The Sentinel-3(A) Mission:
Mission status

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ESA and EUMETSAT Sentinel-3 development and operations teams
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 - optical payload

- **100% overlap** between SLSTR and OLCI
- **Increased number of bands** compared to both AATSR and MERIS allowing
  - Synergy between OLCI and SLSTR measurements
  - Enhanced fire monitoring capabilities
- **Broader swath**
  - OLCI: from 1150 km to 1270 km
  - SLSTR: Nadir view 500km → 1400km, Oblique view: 500km → 740km
- Optical payload **< 2 days global coverage** (with 2 Satellites) in view of the substantially increased swath
- **Increased spatial resolution**:
  - OLCI: 300m for land and ocean
  - SLSTR: 500m for VIS-SWIR, 1km for IR-Fire
- **Mitigation of sun glint** by tilting cameras 12.5 deg in westerly direction
- **Near-Real Time** (< 3 hr) availability of L2 core products
### What happened since launch ...

**Sentinel-3A successfully launched from Plesetsk Cosmodrome (Russia) on 16 February 2016**

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>16 Feb</td>
<td>Successful Launch</td>
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<td>18 Feb</td>
<td>LEOP phase concluded successfully</td>
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<td>✓ Perfect orbit injection from the launcher</td>
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<td>✓ Rapid and smooth Solar Array deployment</td>
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<td>✓ Only one minor anomaly encountered (Star Tracker depointing due to incorrect quaternion data), rapidly identified and corrected</td>
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<tr>
<td>26 Feb</td>
<td>Platform In-Orbit Verification completed</td>
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<td>4 March</td>
<td>Payload In-Orbit Verification completed</td>
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<td></td>
<td>✓ All instrument ON and operating (except SLSTR in decontamination mode, as planned)</td>
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<td>✓ Level-0 products being generated</td>
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<tr>
<td>7 March</td>
<td>Cal/Val Phase of S3 commences</td>
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<tr>
<td>April/May</td>
<td>Mid-Term-Reviews for OLCI, SLSTR and SRAL</td>
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<td>mid- May</td>
<td>Release of sample products to all users for familiarisation</td>
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<td>28-30 June</td>
<td>Expert users meeting – first feedback from S3 validation teams</td>
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<tr>
<td>11/12-July</td>
<td>In-Orbit Commissioning Review (IOCR)—successful completion of commissioning phase, start of ramp-up phase (initial operations)</td>
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<td>13 July</td>
<td>ESA internal handover from development to operations team; Handover of flight operations from ESA to EUMETSAT</td>
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<td>10 October</td>
<td>Handover of Marine PDGS from ESA to EUMETSAT</td>
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<tr>
<td>Q3 2016</td>
<td>Progressive release of Level 1 data</td>
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<tr>
<td>Till RORR</td>
<td>Progressive release of Level 2 data</td>
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<tr>
<td>Dec 2016</td>
<td>Mid-term review check point for ramp-up phase</td>
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<tr>
<td>May 2017</td>
<td>Start of routine operations phase – Routine Operations Readiness Review (RORR)</td>
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**ESA & EUMETSAT SHARE OPERATIONS**

- **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**

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**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

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**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**
Sentinel-3: core data products

- Ocean and Land Colour Instrument
  - Ocean & Atmosphere
    - Water Surface Directional Reflectance
    - Algal Pigment Concentration
    - Total Suspended Matter Concentration
    - Diffused Attenuation Coefficient
    - Coloured Dissolved Matter Absorption
    - Photosynthetically Active Radiation
    - Aerosol Load over Water
    - Integrated Water Vapour
      - Full Resolution -
      - Reduced Resolution -
  - Land & Atmosphere
    - Global Vegetation Index
    - FAPAR in Canopy
    - Terrestrial Chlorophyll index
    - Integrated Water Vapour
      - Full Resolution -
      - Reduced Resolution -
- OLCI+SLSTR SYNERGY
  - Synergy Product
    - Land Surface Reflectances
    - Aerosol Load over Land
  - VGT-P like Product
    - Combined VGT-like TOA Reflectances
  - VGT-S like Product
    - Surface Reflectances
    - NDVI
      - 1 day synthesis -
      - 10 days synthesis -
- Sea and Land Surface Temperature Radiometer
  - Sea Surface Temperature
  - Land Surface Temperature
- Surface Topography Mission
  - Marine
    - 1/100th Ku/C band waveforms and parameters
      - Surface Backscatter
      - Sea Surface Height
      - Significant Wave Height
      - Ocean Depth
      - Tides Height
      - Sea Ice Concentration
      - Sea Ice Freeboard
      - Sea Surface Wind Speed
      - Rain Rate
  - Land
    - 1/100th Ku/C band waveforms and parameters
      - Surface Backscatter
      - Surface Height
      - Altimeter Range
      - Snow Density
      - Snow Depth

of interest for this workshop

Brightness Temperatures and TOA Radiances ortho-
egolocated and resampled
STATUS OF CORE OPTICAL DATA PRODUCTS
OLCI: Status Level 1
(TOA radiances)

Ocean and Land Colour Instrument (OLCI) designed for observation with high absolute (relative) accuracy of 2 (1) % in reflectance, providing continuity for MERIS (Envisat)

Level 1 performance

Radiometry: on-board radiometric calibration based; SNR is compliant with specification; calibration gains show some time variability but stability seems to improve with time; vicarious calibration shows spectrally/spatially/dynamically/X-track consistent results, however a ~+3% bias (yaw steering maneuvers for diffuser BRDF characterization)

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: fully compliant (60m @ Nadir); bi-monthly check that thermo-elastic model is accounting for seasonal variations.

Switch on: 29 Feb 2016
Sample L1/L2 data available: May/June 2016
L1 data release: 20 Oct 2016
L2 data release: Spring 2017
OLCI: Status Level 2 LAND (FAPAR/OGVI, OTCI)

Level 2 product status

- Cloud flag needs improvement
- L2 products unavailable for inland waters
- Improving standard product flags

Level 2 product validation on-going, comparisons between

- OLCI and MERIS Terrestrial Chlorophyll Index shows good consistency
- OLCI and MODIS FAPAR (at 250m) over selected sites show good agreement
- OLCI and in-situ Terrestrial Chlorophyll Index shows good agreement

ESA VAL4VEG project planned for vegetation relevant data products from S2 and S3 (2017)

Credit: J.Dash, University of Southampton
Fiducial Reference Measurements for Vegetation Products (VAL4VEG)

Aim *To establish and maintain SI traceability of Fiducial Reference Measurements (FRM) for land vegetation products (Cab, FAPAR and Surface Reflectance).*

- Laboratory and field individual measurement characterization experiments
- Round-robin performance assessment of Cab, FAPAR and Surface Reflectance measurement methods at OLCI pixel scale
- Kick-Off Q2 2017
Global Land Products

OTCI (global mean, 20-23 September 2016)

OGVI (global mean, 20-23 September 2016)
SLSTR: Status Level 1 (TOA radiances)

- 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)ATSR (Envisat); 100% overlap with OLCI

- Nighttime acquisitions for S1-S4 (“day channels”) over Siberia and Gulf of Guinea in Jan 2017 to be characterize gas flares (9 collocation with VIIRS)

- **Level 1 performance**
  - Corrections to Basic Cloud Screening - improved
  - SWIR calibration – improved, residual of 10%
  - Geometric calibration corrections in Nadir and Oblique – March 2017
  - Saturation thresholds – improved
  - Co-registration of fire channels and their nominal channels (F1/S7 and F2/S8) – end 2017
  - Co-registration of VIS and SWIR – March 2017

<table>
<thead>
<tr>
<th>Switch on</th>
<th>2 March 2016</th>
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<tbody>
<tr>
<td>Sample L1/L2 data available</td>
<td>May/June 2016</td>
</tr>
<tr>
<td>L1 data release</td>
<td>17 Nov 2016</td>
</tr>
<tr>
<td>L2 data release</td>
<td>Spring 2017</td>
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</table>
SLSTR: Status Level 2 (Land Surface Temperature)

Level 2 product status

- Improvements for Level 1
- LST coefficients continuously fine-tuned
- Uncertainty estimates to be improved (future work: use GlobTemperature approach)
- A probabilistic cloud mask will be introduced for better cloud flagging performance

Level 2 validation on-going

- Initial validation using SURFRAD sites shows LST product is near to the mission requirement. The retrieval accuracy varies from 0.6 to 1.6 (MRD requirement < 1K)
- Intercomparison with respect to GlobTemperature MODIS indicates product has very small overall differences
  - Differences correlated with orography and biome
  - Larger differences in bare soil regions where solar insolation is high
- Next validation steps in S3 MPC/ESL will be further comparisons with MODIS and SEVIRI

Land Surface Temperature monthly composite for September 2016 (D. Ghent, University of Leicester)
Combining OLCI and SLSTR radiances = SYNERGY/VGT products

- Combining all OLCI (but O2/H2O absorption) channels and SLSTR S1, 2, 4-6
- Rational for combination: Covering larger spectral range and collocate different info from 2 complementary instruments
S3 SYN-VGT algorithm overview

**SYNERGY** (SY_2_SYN)
Atmospherically corrected land surface reflectance at all OLCI and SLSTR wavebands (both nadir and oblique views), other than within gaseous absorption bands (O2, H2O)

Resolution 300 m, contains:
- Surface Reflectance (per channel on OLCI grid)
- Aerosol Optical Thickness + associated error
- Aerosol Angstrom Exponent
- Aerosol Model File
- Contextual parameters = Lat, long, time, quality flags
- Sub-sampled Contextual parameters = Lat, long, solar and viewing angles, meteo

**VEGETATION** (VGT SY_2_VGP (P/S1/S10): Top of Atmosphere Reflectance product provided for the continuity of the SPOT VGT-P product. Generated from OLCI and SLSTR channels interpolated to VGT bands.

Resolution 1 km Plate Carrée grid (for continuity with Spot-5/ Proba-V continuity, but 300m option

Based on OLCI/SLSTR data interpolated on to 4 channels from Spot-5/Proba-V (= Real heritage product) Both OLCI and SLSTR, contains:
- VGT TOA Reflectance
- NDVI
- 1km Sub-sampled Contextual parameters : VZA; VAA, SAA, SZA, AOT, O3, TCWV

**USER PRODUCTS: SYNERGY and VEGETATION** Sample products expected May 2017, official release summer 2017

Sample SYN L2 product; Surface reflectance at 865 nm derived from OLCI channel and SLSTR nadir channel Credit: C.Henocq/ACRI/MPC

Credit: C.Henocq/ACRI/MPC
NEW PRODUCTS

Fires in Siberia, September 2016

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.
- **Implementation on-going, available in mid-2017 in NRT from EUMETSAT and NTC from ESA**

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 end-2017 in NRT from EUMETSAT and NTC from ESA**
Approx. 4,6 MILLION products were downloaded during Q4-2016 (4,6 PB of data)
ESA Sentinel-3 pre-ops Hub

**Publication of products (#)**
20 Oct 2016 – 8 Feb 2017

**Download of products (#)**
20 Oct 2016 – 8 Feb 2017

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**Publication**
- OL_1_EFR__ NR: Total 26644
- SL_1_RBT__ NR: Total 40630
- SR_1_SRA__ NR: Total 8729
- SR_2_LAN__ NR: Total 5768
- OL_1_EFR__ NT: Total 12893
- OL_1_ERR__ NT: Total 922
- SL_1_RBT__ NT: Total 8684
- SR_1_SRA__ NT: Total 586
- SR_2_LAN__ NT: Total 1654
- SR_1_SRA__ ST: Total 1714
- SR_2_LAN__ ST: Total 1706

**Downloads**
- OL_1_EFR__ NR: Total 193891
- SL_1_RBT__ NR: Total 218278
- SR_1_SRA__ NR: Total 175748
- SR_2_LAN__ NR: Total 165356
- OL_1_EFR__ NT: Total 4788
- SL_1_RBT__ NT: Total 42698
- SR_1_SRA__ NT: Total 2093
- SR_2_LAN__ NT: Total 13248
- SR_1_SRA__ ST: Total 4549
- SR_2_LAN__ ST: Total 11180
- Component Total: 19330
Update on Sentinel-3B

- **Sentinel-3B activities restarted in Q2 2016** after Sentinel-3A launch in Feb 2016
- Implementation of Return of Experience (REX) from S3A on-going
- **Instrument status**
  - **Topography** payload fully available and integrated, no open issues
  - **SLSTR** Proto-Flight Model assembly and testing progressing according to plan:
    Instrument now at RAL for calibration tests before delivery to Prime planned mid-Feb 2017
  - **OLCI-B** model experienced major anomaly (same as for A instrument) during instrument TVAC in July 2016; decision to refurbish all 5 cameras, with new gluing process; delivery of OLCI-B for S/L integration by mid June 2017
- In view of late delivery of OLCI, Sentinel-3B S/L Integration and test activities reorganised to fit launch schedule
- Sentinel-3B Flight Acceptance Review planned for Set/Oct 2017, with a launch of Sentinel-3B on Rockot currently scheduled for Nov 2017
Sentinel-3A and -3B Tandem Phase

TECHNICAL PLANNING

- Operate S3A and S3B in Tandem for ~4-5 months at start of mission.
- One satellite follows the other with 30 sec separation: minimum oceanographic and atmospheric variability reducing uncertainty in comparing measurements from both satellites.
- Tandem and drift phase into final orbit separation of 140 degree between S3A/B separation completed by launch + 7 months.
- Full operational capacity reached by launch + 9 months.

MOTIVATION

GCOS Climate Monitoring Principles (GCMP): need to fully understand biases between satellite missions.

- "Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system."
- "A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations."

Improved data quality for climate (CDR) and operational applications alike.
MAIN MESSAGES

- S-3A in ramp-up phase
- All instruments are switched on and working well.
- **Official data release**
  - OLCI Level 1 NRT: 20 October 2016
  - SLSTR Level 1 NRT: 17 November 2016
  - SRAL L1B and L2 NRT and STC: 13 December 2016
  - OLCI Level 1 NTC: 14 December 2016
  - SLSTR Level 1 NTC: 19 January 2017
  - SRAL L1B NTC: Jan 2017
  - SRAL L1A: 6 March 2017
  - SRAL L1BS STC: end- March 2017
  - SYN/VGP: Q2/ 2017
- **Product evolution**
  - Land product harmonisation/synergy (Proba-V, S3, S2)
  - Improvements to vegetation products
  - Snow cover: SEOM project
- **Data access in operations**
  - **L1/L2 LAND**: ESA through the Sentinel Data Hub, Copernicus Services Hub, Collab Hub etc
  - **L1/L2 MARINE**: EUMETSAT’s Earth Observation Portal (EUMETSAT’s ODA, Data Centre, EUMETCast)
- **Sentinel-3B launch planned for end 2017**

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

→ see presentation by G. Milcinski (Sinergise, Slovenia)
THANK YOU

Susanne Mecklenburg

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