Sentinel-1 Mission Overview
- Approach for Observation Scenario -

Meeting with MyOcean, 10 Sep 2010
Sentinel-1: C-band SAR mission

Applications:
- monitoring sea ice zones & the arctic environment
- surveillance of marine environment
- monitoring land surface motion
- mapping in support of humanitarian aid in crisis situations

The Sentinel-1 mission is based on a constellation of two satellites

2300 Kg spacecraft mass
7 years design life time, consumables for 12 years
Sun synchronous orbit at 693 Km mean altitude
12 days repeat cycle
The two satellites are in the same orbit but with a different mean anomaly

Sentinel-1A to be launched end 2012
Sentinel-1B under procurement, launch date is TBD
Four nominal SAR operation modes:
- strip map (80 km swath, 5x5 m res.)
- interferometric wide swath (250 km swath, 5x20 m res.)
- extra wide swath (400 km swath, 20x40 m res.)
- wave (5X5 m res (TBC), sampled images of 20x20 km at 100 km along the orbit, alternating into 2 incidence angles)

Note: above resolutions are (single look) mode resolutions. See slide 7 for expected product resolution.

SAR Duty cycle:
→ up to 25 min/orbit in high rate acquisition modes

Data recording / transmission capabilities:
- On-board data storage capacity of 1400 Gbit
- Two X-band RF channels of 260 Mpbs each
Sentinel–1 SAR operational modes

Orbit Height

~700 km

Flight Direction

Sub-Satellite Track

Wave Mode

Strip Map Mode

Interferometric Wide Swath Mode

Extra Wide Swath Mode

Sentinel–1 SAR operational modes
### Mission Performance

<table>
<thead>
<tr>
<th>Mode</th>
<th>Access Angle</th>
<th>GR Single Look Resolution</th>
<th>Swath Width</th>
<th>Polarisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip Map</td>
<td>20-45 deg.</td>
<td>Range 5 m</td>
<td>&gt; 80 km</td>
<td>HH or VV or HH+HV or VV+VH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Azimuth 5 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interferometric Wide Swath</td>
<td>&gt; 25 deg.</td>
<td>Range 5 m</td>
<td>&gt; 250 km</td>
<td>HH or VV or HH+HV or VV+VH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Azimuth 20 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extra Wide Swath</td>
<td>&gt; 20 deg.</td>
<td>Range 20 m</td>
<td>&gt; 400 km</td>
<td>HH or VV or HH+HV or VV+VH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Azimuth 40 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wave mode</td>
<td>23 deg. &amp; 36.5 deg.</td>
<td>Range 5 m (TBC)</td>
<td>&gt; 20 x 20 km</td>
<td>HH or VV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Azimuth 5 m (TBC)</td>
<td></td>
<td>Vignettes at 100 km intervals</td>
</tr>
</tbody>
</table>

**For All Modes**

- Radiometric accuracy (3σ): 1 dB
- Noise Equivalent Sigma Zero: -22 dB
- Point Target Ambiguity Ratio: -25 dB
- Distributed Target Ambiguity Ratio: -22 dB
**LEVEL-0 PRODUCTS**
Compressed, unprocessed instrument source packets, with additional annotations and auxiliary information to support the processing.

**LEVEL-1 PRODUCTS**

*Level-1 Slant-Range Single-Look Complex Products (SLC):*
Focused data in slant-range geometry, single look, containing phase and amplitude information.

*Level-1 Ground Range Detected Geo-referenced Products (GRD):*
Focused data projected to ground range, detected and multi-looked. Data is projected to ground range using an Earth ellipsoid model, maintaining the original satellite path direction and including complete geo-reference information.

**LEVEL-2 PRODUCTS**
Level-2 Ocean products
Ocean wind field, swell wave spectra and surface radial velocity information as derived from SAR data.
### Planned operational ESA Sentinel-1 products - L1 characteristics

<table>
<thead>
<tr>
<th>Acq. Mode</th>
<th>Product Type</th>
<th>Resolution Class</th>
<th>Resolution [Rng x Azi] [m]</th>
<th>Pixel Spacing [Rng x Azi]</th>
<th>No. Looks [Rng x Azi]</th>
<th>ENL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM</td>
<td>SLC</td>
<td>-</td>
<td>1.7 x 4.3 to 3.6 x 4.9</td>
<td>1.5 x 3.6 to 3.1 x 4.1</td>
<td>1 x 1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SLC</td>
<td>FR</td>
<td>9 x 9</td>
<td>4 x 4</td>
<td>2 x 2</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>SLC</td>
<td>HR</td>
<td>23 x 23</td>
<td>10 x10</td>
<td>6 x 6</td>
<td>34.4</td>
</tr>
<tr>
<td></td>
<td>SLC</td>
<td>MR</td>
<td>84 x 84</td>
<td>40 x 40</td>
<td>22 x 22</td>
<td>464.7</td>
</tr>
<tr>
<td></td>
<td>GRD</td>
<td>FR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GRD</td>
<td>HR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GRD</td>
<td>MR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IW</td>
<td>SLC</td>
<td>-</td>
<td>2.7 x 22 to 3.5 x 22</td>
<td>2.3 x 17.4 to 3 x 17.4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SLC</td>
<td>HR</td>
<td>20 x 22</td>
<td>10 x 10</td>
<td>5 x 1</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>SLC</td>
<td>MR</td>
<td>88 x 89</td>
<td>40 x 40</td>
<td>22 x 5</td>
<td>105.7</td>
</tr>
<tr>
<td>EW</td>
<td>SLC</td>
<td>-</td>
<td>7.9 x 42 to 14.4 x 43</td>
<td>5.9 x 34.7 to 12.5 x 34.7</td>
<td>1 x 1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SLC</td>
<td>HR</td>
<td>50 x 50</td>
<td>25 x 25</td>
<td>3 x 1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SLC</td>
<td>MR</td>
<td>93 x 87</td>
<td>40 x 40</td>
<td>6 x 2</td>
<td>12</td>
</tr>
<tr>
<td>WV</td>
<td>SLC</td>
<td>-</td>
<td>2.0 x 4.8 and 3.1 x 4.8</td>
<td>1.7 x 4.1 and 2.7 x 4.1</td>
<td>1 x 1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>GRD</td>
<td>MR</td>
<td>52 x 51</td>
<td>25 x 25</td>
<td>13 x 13</td>
<td>139.7</td>
</tr>
</tbody>
</table>

- For Ground Range Products, the resolution corresponds to the mid range value at mid orbit altitude, averaged over all swaths.
- For SLC SM/IW/EW products, the resolution and pixel spacing are provided from lowest to highest incidence angle. For SLC WV products, the resolution and pixel spacing are provided for beams WV1 and WV2.
- For SLC products, the range coordinate is in slant range. All the other products are in ground range.
APPROACH FOR SENTINEL-1 OBSERVATION SCENARIO
Sentinel-1 mission key operational concepts

- **Pre-defined stable mission observation plan**, to support operational activities (e.g. sea-ice monitoring, oil spill monitoring, ground motion monitoring)

- **On-request satellite tasking**, processing and dissemination capability *limited* to support exceptional cases (e.g. Emergency & Security GMES Services)

- **Systematic processing and dissemination** of all acquired data within 24 h

- **Systematic NRT data access capability** (from 3 h after data sensing to less than 1h after sensing)

- **Easy access** to systematic products flow

- **Stable and traceable product quality** meeting the quality requirements and accurate product calibration

- **On line data access** for fresh and past data
**Sentinel-1 observation scenario**

- **Objective:** Implement a pre-defined and conflict-free observation plan, aiming at fulfilling, to the max. feasible extent, the observation requirements from the various GMES and National services.

- Need to find *a priori* the solutions on the potential conflict among services (e.g. different SAR operation modes / polarisation required over same geographical area).

- The observation plan shall be regularly updated based on:
  - The evolution of the requirements from the services.
  - The constraints on the space and ground segment resources (high data rates and volume generated by the mission, instrument duty cycle, core ground station network and the overall data acquisition strategy).
  - The main system capacity scenarios (e.g. inclusion of the 2nd Sentinel-1 satellite, use of EDRS).
  - The contribution of (and interoperability with) the Radarsat Constellation Mission (RCM).
Areas of interest from MyOcean for C-band SAR as defined in the DAP-R (North Hemisphere)
Areas of interest from MyOcean for C-band SAR as defined in the DAP-R (Antarctica)
Merger of all areas of interest related to RT/NRT requirements from various services
Anticipated observation requirements for sea-ice monitoring

- Data latency: NRT 3h in most of the cases, with possibly, to be discussed, NRT 1h for Baltic sea and Eurartic 1

- Mode / polarisation:
  - EWS or IWS: to be discussed
    - IWS: 250 km swath, 20m res. (5 ENL) or 90m res. (105 ENL)
    - EWS: 400 km swath, 50m res. (3 ENL) or 90m res. (12 ENL)

- Polarisation: to be discussed
  - ideally (for sea-ice) the dual-polarisation (HH+HV)
  - would single polarisation be acceptable (HH)?

  → note: dual-pol has a strong impact on the overall acquisition scenario as it requires the use of both X-band RF channels (further analysis will determine whether the EWS mode can be downlinked on a unique channel – this is possible in terms of data rate)

- Potential conflicts, mainly with:
  - EMSA oil spill monitoring services
  - Ship detection services (Baltic sea)
  - Land requirements regarding coastal zones (mode transition)
Sentinel-1 observation scenario and impact on data volumes

- Sentinel-1 systematic observation scenario in one/two main HBR modes of operation will result in significantly large acquisition segments (data takes of few minutes)

- 25min in HBR leads to about 2.4 TBytes of compressed raw data per day for the 2 satellites

- Wave Mode is operated continuously over ocean where HBR not used

16 GB for SLC
4 GB for GRD-HR

46 GB for SLC
12 GB for GRD-HR
Concluding remarks

- The Sentinel-1 mission will provide **continuity** to ERS and ENVISAT with **improved performance and revisiting**

- Sentinel-1 will be operated with a **predefined systematic observation scenario**, with systematic processing to a predefined set of operational products
  - Need to agree the baseline observation scenario with key users

- **On-line data access** mechanism, through subscription for routine data flows

- **Free and open access** to Sentinel data for all users