Sentinel (-1/-2/-3) Status

Pierre Potin, ESA

CCI collocation, 6 February 2014, ESRIN
- Sentinel (-1 / -2 / -3) Status

- Sentinel-1 Observation Concept Overview

- Sentinel-1 Mission Ramp-Up

- Sentinel Data Access Overview
Sentinel-1 Mission Facts

- Constellation of two satellites (A & B units)
- C-Band Synthetic Aperture Radar Payload (at 5.405 GHz)
- 7 years design life time with consumables for 12 years
- Near-Polar sun-synchronous (dawn-dusk) orbit at 698 km
- 12 days repeat cycle (1 satellite), 6 days for the constellation
- Both Sentinel-1 satellites in the same orbital plane (180 deg phased in orbit)
- Optical Communication Payload (OCP) for data transfer via laser link with the GEO European Data Relay Satellite (EDRS)
- Launch of Sentinel-1A scheduled for 28 March 2014 (Sentinel-1B ready for launch by end 2015)
4 mutually exclusive SAR modes with different resolution and coverage

- Polarisation schemes for IW, EW & SM:
  - single polarisation: HH or VV
  - dual polarisation: HH+HV or VV+VH

- Wave mode: HH or VV

- SAR duty cycle per orbit:
  - up to 25 min in any of the imaging modes
  - up to 74 min in Wave mode

Main modes of operations:
- IW over land and coastal waters
- EW over extended sea and sea-ice areas
- WV over open oceans
Satellite External Views

Deployed Configuration
21 m
12.3 m

Stowed Configuration
3.4 m

Soyuz ST

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SENTINEL-1 STATUS

QAR KO (Satellite Qualification Review) → January 13th, 2014

QAR Conclusion → February 18th, 2014

Shipment to Kourou → February 21st, 2014

Launch Campaign Start → February 24th, 2014

Launch → March 28th, 2014

IOCR (Satellite In-Orbit Commissioning Review) → July, 2014

European Space Agency
### Sentinel-2 Mission Overview / Main Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spacecrafts</strong></td>
<td>2 operating in twin configuration</td>
</tr>
<tr>
<td><strong>Instrument</strong></td>
<td>MSI (Multi-Spectral Instrument) operating in pushbroom principle (filter based optical system)</td>
</tr>
<tr>
<td><strong>Spectral bands</strong></td>
<td>13 (VIS–NIR–SWIR)</td>
</tr>
<tr>
<td><strong>Spatial Resolution</strong></td>
<td>10m / 20m / 60m</td>
</tr>
<tr>
<td><strong>Swath</strong></td>
<td>290 km</td>
</tr>
<tr>
<td><strong>Orbit</strong></td>
<td>Sun-synchronous at 786 km (14+3/10 revs per day), with LTDN 10:30 AM</td>
</tr>
</tbody>
</table>
| **Revisit Periodicity** | 10-day with 1 satellite  
5 day with 2 satellites                                                                 |
| **Lifetime**       | 7.25 years, extendable to 12 years                                                                                                           |
Sentinel-2 Coverage

- Systematic acquisition of:
  - All land surfaces (-56° and +84° latitude);
  - Major (greater than 100 km² size) and EU islands;
  - Coastal/inland waters, Mediterranean Sea and all closed seas;
  - Cal/Val sites.

![Effective Covered Area Map](image-url)
Sentinel-2 Bands and Resolutions
Sentinel-2: Status Update

- Sentinel-2A Platform fully integrated, with the exception of the Reaction Wheel Assembly (RWA)
- Multi-Spectral Instrument (MSI-A) fully integrated, with the exception of the secondary structure (delivered)
- Sentinel-2A Payload Data Handling and Transmission & Attitude and Orbit Control Subsystem (in closed loop) Integrated System Tests successfully completed
- Ground Segment CDR Review completed
- Sentinel-2A will be launched with VEGA, with launch readiness assumed in spring 2015
Sentinel-3 implements 3 core missions to deliver continuity to:

**Sea and land color data**, through **OLCI (Ocean and Land Color Instrument)** at least at the level of quality of the Medium Resolution Imaging Spectrometer (MERIS) instrument

**Sea and land surface temperature**, through the **SLSTR (Sea and Land Surface Temperature Radiometer)** at least at the level of quality of the Advanced Along-Track Scanning Radiometer (AATSR) instrument

**Sea surface topography data**, through a Topo P/L including a **Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL)** and a bi-frequency **MicroWave Radiometer (MWR)**, at least at the level of quality of the Envisat Radar Altimeter (RA) system

In addition, the payload design will allow

- Data continuity of the Vegetation instrument (on SPOT4/5),
- Enhanced fire monitoring capabilities,
- Along-track SAR for coastal zones, in-land water and sea-ice topography
Development status

- Most equipment required for Sentinel-3A and -3B already delivered

- Sentinel-3A Satellite integration well advanced

- Sentinel-3B Platform integration almost completed

Launch of the Sentinel-3A currently foreseen for June 2015

FAR of the Sentinel-3B satellite planned approx. 1 year after S3A FAR
Data will be acquired **systematically** based on a pre-set nominal mission scenario, as defined in the HLOP:

Operations for OLCI and the visible channels of the SLSTR are based on specific solar illumination conditions \((SZA < 80\text{deg})\)

MWR acquires data over the whole orbit.

SRAL acquires data over the whole orbit with a pre-defined, automatically performed split between Low Resolution Mode (LRM) and SAR mode.

→ **see next slide for update**
Original operational baseline: split between LRM and SAR mode

Autumn 2013: Request by the Copernicus user community to extend usage of SAR mode for the S-3 SRAL instrument up to 100% of Earth coverage -> ESA/EUMETSAT assessment approved by EC now for implementation, subject to a detailed cost/schedule assessment and final go ahead by EU

Note: it is assumed that the LRM shall be kept as a back-up to reduce operational risks and to allow a possible switch to the LRM scenario if necessary

During SAR mode, an increased number of waveforms is shot with respect to LRM → increased instrument power consumption increased instrument data rates; SAR mode benefit to users:
- Increased resolution along-track
- Scope for better accuracy over challenging surfaces

100% SAR mode

(Credits: H. Snaith and P. Cippolini, NOC, UK)
Request from EC for two new operational products:

a. **Fire Radiative Power (from SLSTR)**
   - FRP in core product list
   - FRP at 1 km (pixel level)
   - Accuracy: goal 10%, threshold 30%
   - Threshold Detection: Goal 5MW, threshold 50 MW
   - NRT (< 3 h)

b. **Aerosol (Global) (from SLSTR and OLCI)**
   - Global Aerosol in core product list
   - Aerosol at pixel level (goal)
   - Accuracy: goal AOD 0.1 over land, AOD 0.05 over ocean
   - NRT (< 3 h)
   - AOD 550 nm over ocean and land (goal)
   - Include uncertainties at pixel level (goal)
SENTINEL-1 Observation Concept Overview
-
Mission Ramp-Up
In line with the Sentinel operations strategy objectives:

→ Implement a **pre-defined** and **conflict-free** observation plan, aiming at fulfilling, to the best extent, the observation requirements from:
   - the **Copernicus services**
   - the **use by ESA / EU Member States**

→ In addition, on best effort basis:
   - ensure continuity of **ERS/ENVISAT**
   - implement requirements from the **science community**
   - contribute to **international cooperation** activities.

→ Need to find **a priori** the solutions on the potential conflict among users (e.g. different SAR operation modes / polarisation required over same geographical area)
## Collecting the Sentinel-1 observation requirements

<table>
<thead>
<tr>
<th>Group</th>
<th>Source of Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Copernicus services and Copernicus use</strong></td>
<td>- Extrapolation of Copernicus Data Access Data Warehouse requirements</td>
</tr>
<tr>
<td></td>
<td>- Direct discussions with Copernicus services and EU Agencies (e.g. EMSA)</td>
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<tr>
<td><strong>National services and use by ESA and EU Member States</strong></td>
<td>- Discussions with Member States Delegations</td>
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<td>- Reply to Collaborative Ground Segment questionnaire (in the framework of the GOCG)</td>
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<td><strong>Scientific use, on-going projects, continuity of ERS/ENVISAT</strong></td>
<td>- Recommendations from scientists at key SAR workshops (FRINGE, SEASAR), and others ESA organised workshop (e.g. SEN4SCI, Cryosphere, Int. Forum on Geohazards, etc.)</td>
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<td>- ESA GSE Projects (e.g. Polar View, MARISS, Terrafirma, GMFS, etc.)</td>
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<td>- Glob-series projects, CCI, SEOM, etc.</td>
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<tr>
<td></td>
<td>- Extrapolation of ERS/ENVISAT projects</td>
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<tr>
<td><strong>International Initiatives, International cooperation</strong></td>
<td>- GEO/CEOS (e.g. FCT, GFOI, Geo-hazard Supersites), IGOS, FAO, REDD, PSTG, IICWG, GCOS, CliC, TIGER, DRAGON, etc.</td>
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<td></td>
<td>- Requests from international partners (e.g. US (NOAA / NASA / USGS), Australia, China, etc.)</td>
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<tr>
<td><strong>Other use including use for commercial value-adding</strong></td>
<td>EARSC, etc.</td>
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</table>
Sentinel-1 mission operations is characterized by phases:

- **A gradual ramp-up** allowing adapting the Sentinel-1 exploitation capacity to the increasing needs of the users while optimizing the available resources
- **Progressive evolution** in the availability of the overall system, the data throughput and timeliness, the committed services to users
Sentinel-1 gradual capacity increase: data download & sensing time

- Average total downlink time per orbit [min]
- Average observation time per orbit (high bit rate modes) [min]
Indicative observations plan for cycles 1 and 2 after IOCR
Acquisitions over 1 repeat cycle
Example of optimisation: accommodation of Ice sheet monitoring campaign over Greenland (ascending passes)

Objectives:
- provide a full mapping in IW mode of Greenland ice sheet during 1 repeat cycle; then repeated once or twice during following cycle(s)
- Limit the impact on the MyOcean sea-ice observations in EW mode

Results:
- 12 IW HH tracks are needed
- The IW tracks are extended to cover the full Eurarctic AOI as well so that they can be used for sea-ice monitoring
- These few tracks in IW HH enable another full coverage in EW HH-HV mode during the 12 day cycle in ascending passes
Example of potential Ice Sheet Monitoring Campaign in Antarctica - 3 repeat cycle during first 6 months (tracks from coast to coast)

**Ascending passes**

**Descending passes**
Gradual provision of qualified products
Relevance of Sentinel-1 Observation scenario for: Ice sheets, Glaciers, Sea-Ice

**Ice sheets:**
- Regular campaigns will be organised in particular over Greenland and Antarctica, starting during the mission ramp-up phase.
- Sentinel-1 observation requirements are discussed in the Polar Space Task Group (PSTG), SAR Working Group.

**Glaciers:**
- Regular observation of European glaciers will start early during the mission, allowing CCI projects to start testing Sentinel-1 data.
- It is planned during Full Operations Capacity to regularly cover all land areas at global level and therefore observation of glaciers worldwide.

**Sea-Ice**
- Sea-ice monitoring is addressed by one of the key Copernicus service for Sentinel-1 (MyOcean), and extended sea-ice areas will regularly be planned, starting early during mission operations.
- Sea-ice areas outside MyOcean areas (e.g. Western Arctic) are also planned to be regularly covered starting early during the mission.
Land Cover and Soil Moisture:

- Regular observation of whole Europe will start early during the mission, allowing CCI projects to start testing Sentinel-1 data.

- It is planned during Full Operations Capacity to regularly cover all land areas at global level, providing potential data sets for SAR-based Land Cover and Soil Moisture.

- Required frequency of observations may be an issue for both Land Cover and Soil Moisture, areas should be prioritised.
SENTINEL DATA ACCESS CONCEPT
Use Typologies

Copernicus Services

- Copernicus Core & Downstream Services
  - Other EU needs assimilated to Copernicus services (e.g. EMSA, EEA, EUSC, JRC)

Other use

- Science use
- EU MSs + Public Value Adding use
- Commercial Value Adding use

- ESA Member States needs (Collaborative GS)
- ESA funded R&D projects
- International Agreements
Sentinel Data Access
Different infrastructures adapted to different needs

Sentinel data made available thanks to the operations of core production, archiving and retrieval systems and facilities

- Scientific / Other Use Infrastructure
- Copernicus Services Infrastructure
- ESA Collaborative Infrastructure
- EU International Agreements Infrastructure

Operated by ESA MSs
Operated by int. partners

Tailored data access infrastructures...
...serving different user needs
The Sentinel Data Policy and the funded operational accesses offer a dedicated access per user type potentially complemented by additional data retrieval points.
Thank you!

On the web:

Sentinel Net web site:  
http://sentinel.esa.int

Sentinel-1 sample products:  
https://scihub.esa.int/  
http://s1hub.esa.int/  
https://earth.esa.int/web/guest/campaigns