine changes during full operations (e.g. due to technical reasons) will be done at the discretion of ESA.

8.5 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 are 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 supports the phase E1
  • ramp-up phase: the scenario gradually evolves in line with the ground segment operational capacity and incorporating the priority user requirements (Copernicus, National) to reach the routine exploitation of the first satellite.

Evolution during CSC operational phase, to cope in particular with:
  The main system capacity scenarios, including:
  o the inclusion of the second Sentinel satellite leading to the Full Operational Capacity of the missions with the 2-satellite constellation
  o for Sentinel-1 and -2, the gradual use of the European Data Relay System (EDRS) to e.g. enhance the data download capacity
• The evolution of the requirements from the Copernicus services, the evolution of the “perimeter” of the Copernicus services as defined by the European Commission, the inclusion of new Commission projects (e.g. under H2020)
• 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 as defined in Table 1
• The constraints on the use of the space and ground segment resources (e.g. core and collaborative local 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 1

Sentinel-1 baseline observation scenario

1. **Scope**

The scope of this annex is to describe the principles based on which the Sentinel-1 observation scenario is established. These principles have been applied during the ramp-up phase of Sentinel-1A and also constitute the basis for the routine phase. This annex also addresses the high level approach that is followed with Sentinel-1B in operations.

The Sentinel-1 observation scenario is based on the current best knowledge of the Sentinel-1 observation requirements (from Copernicus, ESA/EU Member States, scientific communities, etc.). The scenario has been established on the basis of the requirements collected over the past. This list is provided in the Appendix to this Annex 1. The observation scenario is anticipated to evolve during the course of routine operations, based on the revision process described in Chapter 8.

2. **Assumptions and constraints**

The current observation scenario, at the start of the Sentinel-1B routine operations, is based on the following assumptions and constraints:

- The availability of the Matera, Svalbard and Maspalomas core ground stations. Further consolidation of the observation scenario will be performed with the operational inclusion of the 4th high latitude core station and once the EDRS service user commissioning will be completed.

- A priority given to Copernicus services, as well as to National services and use by Copernicus and GSC Participating States, and by relevant EU institutions, as stipulated in Chapter 6.

3. **Sentinel-1 baseline observation scenario description**

3.1 Observations

**Europe, European waters, and Arctic**

- A full coverage of European land (EEA-39 countries) and surrounding seas (Exclusive Economic Zones - EEZ) is performed at each constellation repeat cycle (6 days) to support many Copernicus and national activities. A careful selection of the passes is made to ensure
an optimisation of the coverage reducing the overlaps between passes in order to save satellite resources. A full coverage is ensured every constellation repeat cycle both in ascending and descending passes, thus providing a very good revisiting frequency. The selected mode and polarisation is IWS VV+VH, which adequately supports the various land cover applications. This regular and frequent mapping of European land supports the Copernicus Global Land service soil moisture / hydrology component, noting that Europe is the area defined as Priority 1 by the service partner. This high coverage frequency also provides a possibility to support the Copernicus Land service over Europe with SAR imagery. Long segments are acquired over Europe and the Mediterranean Sea / adjacent EEZs without SAR mode switches to avoid data gap either on the coasts or on the water coastal areas (with few exceptions, see below). The polarisation VV+VH is also essential for wind / wave monitoring and suitable for oil spill monitoring, while for land key applications based on InSAR, the difference is minor between vertical and horizontal polarisation.

- On the western European waters outside both the EEZs and the sea-ice monitoring areas, the background selected mode is EWS VV+VH to allow oil spill monitoring. This mode which features a larger swath is best suited (with respect to the IWS mode) to the support to EMSA CleanSeaNet activities. It also supports the wind-wave monitoring activities, based on national requirements as well as in the future for the extension of the Copernicus Marine Environment Monitoring Service with SAR-based sea-state activities.

- The principle of the European continental land coverage is replicated over minor European islands in the open ocean (e.g. Azores, Canaries) with a set of IWS (VV+VH) tracks covering the islands and their associated EEZs, and a set of EWS (VV or VV+VH) tracks covering the wider EEZ area of the islands in accordance with maritime surveillance requirements.

- For sea-ice and iceberg monitoring (Copernicus Marine Environment Monitoring Service and national services) the most suitable mode is EWS HH+HV (GRD product in medium resolution at 90 m ensuring a very high radiometric resolution). The EWS is preferred to the IWS mode in order to privilege the coverage capability (400km swath with EWS, 250km swath with IWS). It is systematically used for most passes in both ascending and descending to get the maximum revisit time. Some regions in the high Arctic (~north of 78 deg latitude) are covered in EWS HH polarisation following the requirements of the Copernicus Marine Environment Monitoring Service. In the particular case of the Baltic Sea surrounded almost completely by land territories of EU/ESA Member States, sea-ice monitoring activities require as well data in EWS mode, HH+HV polarisation (activities performed during winter for typically 7-8 months in the Northern part and 2-3 months in the southern part). For this specific case of the Baltic Sea, in order to address the best the conflicting requirements of the European Land coverage (IW VV+VH, mostly free of gaps) and the seasonal sea-ice monitoring (EW HH+HV), a spatially optimised set of passes has been selected for the service of sea-ice monitoring in EWS HH+HV, while a reduced but complete coverage for the land services in IW VV+VH is maintained, exploiting the spatial overlap between neighbouring passes at high latitudes. In order to limit the impact on some land activities when using the EW mode, a switch between EW and IW mode is implemented for some specific orbits, EW being used over seas, IW over land. The
scenario takes into account the variations of the sea-ice monitoring areas of interest during the year. This particular scheme, previously implemented with Sentinel-1A during the winter period to support the Baltic sea-ice monitoring, is currently implemented with Sentinel-1B only. For Sentinel-1A, IW VV+VH observations are made over the Baltic, in the same mode used for the mapping of the whole Europe EEA-39 and coastal waters, to ensure full consistency.

- A specific strategy is adopted regarding Greenland ice sheets monitoring, allowing users to derive, among others, glacier velocity maps, very relevant for climate change monitoring (estimation to contribution to global sea-level rise). At least one campaign per year during winter season covering the whole Greenland ice sheet is planned in IW HH, made of 4 to 6 consecutive repeat cycles at 6 days interval, using both Sentinel-1A and Sentinel-1B. This also includes coverage of surrounding waters – without mode switch to avoid data gap – also used by the Copernicus Marine Environment Monitoring Service (CMEMS) for sea-ice and iceberg monitoring. A similar strategy is implemented for monitoring Svalbard glaciers, on top of which regular additional observations are performed. In addition and in agreement with CMEMS, 6 long passes in IW HH, specifically selected to cover almost completely the Greenland margins are systematically acquired every 6 days using both satellites, starting at the beginning of the routine operations phase, with the objective of ensuring a very regular monitoring of the highly changing outlet glaciers of the Greenland ice sheet. These passes in IW mode are also of interest for CMEMS for Greenland inshore areas and for fast ice detection.

Outside Europe, outside European Waters / Arctic

Sentinel-1 resources are available to complement the European observations and support in particular some Copernicus 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), as well as to support international cooperation. Additional observations are performed to support key activities only possible with SAR data (e.g. InSAR related applications for geo-hazard and tectonic areas monitoring). 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 QRT data.

The following observations are included in the Sentinel-1 observation scenario:

- Copernicus Marine Environment Monitoring Service 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 over key areas, as starting point, then increased with Sentinel-1B in operations

- For Northern polar areas Not covered by the Copernicus Marine Environment Monitoring Service (i.e. “Western Arctic”), a regular mapping is performed as well, although due to satellite resource issues at a lower frequency w.r.t what is ensured for CMEMS, taking into
account seasonal conditions. The plan with the constellation is to have at least a full coverage every constellation cycle, i.e. every 6 days. Further increase is planned during Full Operations Capacity with the use of EDRS and the 4th core station.

- Background observations to provide reference map for Copernicus Emergency Management Service and Copernicus Security Service (IWS VV+VH or IWS HH+HV depending on the area). These observations represent limited SAR resources as 1 or 2 reference product is to be provided per year. Some of the areas are covered by the mapping of tectonic and volcanic areas at global level – see below

- Regular observations in IW VV+VH to support the Copernicus Global Land Service, for identified priority areas on all continents except Antarctica. The requirement for soil moisture monitoring asks for a short revisiting in the order of 1 to 2 weeks. With the start of the constellation operations, the first target is to provide a full mapping of global land areas every 12 days (except Antarctica and Greenland which are subject to specific campaigns) in IW VV+VH, with a combined use of S1A and S1B. For system capacity reason, the Boreal forest, in a first step, is expected to be covered every 24 days. It shall be noted that some global tectonic areas may remain observed in single polarisation VV, the full coverage in dual-pol is expected to be reached once in full operations capacity. As indicted above, Europe EEA-39 is covered every 6 days in both ascending and descending passes

- Regular coverage of global tectonic and volcanic active areas in a stable full two-pass IWS mode, VV polarization, with a revisit frequency of 24 days per pass (alternating ascending and descending passes, i.e. a particular area is observed every 12 days, interferometric pairs are available every 24 days). It must be noted that with the constellation, tectonic and volcanic active areas located within Europe are revisited every 6 days per pass in IW VV+VH, giving the possibility to perform InSAR in both ascending and descending every 6 days. The so-called geo-hazard supersites worldwide will also be observed in both ascending and descending at least every 12 days in IW VV, possibly every 6 days. The above strategy has been agreed with experts in the domain and is in place since the start of the Sentinel-1A ramp-up phase.

Note: for a number of small volcanic islands worldwide, from May 2015 onwards, the Stripmap mode (SM) is used for the regular coverage. This is implemented in the case a SM swath fully covers the island in one pass, and no maritime surveillance activities take place around the island. The SM mode features (at a comparable system resource consumption) a smaller swath w.r.t the IW mode (in the order of 80 km vs 250 km) but ensures a higher spatial resolution, of particular interest for volcano monitoring.

- Regular observations to support Canadian operational services, in particular sea-ice monitoring services (EW HH+HV or EW HH) and the sea-state monitoring activities (EW VV+VH), as well as monitoring of Canadian lakes.

- Regular observations to support French overseas territories / dept. operational services (maritime surveillance) starting with Kerguelen and Crozet Islands (IW HH), La Réunion and the Iles Eparses (EW VV+VH). Based on provided requirements, a specific strategy is
adopted for La Reunion Island, for which a coverage is ensured every repeat cycle (as for Europe), but alternating the use of the SM mode and the IW mode, to support both land monitoring (incl. volcano) and maritime surveillance

- A specific strategy is adopted regarding Antarctica ice sheets monitoring, allowing experts to derive, among others, glacier velocity maps. At least one campaign per year during local winter season covering the Antarctica ice sheet margins is planned in IW HH, made of 4 to 6 consecutive repeat cycles of 12 days or if possible 6 days. Considering the large extent of the areas to be covered, the campaign is organised by sectors of the Antarctica coastal zone. The Antarctica ice sheet wide acquisition campaign (visible interior) is performed every 3 years for 3 to 4 consecutive passes, using both satellites. Contribution from other SAR missions is assumed, as discussed in the frame of the Polar Space Task Group. A continuous coverage of the Antarctic Peninsula and the major outlet glaciers of the Antarctic ice shield flowing into Pine Island bay is provided in IW HH every constellation cycle (6 days), outside the campaign seasons. This region currently undergoing drastic changes is very relevant for climate change monitoring (e.g. estimation to contribution to global sea-level rise).

- Campaigns to support forest monitoring international activities (IW VV+VH), as part of GFOI activities in particular, in support of REDD. GFOI sites include areas in Vietnam, Ecuador, Colombia, Peru, Amazon, Tanzania and Lake Victoria region. Note: some of the relevant passes including tectonic areas are imaged in VV+VH during these campaigns (instead of only VV for InSAR). Such campaigns, unless they require a repeat frequency less than 12 days, will no longer be necessary due to the fact that a full mapping of global land areas is planned every 12 days in IW VV+VH, as mentioned earlier. Some key areas like the Vietnam Mekong delta are planned to be observed every constellation cycle, i.e. 6 days

- Regular observations of key acquisition zones (with a 12-day revisit) in IW VV+VH focusing on the world’s most important agricultural production areas. This also includes campaigns to support agriculture / crop monitoring activities worldwide in the frame of GEOGLAM actions, among others. GEOGLAM-SIGMA sites include areas in Taiwan, Malaysia, Indonesia, Thailand, Philippines, Laos, China and Pakistan. Observations also include priority areas established by IRRI for rice monitoring in the following countries (some being the same as the GEOGLAM sites): India (Tamil Nadu and Odisha states), Vietnam, Philippines, Thailand and Cambodia. Similarly than for GFOI / REDD supporting activities, unless they require a repeat frequency less than 12 days, these campaigns will no longer be necessary due to the fact that a full mapping of global land areas is planned every 12 days in IW VV+VH, as mentioned earlier. For some critical areas and if necessary, a repeat frequency of 6 days may be envisaged. Note: some of the relevant passes including tectonic areas are imaged in VV+VH (instead of only VV for InSAR)

- Observations in Africa in IW (VV or VV+VH) to support in particular GMES-Copernicus Africa activities, EC Copernicus Projects (e.g. ERMES for rice monitoring), as well as TIGER follow-on activities. The 12 days global land coverage in IW VV+VH is a key asset to support such activities.
- Systematic observations in IW VV+VH or EW VV+VH of “super-sites” for current / wave monitoring, including outside European waters the Agulhas area, the Gulf of Maine, key areas along the US West coast and the waters around Hawai.

**Calibration – Validation activities**

Aiming at the best achievable data quality of Sentinel-1 products, calibration and validation activities are routinely performed during the routine operations phase. These priority activities may locally and temporarily interfere the delivery of coverage in consistent mode-polarization combination. Major regions affected by these activities are Northern Alpine Lowlands (Germany, Austria and Switzerland) and the narrow surroundings of Sao Paulo (Brazil), Houston and Chicago (USA). Limiting the consistency of static mode–polarization coverage and causing small observation gaps due to instrument switches, these activities bring the opportunity to explore the variety of the Sentinel-1 image modes to data users of the affected areas.

**3.2 Production**

The production scheme, gradually implemented during 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:

- NRT3h acquisition and processing timeliness has been 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/3h-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 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 local passive X-band stations and are planned to also be supported by the CSC ground segment by provision of Quasi-Real Time data stream (via e.g. EDRS service and/or X-band core 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, originally planned to be generated over regional areas of interest only – see below)
- Systematic generation of SLC products, relevant to InSAR applications, is provided at least over relevant tectonic areas and in Europe. Since July 2015, the generation of SLC products is systematically performed at global level for IW and has been subsequently performed for SM acquisitions as well.

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

- Gradual increase of systematic wave mode data processing into Level-2 products. Since July 2015, Wave Mode data are regularly acquired over open oceans and systematically processed to Level-2 OCN products. Sentinel-1 IW and EW Level-2 OCN products over regional ocean areas are also available to users

It should be noted that during the routine phase, the activities of operational user products quality verification, calibration and validation are 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 sensing 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 land is explained in section 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) and polar areas, 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 and Copernicus projects) 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, with stable observation conditions. As a general principle, the use of the SM mode in the standard observation plan is limited to the specific cases where there is no other use in competition (e.g. a small volcanic island in the middle of an ocean, see section 3.1 above). In full operational capacity, an increase in utilisation of the SM mode may be 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.

5. Sentinel-1B

The Sentinel-1 mission relies on a 2-satellite constellation, which, together with the use of EDRS and the 4th core station, permits to reach the Full Operations Capacity (FOC). The availability of the 2-satellite constellation is a pre-requisite to remove the vast majority of remaining conflicts that arise with one satellite only, and to fulfil the necessary revisiting requirements of the key operational services. It also allows performing InSAR every 6 days over extended areas, resulting in great progress expected in the operational application, operational science and scientific domains in general.

The inclusion of Sentinel-1B has been assessed in details to optimize the use of the 2-satellite constellation resources. Further consolidation activities are on-going to anticipate the full operations capacity. This additional capacity is largely used to increase the revisiting frequency and enlarge the worldwide areas regularly covered. Related benefits include (not exhaustive):
• The increase of revisiting frequency for the Copernicus Marine Environment Monitoring Service. The CMEMS requirement is to provide information maps on a daily coverage basis. Sentinel-1B allows increasing the revisiting frequency by a factor 2, w.r.t Sentinel-1A alone. For the lower latitudes areas, the 2-satellite constellation is still not be sufficient for achieving this daily mapping, as evidenced in the Sentinel-1 Mission Requirements Document [RD6]. Contribution from other SAR missions may therefore be still necessary.

• The possibility, for critical areas, to perform interferometry every 6 days. This is implemented for Europe EEA-39, in both ascending and descending passes. This is particularly relevant for a number of applications, such as landslide monitoring. Another example is the monitoring of fast moving glaciers. In some cases the 12-day revisit is not short enough to get InSAR coherence between two acquisitions due to the speed of the glacier (other effects during winter for ice sheets are snowfall and redistribution of surface snow due to wind, causing temporal decorrelation).

• For an identified set of tectonic areas, the revisiting is planned to be increased by a factor 2 as an extension of what is achieved with Sentinel-1A (see section 3.1 above), allowing performing InSAR every 12 days both in ascending and descending, alternatively. This is planned to be implemented once in full operations capacity, and will be applied to areas subject to ground motion instability, for which InSAR every 12 days represents an added value.

• Increase of global land mapping frequency, in particular in support activities of the Copernicus Global Land service, but also crop monitoring activities that requires short revisit time, e.g. rice monitoring in key areas worldwide (see earlier).

• Potentially use of the SM mode for specific campaigns to respond to user expectations. The implementation of such campaign shall be assessed in detail, in order to limit the impact on applications requiring frequent coverage in the same mode.

6. **Resulting detailed observation plan**

The Sentinel-1 constellation observation scenario resulting from the above is published in the form of coverage maps, including modes, polarisation, ascending / descending passes, revisit and coverage frequency at: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario

An overview of the observation scenario is provided in the following three maps (status: October 2016).
In addition, the detailed planned acquisitions segments including information of mode, polarisation, date, start and stop times, orbit number etc. for both Sentinel-1A and Sentinel-1B are published in the form of kml files at (see example below): https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-1/observation-scenario/acquisition-segments
Appendix to Annex 1:

Overview of Sentinel-1 observation needs collection considered for the definition of the observation scenario

The following tables provide an overview of the various Sentinel-1 observation needs collected in the past and used for the consolidation of the observation scenario defined in Annex-1. Detailed additional information, not reported below, is available for some of them (shape files, period of the year, etc.). These needs are considered for the Sentinel-1A and Sentinel-1B routine operations, some of them will only be fulfilled during the Full Operations Capacity phase with the use of EDRS and the 4th core station. This list has been included with the main purpose to provide full transparency to all stakeholders on the needs expressed by relevant use typologies.

The list includes a number of projects (e.g. from FP7) or initiatives that have not necessarily provided observation needs but which are assumed to be served by Sentinel-1 observations.

Notes:

- The collection of observation needs is a continuous process, managed in close coordination with the Commission, and allowing capturing evolving user scenarios. Future revisions of the HLOP will include new observation needs as well as an historical view of observation needs collected in the past.

- some of the projects listed in the first column has been completed or are limited in time (e.g. FP7 projects, ESA GMES Service Element projects, etc.). They are intentionally kept in the list as reference for relevant Sentinel-1 observation needs and examples of Sentinel-1 based applications.

- in case of inconsistency between the user typologies definition and order reported in the tables below and the definition of the categories of source of requirements provided under chapter 8.2, the latter takes precedence.

<table>
<thead>
<tr>
<th>OVER OCEANS &amp; SEAS, SEA-ICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of requirements</td>
</tr>
<tr>
<td>Sea-ice and iceberg monitoring</td>
</tr>
</tbody>
</table>

Copernicus services / projects and Copernicus use
| Copernicus Marine Environment Monitoring Service (CMEMS), MONARCH-A, SIDARUS Polar Ice SWARP | CMEMS: Sea-ice and iceberg monitoring in Baltic Sea, Eurartic Waters, Greenland waters (incl. South), Davis Strait, Labrador Sea, Baffin Bay, Antarctica (Southern Ocean) | 1 hour to 3 hours, dependin on the areas | EWS HHHV or IWS HHHV (iceberg) | 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. |

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

| National requirements from Canada, Denmark, Finland, France, Norway, UK | Baltic Sea, Northwest Atlantic, Greenland waters, Faroe Islands waters, 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, dependin on the areas | EWS HHHV or IWS HHHV (iceberg) 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 |

| Polar View | Davis Strait, Labrador Sea, Baffin Bay, Eastern Canadian Coast | NRT | EWS HHHV or IWS HHHV (iceberg) | Every opportunity or daily coverage, in some cases sample strategy. Seasonal acquisition scheme. Coverage around Antarctica at least 1 every 3 days |  |

| Science Requirement | Beaufort Sea and Arctic Waters | not NRT | EWS HHHV | Regular mapping at daily to weekly frequency | ESA Beaufort Sea Envisat BRM |
### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Requirements</th>
<th>IICWG</th>
<th>NOAA</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>IICWG</td>
<td>Ice concentration, ice type, ice depth, ice motion, ice extent, All ice covered regions of world, including the Great Lakes</td>
<td>EWS or IWS</td>
<td>NRT (SM not selected)</td>
<td>Daily to weekly</td>
</tr>
<tr>
<td>NOAA (US coordinated requirements)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSTG SAR Coordination Group (NOAA)</td>
<td>Polar floating ice (scientific use)</td>
<td>No NRT</td>
<td>EWS or IWS</td>
<td>3-day repeat coverage frequency ideally</td>
</tr>
</tbody>
</table>

### Other use including commercial use

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Coverage Area</th>
<th>Data Type</th>
<th>Coverage</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar View, Support to oil and gas industry</td>
<td>Barents Sea, Greenland Sea, South and West Greenland waters, Norwegian Sea, Beaufort Sea</td>
<td>NRT</td>
<td>Daily to weekly coverage</td>
<td>During relevant seasons only</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EWS HHHV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Oil spill monitoring and polluter identification

**Copernicus services / projects and Copernicus use - EMSA**

| EMSA, SeaU | Large coverage of European waters | 10 min | EWS VVVH or HHHV - or IWS VVH or HHHV | Frequent observations but not necessarily every opportunity (sampling concept) | CleanSeaNet station network (part of collaborative GS): Matera, Brest, Azores, Tromsø, Svalbard |

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

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

| Canadian Waters | 60-120 min EWS VVVH or HHHV or IWS VVVH or HHHV | Every opportunity, all year | TBC: use of Canadian collaborative stations: Gatineau, Prince-Albert, Inuvik |

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

| Science Requirement | Global shipping and drilling areas | Not NRT | EWS VVVH or HHHV | TBD | former Envisat SDS BRM |

### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>INPE, IBAMA (Brazil)</th>
<th>Brazilian Coast near Rio / Sao Paolo</th>
<th>Quasi-real time</th>
<th>TBD</th>
<th>Frequent observation s but not necessarily every opportunity (sampling concept)</th>
<th>former Envisat SDS BRM</th>
</tr>
</thead>
<tbody>
<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 (SM not selected)</td>
<td>Daily to 3-days</td>
<td>Receiving capabilities to be clarified</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>EMSA, SeaU, DOLPHIN, NEREIDS SAGRES LOBOS</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 observation s but not necessarily every opportunity (sampling concept)</th>
<th>CleanSeaNet station network (part of collaborative GS): Matera, Brest, Azores, Tromsö, 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 observation s but not necessarily every opportunity (sampling concept)</td>
<td>Observation needs and areas to be confirmed/ clarified. EDRS planned to be used</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, Faroe Islands waters, French overseas territories / dept (Indian Ocean, Northern part of South American Coast), Eastern and Western African coasts. | 10 to 30 min | EWS VVVH or HHHV, or IWS | Very frequent observations, sampling strategy | Potential collaborative stations: Brest, Matera, Neustrelitz, Tromsø/Svalbard, Kiruna (TBC), Sodankylä, Azores, TBC: Maspalomas, Kerguelen, La Reunion, French Guyana, Gatineau, Prince-Albert, Inuvik. Use of EDRS outside Europe |
| 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 VVVH or HHHV – or IWS VV VH or HHHV depending on the areas | Very frequent observations, sampling strategy | Collaborative stations, TBC: 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 VV VH | Very frequent observations, sampling strategy |

### International Initiatives, International cooperation
### NOAAs (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

<table>
<thead>
<tr>
<th>Quasi to near real time</th>
<th>SM (not selected), IWS</th>
<th>Hourly to 3 days</th>
</tr>
</thead>
</table>

### Sea-state monitoring (wind, wave, current)

### Copernicus services / projects and Copernicus use

<table>
<thead>
<tr>
<th>Copernicus services / projects and Copernicus use</th>
<th>Global and regional scale TBC</th>
<th>WM, EWS, IWS (OCN product)</th>
<th>Where OCN product is available</th>
<th>Details to be discussed, start of use of Wave data by CMEMS planned for 2016-2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copernicus Marine Environment Monitoring Service (CMEMS) MyWave SWARP</td>
<td>Use of Ocean Product (for Wave information)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>National requirements from Denmark, France, Germany, Portugal, UK</th>
<th>North and Baltic Seas, large coverage of European waters (all free of ice), Greenland waters, Faroe Islands waters</th>
<th>10 min to 3 hours</th>
<th>EWS VVH or IWS VVVH</th>
<th>If possible every opportunity, all year</th>
<th>Note: quasi-real time requirement assumed to be implemented by collaborative GS or by QRT from core stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>National requirements from Canada</td>
<td>Canadian East and West coasts, Hudson Bay, Great Lakes, Northern Lakes and Southern Lakes</td>
<td>60 min</td>
<td>EWS VVH or HHHV</td>
<td>Acquisition window according to AOI</td>
<td></td>
</tr>
<tr>
<td>National requirements from France</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
### Science Requirement

Global Open Ocean monitoring (incl. Sea State ECV)  

- not NRT
- Wave mode and possibly high rate modes
- Routine observations

### International Initiatives, International cooperation

| NOAA (US coordinated requirements) | 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 | Quasi or near real time | Wave mode and high rate modes | Hourly to 3 days |

### OVER LAND

<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>
</table>

### Glacier, Snow and Permafrost monitoring

| CRYOLAND | Snow monitoring and Land ice monitoring. First phase: regions in Europe; e.g. Scandinavia and the Alps, Pyrenees, (including foothills) | 12 hours for NRT service | IWS (preferably SLC products) | Frequent coverage during melting period (Mar to Aug for the Alps) | Ascending & descending passes |

### Copernicus services / projects and Copernicus use

<p>| National services and use by ESA and EU Member States |</p>
<table>
<thead>
<tr>
<th>National requirements from Austria, Finland, Germany, Italy, Norway, Romania</th>
<th>Snow monitoring: Central/Eastern Europe, Alpine Arc, Northern Europe / Scandinavia, Baltic Sea (drainage)</th>
<th>3 hours</th>
<th>IWS HHHV (VVVH selected over land)</th>
<th>Frequent coverage during snow season</th>
<th>Ascending &amp; descending passes</th>
</tr>
</thead>
<tbody>
<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 VVVH</td>
<td>Daily (Northern Hemisphere), weekly (global)</td>
<td></td>
</tr>
<tr>
<td>National requirements from Norway and Canada</td>
<td>Glaciology: Svalbard glaciers, about 10 northern latitude glaciers (Canada)</td>
<td>Not NRT</td>
<td>IWS HHHV or HH (Svalbard) or SM HHHV (IW used instead of SM)</td>
<td>Frequent coverage (Svalbard) Once a year (Canada)</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Polar View</th>
<th>Snow monitoring: Central Europe, Alpine Arc, Scandinavia, Baltic Sea area</th>
<th>NRT or not NRT depending on area</th>
<th>IWS HH TBC</th>
<th>Frequent coverage during snow season</th>
<th></th>
</tr>
</thead>
<tbody>
<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>Glob-Permafrost</td>
<td>Global permafrost monitoring</td>
<td>Not NRT</td>
<td>IWS or EW</td>
<td>Regular monitoring</td>
<td>See PSTG below</td>
</tr>
</tbody>
</table>
### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>NOAA (US coordinated requirements)</th>
<th>Snow cover, depth, state: Global Land, priority for North America</th>
<th>NRT</th>
<th>EWS or IWS</th>
<th>3 to 120 h</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSTG SAR Coordination Group</td>
<td>Permafrost monitoring.</td>
<td>not NRT</td>
<td>EWS or IWS</td>
<td>Regular coverage</td>
</tr>
</tbody>
</table>

### Ice sheets / shelves monitoring

### Copernicus services / projects and Copernicus use

| MONARCH-ACRYOLAND | Antarctic Ice Sheet, Greenland Ice Sheet | not NRT | IWS HH TBC | TBD |

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

| National requirements from Denmark, Germany, Norway, Italy, UK | Antarctic Ice Sheet, Greenland Ice Sheet, Greenland & Antarctica outland glaciers / coastline | not NRT | IWS HH | Full and regular coverage | Observation scenario: see PSTG below |

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

| CCI | Antarctic Ice Sheet, Greenland Ice Sheet | not NRT | IWS HH | Antarctica coverage/year at least, Tentatively monthly coverage for Greenland |

### International Initiatives, International cooperation
| PSTG SAR Coordination Group | Antarctica Ice Sheet, Greenland Ice Sheet, Svalbard | not NRT | IWS HH, SM HH | Observation strategy: Greenland: 1 campaign once a year with 4 to 6 passes at 6 days, plus 6 tracks systematically covering every 6 days the Greenland margins. Antarctica ice sheet margins: 1 coverage per year with 4 to 6 passes at 6 days. | Greenland: 1 campaign once a year with 4 to 6 passes at 6 days, plus 6 tracks systematically covering every 6 days the Greenland margins. | Observation strategy: Greenland: 1 campaign once a year with 4 to 6 passes at 6 days, plus 6 tracks systematically covering every 6 days the Greenland margins. Antarctica ice sheet margins: 1 coverage per year with 4 to 6 passes at 6 days. Areas of special interest in Antarctic: Peninsula E&W coast and major outlet glaciers (e.g. PIG): systematic coverage every 1 or 2 repeat cycle. | Greenland: 1 campaign once a year with 4 to 6 passes at 6 days, plus 6 tracks systematically covering every 6 days the Greenland margins. Antarctica ice sheet margins: 1 coverage per year with 4 to 6 passes at 6 days. Areas of special interest in Antarctic: Peninsula E&W coast and major outlet glaciers (e.g. PIG): systematic coverage every 1 or 2 repeat cycle. | Greenland: 1 campaign once a year with 4 to 6 passes at 6 days, plus 6 tracks systematically covering every 6 days the Greenland margins. Antarctica ice sheet margins: 1 coverage per year with 4 to 6 passes at 6 days. Areas of special interest in Antarctic: Peninsula E&W coast and major outlet glaciers (e.g. PIG): systematic coverage every 1 or 2 repeat cycle. | Greenland: 1 campaign once a year with 4 to 6 passes at 6 days, plus 6 tracks systematically covering every 6 days the Greenland margins. Antarctica ice sheet margins: 1 coverage per year with 4 to 6 passes at 6 days. Areas of special interest in Antarctic: Peninsula E&W coast and major outlet glaciers (e.g. PIG): systematic coverage every 1 or 2 repeat cycle. |

### 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>
<tr>
<td><strong>Canada</strong></td>
</tr>
<tr>
<td><strong>Canada</strong></td>
</tr>
</tbody>
</table>
### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>NOAA (US coordinated requirements)</th>
<th>Northern North America rivers (especially Yellowstone River and Alaska rivers), especially in spring.</th>
<th>NRT</th>
<th>EW, IWS or SM (SM not selected)</th>
<th>Daily</th>
</tr>
</thead>
</table>

### Crisis Mapping, Emergency Support, GeoHazards, Terrain motion monitoring (subsidence, landslides)

### Copernicus services / projects and Copernicus use

<table>
<thead>
<tr>
<th>Copernicus EMS (incl. former SAFER)</th>
<th>Flooding: Europe Floodplains, Global Floodplain Background monitoring</th>
<th>not NRT</th>
<th>IWS HH (VV actually used over land)</th>
<th>Every cycle in Europe, twice / year outside Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFAS RASOR</td>
<td>Asset mapping: West Romania, West Central Bulgaria, North Central Bulgaria, North East Spain, South East France</td>
<td>not NRT</td>
<td>IWS VV or HH</td>
<td>Twice a year per area</td>
</tr>
<tr>
<td>Copernicus EMS (incl. former SAFER)</td>
<td>Terrain motion in Europe and worldwide (based on relevant map of risks)</td>
<td>not NRT</td>
<td>IWS VV or HH</td>
<td>Frequent observations. Background mapping for global observations</td>
</tr>
</tbody>
</table>

| Copernicus EMS (incl. former SAFER), DORIS, SubCoast RASOR PanGeo LAMPRE SENSUM INCREO MARSITE | Terrain motion: Italy, Mediterranean Sea relevant islands, Iceland, selected cities, South East Europe, Balkan and Middle East. Hotspot areas for natural hazards worldwide with special focus on Africa (esp. Western and Southern Africa), Indonesia and Chile. | NRT or not NRT dependin on areas | IWS VV or HH | Max. revisit, every opportunity | Ascending & Descending, no land/sea discontinuities |

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

| National requirements from Czech Republic, Italy, Germany, Greece, France, Norway, Romania, UK, Canada | Terrain motion: Italy, Mediterranean Sea relevant islands, Iceland, selected cities, South East Europe, Balkan and Middle East. Hotspot areas for natural hazards worldwide with special focus on Africa (esp. Western and Southern Africa), Indonesia and Chile. | NRT or not NRT dependin on areas | IWS VV or HH | Max. revisit, every opportunity | Ascending & Descending, no land/sea discontinuities |
### National requirements from Czech Republic, Germany, UK, Canada

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
<th>Mode</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood mapping in cities and at European continental level. Global flood mapping.</td>
<td>NRT</td>
<td>IWS HH (VV actually used over land)</td>
<td>Frequent observations</td>
</tr>
</tbody>
</table>

### National requirements from Greece, Italy

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
<th>Mode</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire monitoring, burn scar mapping at national / regional level in Europe</td>
<td>NRT or not NRT depending on application</td>
<td>IWS</td>
<td>Frequent observations</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Science Requirement</th>
<th>Description</th>
<th>Mode</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Subsidence background monitoring, focus on large urban areas</td>
<td>not NRT</td>
<td>IWS HH</td>
<td>Monthly, yearly</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RESPOND</th>
<th>Description</th>
<th>Mode</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa, Latin America, South-East and Central Asia, Middle East</td>
<td>normal</td>
<td>TBD (IWS assumed)</td>
<td>Yearly</td>
</tr>
</tbody>
</table>

### Terrafirma

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered by national requirements</td>
<td></td>
</tr>
</tbody>
</table>

### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>Former Cat 2 Envisat</th>
<th>Description</th>
<th>Mode</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Asia: Flooding / Typhoon monitoring</td>
<td>NRT</td>
<td>TBD, dual pol</td>
<td>During flooding / typhoon season</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Former Cat 2 Envisat</th>
<th>Description</th>
<th>Mode</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>US East Coast, Caribbean, Gulf of Mexico (Miami station coverage): Hurricane monitoring</td>
<td>NRT</td>
<td>TBD, dual pol</td>
<td>During hurricane season</td>
</tr>
</tbody>
</table>

### Tectonic Areas and Volcano Monitoring

### Copernicus services/ projects and Copernicus use
### EVOSS, Copernicus EMS (incl. former SAFER)
APhoRISM FUTUREVOLC MEDSUV

<table>
<thead>
<tr>
<th>Subset of volcanoes worldwide.</th>
<th>NRT 1h or not NRT depending on volcano</th>
<th>IWS HH or VV</th>
<th>Every repeat cycle</th>
<th>Ascending and descending</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVOSS test sites: Jebel Zubair, El Hierro, Nabro, Grímsvötn, Eyjafjallajökull, Dalafilla, Dabbahu, Erta’Ale, Manda Hararo, Ol’Doinyo Lengai, Jebel-al-Tair, Stromboli, Mt. Etna, Nyiragongo, Piton de la Fournaise, Karthala, Soufriere Hills, Nyamuragira.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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

### 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>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>GEO Geohazard Supersites</th>
<th>Supersites worldwide: Los Angeles, Vancouver/Seattle, Hawaii, Istanbul, Tokyo-Mt Fuji, Mt Etna, Vesuvius, Haiti, Chile, Tohoku-oki, Wenchuan</th>
<th>Not NRT</th>
<th>SM (not selected) or IWS</th>
<th>Frequent revisit</th>
<th>Ascending and descending</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Specific Copernicus Security Services (land), Critical Assets Monitoring, Illegal Mining

### Copernicus services and Copernicus use
<table>
<thead>
<tr>
<th>Former G-MOSAIC G-SEXTANT G-NEXT</th>
<th>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)</th>
<th>Not NRT</th>
<th>IWS HHHV or VVVH</th>
<th>3 times a year</th>
<th>SEC_002 – Crisis Indicators: Exploitation of natural resources. Note: these were test sites and should be reconsidered.</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Copernicus security service</td>
<td>Requirements TBD</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

*TBD*
## Copernicus services / projects and Copernicus use

<table>
<thead>
<tr>
<th>Service/Project</th>
<th>Description</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geoland-2</td>
<td>Priority for Europe, potentially outside Europe, at global level.</td>
<td>not NRT for Advanced SAR project: SM with various sub-swath and narrow time window (in contradiction with S1 standard mapping based on IW mode)</td>
</tr>
<tr>
<td>EUFODOS</td>
<td></td>
<td>ERMES, North State projects: as frequent as possible</td>
</tr>
<tr>
<td>REDDAF</td>
<td>Focus on generally cloudy areas (Northern Europe, Equatorial regions for forest monitoring)</td>
<td>IMAGINES, crop mapping demonstration. Test sites in Russia (Top left: 54.861°N, 35.900°E; Bottom right: 52.945°N, 38.052°E) and South Africa (Top left: 26.851°S, 24.548°E; Bottom right: 30.741°S, 29.770°E)</td>
</tr>
<tr>
<td>ReCover</td>
<td></td>
<td>ERMES: IW VVVH or HHHV</td>
</tr>
<tr>
<td>REDDINESS</td>
<td></td>
<td>North State: IW VVVH</td>
</tr>
<tr>
<td>ISAC</td>
<td>Other EU projects related to REDD / Deforestation: focus on tropical and sub-tropical forests</td>
<td>IMAGINES: SM VVVH (in contradiction with S1 standard mapping based on IW mode)</td>
</tr>
<tr>
<td>Advanced_SA</td>
<td>ISAC: agriculture and the agro-environment in Europe and Africa</td>
<td>ERMES: IW VVVH or HHHV</td>
</tr>
<tr>
<td>R</td>
<td></td>
<td>North State: IW VVVH</td>
</tr>
<tr>
<td>IMAGINES</td>
<td></td>
<td>SEN3APP: IW SLC complete coverage of the northern hemisphere with IW SLC data</td>
</tr>
<tr>
<td>ERMES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North-State</td>
<td>Advanced-SAR: Advanced Techniques for Forest Biomass and Biomass Change Mapping: test sites: Evo Finland and Remningstorp, Sweden</td>
<td></td>
</tr>
<tr>
<td>SEN3APP</td>
<td>IMAGINES: crop mapping demonstration. Test sites in Russia (Top left: 54.861°N, 35.900°E; Bottom right: 52.945°N, 38.052°E) and South Africa (Top left: 26.851°S, 24.548°E; Bottom right: 30.741°S, 29.770°E)</td>
<td>ERMES, North State projects: as frequent as possible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SEN3APP: frequent coverage</td>
</tr>
</tbody>
</table>

### Forest monitoring, Agriculture monitoring, Crop Mapping

- **Copernicus services / projects and Copernicus use**
- **Geoland-2**: priority for Europe, potentially outside Europe, at global level.
- **EUFODOS**
- **REDDAF**
- **ReCover**
- **REDDINESS**
- **ISAC**
- **Advanced_SA R**
- **IMAGINES**
- **ERMES**
- **North-State**
- **SEN3APP**

### Contents
- **Forest monitoring**
- **Agriculture monitoring**
- **Crop Mapping**

### Key Points
- **Copernicus services / projects and Copernicus use**
- Geoland-2: priority for Europe, potentially outside Europe, at global level.
- **EUFODOS**
- **REDDAF**
- **ReCover**
- **REDDINESS**
- **ISAC**
- **Advanced_SA R**
- **IMAGINES**
- **ERMES**
- **North-State**
- **SEN3APP**

### Additional Information
- **Forest monitoring**
- **Agriculture monitoring**
- **Crop Mapping**

---

**COPE-S1OP-EOPG-PL-15-0020**

Page 61/75

Issue 2 Rev 0
### National services and use by ESA and EU Member States

<table>
<thead>
<tr>
<th>National requirement from Czech Republic, France, Germany, Italy, Norway, Romania, Spain, Switzerland, UK, Canada</th>
<th>Agriculture and forestry in Europe and Canada.</th>
<th>not NRT</th>
<th>IWS VVVH or HHHV</th>
<th>Regular coverage, depending on growing season for agriculture / crop monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Involvement in international partnership / projects at global level.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monitoring deforestation (special focus in South America).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>GMFS</th>
<th>African territories involved in GMFS</th>
<th>not NRT</th>
<th>IWS VVVH or HHHV</th>
<th>Regular coverage, depending on season</th>
</tr>
</thead>
</table>

### International Initiatives, International cooperation

<table>
<thead>
<tr>
<th>REDD, FCT, GFOI, GEOGLAM-SIGMA, IRRI</th>
<th>Tropical forest globally, UN REDD Participating Countries, potentially all forests worldwide</th>
<th>not NRT</th>
<th>IWS VVVH or HHHV</th>
<th>4 coverage per year typically for forest. For rice monitoring: every 12-day repeat cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GFOI sites: Vietnam, Ecuador, Colombia, Peru, Amazon, Tanzania, Lake Victoria region. GEOGLAM-SIGMA sites in Taiwan, Malaysia, Indonesia, Thailand, Philippines, Laos, China, Pakistan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IRRI priority areas for rice monitoring in following countries: India (Tamil Nadu and Odisha states), Vietnam, Philippines, Thailand, Cambodia</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Land Use, Hydrology, Soil Moisture

## Copernicus services and Copernicus use

<table>
<thead>
<tr>
<th>Geoland-2 HELM Copernicus Global Land</th>
<th>Land use in Europe – Copernicus Global Land: both Europe and Global components. Priority areas: 1- Europe, 2 – Africa, 3- rest of the world</th>
<th>No NRT – NRT for soil moisture / hydrology in Europe)</th>
<th>Europe: IWS HH or VV (product GRD-HR)</th>
<th>Global: IW HH or VV, MR (product GRD-MR)</th>
<th>Systematic / very high frequent coverage</th>
<th>Copernicus Global land component: (MR1_SAR_GLOBAL) assumes the service is provided by Sentinel-1 at low resolution (MR1: 30m/100m)) with a “daily composite”: the mission design cannot technically cope with such coverage frequency, due to the orbit repeat cycle and onboard constraints. Proposal: 12-day at global level, 6 days over Europe EEA-39 in both asc and desc</th>
</tr>
</thead>
</table>

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

...
### National requirements from Austria, Czech Republic, 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)

<table>
<thead>
<tr>
<th>Scientific use, on-going ESA projects, continuity of ERS/ENVISAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CCI Land Cover</strong></td>
</tr>
<tr>
<td><strong>International Initiatives, International cooperation</strong></td>
</tr>
<tr>
<td><strong>GEO, UN, EEA, etc.</strong></td>
</tr>
<tr>
<td><strong>NOAA (US coordinated requirements)</strong></td>
</tr>
</tbody>
</table>

<p>| | | | | |
| | | | | |
| <strong>IWS HH</strong> or <strong>IWS HHHV</strong> | | | | |</p>
<table>
<thead>
<tr>
<th>Cooperation with US SMAP mission</th>
<th>Support SMAP mission objectives with C-band radar data</th>
<th>Not NRT</th>
<th>IWS VV+VH</th>
<th>All passes (requirement)</th>
</tr>
</thead>
</table>

The implementation of all S1A+S1B passes over the whole US is not technically possible. The plan is to provide a 12-day repeat coverage (like for other global land areas outside Europe), in ascending orbits with combined S1A + S1B acquisitions.
ANNEX 2

Sentinel-2 baseline observation scenario

A similar observation approach as for Sentinel-1 with a ramp-up scenario has been executed for Sentinel-2A.

During this gradual ramp-up, the observations as well as the mission performance level was gradually increased in a stepwise approach. This included:

- gradual increase of acquisition capacity from an initial observation/processing scenario (3min/orbit) to systematic observation at given intervals (10-20 days revisit) with a current maximum of 14.2 min/orbit average
- ensuring coverage of global Cal/Val needs
- ensuring as early as possible Copernicus Services dataset needs starting from Europe and extending gradually to the world
- ensuring maximum coverage/optimized orbit length for generation of a Global Reference Image (GRI), required to produce high accuracy L1C products. Due to cloudiness of resulting imagery, this is an ongoing activity, with the acquisitions selection expected to be completed in 2017. Global GRI delivery is expected by end 2017. The GRI is composed of sub-continental blocks. This allows to optimize resources by planning/re-planning smaller units and to acquire data in different parts of the world instead of within a continent for a given period. The sub-division of GRI-blocks is as follows:
After a steady increase of observation and processing capacity between IOCR (Oct 2015) and IOCR+ 8 months (May 2016), the observation scenario has followed a systematic regular pattern: with the current 3 X-band stations available, Sentinel-2 acquisitions are operated on the following basis:
- 10 days revisit Europe, Africa and Greenland,
- 20 days revisit for the rest of the world.

During the period November 2016 to February/March 2017 there is reduced illumination in Northern latitudes; as a result, a different scheme is operated:
- 10 days revisit Europe, Africa and (southern) Greenland
- 20 days revisit for the rest of the world, interleaved by a regular pattern of 10-day revisit alternating between the Americas and Asia/Oceania South of 37 degrees N:

Where possible from observation and downlink capacity viewpoint, campaigns for Antarctica (partial or full, up to 84 deg. south) coverage are inserted during this Southern hemisphere summer period, to use all available satellite capacity, support the CMEMS Sea Ice activities and complement Antarctic Observations of partner missions such as Landsat for other use in application areas such as Climate Change. It is planned to perform observation of the whole Antarctica at least once a year, tentatively.

The detailed planned acquisitions segments per cycle are published in the form of kml files at (see example below):
https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/acquisition-plans

Once the 4th X-bad core station and/or the routine EDRS service will be available, all land masses on the globe as per MRD definition will be acquired at 10 day revisit. The final 10-day acquisition pattern will be as follows: