The Sentinel-3(A) Mission:
Status and update on land and marine products

Susanne Mecklenburg, ESA S3 Mission Manager
B. Berruti (ESA), P. Goryl (ESA), P. Féménias (ESA), S. Dransfeld (ESA), C. Donlon (ESA), H. Wilson (EUMETSAT), D. Provost (EUMETSAT)
ESA’s Earth Observation Programmes

Meteorological Programme
- driven mainly by weather forecasting and climate monitoring needs. These missions developed in partnership with EUMETSAT include the Meteorological Operational satellite programs (Meteosat), forming the core segment of EUMETSAT’s Polar System (EPS), and the new generation of Geostationary Meteosat satellites (Meteosat-10, MSG-4).

Sentinel Missions
- driven by user needs to contribute to the Copernicus initiative. These satellite missions developed in partnership with the EU include Copernicus Imaging Radar (Sentinel-1), high-resolution optical (Sentinel-2), optical and infrared nadir sensor (Sentinel-3) and atmospheric composition monitoring (Sentinel-5). Sentinel-5 on board Met missions MSG and EPS are successors of MSG and EPS-SG respectively.

Earth Explorer Missions
- driven by scientific needs to advance our understanding of how the ocean, atmosphere, hydrosphere, cryosphere and Earth’s interior operate and interact as part of an interconnected system. These research missions, advancing European excellence in technological innovation, form the way towards new developments in future Earth applications.

Earth Observation Envelope Programme

Data from non-ESA Missions

EOP Operated Missions
**SENTINEL-3**
**MISSION OVERVIEW**

- Operational mission in high-inclination, low Earth orbit
- Full performance achieved with 2 satellites in orbit (S-3A,-3B)

**Optical Mission Payload providing**
- Sea and land color data, through OLCI (Ocean and Land Color Instrument)
- Sea and land surface temperature, through the SLSTR (Sea and Land Surface Temperature Radiometer)

**Topography Mission Payload providing**
- Sea surface topography data, through a Topo P/L including a Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL), a bi-frequency MicroWave Radiometer (MWR), and a Precise Orbit Determination (POD) including:
  - GNSS Receiver
  - DORIS
  - Laser Retro-Reflector

In addition, the payload design will allow
- Data continuity of the Vegetation instrument (on SPOT4/5),
- Enhanced fire monitoring capabilities, river and lake height, atmospheric products
NEW FEATURES

- European global land and ocean monitoring mission
  - Optical mission to cover sea and land colour and surface temperature
  - Altimetry mission in support of sea-surface and land-ice topography
  - Vegetation products through synergy between optical instruments
  - Enhanced fire monitoring capabilities, river and lake height, atmospheric products

- Increased number of bands compared to both AATSR and MERIS allowing
  - Overlap and synergy between OLCI and SLSTR
  - Enhanced fire monitoring capabilities

- Optical payload < 2 days global coverage with 2 Satellites in view of the substantially increased swath

- Improved altimetry mission with
  - 100% Along-track SAR topography
  - Open-loop tracking for rough zones

- Very accurate POD providing
  - A radial POD accuracy of 2-3 cm in ground processing.
  - On-board navigation solution (3m) for real time range control of SRAL (Open Loop)

- Near-Real Time (< 3 hr) availability of L2 core products

Instrument Swath Patterns

<table>
<thead>
<tr>
<th>Orbit type</th>
<th>Repeating frozen SSO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeat cycle</td>
<td>27 days (14 + 7/27 orbits/day)</td>
</tr>
<tr>
<td>LTDN</td>
<td>10:00</td>
</tr>
<tr>
<td>Average altitude</td>
<td>815 km</td>
</tr>
<tr>
<td>Inclination</td>
<td>98.65 deg</td>
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Copernicus Marine Environment Monitoring Service (CMESM) asked for optimising orbit phase shift to **improve interleave between S3A and S3B for improved SRAL meso-scale sampling at 4-7 days**

- Solution of **140°** separation recommended by ESA
- EC has confirmed implementation for S3B

**Minimal impact on optical mission:**
- OLCI over ocean: global coverage <2 days but parts of the swath will be impacted by sun-glint. Sun-glint free coverage by OLCI will be attained in ~3 days over the ocean.
- SLSTR over ocean: coverage and revisit of the SLSTR remains compliant with requirements.
- Over land (sun glint unproblematic, unless inland water) OLCI and SLSTR coverage is expected to remain compliant with requirements.
Sentinel-3A successfully launched from Plesetsk Cosmodrome (Russia) on 16 February 2016

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
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<tbody>
<tr>
<td>16 Feb</td>
<td>Successful Launch</td>
</tr>
<tr>
<td>18 Feb</td>
<td>LEOP phase concluded successfully</td>
</tr>
<tr>
<td></td>
<td>✓ Perfect orbit injection from the launcher</td>
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<tr>
<td></td>
<td>✓ Rapid and smooth Solar Array deployment</td>
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<tr>
<td></td>
<td>✓ Only one minor anomaly encountered (Star Tracker depointing due to incorrect quaternion data), rapidly identified and corrected</td>
</tr>
<tr>
<td>26 Feb</td>
<td>Platform In-Orbit Verification completed</td>
</tr>
<tr>
<td>4 March</td>
<td>Payload In-Orbit Verification completed</td>
</tr>
<tr>
<td></td>
<td>✓ All instrument ON and operating (except SLSTR in decontamination mode, as planned)</td>
</tr>
<tr>
<td></td>
<td>✓ Level-0 products being generated</td>
</tr>
<tr>
<td>7 March</td>
<td>Cal/Val Phase of S3 commences</td>
</tr>
<tr>
<td>April/May</td>
<td>Mid-Term-Reviews for OLCI, SLSTR and SRAL</td>
</tr>
<tr>
<td>mid-May</td>
<td>Release of sample products to all users for familiarisation</td>
</tr>
<tr>
<td>28-30 June</td>
<td>Expert users meeting – first feedback from S3 validation teams</td>
</tr>
<tr>
<td>11/12-July</td>
<td>In-Orbit Commissioning Review (IOCR) – successful completion of commissioning phase, start of ramp-up phase (initial operational)</td>
</tr>
<tr>
<td>October 2016</td>
<td>Release of Level 1 data</td>
</tr>
<tr>
<td>Ramp-up phase IOCR+9months</td>
<td>Release of Level 2 data</td>
</tr>
</tbody>
</table>
Ocean and Land Colour Instrument (OLCI) designed for observation with high absolute (relative) accuracy of 2 (0.5) % in reflectance, providing continuity for MERIS (Envisat); 100% overlap with SLSTR.

OLCI working nominally since 29 Feb 2016.

Sample Level 1 and Level 2 data products are available since May/June.

**Level 1 performance:**

- **Radiometry**: on-board radiometric calibration functional; SNR is compliant with specification; calibration gains show time variability but stability seems to improve with time; vicarious calibration shows spectrally/spatially/dynamically/X-track consistent results, however a ~+3% bias.
- **Spectrally**: fully compliant; pre-flight characterisation confirmed for all cameras in-flight (<0.15nm); small temporal trends since beginning of the mission (comparable to MERIS)
- **Geometry**: early mission pointing issues fixed (e.g.: star tracker software), recent correction resulting into sub-pixel accuracies; further work to fit thermo-elastic model (seasonal variations) to further improve calibration.

**Level 2 validation started.**

- Cloud flag needs improvement
- L2 products unavailable for inland waters
- Improvement in the atmospheric correction
- Improving standard product flags

**Release of Level 1 planned for October.**

**Release of Level 2 planned for end 2016.**
Sea and Land Surface Temperature Radiometer (SLSTR) designed for observations with high radiometric accuracy <2% (BOL)/<5% (EOL); < 0.2K (0.1K goal), providing continuity for (A)ATS (Envisat); 100% overlap with OLCI

SLSTR first switched on 2 March.

IR and VIS channel detectors work in different thermal environment: IR channels need decontamination before being put into measurement mode.

Current anomaly causing slight increase in SLSTR instrument detector temperature (~1K); impact on data quality assessed but appears to have reached an equivalent level as prior to anomaly; investigation on-going.

Sample Level 1 and Level 2 data products are available since May/June.
Level 1 performance, open points from IOCR:
- Corrections to Basic Cloud Screening - solved, part of official data release in Oct
- SWIR calibration for S5/6 - not yet fully solved, will be part of later release post-Oct
- Geometric calibration corrections in Nadir and Oblique (nadir ok, oblique view still off by several pixels, possibly solved before end of Sept 2016)
- Saturation flags not yet correctly set - will be part of later release post-Oct
- VIS-SWIR co-registration – solution discussed, part of official release in Oct

Level 2 performance
- Level 2 validation started
- Depending on Level 1 quality
- Need for fine tuning LST and SST coefficients identified

Release of Level 1 planned for October.
Release of Level 2 planned for end 2016.
Additional products added to Sentinel-3 core product list (AOD, FRP, improved SYN latency, 100% SAR)
Fire detection: Fort McMurray in Alberta

Fires around Fort McMurray in Alberta, Canada, were captured the Sentinel-3A Sea and Land Surface Temperature Radiometer’s visible and infrared fire channels on 7 May 2016. The red dots show active fires.

Aerosol Optical Depth (AOD)

- **AOD NRT:** Based on P.North (2002): “Estimation of aerosol opacity and land surface bi-directional reflectance from ATSR-2 dual-angle imagery: operational method and validation”; Validated with AATSR data within ESA’s CCI: provides best results when compared with AERONET and over bright surface.
- **AOD NTC:** Based on above algorithm adapted for SYNERGY products including spectral capacities of OLCI (North et al., 2010); Validated using MERIS and AATSR.
- The above algorithms will need to be extended to cover the retrieval of aerosol properties over ocean.

Fire Radiative Power (FRP)

- Needs to be extended to include detection of fire over sea surface in coastal areas and in known oil-gas producing areas.
- Database of land and ocean gas flare and volcano masks will be included in the data product to provide a hotspot classification/type to users.

Implementation on-going, available in mid-2017 in NRT from EUMETSAT and NTC from ESA
SRAL: Dual frequency Ku/C band Radar Altimeter
- Ku-Band (13.575 GHz) : main frequency
- C-Band (5.41 GHz) : ionosphere corrections
- Cryosat and Jason Heritage
- SRAL switched on 1 March 2016.
- Sample L1 and L2 data available since June 2016.
- At end of commissioning SRAL L1 data products were considered to be ready for official release.
- SRAL now in 100% SAR Mode with CL/OL transitions.
- Additional L1A and L1BS core data products will be released in October after successful deployment of upgrade in ground segment.

<table>
<thead>
<tr>
<th>Product Level</th>
<th>Product Description</th>
<th>Relevance for</th>
</tr>
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<tbody>
<tr>
<td>L1A</td>
<td>Unpacked L0 data processed to engineering parameters with geo-location information</td>
<td>SAR processing specialists allowing fundamental studies on SAR processing such as Doppler beam formation and calibration studies using ground-based Transponders</td>
</tr>
<tr>
<td>L1B-SC</td>
<td>Geo-located, Calibrated gathered azimuth formed complex (I and Q) power echoes after slant/Doppler range correction</td>
<td>geophysical retrieval algorithm developers (over ocean, land and ice surfaces), surface characterisations studies (e.g. impact of sea state bias, wave directional effects etc) and QC systems</td>
</tr>
<tr>
<td>L1B</td>
<td>Geo-located, Calibrated Multi-looked power waveforms</td>
<td>geophysical retrieval algorithm developers and QC systems</td>
</tr>
</tbody>
</table>
Assessment over **in-land waters** in progress

Assessment over **land ice**:
- using SAR mode technique for first time to measure topography over land ice.
- First results are encouraging.
- Data gaps are observed and are due to the altimeter operating mode which is not yet optimised over the steeper regions over the margins.

**Sea Level**: S3 data provide a valuable data set
- strong reduction of the 20Hz SWH noise
- Same wavelength patterns as Jason-2 observed

**Wind and Wave**: observations of good quality for wave, some weaknesses on the wind speed (to be corrected with the next processor version)
Released sample data products so far

Data available from
- *ESA’s Sentinel Data Hub for expert users ( )* 
- *EUMETSAT’s ODA, Data Centre, EUMETCast*

<table>
<thead>
<tr>
<th>Data product ( * )</th>
<th>Released on</th>
<th>Available data</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLCI L1 ( FR )</td>
<td>11 May</td>
<td>9 May – today</td>
</tr>
<tr>
<td>OLCI L2 over land (ESA)</td>
<td>20 June</td>
<td>20 June – today</td>
</tr>
<tr>
<td>OLCI L2 over ocean (EUMETSAT)</td>
<td>22 June</td>
<td>22 June – today</td>
</tr>
<tr>
<td>SLSTR L1</td>
<td>13 June</td>
<td>8 June – today</td>
</tr>
<tr>
<td>SLSTR L2 - LST (ESA)</td>
<td>20 June</td>
<td>9 June – today</td>
</tr>
<tr>
<td>SLSTR L2 - SST (EUMETSAT)</td>
<td>21 June</td>
<td>21 June – today</td>
</tr>
<tr>
<td>SRAL L1B ( ** )</td>
<td>15 June</td>
<td>6 April – 6 May (SAR), 9-12 April (LRM); 18 June – today</td>
</tr>
<tr>
<td>SRAL L2 over land (ESA)</td>
<td>15 June</td>
<td>6 April – 6 May (SAR), 9-12 April (LRM); 18 June – today</td>
</tr>
<tr>
<td>SRAL L2 over ocean (EUMETSAT)</td>
<td>15 June</td>
<td>6 April – 6 May (SAR), 9-12 April (LRM); 12 July – today</td>
</tr>
</tbody>
</table>

SYN, AOD, FRP products to be released in ramp-up phase

* In addition: some sample products on General Sentinel Data Hub for familiarisation for data users
What happens next?

**Ramp-up phase starts:** Gradual ramp-up of operations and progressive release of level 1 and 2 core products

**In-orbit Commissioning Review (IOCR)**
Mid-Term Review (MTR)
Routine Operation Readiness Review (RORR)

**S3A Operational qualification**

**S3A-Launch 16 Feb 2016**
S3A IOCR L+5m
S3A MTR IOCR+4m
S3A RORR IOCR+9 months
S3B FAR* S3B IOCR L+3m
S3B RORR

*S3B launch 2017*

**IOCR:** Your feedback provides valuable input to the IOCR.

**Full operational capacity reached**

**S3 Full Operational Capacity**

**S3A Routine Operations**

**S3B Operational qualification**
EU Copernicus Regulation: full, open and free data policy, defining responsibilities for ESA and EUMETSAT and overall financial envelope

Dedicated EU-ESA and EU-EUMETSAT Copernicus agreements

Operations, maintenance and evolution of

- the Flight Operations Segment for LEOP and Commissioning phases
- CSC shared multi-mission services (e.g. X-Band acquisition, POD)
- the Sentinel-3 Land Payload Data Ground Segment and Post-Launch space segment support activities

Operations, maintenance and evolution of

- the Flight Operations Segment for routine phase, including mission planning, and
- EUMETSAT multi-mission (e.g. network) and specific facilities (e.g. processing, archiving, distribution) in support of the Sentinel-3 Marine Payload Data Ground Segment
ESA data access:
Current Operation Baseline

Scientific Data Hub
- Self Registration
- > 33,000 Users
- No Rolling Policy Applied
- Sentinel-1A NTC
- Sentinel-2A L1C
- 03-Oct-2014
- Max 2 Concurrent Downloads

Collaborative Data Hub
- 11 Collaborative Users
- 4 Data Hub Relay Users
- Node 1: 30 days
- Node 2: 9 days
- Sentinel-1A NRT & NTC
- Sentinel-2A L1C

International Access Hub
- 4 Users
- 30 Days
- Sentinel-1A NTC
- Sentinel-2A L1C
- Node 1: Max 10 downloads
- Node 2: No limits

Copernicus Services Data Hub
- 108 Users
- No Rolling Policy Applied
- Sentinel-1A NRT$^1$ & NTC
- Sentinel-2A L1C
- 01-Dec-2015
- Max 10 concurrent downloads

ESA has signed technical operating arrangements with NOAA, NASA and USGS

NRT$^1$ via dedicated ftp
L1C$^1$ coming soon
ESA offers free access for all users to Sentinel products: most recent as well as complete long term archive.

Any user can self-register at sentinels.copernicus.eu

ESA Data Hub provides an **OPEN SOURCE Web interface**: Users can set own scripts to automatically retrieve, filter and download products.

ESA delivers all Sentinel products on 24/7 basis in Near Real Time (3 hours from sensing) as well as Non Time Critical (24-72 hours from sensing).

**Sentinel Toolbox available as open source software** https://github.com/senbox-org

**Data Hub Server available as open source software** https://github.com/SentinelDataHub/DataHubSystem.
> 625,000 products available

> 38,800 Registered users

> 4.7 Million products downloaded

> 5.2 PB Data volume downloaded

Statistics: 30 June 2016

https://scihub.copernicus.eu
EUMETSAT data access
MAIN MESSAGES

- Sentinel-3A successfully launched on 16 February 2016
- Commissioning phase successfully completed in July 2016 and S-3A now in ramp-up phase.
- All instruments are switched on, have delivered data and are working well.
- Sample data products for expert users are available on ESA's Sent Expert User Hub and EUMETSAT’s EO portal (on invitation and login protected)
- Level 1 data release planned for October 2016.
- Level 2 data release throughout ramp-up phase till spring 2017.
- Data access in operations will be provided by ESA through the Sentinel Data Hub and through EUMETSAT’s Earth Observation Portal (EUMETSAT’s ODA, Data Centre, EUMETCast)
- EC change requests (SRAL 100% SAR operations; additional products: AOD, FRP; SYN within 24 h, orbit shift between S3A and S3B) in process to be implemented.
- S3 Validation team
  - Rolling Call on ESA Earth Online
  - CHANGE OF DATE! Next S3VT meeting planned for 15-17 February 2016 in Frascati, ESA-ESRIN

Weekly mission status on https://sentinel.esa.int/web/sentinel/missions/sentinel-3/mission-status