Sentinel-3 OLCI and SLSTR

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Medspiration/GlobColour symposium

ESA - ESRIN

Outline

- Overview of User Requirements
- Overview of OLCI instrument
- Overview of SLSTR instrument
- Current activities
- Timeline
- Summary

GMES Observational Infrastructure

- The GMES initiative federates a wide range of observations from space and *in situ* infrastructures.
- The space component :
  - Shall ensure sustainable provision of satellite derived Earth observation data to all GMES services.
  - Shall ensure that the architecture of the component is derived from service requirements
- ESA and EUMETSAT are two main European actors in this area who play the major role in co-ordination, implementation and operating the GMES space infrastructure.

GMES Sentinel-3 Mission Overview

- **ESA is currently developing 3 satellite systems forming part of the Space Component of GMES programme (Global Monitoring for Environment and Security):**
  - **S1: C-band SAR,**
  - **S2: Multispectral high resolution optical imager,**
  - **S3: Wide-swath, low resolution VIS - IR spectro-radiometers and a radar altimeter package.**

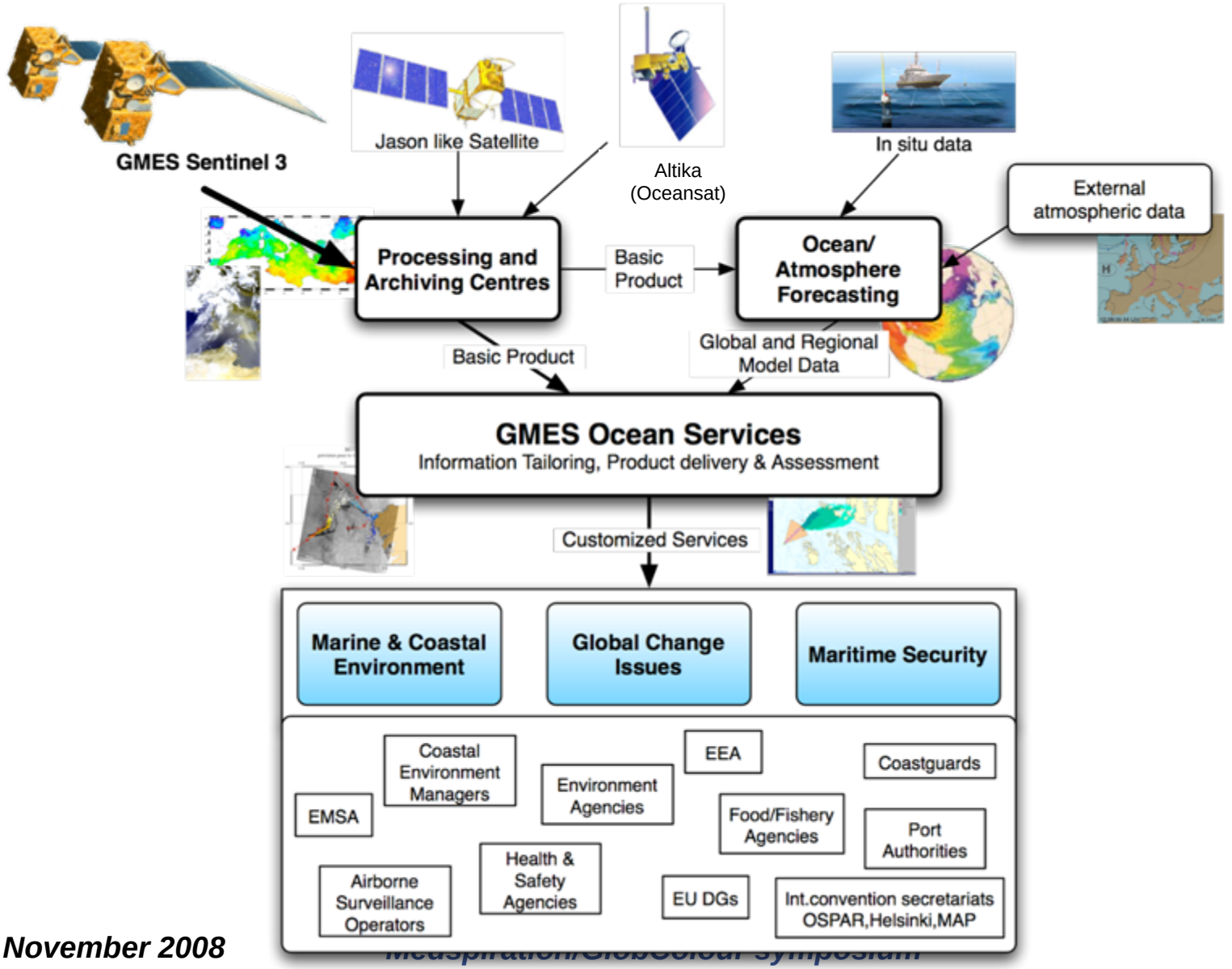
- **Each Sentinel mission has stringent revisit, coverage and mission life cycle requirements (>15 years), which require the deployment of several satellites for each mission.**

Key user communities for Sentinel-3 data and services

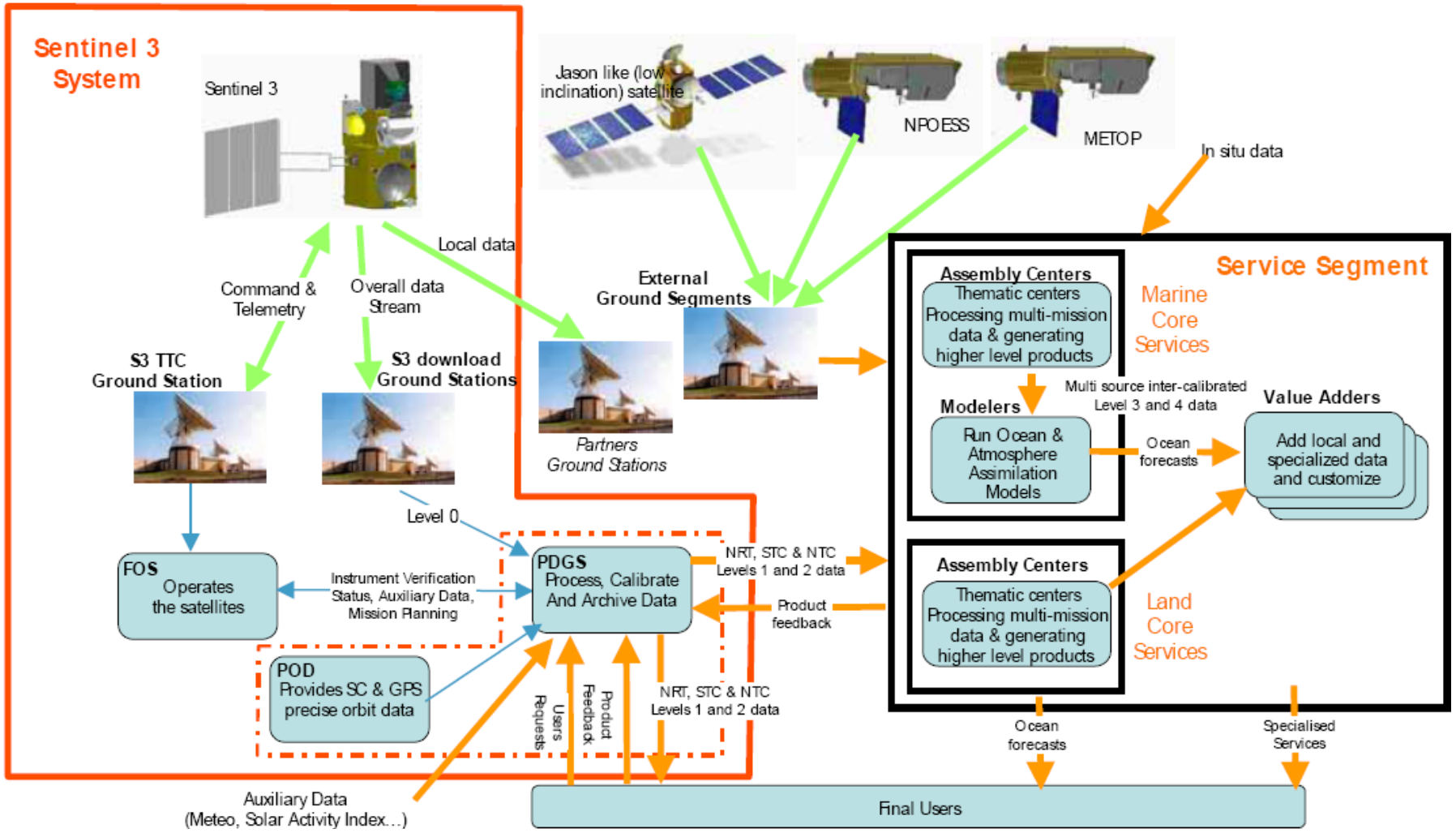
Ocean, coastal zones & sea ice applications

Land, inland water & land ice applications

Fire monitoring Applications


GMES Sentinel 3
Jason like Satellite
Altika
(Oceansat)
In situ data
External
atmospheric data
Processing and
Archiving Centres
Basic
Product
Ocean/
Atmosphere
Forecasting
Basic Product
Global and Regional
Model Data
GMES Ocean Services
Information Tailoring, Product delivery & Assessment
Customized Services
Marine & Coastal
Environment
Global Change
Issues
Maritime Security
Coastal
Environment
Managers
EMSA
Environment
Agencies
EEA
Coastguards
Food/Fishery
Agencies
Port
Authorities
Airborne
Surveillance
Operators
Health &
Safety
Agencies
EU DGs
Int.convention secretariats
OSPAR,Helsinki,MAP

Mission Context

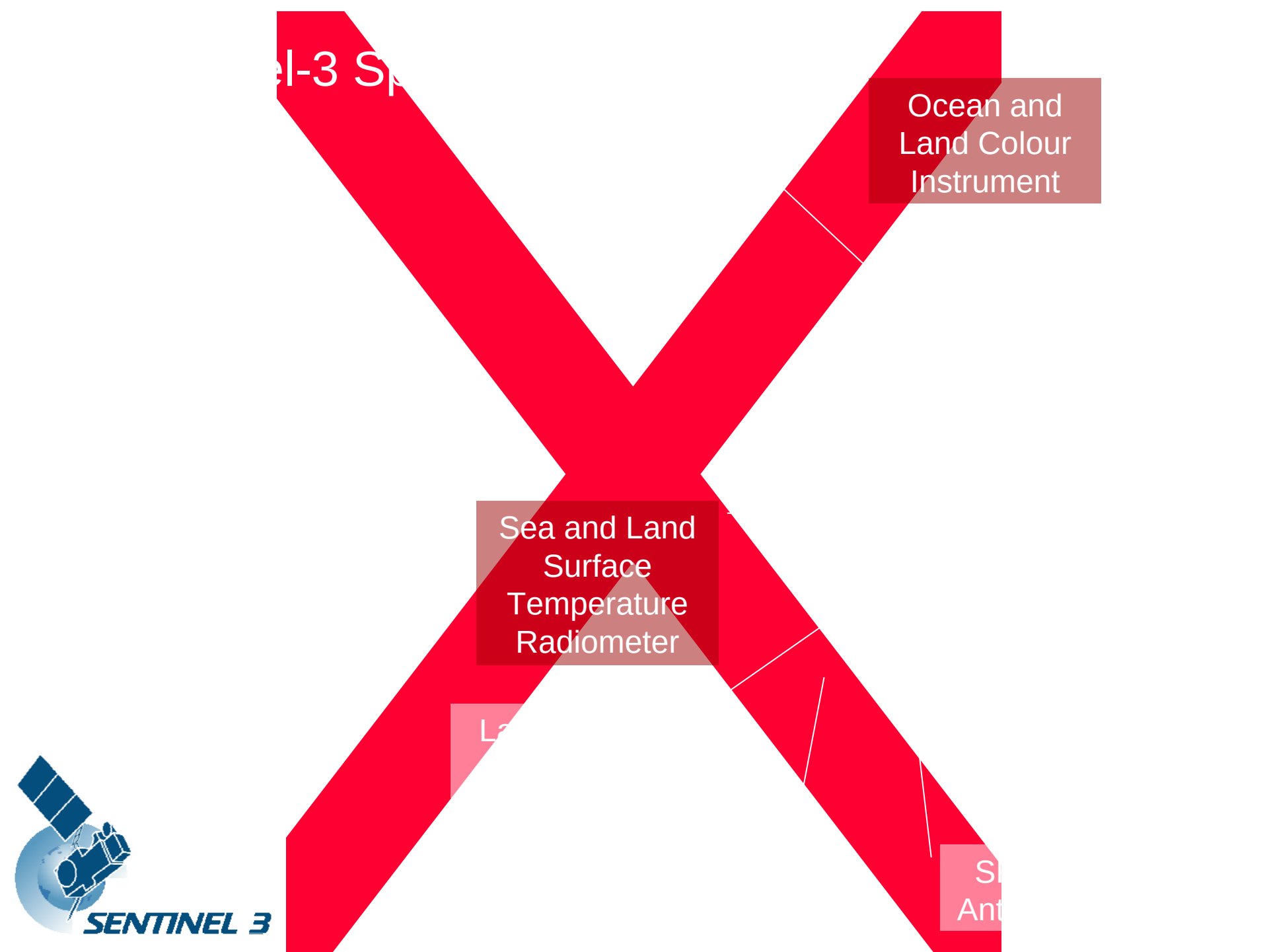


Marine Services

GMES Initial Service	S-3 Requirement
Marine and Coastal Environment	sea-surface topography mesoscale circulation water quality sea-surface temperature wave height and wind sediment load and transport eutrophication
Polar Environment monitoring	sea-ice thickness ice surface temperature
Maritime Security	ocean-current forecasting water transparency wind and wave height
Global Change Ocean	global sea-level rise global ocean warming ocean CO_2 flux

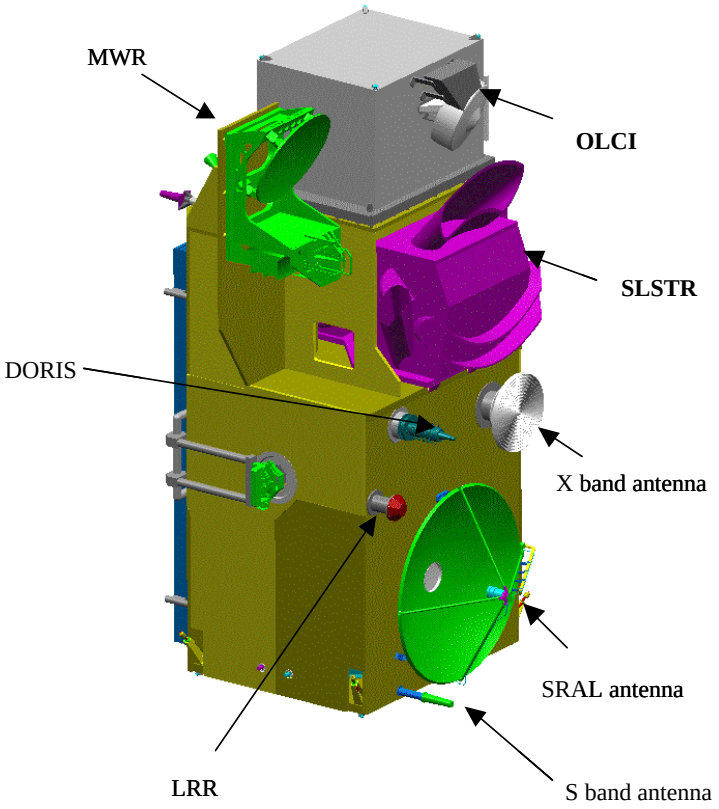
Land Services

GMES Initial Service	S-3 Requirement
Global Change Land	forest cover change mapping soil degradation mapping
Land cover & Land use change	land use mapping Vegetation indices
Forest Monitoring	forest cover mapping
Food Security early warning	regional land-cover mapping drought monitoring
Humanitarian Aid	land use mapping
Air Pollution (local to regional scales)	aerosol concentration
Risk Management (flood and fires)	burned scar mapping fire detection


el-3 Sp
Ocean and Land Colour Instrument
Sea and Land Surface Temperature Radiometer
La
Sl
Ant
SENTINEL 3

Orbit characteristics

- Average altitude ~815 km
- LTDN between 10 – 10:30
- Near-Polar frozen Sun-Synchronous (98.6 deg. inclination)
- 27 days exact repeat cycle
- 4 day global coverage (optical mission) with 1 Satellite (less than 2 days with two Satellites)



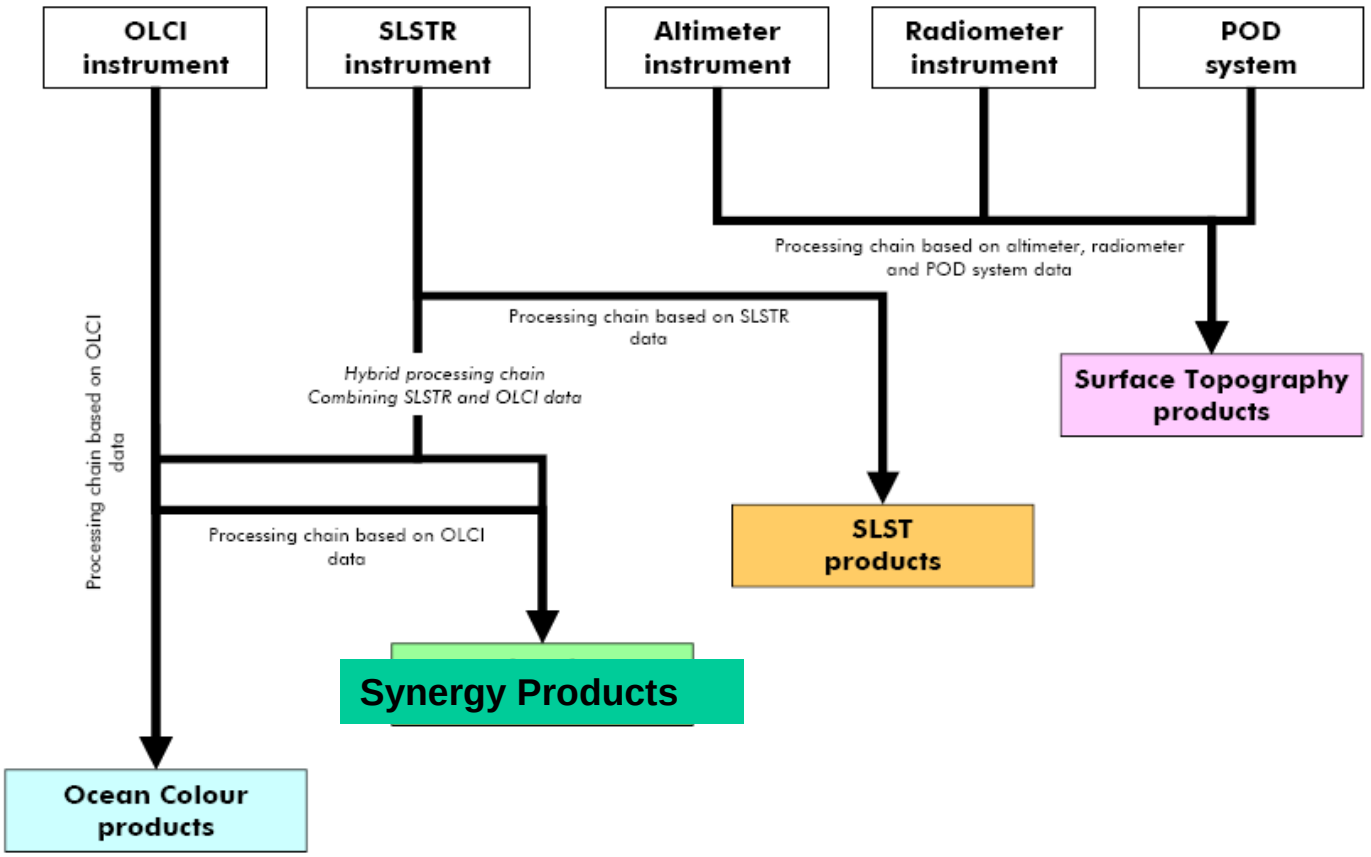
Main satellite characteristics

- 1198 kg maximal mass
- Volume in 3.89 m x 2.202 m x 2.207 m
- Average power consumption of 1100 W
- 7.5 years lifetime (fuel for 5 add. years)
- Large cold face for optical instruments thermal control
- Modular accommodation for a simplified management of industrial interfaces
- Launch second half 2012

Observation Data Management

- 200 Gb of observation data per orbit
- Space to ground data rate of 450 Mb/s
- 1 contact per orbit
- 3h timeliness

Sentinel-3 Data Chains

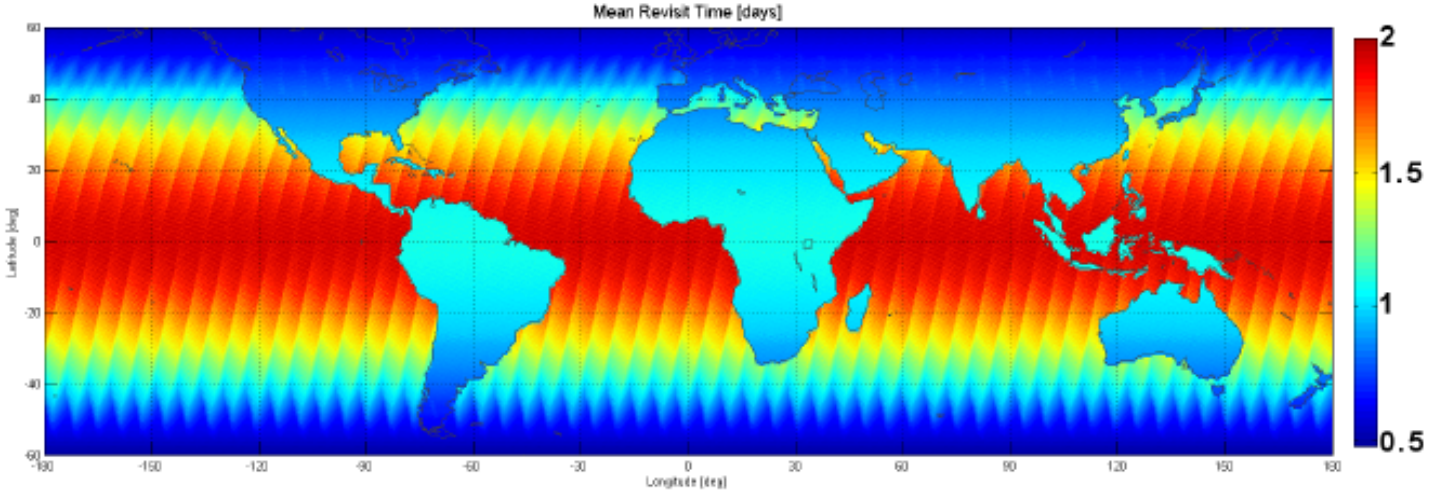


User Requirements: OLCI

Parameter	Range	Accuracy Case 1 water	Accuracy Case 2 water
Marine Reflectance [at 442 nm]	0.001 – 0.04	5×10^{-4}	5×10^{-4}
Water leaving radiance L_w (λ) (atmospherically corrected) [$mW/cm^2/\mu m/Sr$]	0.0 – 1.0	5%	5%
Photosynthetically available radiation, PAR [μmol quanta/m^2/s]	0 – 1400	5%	5%
Diffuse attenuation coefficient (or turbidity), K [m^{-1}]	0.001 – 0.1	5%	5%
Chlorophyll, Chl [mg/m^3]	0.001 – 150	threshold 30 % goal 10 %	threshold 70 % goal 10 %
Total Suspended Matter [g/m^3]	0.0 – 100	threshold 30 % goal 10 %	threshold 70 % goal 10 %
Coloured Dissolved Organic Material (CDOM) (a_{412} [m^{-1}])	0.01 – 2	threshold 50 % goal 10 %	threshold 70 % goal 10 %
Harmful Algae Bloom [mg/m^3] (same req. as Chlorophyll)	0.1 – 100	threshold 30 % goal 20 %	threshold 70 % goal 30 %

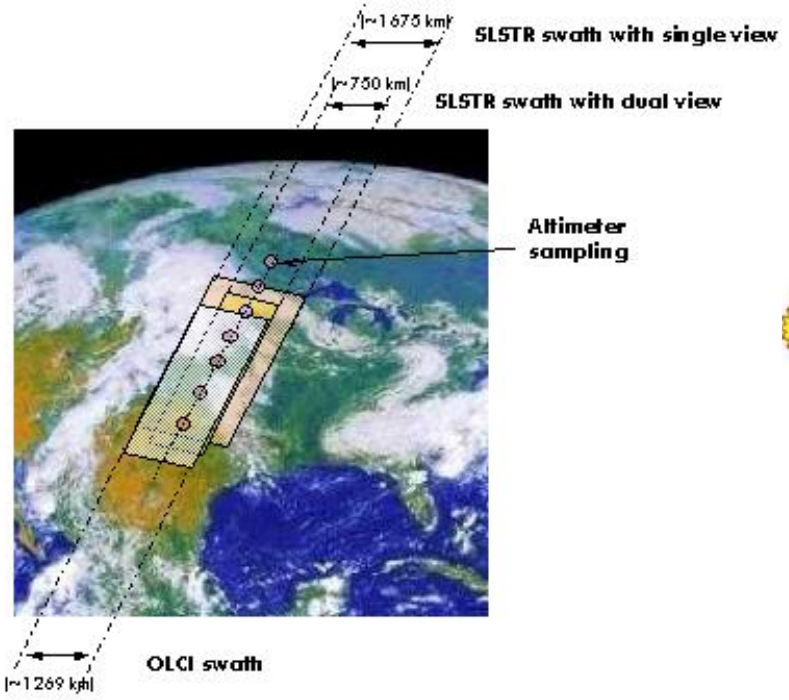
OLCI mean revisit time in 2 satellite configuration

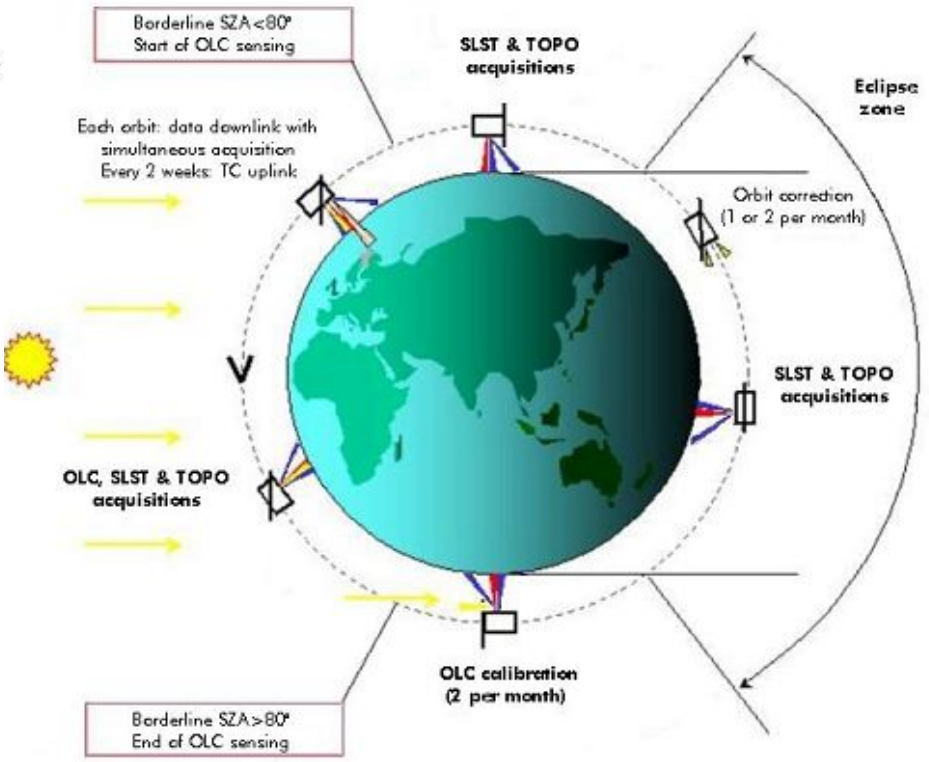
		1 S/C	2 S/C @ 180°
Requirements	SEA	-	2.0
	LAND	-	2.0
Max. of Longitude-Averaged Mean Rev. Time ($LAMRT_{MAX}$)	SEA	3.8	1.9
	LAND	2.2	1.1
Max. of Longitude-Averaged Maximum Rev. Time	SEA	4.0	2.0
	LAND	3.5	2.0



OLCI mean revisit time with 2 S/C (after one full repeat cycle)

Data Acquisition Geometry





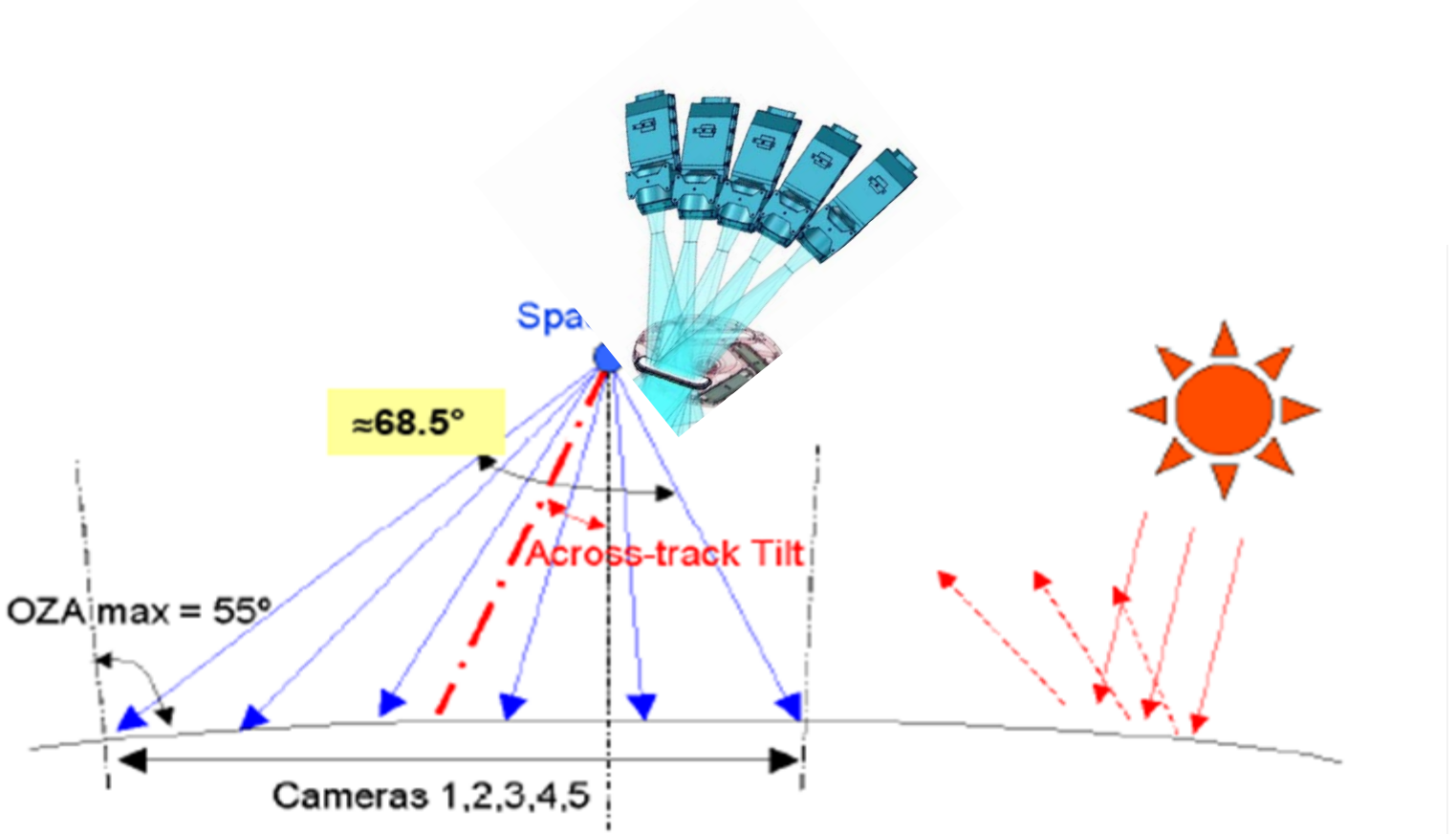
Instrument operations are repetitive according to the satellite position

- SLSTR incl. nadir & backward view
- OLCI FOV optimised to avoid sun glint
- SLSTR & OLCI will be available as L1C co-registered product
- SLSTR (IR channels) and TOPO are always acquiring data

Ocean & Land Color Instrument (OLCI)

VIS-NIR programmable imaging spectrometer:

- **5 cameras in fan-shaped form,**
- **overall instrument FoV is 68.5 degrees, i.e., ~1300km**
- **instrument assembly tilted by about 12 deg across-track away from Sun avoiding sun-glint effects.**



Technical:

Basic set-up:

5 fan-arranged Camera Optical Sub Assemblies (COSA),

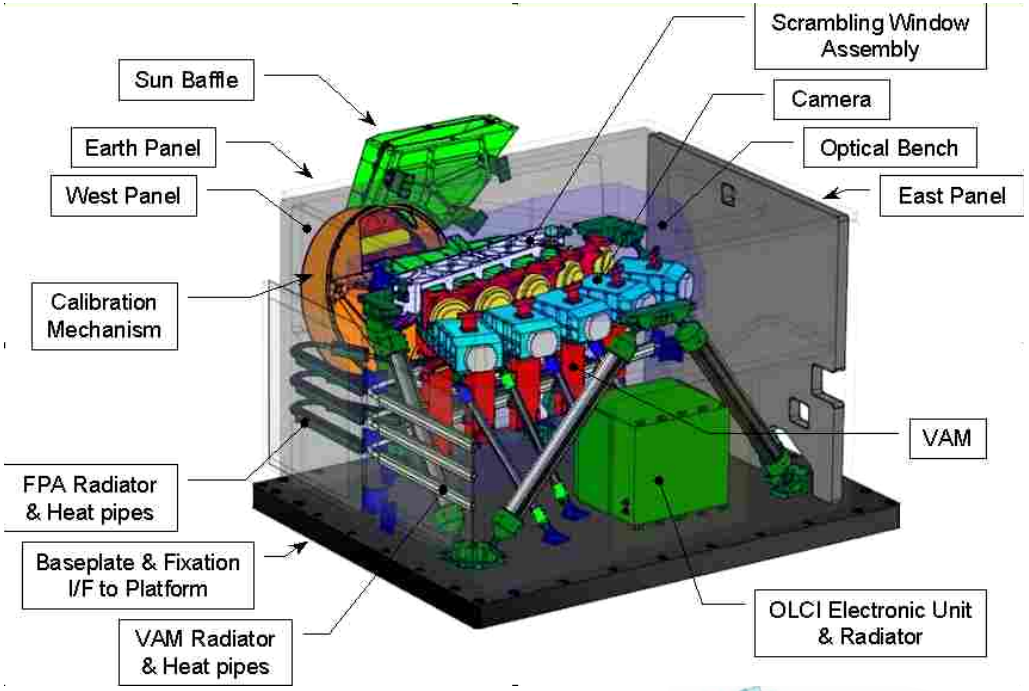
5 Focal Plane Assemblies (FPA),

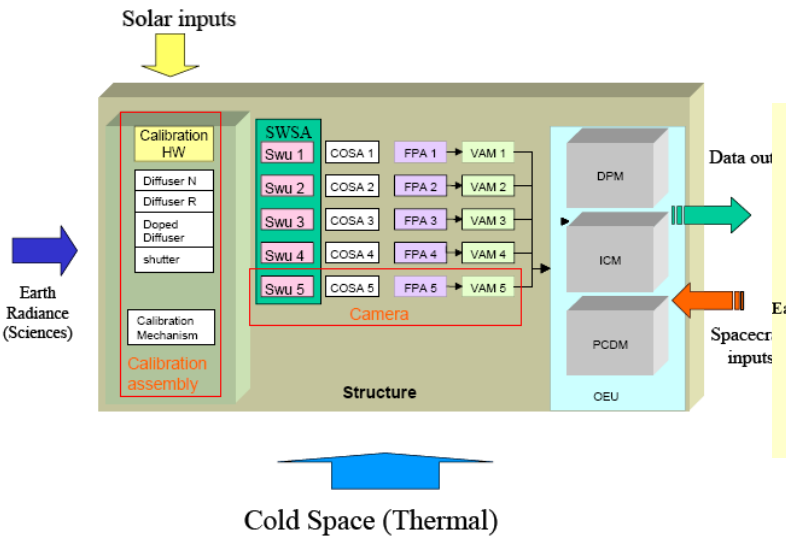
1 Scrambling Window Assembly (SWA),

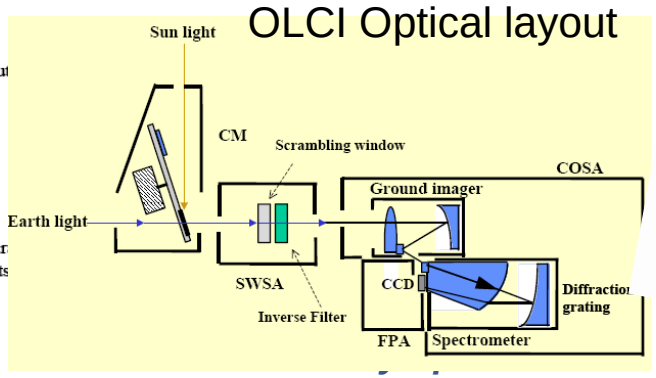
5 Video Acquisition Modules (VAM),

1 OLCI Electronic Unit (OEU) managing all the instrument functions,

1 calibration assembly allowing a radiometric and spectral calibration.







OLCI *(vs. Meris)* Bands

SENTINEL 3

Band #	λ center	Width	Lref	Lsat radiance		SNR
	nm	nm	W/(m².sr.µm)	Lsat/Lmax	W/(m².sr.µm)	[-]
O1	400	15	62.95	0.8	413.5	2188
O2	412.5	10	74.14	1	501.3	2061
O3	442.5	10	65.61	0.8	466.1	1811
O4	490	10	51.21	0.8	483.3	1541
O5	510	10	44.39	0.8	449.6	1488
O6	560	10	31.49	1	524.5	1280
O7	620	10	21.14	0.8	397.9	997
O8	665	10	16.38	0.8	364.9	883
O22	673.75	7.5	15.70	1	443.1	707
O9	681.25	7.5	15.11	0.8	350.3	745
O10	708.75	10	12.73	0.8	332.4	785
O11	753.75	7.5				
O12	761.25	2.5				
O13	764.375	3.75				
O23	767.5	2.5	7.58	0.68	250.0	330
O14/15	778.75	15	9.18	0.8	277.5	812
O16/17	865	20	6.17	0.8	229.5	666
O18	885	10	6.00	1	281.0	395
O19	900	10	4.73	0.9	237.6	308
O20	940	20	2.39	0.7	171.7	203
O21	1020	40	3.86	0.8	163.7	152

additional bands **still subject to change for better app/s, SNR/s and data-rates.**

MERIS heritage

OLCI new bands

OLCI Performance

Spectro-radiometric performance req.:

Absolute radiometric accuracy	**< 2%**
Stability (during day time part of the orbit)	**< 0.1%**
Spectral misregistration	**< 0.0014 μm**
Inter-channel spatial co-registration	**< 0.4 FR SSD (400 - 900 nm)**
Inter-channel radiometric accuracy	**< 1%**
Out-of-band signal	**< 1%**
Polarization sensitivity	**< 0.01**

Geometric performance req.:

- **FOV: 68.4º**
- **Sampling Distance (in km):**

Open Ocean	**1.2**	**1.2**	**RR**
Coastal Zone	**0.3**	**0.3**	**FR**
Land	**0.3**	**0.3**	**FR**

- **Distortion < 1.4 %**
- **Modulation Transfer Function (MTF) > 0.28 (at Nyquist)**

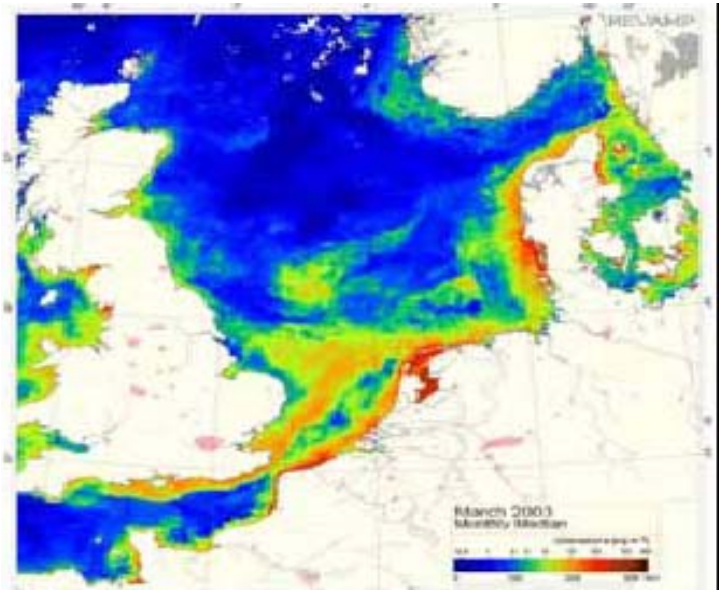
Close heritage to MERIS (spectral bands and radiometric performances)

Improvement of MERIS performances:
- number of spectral bands (from 15 to 21)
- Reduced sun glint by camera tilt in west direction
- Full Resolution (FR, 300m) also over land/ocean,
- Reduced Resolution (RR, 1200m) over Ocean binned on ground (L1B)
- improved stray light characterisation
- improved coverage Ocean < 4 days, Land < 3 days (MERIS eff. 15 days!)
- Timeliness: 3 hours NRT Level 1 product

-100% overlap with SLSTR

-Trying to derive instrument uncertainty estimates

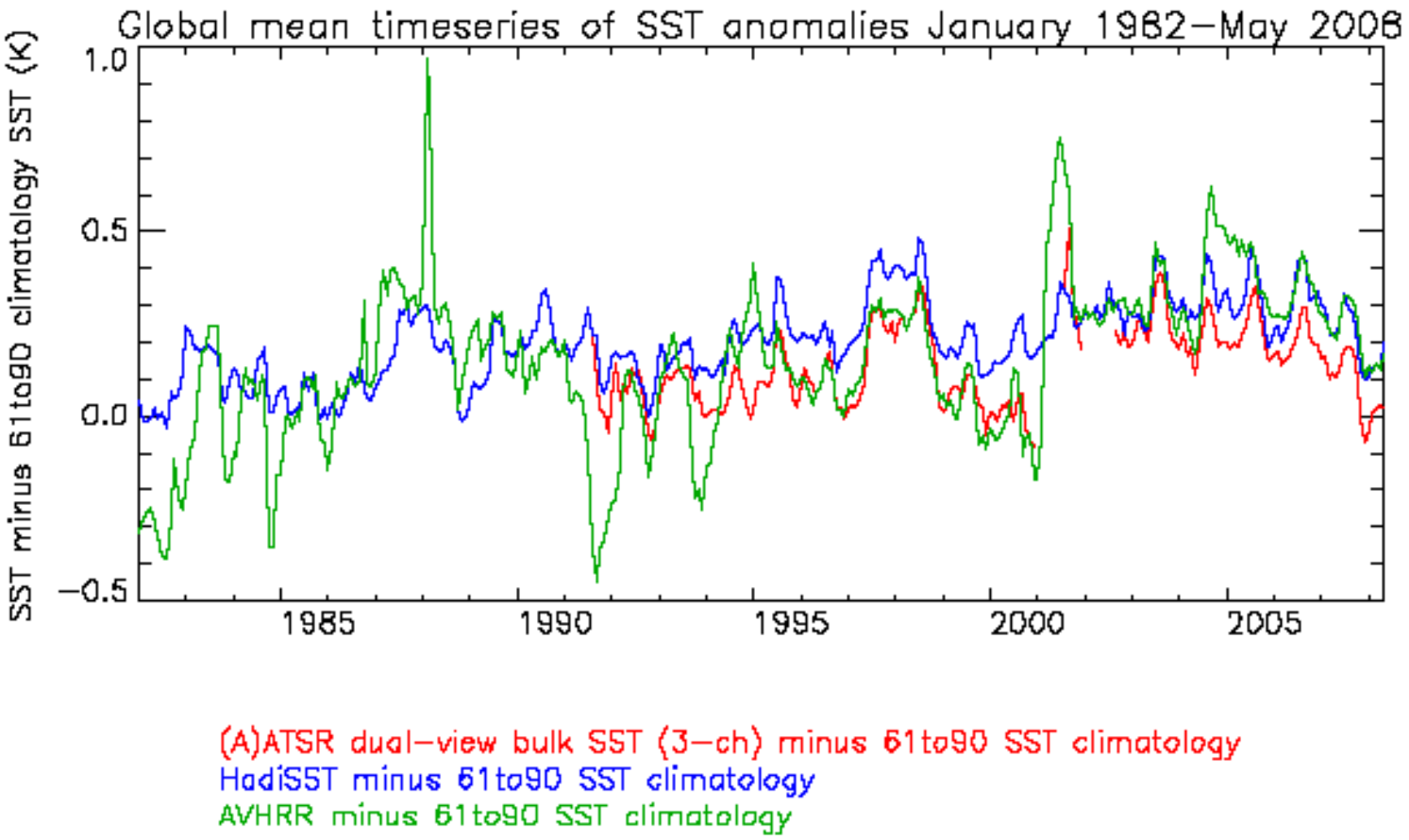
Comparison MERIS-OLCI



Chlorophyll Atlas of the North Sea (MERIS)

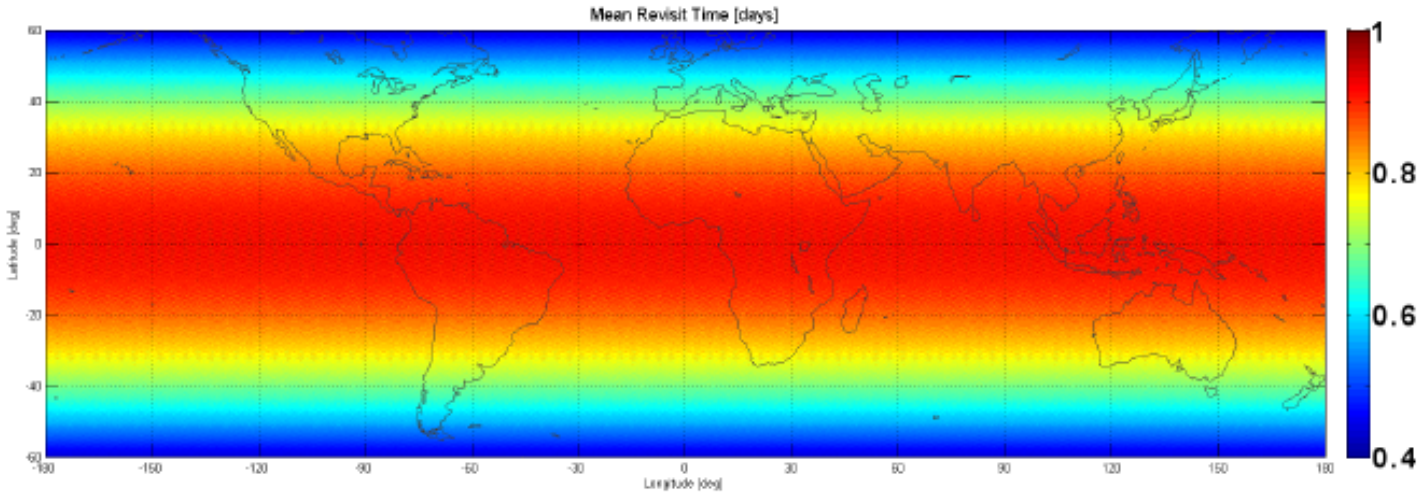
=> improved L2 products (e.g., Cla, HAB, Transparency, Sediment loading, Turbidity, NDVI, MGVI, MTCI, faPAR, LAI)

User Requirements: SLSTR



SLSTR revisit time in 2 satellite configuration

	Nadir View		Dual View	
	1 S/C	2 S/C	1 S/C	2 S/C
Requirements	-	1.0	-	4.0
Max. of Longitude-Averaged Maximum Rev. Time [days]	2.6	0.6	3.5	1.5
Max. of Longitude-Averaged Mean Rev. Time [days]	1.0	0.5	1.9	0.9

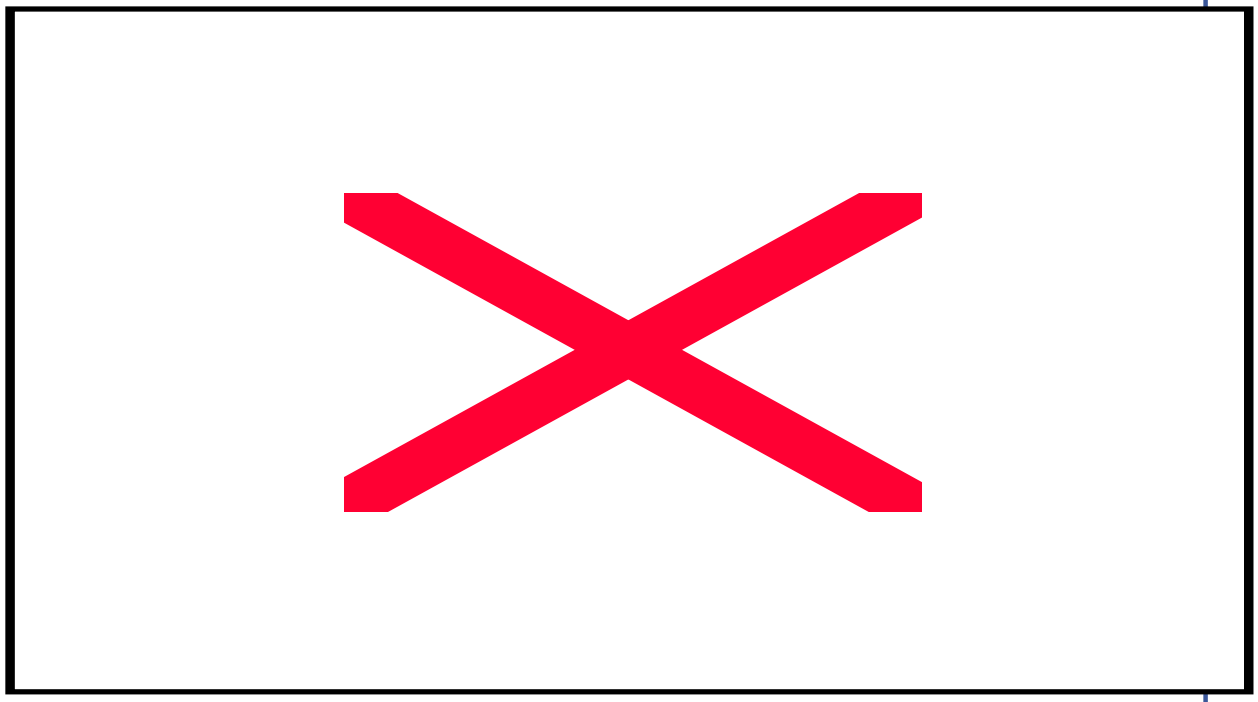


SLSTR Dual View mean revisit time with 2 S/C (after one RC)

Sea and Land Surface Temperature Radiometer (SLSTR)

SLSTR Objectives

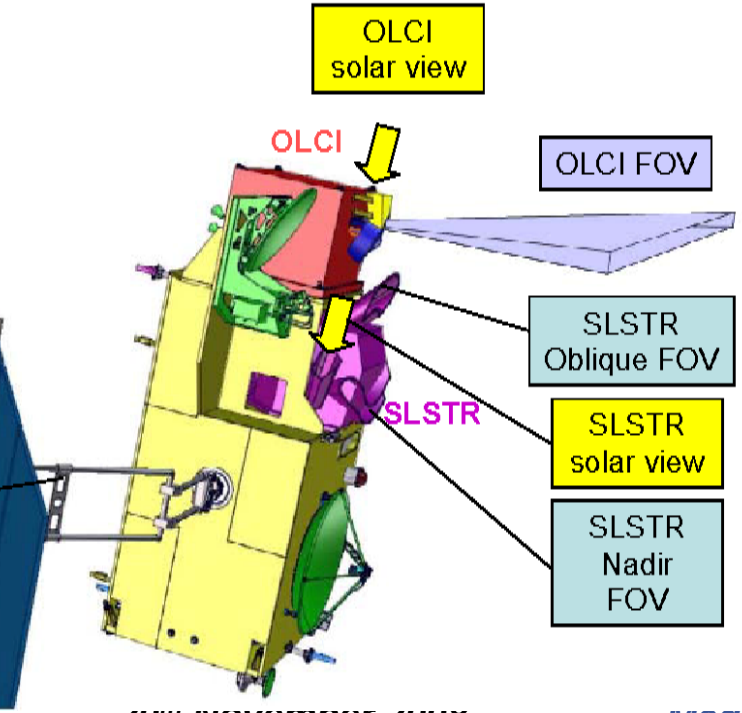
- Strong heritage from A(A)TSR (spectral channels and rad. performances)
- Continue high precision IR SST series from A(A)TSR!
- Land Surface Temperatures
- Surface albedo over water/land

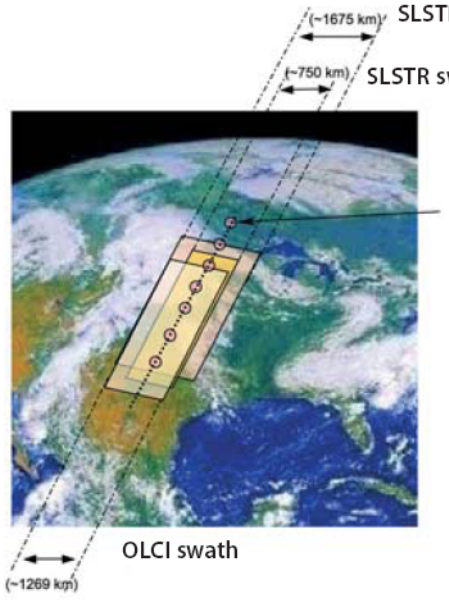


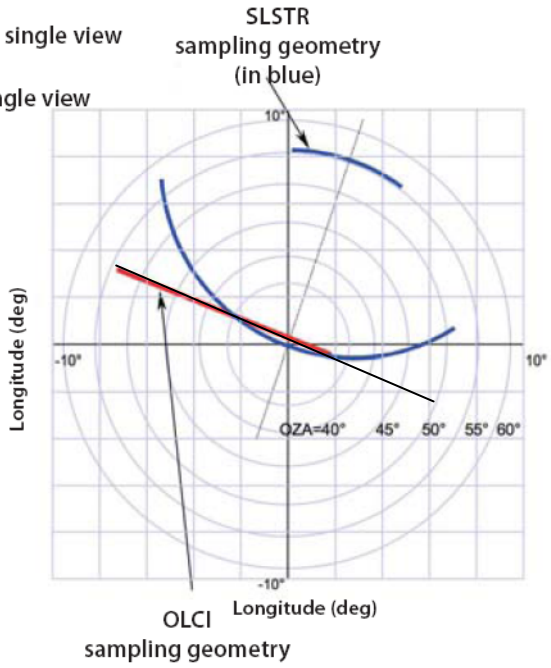
- Synergy between OLCI and SLSTR (new products)
- For Level 2 products, same or better performance as ENVISAT
- Support of VEGETATION-type products (option)
- IR channels adapted to support Fire Monitoring (option)

SLSTR Swath Geometry

- **2 observation views (dual view):**
  - **Near-nadir view: FOV allowing a swath: ~1700km**
  - **Inclined view with an OZA of 55º, i.e., swath: ~750km**
    - looking in backward direction
- **On ground resolution:**
  - **500 m (solar, 0.55-2.2μm)**
  - **1000 m (TIR, 3.7/10.95/12μm)**
- **Inter-channel spatial co-registration: < 0.1 SSD**

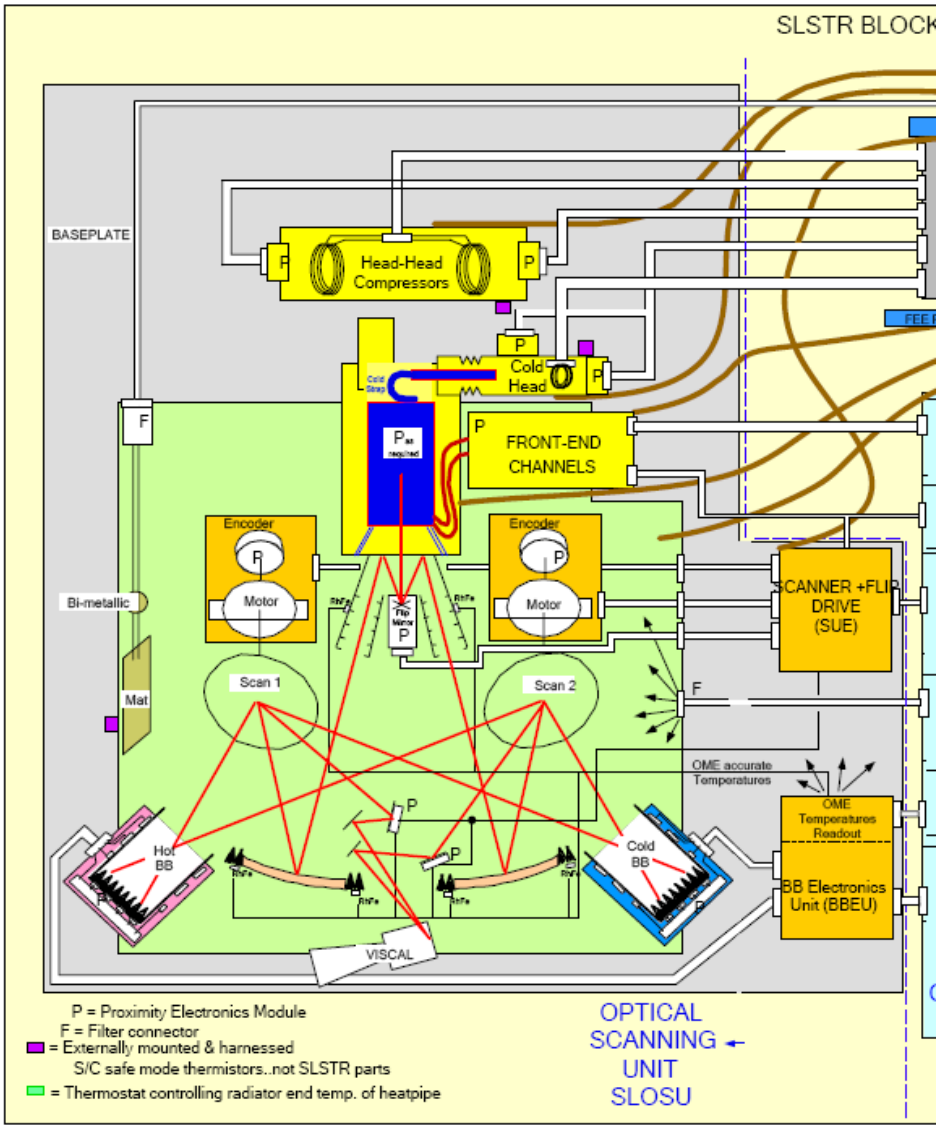




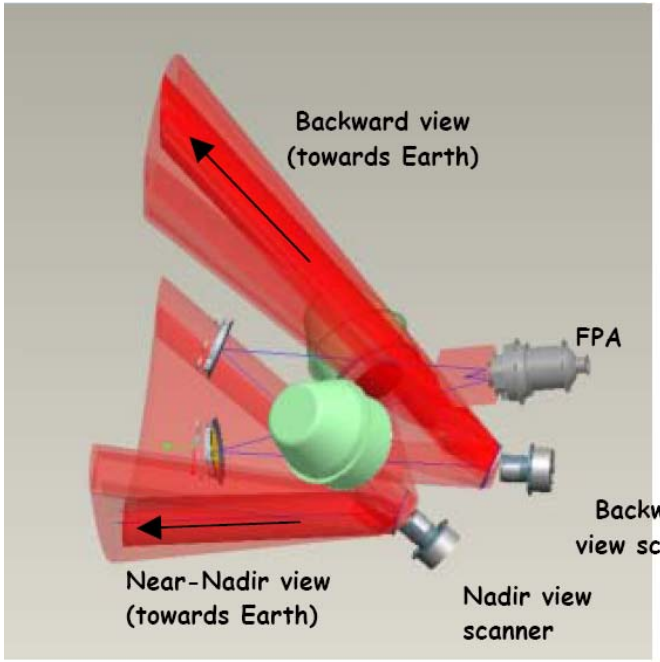


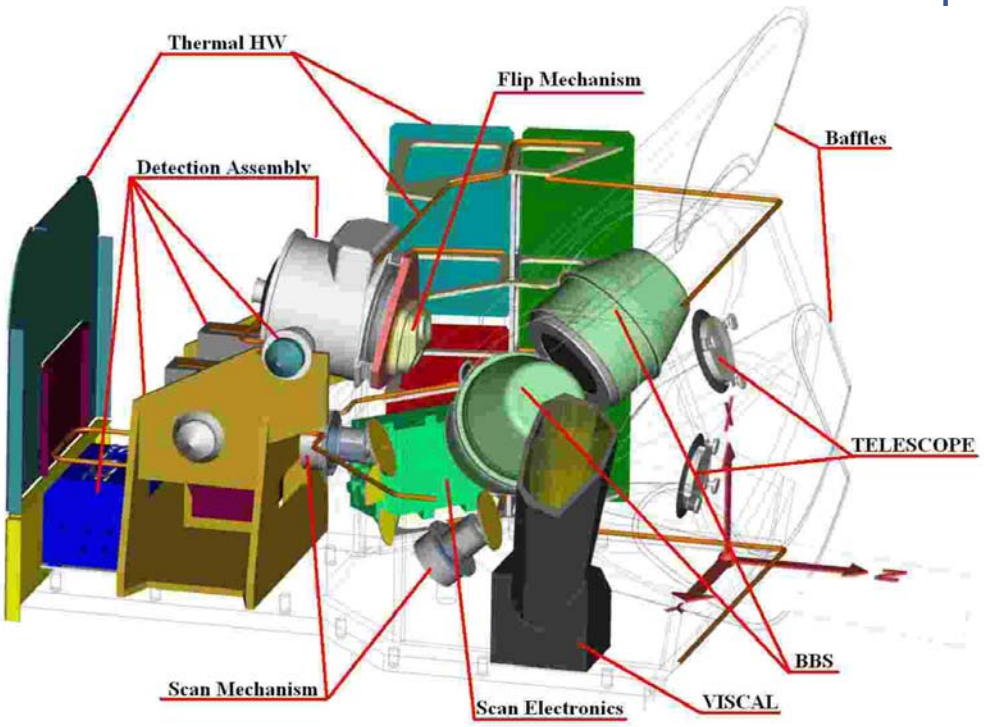
SLSTR Instrument

- 2 Blackbodies
- 2 scan mirrors
- 1 flip mirror
- viscal
- Cooled detectors
- Dedicated fire channels



SLSTR Instrument Principle

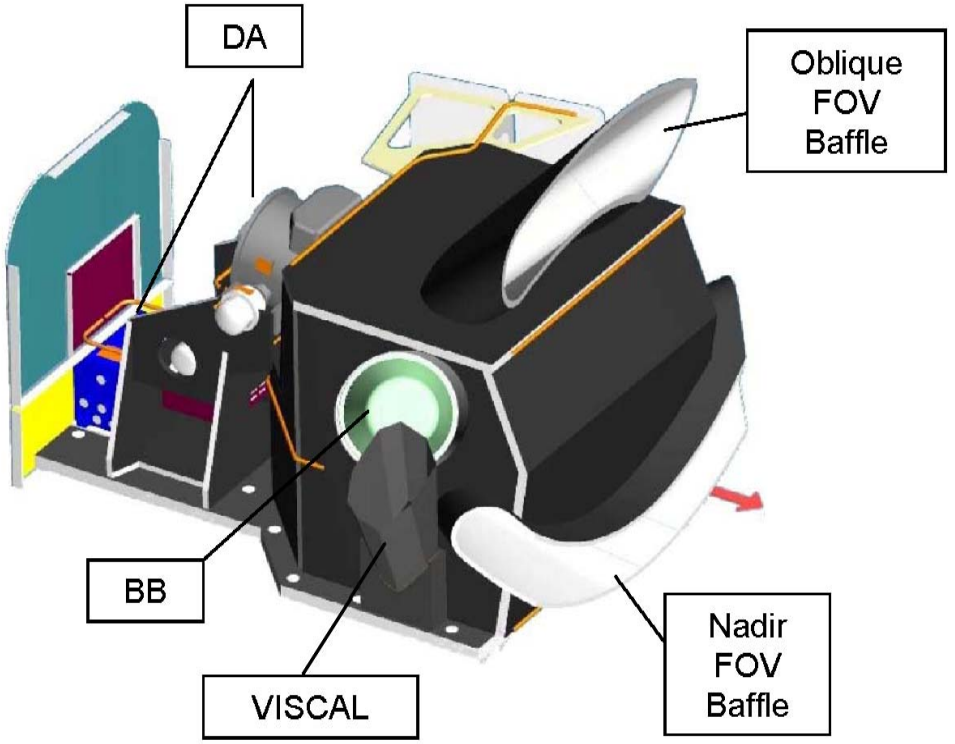




- dual view, each having its own scanner (flat scan mirrors)
- scan of 2 x Earth and calibration sources (BBs, VISCAL)
- views are seen by the front collecting and refocusing optics (Primary Mirrors)
- recombination optics to bring 2 optical paths into a single set of Focal Plane Assemblies (FPA) after a common field plane used as intermediate field stop
- FPA consists of a cryogenically cooled dewar, hosting the 6 (SW)IR and 3 VIS bands

Technical:

- 7 AATSR & 2 additional bands (1.375 , 2.2μm)
- NEDT < 0.08K (TIR)
- SNR = 20 (solar @ L_{min})
- Absolute accuracy < 2-5%, 0.2K
- Radiom. Stability < 0.1%, 0.08K
- Polarisation sensitivity < 0.07



Compared to AATSR:

- 3 instead of 1 mechanism (2 scanners and one flip mechanism)
- More complex front-end and electronics
- New detector technology (multiple pixels)
- Trying to derive instrument uncertainty estimates

Sea & Land Surface Bands

- absolute rad. accuracy (S1-S6) : <5% (EOL) <2% (BOL)
- absolute rad. accuracy (S7/8/9) : 0.2 K
- polarisation sensitivity < 0.07 (S1-S6) or < 0.10 (S7/8/9)
- stability (S1-S6): <0.1%
- stability (S7/8/9): <0.08K

Band	λcenter [μm]	Δλ [μm]	SNR [-] / NeΔT [mK]	SSD [km]
S1	0.555	0.02	20	0.5
S2	0.659	0.02	20	0.5
S3	0.865	0.02	20	0.5
S4	1.375	0.015	20	0.5
S5	1.61	0.06	20	0.5
S6	2.25	0.05	20	0.5
S7	3.74	0.38	80 mK	1.0
S8	10.95	0.9	80 mK	1.0
S9	12	1.0	80 mK	1.0

Active Fire Bands

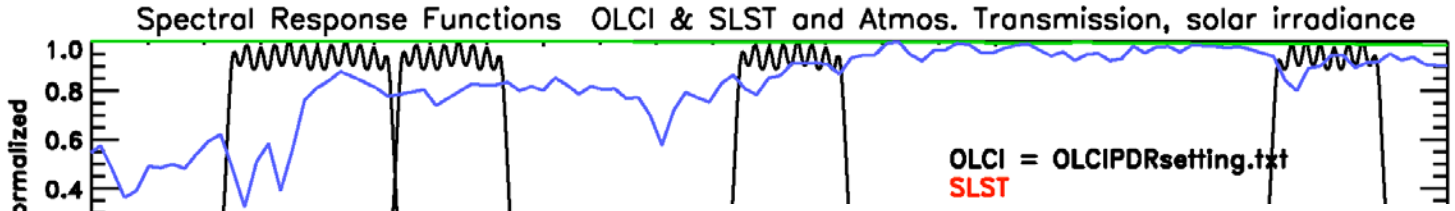
Band	λcenter [μm]	Δλ [μm]	Tmax [K]	SSD [km]
F1	3.74	0.38	500	1.0
F2	10.95	0.9	400	1.0

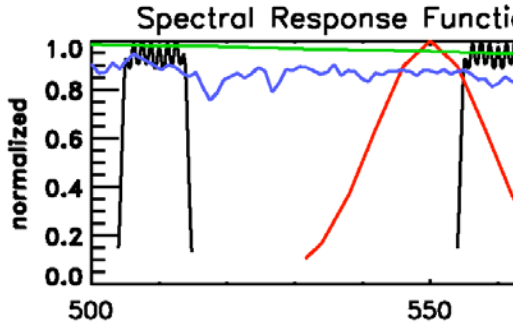
AATSR heritage

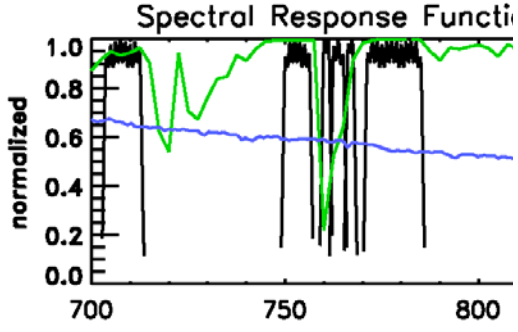
SLSTR new bands

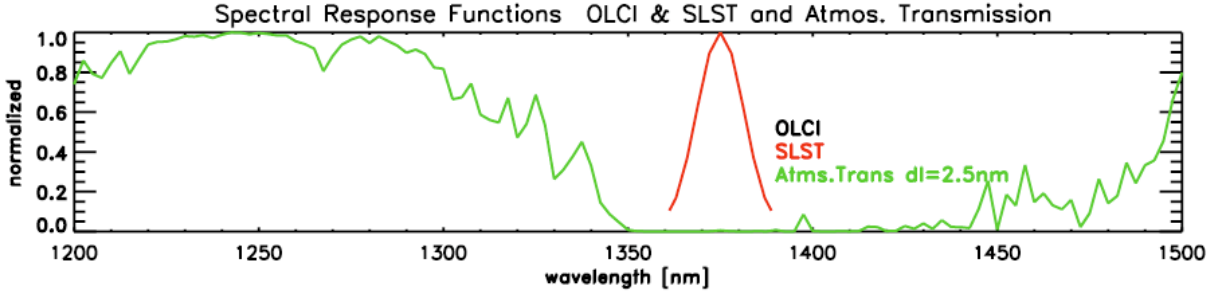
final decision on F1 & F2 implementation after PDR

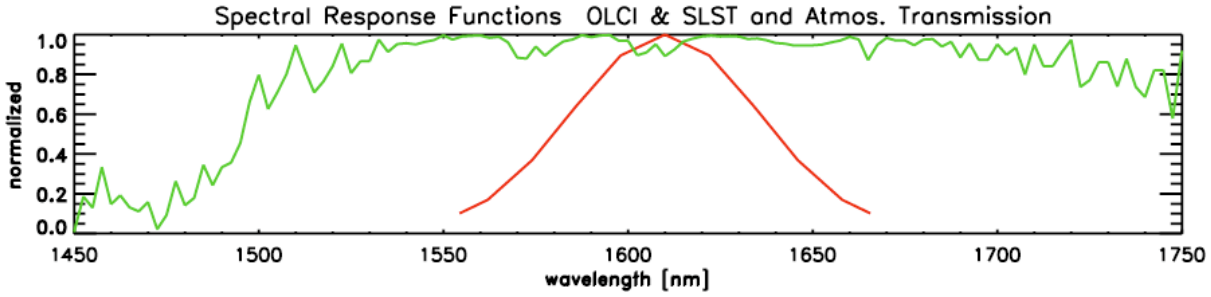
OLCI/SLSTR solar bands

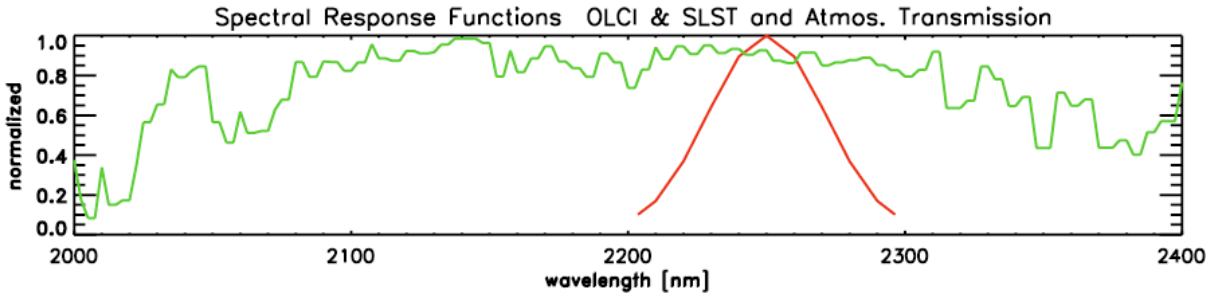












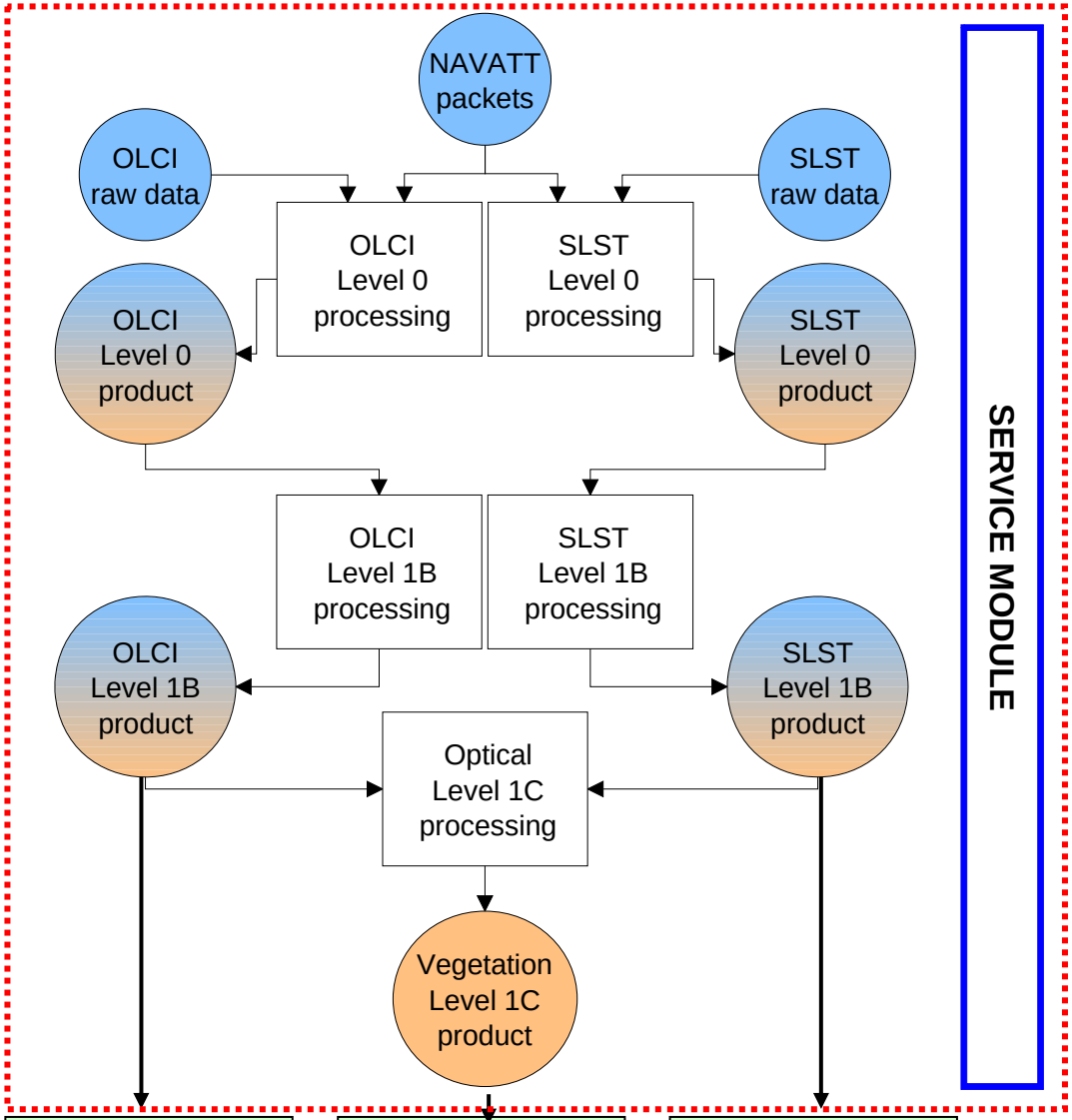
Ground Processor Prototype

SENTINEL 3

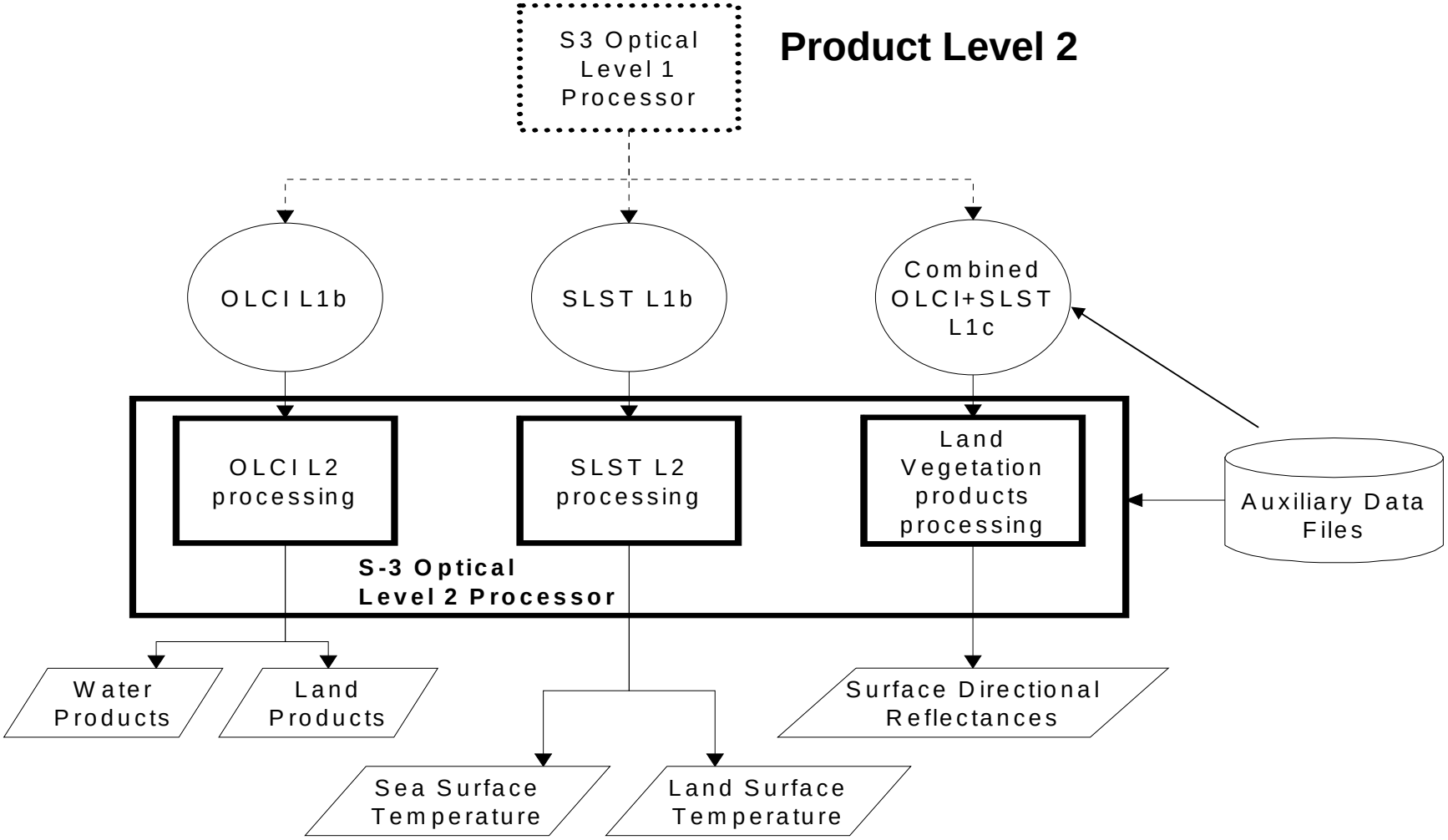
-To develop a prototype for the final operation processor generating Level 1-2 products

-- to test overall instrument performance:

-> part of a larger Instrument Performance Simulator



Product Level 2



Sentinel-3 Status: General

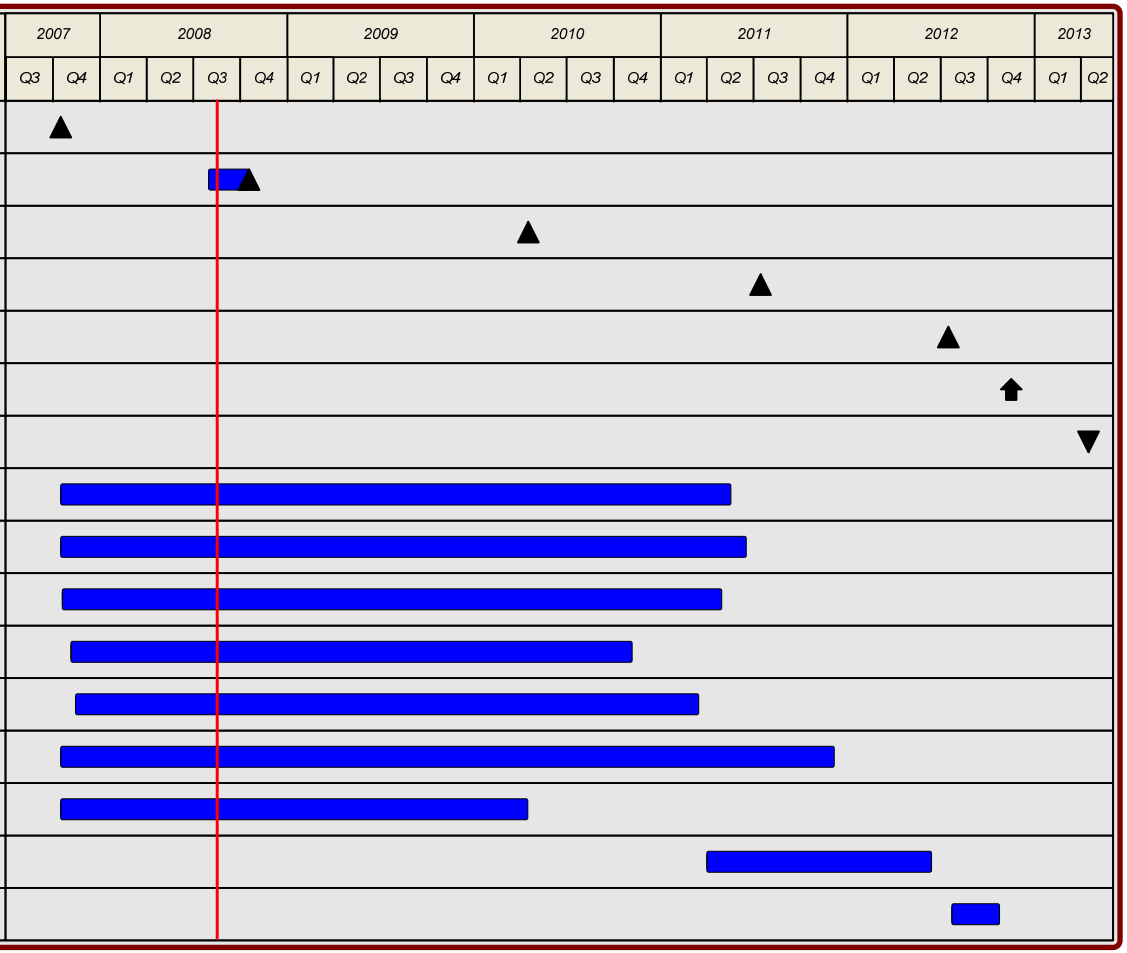
- Sentinel-3 Prime Phase B2 Kicked-Off on 16th of October 2007
  - All other Industrial Core and Key Partners (17) Kicked-Off by the end of November 2007
- Cooperation agreement between ESA and the EC signed in Feb 2008: approx 45% of Segment 1 (up to Sentinel's FAR) financed by EC
- Main Contract signed between ESA and TAS-F on 14th of April
- Definition of remaining procurements on-going
  - Need to setup about 110 subcontracts(!)
  - Process amended to reflect requirements coming from the

Preliminary Design Review ongoing

review of all requirement for instruments and satellite platform

Sentinel-3 Schedule Summary

ID	Task Name	Start	Finish
1	Phase B2/C/D/E1 Kick Off	16/10/2007	16/10/2007
2	Satellite PDR	31/07/2008	17/10/2008
3	Satellite CDR	16/04/2010	16/04/2010
4	Satellite QR	15/07/2011	15/07/2011
5	Satellite FAR/FRR	16/07/2012	16/07/2012
6	Sentinel-3 Launch	16/11/2012	16/11/2012
7	Sentinel-3 IOCR	16/04/2013	16/04/2013
8	OLCI Instrument	16/10/2007	17/05/2011
9	SLST Instrument	16/10/2007	16/06/2011
10	Radar Altimeter	19/10/2007	29/04/2011
11	Microwawe Radiometer	05/11/2007	05/11/2010
12	Platform	14/11/2007	15/03/2011
13	Avionics	16/10/2007	05/12/2011
14	GPP & SPS	16/10/2007	15/04/2010
15	PFM AIT	01/04/2011	12/06/2012
16	Launch Campaign	23/07/2012	23/10/2012



Summary

GMES Sentinel-3 is a series of operational satellites that will guarantee access to an uninterrupted flow of robust global data products.

Together with the other Sentinels, this mission will fulfil the monitoring needs of the GMES marine and land services and climate research communities.

The improved design of the optical payload and the respective data products will allow a data continuity the next decade to come.

Working on developing instrument level uncertainty estimates

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Next steps:

OLCI PDR:	15-Oct-2008 (close out)
Sat PDR:	End Oct-2008 (close out)
PDR of SLSTR:	End-2008 (in progress)
Sat CDR:	Apr-2010
Sat FAR:	2012