Sentinel-3 OLCI: Status

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Outline

- Background
- OLCI development status
- Assembly, Testing & Integration (AIT)
- Camera EM and FM test results
- OLCI core products
- Summary
Sentinel-3 operations and acquisitions for each orbit
Basic configuration similar to MERIS:
- 5 Camera Optical Sub Assemblies (COSA),
  - 5 Focal Plane Assemblies (FPA),
  - 5 Video Acquisition Modules (VAM),
- 1 Scrambling Window Assembly (SWA),
- 1 OLCI Electronic Unit (OEU) managing all the instrument functions,
- 1 calibration assembly allowing radiometric and spectral calibration.

Optical layout
OLCI Structure

OLCI structure: side panels fit check

OLCI structure: Camera bench (top), baseplate (bottom) and VAM bench (vertical)
Sentinel-3 OLCI Basic Geometry

- 5 cameras
- Calibration Assembly
- ~68.5° FoV
- Across-track-tilt
- 1270 km
- ~09:00 LST
- ~10:30 LST
- West 55 deg_OZA
Transect showing MERIS sunglint
MERIS band 9 (708 nm) Hawaii

Approximate position of OLCI cameras

TOA radiance [mW/(m²*sr*nm)]

(R. Doerffer)
OLCI: Ocean and Land Colour
Instrument comparison to MERIS

Pushbroom Imaging Spectrometer (VIS-NIR) – similar to MERIS

Key Improvements/Features:
- More spectral bands (from 15 to 21): 400-1020 nm
- Broader swath: 1270 km
- Reduced sun glint by camera tilt in west direction (12.20°)
- Absolute (relative) accuracy of 2% (relative 0.5%)
- Polarisation sensitivity < 1%
- Full res. 300m acquired systematically for land & ocean
- Reduced res. 1200m binned on ground (L1b)
- Improved characterization, e.g. straylight, camera boundary characterization
- Ocean coverage < 4 days, (< 2 days, 2 satellites)
- Timeliness: 3 hours NRT Level 2 product
- 100% overlap with SLSTR

<table>
<thead>
<tr>
<th>MERIS Bands</th>
<th>λ center</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow substanace/detrital pigments</td>
<td>412.5</td>
<td>10</td>
</tr>
<tr>
<td>Chl.. Abs. Max</td>
<td>442.5</td>
<td>10</td>
</tr>
<tr>
<td>Chl &amp; other pigments</td>
<td>490</td>
<td>10</td>
</tr>
<tr>
<td>Susp. Sediments, red tide</td>
<td>510</td>
<td>10</td>
</tr>
<tr>
<td>Chl. Abs. Min</td>
<td>560</td>
<td>10</td>
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<tr>
<td>Suspended sediment</td>
<td>620</td>
<td>10</td>
</tr>
<tr>
<td>Chl. Abs, Chl. fluorescence</td>
<td>665</td>
<td>10</td>
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<tr>
<td>Chl. fluorescence peak</td>
<td>681.25</td>
<td>7.5</td>
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<tr>
<td>Chl. fluorescence ref., Atm. Corr.</td>
<td>708.75</td>
<td>10</td>
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<tr>
<td>Vegetation, clouds</td>
<td>753.75</td>
<td>7.5</td>
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<tr>
<td>O₂ R-branch abs.</td>
<td>761.25</td>
<td>2.5</td>
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<tr>
<td>O₂ P-branch abs.</td>
<td>778.75</td>
<td>15</td>
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<tr>
<td>Atm corr</td>
<td>865</td>
<td>20</td>
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<tr>
<td>Vegetation, H₂O vap. Ref.</td>
<td>885</td>
<td>10</td>
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<table>
<thead>
<tr>
<th>New OLCI bands</th>
<th>λ center</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerosol, in-water property</td>
<td>400</td>
<td>15</td>
</tr>
<tr>
<td>Fluorescence retrieval</td>
<td>673.75</td>
<td>7.5</td>
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<tr>
<td>Atmospheric parameter</td>
<td>764.375</td>
<td>3.75</td>
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<tr>
<td>Cloud top pressure</td>
<td>767.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Atmos./aerosol correction</td>
<td>940</td>
<td>20</td>
</tr>
<tr>
<td>Atmos./aerosol correction</td>
<td>1020</td>
<td>40</td>
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S3A OLCI development status
(Sep-2013)

For the OLCI subsystems, all CDR are closed, EM tested and most of PFM HW is delivered:
- **Camera Optical Sub-Assembly (COSA)**: all FM Cameras successfully delivered.
- **Calibration Mechanism (CM)**: PFM with characterized FM diffusers delivered.
- **Scrambling Window Assembly (SWA)**: SWU GSE and PFM delivered.
- **Charge Coupled Devices (CCDs)**: all CCDs for S3A and S3B delivered.
- **Video Acquisition Module (VAM) and Focal Plane Assembly (FPA)**: FPA PFM/FM2/3/4/5 and VAM PFM and FM2 delivered and integrated in cameras.
- **OLCI Electronics Unit (OEU)**: EM integrated in the OLCI EM instrument, PFM delivery in preparation.
- **PFM Instrument** Integration has started

OLCI Status 26 Nov 2013 | ESRIN
• AIT for 5 cameras completed
  – Camera Integration in OLCI-A structure started,
  – Calibration mechanism has been characterised and delivered, ready for integration,
  – Instrument delivery to satellite level planned end of this year.

• The integration of 5 cameras in the PFM instrument has started.
OLCI Camera AIT

Camera mounted on the test bench (top) and with VAM (left)
Camera test & characterisation sequence

- **FPA+CCD**
- **Video chain (VAM)**
- **Optics (COSA)**

**Integration**
- Mech. & Elec. integration
- Shim plate machining
- MTF / Focus verification
- FPA lateral alignment
- Camera assembled

**Qualif. Accept.**
- Reference tests #2
- Thermal cycling
- Vibrations
- Reference tests #1

**Characterisation**
- **Geometry**
  - distortion, spatial registration
- **Radiometry**
  - dark signal, noise responsivity, saturation level
- **Spectrometry**
  - spectral localisation / registration / resolution
- **MTF (ALT / ACT)**
- Optical Vacuum testing (CCD Temp -22.5°C) ~12 days

**Instrument**
- Stray Light charact.
- Instrument characterisation
  - Cameras pointing
  - Instrument FoV
  - Video chains linearity

- Camera delivery to instrument
- Spectral (theoretical) linear dispersion model: $\lambda = 1.25x + C$
- Deviation from linear model is characterised for central column →

**Characterized central wavelength for MERIS Camera 4**

*Same behavior as for MERIS*
Spectral registration

MERIS all cameras @ 681nm

Better Performance than for MERIS

OL-DE-020: The spectral misregistration shall be less than 0.0014 um (goal: 0.001 um)

OLCI Results:
- FM#3 is compliant with goal,
- All cameras will have similar shape
- Preliminary Results on Instrument level very promising

OLCI A spectral mis-registration at center wavelength of spectral channels

Preliminary results on instrument level:
Max smile: 1.33nm @ 1020 nm

Camera FM3 - Spectral Registration $\Delta \lambda (l,k)$

OLCI Status
FWHM for Oa21 will not be 40nm but 23nm due to optical transmission and detector response. Note, SNR performance remains compliant with large margins. (SNR EoL prediction: 197 vs Spec: 152)


Same behavior as for MERIS
OL-DE-160:
The inter-channel spatial co-registration shall be less than 0.4 FR SSD in the spectral range from 400 to 900 nm (goal 0.3 FR SSD).

OLCI Results:
• FM#3 is compliant with goal,
• All cameras will have similar shape,
• Preliminary Results on Instrument level very promising.

Better Performance than for MERIS

Instrument level Preliminary Results: Overall spatial mis-registration worse measured performance (in SSD)
During OLCI ground campaign (EM and FM2) Noise Spikes were detected. Most likely related to cosmic rays hitting the CCD.

Next Steps:
- During Phase E1: Investigation on occurrence
- Mitigation via ground processing (TBD):
  - comparison of pixels with unexpected high levels with surrounding pixels, or
  - the comparison of these pixels with unexpected high levels with themselves in different temporal acquisitions.

Same behavior as for MERIS
Oscillation anomaly.

- Dark signal with frequency around 70KHz at the beginning (around 150pixels) of some micro-bands.
- Phenomenon especially after dumping/binning many lines.
- On FPA, CCD or VAM level no oscillations.
- Impact: on radiometric stability and absolute accuracy for Oa13,14,15 and Oa19,20.

- Investigations on all levels and models (e.g., EGSE, grounding, EMC) ongoing.
- Potential mitigation:
  - Full characterisation (vacuum vs ambient) on instrument level (TBC)
  - Ground correction (for the stable portion of the oscillation) (TBC)
OLCI Status: 26 Nov 2013 | ESRIN

OLCI Results:
Measured RR SNR is close to predictions:
- Predicted SNR in flight.
- Requirement is met except marginally for extreme blue channels.

Similar/better Performance than for MERIS

Note, SNR is difficult to measure and to compare directly with SRD Req. (dependence on signal level). Instrument test will provide confirmation.
New spatial NUST set-up provides good results for the correlation with ASAP model => Baseline for efficient straylight correction!
Diffuser characterisation (1/2)

Diffuser BRDF

- BRDF measurements (relative and absolute) for FMA and FMB for several set of wavelengths, incidence and observation angles covering the whole flight range.
- Mathematical BRDF model were tested to fit the absolute measurements, but only 2 models (based on Rahman) gave good results.
- Traceability to international standards by PTB/NPL.
- Final cross-validation between SLSTR and OLCI is ongoing (2 NCRs still open).
Diffuser characterisation (2/2)
spectral calibration

Within OLCI a maximum of 3 peaks each with 15 spectral lines can be used.

Better Characterisation than for MERIS

3 absorption peaks are proposed for nominal spectral calibration

3 other peaks optional: 490 nm, 658 nm, 975 nm.

OLCI Status 26 Nov 2013 | ESRIN
• Measurement performed on PFM camera

Better Characterisation than for MERIS

• Improvements with respect to MERIS testing: 3 dichroic polarisers instead of 1
• Characterisation of transmission uniformity for each polariser, main contributor to error budget

<table>
<thead>
<tr>
<th>Channel</th>
<th>FoV</th>
<th>Polarisation ratio PR (%)</th>
<th>Compliance</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>without SWU</td>
<td>with SWU</td>
<td>&lt; 1% with SWU</td>
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<tr>
<td>Oa1</td>
<td>0°</td>
<td>0.81</td>
<td>0.2</td>
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<tr>
<td></td>
<td>7°</td>
<td>0.71</td>
<td>0.12</td>
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<tr>
<td>Oa2</td>
<td>0°</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>7°</td>
<td>0.23</td>
<td>/</td>
</tr>
<tr>
<td>Oa3</td>
<td>0°</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>7°</td>
<td>0.31</td>
<td>/</td>
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<tr>
<td>Oa5</td>
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<tr>
<td></td>
<td>7°</td>
<td>0.77</td>
<td>0.34</td>
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<tr>
<td>Oa13</td>
<td>0°</td>
<td>1.16</td>
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<td>7°</td>
<td>0.94</td>
<td>0.14</td>
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<td>Oa18</td>
<td>0°</td>
<td>1.16</td>
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<td>7°</td>
<td>1.01</td>
<td>0.16</td>
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<tr>
<td>Oa21</td>
<td>0°</td>
<td>0.8</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>7°</td>
<td>0.8</td>
<td>0.17</td>
</tr>
</tbody>
</table>
Conclusion

• OLCI Development is built on MERIS heritage

• Maintain heritage:
  – Camera design, calibration principle, spectral bands

• Provides Improvement:
  – More spectral bands, 300m FR over land and ocean, NRT, improved characterization…

• OLCI A and B units are under development:
  a. OLCI PFM delivered end of 2013,
  b. OLCI FM2 delivered Q3 2014.

• OLCI camera test results and performance prediction demonstrate improved or similar performances as MERIS.

• OLCI will secure the continuity of ocean and land colour observation for the next decade.