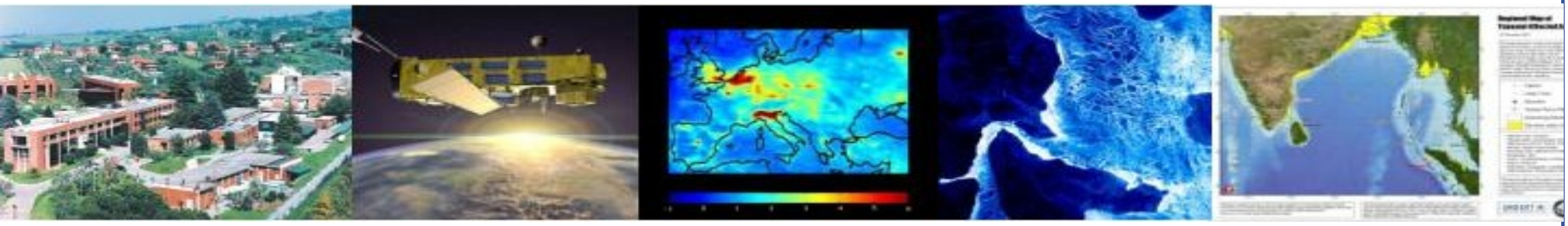
GMES Sentinel-3



M. Drinkwater
European Space Agency
Earth Observation Programmes

Sentinel-3 Overview

- The Sentinel 3 Mission is part of the Global Monitoring for Environment and Security (GMES) initiative
- Sentinel- 3 is an operational mission in low earth orbit
- The Sentinel-3 implement 3 core missions in continuity of existing ones, delivering:
  - Sea and land colour data, at least at the level of quality of the MEdium Resolution Imaging Spectrometer (MERIS) instrument
  - Sea and Land surface temperature, at least at the level of quality of the Advanced Along-Track Scanning Radiometer (AATSR) instrument
  - Sea surface topography data, at least at the level of quality of the Envisat Radar Altimeter (RA) system
- In addition the foreseen payload will also allow a certain degree of continuity to the Vegetation instrument

Marine Services

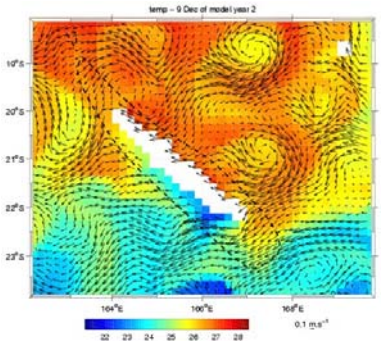
GMES Initial Service	S-3 Requirement
Marine and Coastal Environment	sea-surface topography mesoscale circulation water quality sea-surface temperature wave height and wind sediment load and transport eutrophication
Polar Environment monitoring	sea-ice thickness ice surface temperature
Maritime Security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

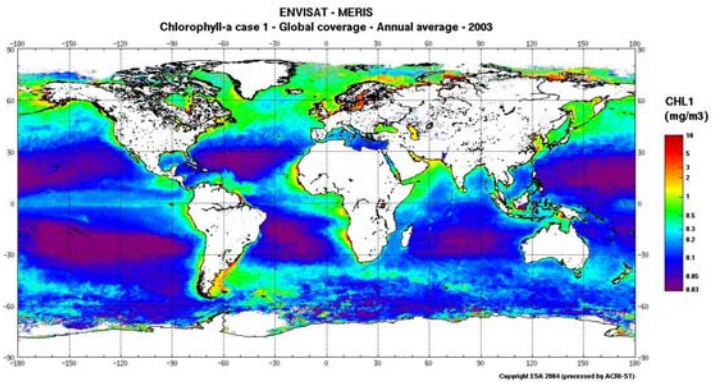
Land Services

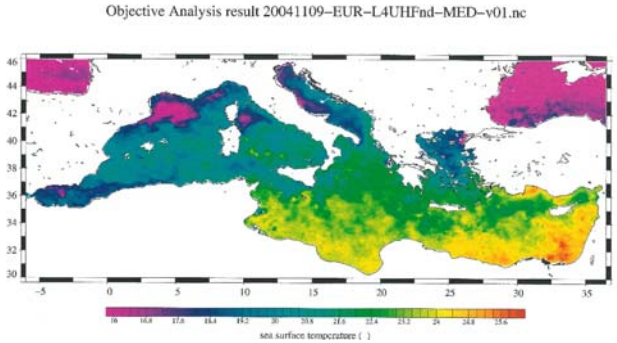
GMES Initial Service	S-3 Requirement
Global Change Land	forest cover change mapping soil degradation mapping
Land cover & Land use change	land use mapping Vegetation indices
Forest Monitoring	forest cover mapping
Food Security early warning	regional land-cover mapping drought monitoring
Humanitarian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

Products

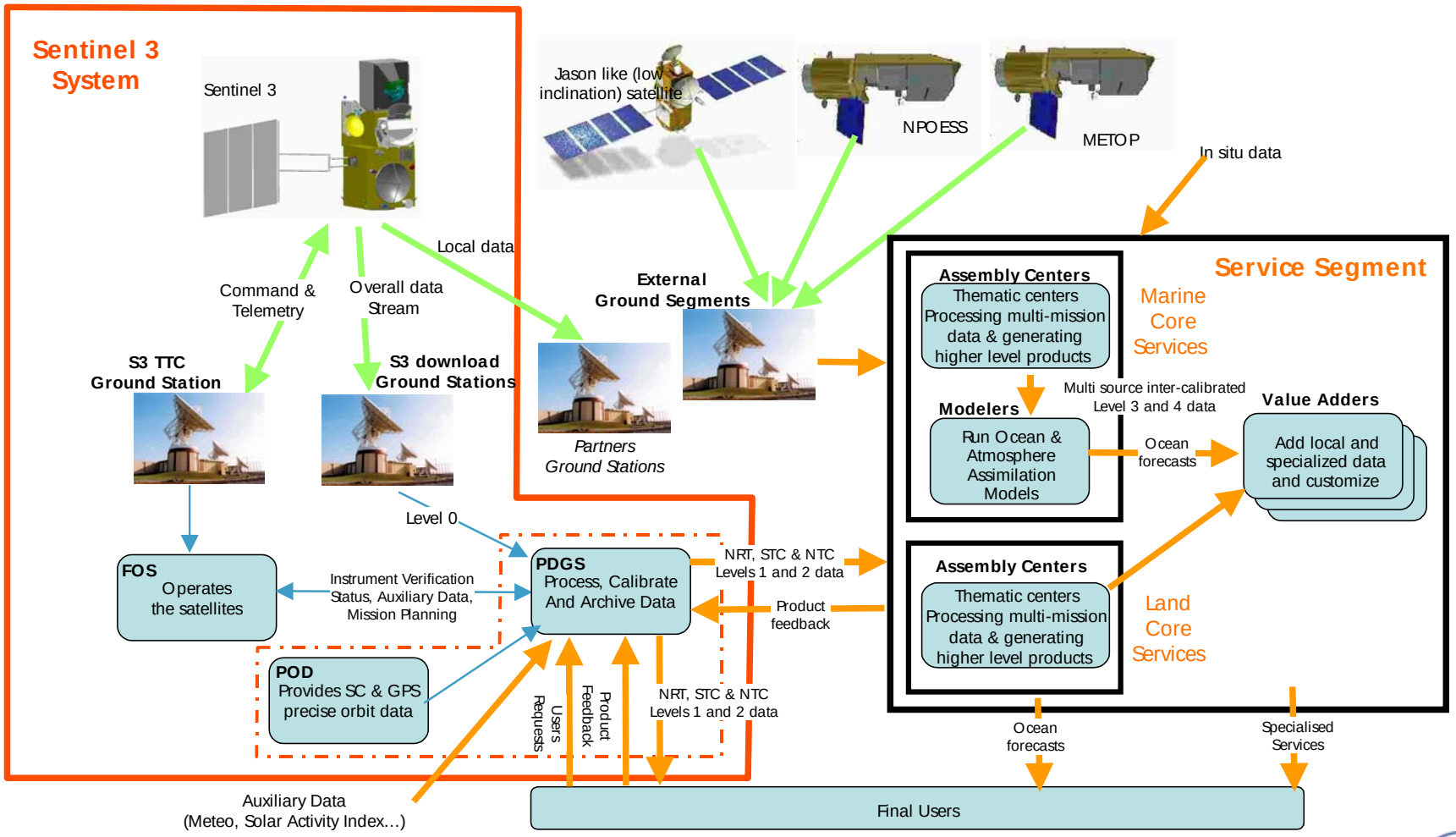
- **Surface Topography:**
  - SSH, SWH, Wind, Geostrophic Currents
  - Sea-ice thickness
- **Ocean Surface Colour**
  - Cla, PFTs, HAB, Transparency, Sediment loading, Turbidity
- **Land Cover and Vegetation**
  - NDVI, MGVI, MTCI, faPAR, LAI
- **Sea Surface Temp.**
- **Land Surface Temp.**
- **By-products:**
  - Atmospheric Aerosols
  - Clouds







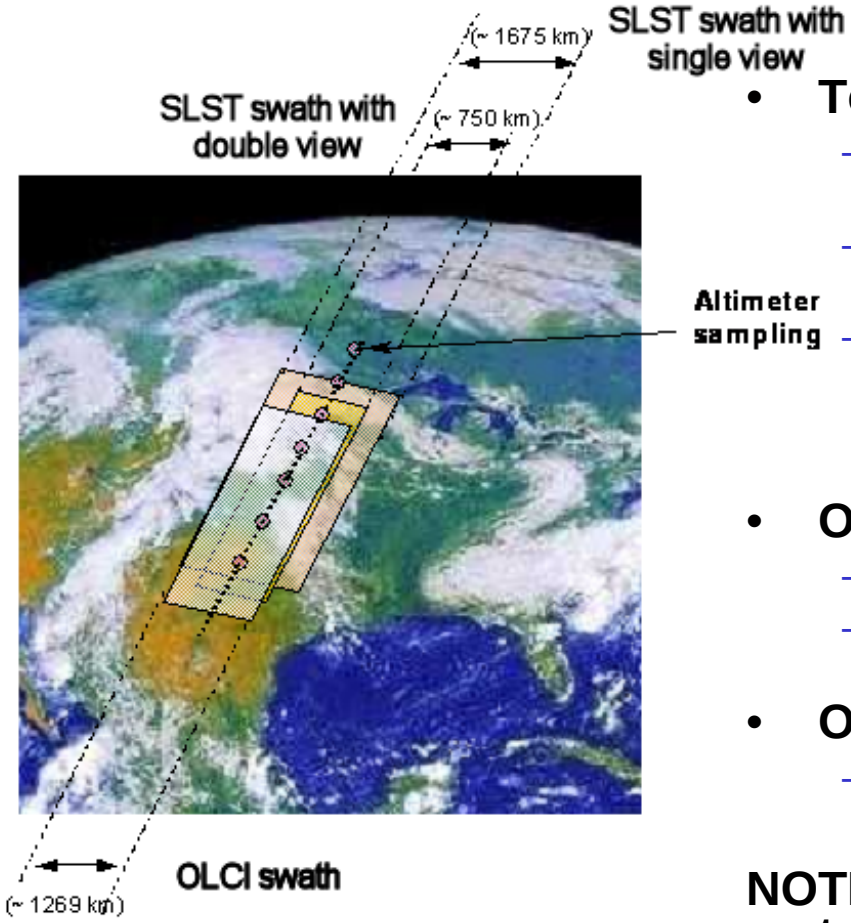
Mission Context



Orbit Selection/Coverage

- **Key requirements for orbit selection:**
  - **Sun-synchronous frozen orbit**
  - **Topography mission requirements**
    - Repeat cycle > 20 days,
    - Optimum Topography mission spatial sampling
    - Minimization of aliasing
  - **Ocean Colour mission requirements**
    - 2-day global coverage with 2 satellites
    - OZA < 55 deg
    - Local time of observation shall be > 10 h to avoid morning haze
  - **Sea Surface Temperature mission requirements**
    - Local time at node shall be < 11 h to avoid skin effects
- **A Reference Orbit 14+7/27 (average altitude ~815 km) selected, LTDN between 10 – 10:30**
  - **Near-Polar frozen Sun-Synchronous**
  - **27 days exact repeat cycle**
  - **4 day global coverage (optical mission) with 1 Satellite**

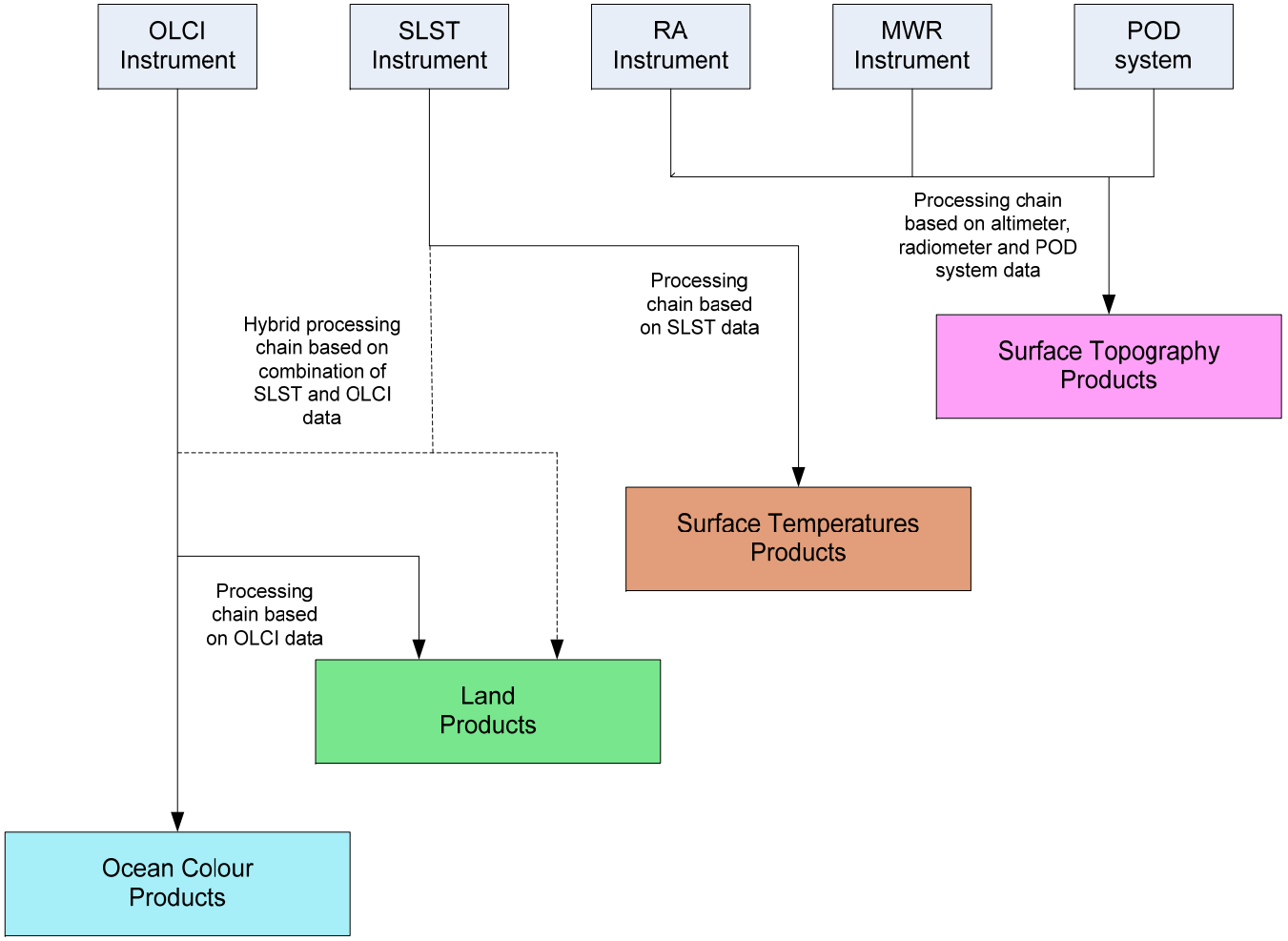
Payload Complement



- **Topography Mission**
  - Bi-frequency Synthetic Aperture Radar Altimeter
  - MicroWave Radiometer (Bi- or Three-frequency)
  - Precise Orbit Determination (POD) including
    - GNSS Receiver
    - Laser Retro-Reflector
- **Optical Payload**
  - Ocean and Land Color Instrument (OLCI)
  - Sea and Land Surface Temperature (SLST) Radiometer
- **Optional Payload**
  - FIRE Infrared Element

NOTE: Decision to embark FIRE to be taken by PDR.

Mission chains summary



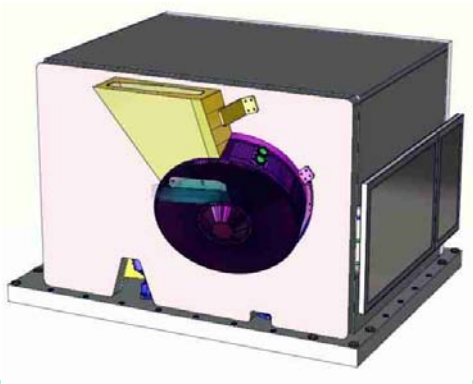
Revisit time

- **Key elements of the Sentinel-3 mission are:**
  - **Improved Revisit times for optical payload, even with 1 single satellite:**

		Revisit at Equator (Phase B1)	Revisit for latitude > 30° (Phase B1)	Specification
OC (Sun-glint free)	1 Satellite	**< 3.8 days**	**< 2.8 days**	**< 2 days**
	2 Satellite	**< 1.9 days**	**< 1.4 days**	
Land Colour	1 Satellite	**< 2.2 days**	**< 1.8 days**	**< 2 days**
	2 Satellite	**< 1.1 day**	**< 0.9 day**	
SLST dual view	1 Satellite	**< 1.8 days**	**< 1.5 days**	**< 4 days**
	2 Satellite	**< 0.9 day**	**< 0.8 day**	

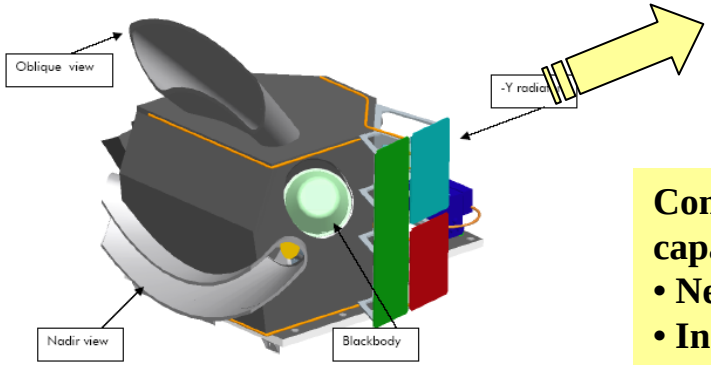
  - **Near-Real Time (< 3 hr) availability of the L2 products**
  - **Slow Time Critical (STC) (1 to 2 days) delivery of higher quality products for assimilation in models (e.g. SSH, SST)**

Resolution of optical instruments



Pushbroom type imager spectrometer
21 Spectral Channels
Full Resolution: Coastal/Land
Reduced Resolution: Open Ocean

OLCI – Open ocean	1.2 km
OLCI – Coastal ocean	300 m
OLCI - Land	300 m
SLST – solar channels	500 m
SLST – Thermal channels	1 km

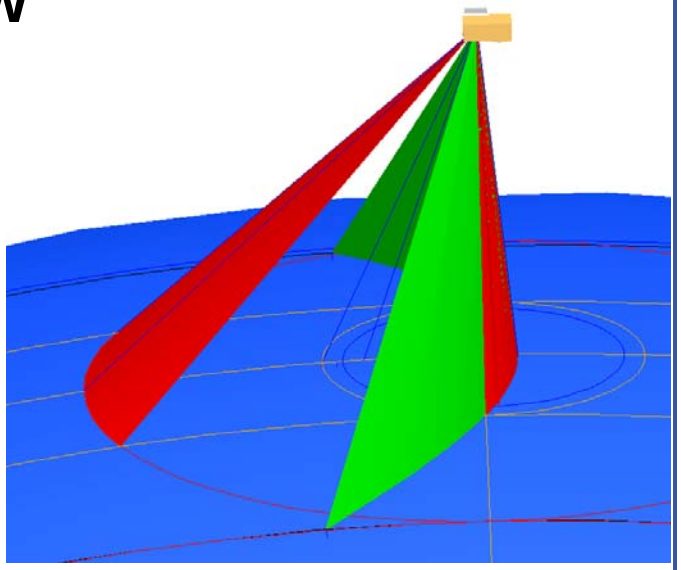


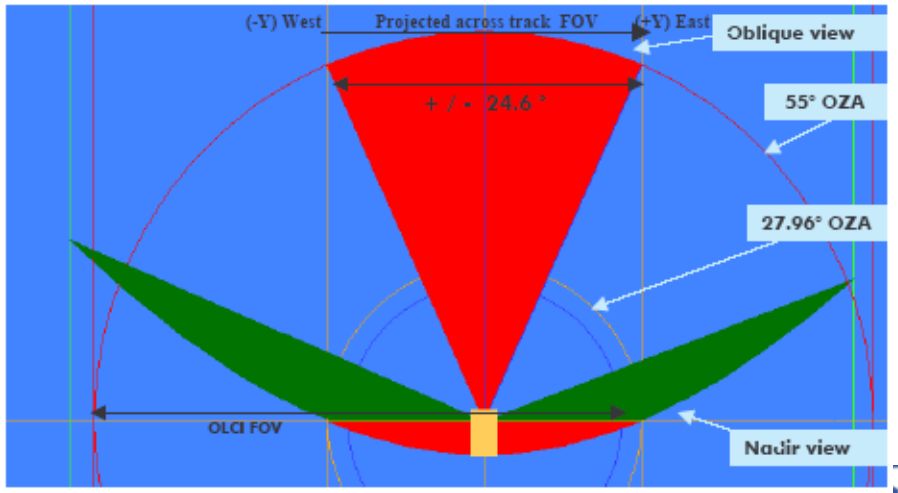
Conical scanning imaging radiometer with a dual view capability:
- **Near-nadir view**
- **Inclined view with an OZA of 55º ± 0.1º**

9 Spectral Channels + 2 (option) for Active FIRE

SLST Overview

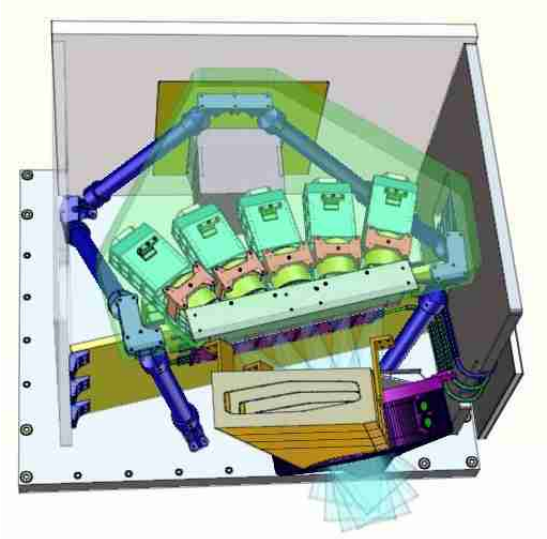
- **Heritage from AATSR, dual-view (nadir and backward) required for aerosol corrections:**
  - **Nadir swath >74° (1300 km min up to 1800 km)**
  - **Dual view swath 49° 750 km**
  - **Nadir swath covering OLCI**
- **9 spectral bands:**
  - **Visible : 555 – 659 – 865 nm**
  - **SWIR : 1.38 – 1.61 – 2.25 µm**
  - **TIR : 3.74 – 10.85 – 12 µm**
- **One Vis/IR channel used for co-registration with OLCI**

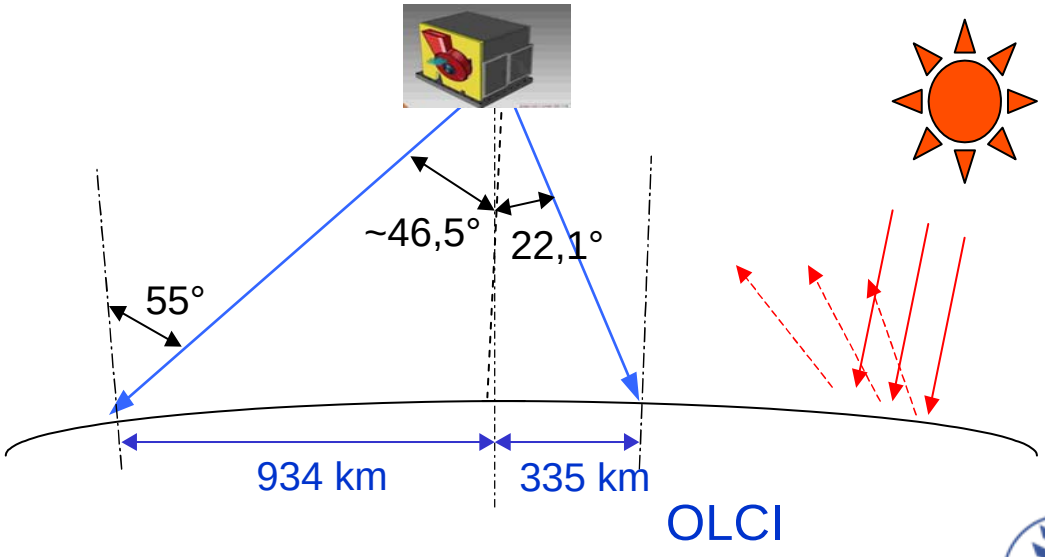




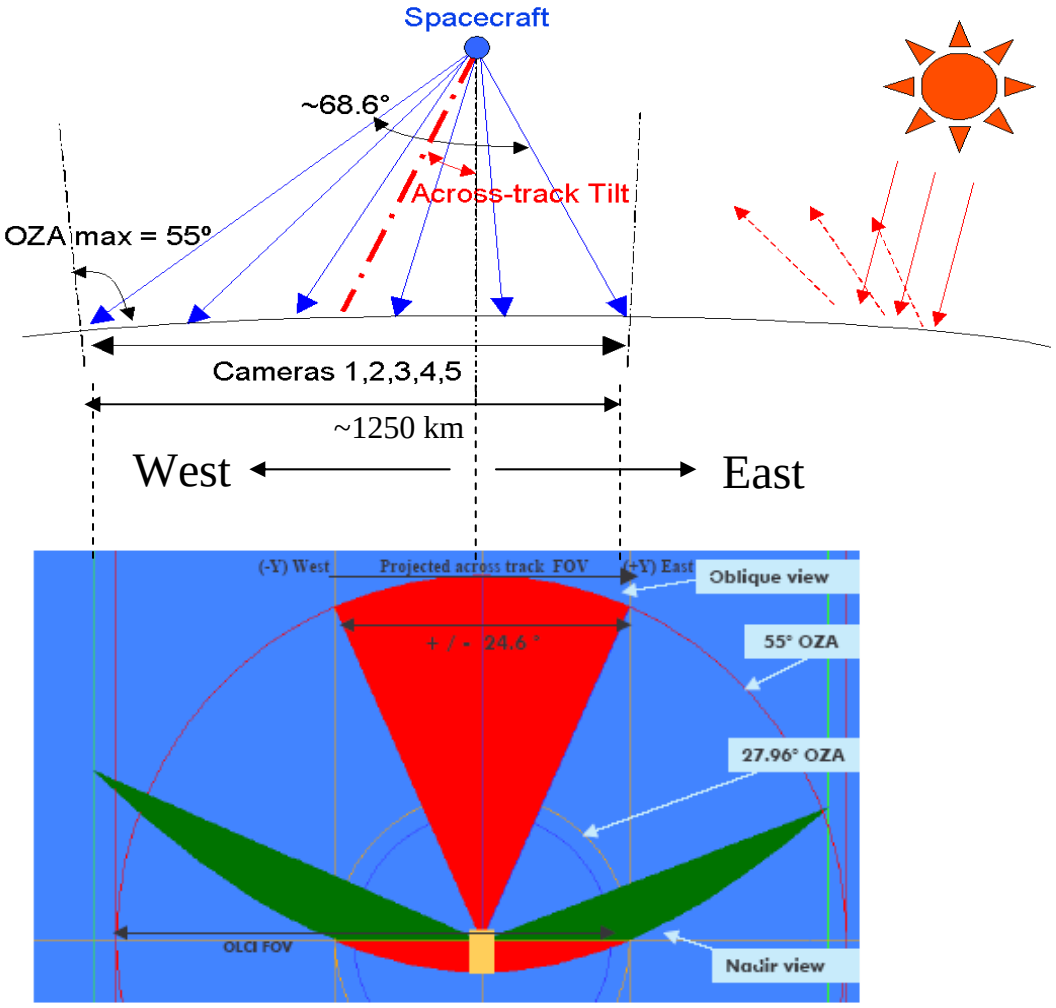
OLCI Overview

- Heritage from MERIS
- 5 cameras, 21 programmable spectral bands (incl. channels for MERIS & VGT legacy products)
- Low polarisation < 1%
- Sun Glint free configuration by design
- Swath covered by SLST for atmospheric correction





Swath Overlap



OLCI

across-track tilt = 12.20°

“West” FoV = 34.3 +12.2 = 46.5°

“East” FoV = 34.3 -12.2 = 22.1°

SLSTR

Dual view

FoV = 2 x 24.62° = 49.24°

Single view

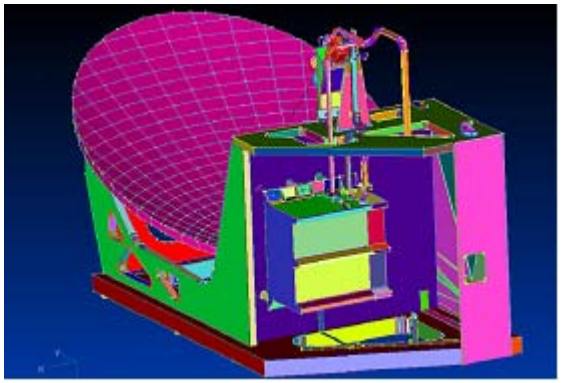
“West” FoV = 46.5°

“East” FoV ≅ 45° (TBC)

Accuracy of Microwave instruments

- **Radar Altimeter (dual-frequency Ku/C Band SAR)**
  - **Real time: 45 cm**
  - **Post-processed: 1.6 cm**

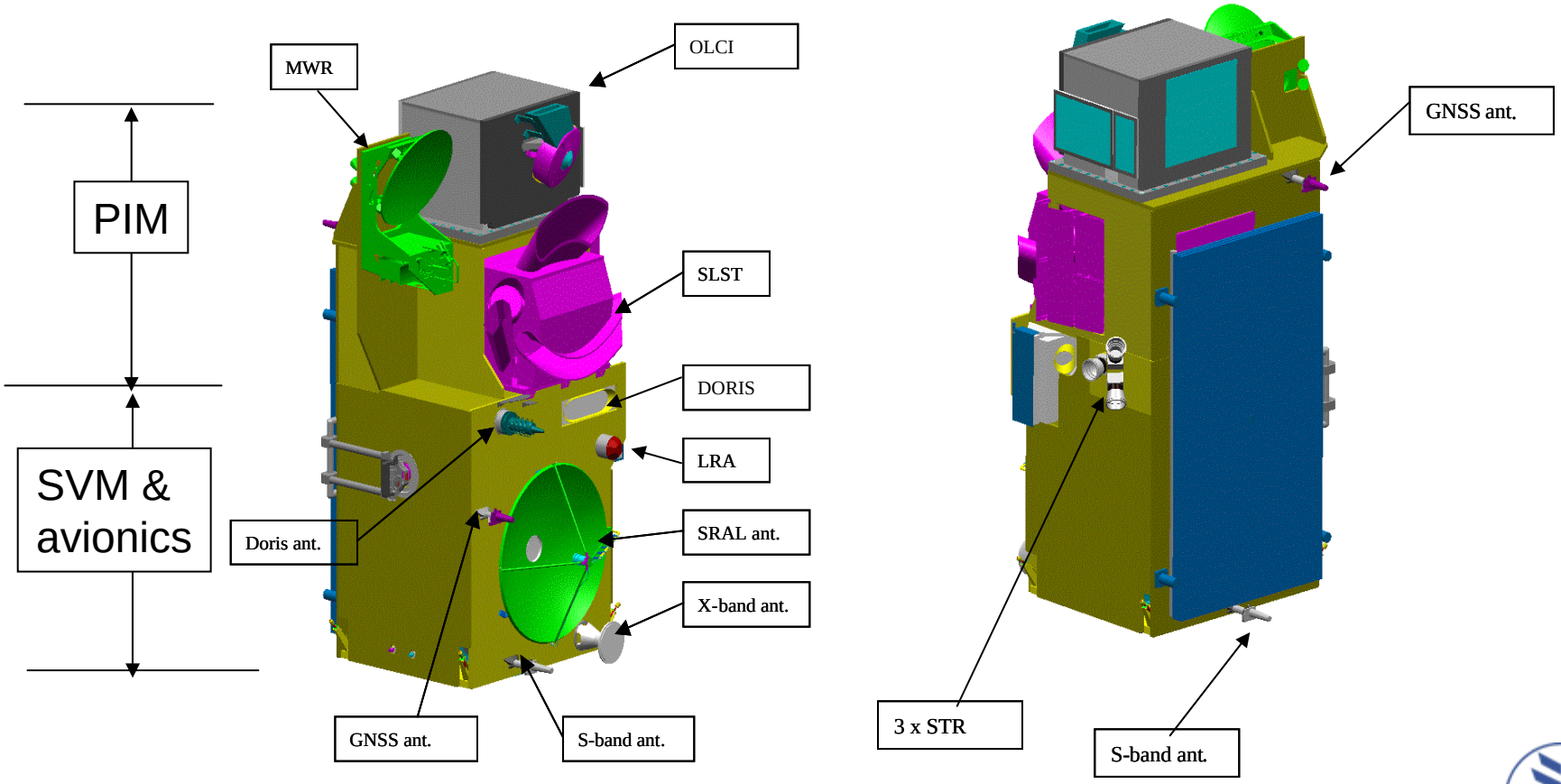
- **MWR (3 or 2 frequencies concept)**
  - **Wet Troposphere correction:**
  - **1.4 cm**



- **GNSS (dual frequency GPS + dual frequency Galileo)**
  - **Real time navigation: 3 m**
  - **POD ground processing**
    - Near real time: 10 cm
    - 1 month: 2 cm

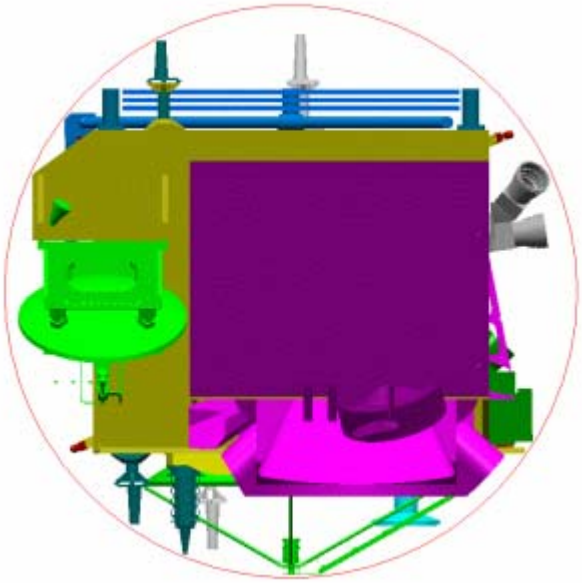
Sentinel-3 Satellite Configuration Overview (Phase B1)

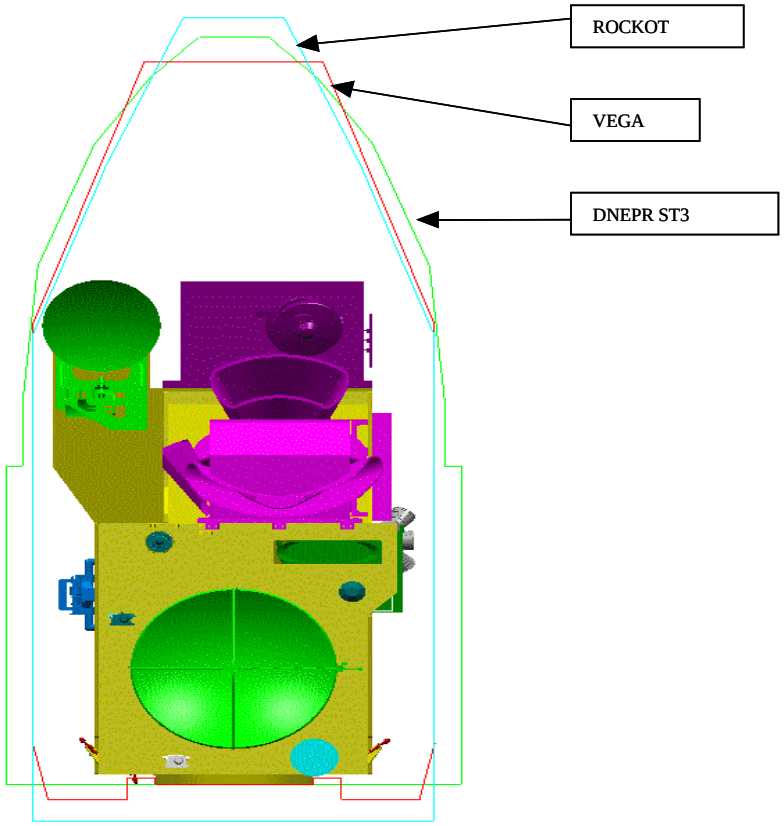
- **Configuration driven by Instruments FoV constraints….**



Sentinel-3 Satellite Configuration Overview (Phase B1)

- and Compliance with small launcher fairings:
  - VEGA nominal launcher
  - Rockot, Dnepr,…possible back-ups

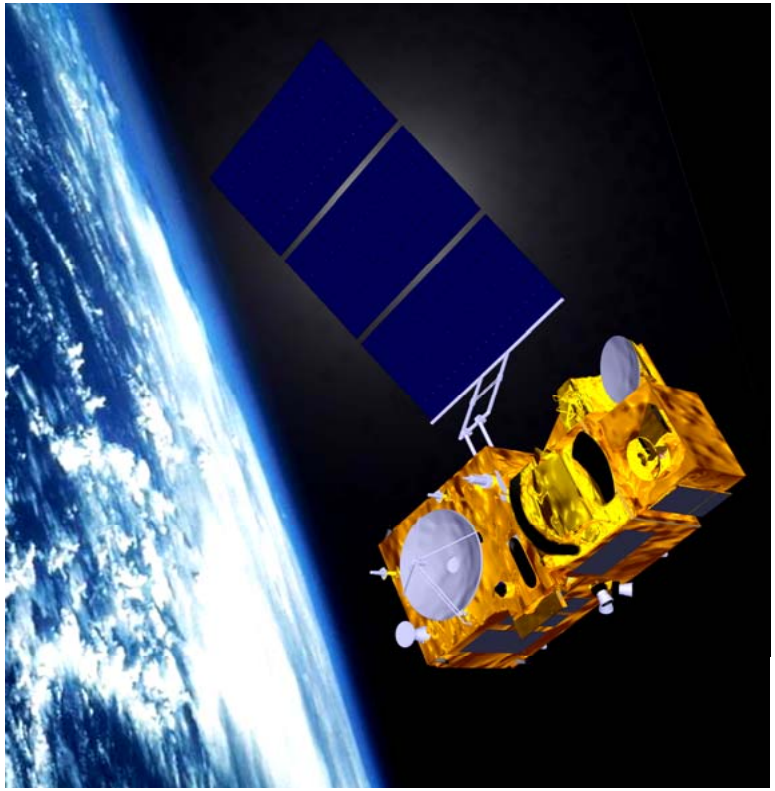




- Mass ~1270 Kg
- Power ~ 1100 W
- Downlink TM Data Rate ~ 300 Mbps

Main Satellite Characteristics (Phase B1)

- Mass ~1270 Kg
  - OLCI ~ 175 Kg
  - SLST ~100 Kg
  - RA ~65 Kg
  - MWR ~25 Kg
  - POD ~12 Kg
  - FIRE ~50 Kg
- Power ~ 1100 W
  - OLCI ~ 125 W
  - SLST ~ 165 W
  - RA ~ 95 W
  - MWR ~ 30 W
  - POD ~ 23 W
  - FIRE ~ 60 W
- Downlink TM Data Rate ~ 300 Mbps
- Data Volume ~130 Gbit



Sentinel 3 versus User Requirements

- **Applicable Sentinel-3 user requirements identified through surveys conducted within the relevant user groups:**
  - **Operational and Institutional Oceanography Groups**
  - **Oceanographic Research Users**
  - **Land Users**
- **Measurement priorities established based on**
  - **“Fast Tracks Services” recommendations**
  - **Measurements Heritage**
  - **Continuity of presently operating space infrastructures**
  - **Synergy with external missions**
- **Sentinel-3 system definition very stable in the last year**
  - **Instruments definition optimised based on heritage an minimization of programme risks**
- **Enclosed tables summarise Sentinel-3 compliance with User Requirements**

Ocean Colour

	User Requirements	Sentinel-3 Implementation
Spectral Bands	Minimum of 15 bands from 400-1050 nm. The role of the bands for Case 1 (open ocean) and Case 2 (coastal) waters is: • 413 nm: *CDOM* discrimination in open ocean • 443, 490, 510, 560 nm: *Chl* retrieval from blue-green ratio algorithms • 560, 620, 665 nm + …: Retrieval of Case 2 water column properties using red-green algorithms • 665, 681, 709 nm + …: Use of fluorescence peak for *Chl* retrieval • 779, 870 nm for atmospheric correction • additional band required above 1000 nm to improve atmospheric correction over turbid water	All bands included.
Spatial Resolution	2-4 km (global monitoring) - 0.2-0.5 km (coastal)	1.2 km (open ocean) - 0.3 km (coastal)
Revisit time	1 day (coastal) – 2-3 days (global)	Spec: 2 days global, sunglint-free (2 satellites) Achieved: 1.9 days (equator), 1.4 days (latitude >30deg)
Observation time	optimised to minimise sun-glint and cloud cover	LTDN 10:00 to 10:30

Sea Surface Temperature

	User Requirements	Sentinel-3 Implementation
Spatial Resolution	1 km	0.5km (solar channels) 1km (thermal channels) on satellite track
Coverage	global in 2-3 days at equator	< 1 day
Revisit time	1 d (optimal) 2 - 3d (minimum) (at European shelf sea latitudes)	Spec: 1 day with single view, 4 days dual view (2 satellites) Achieved: <1 day, single view and dual view
Observation time	Local time around 10:00 optimal (but synergy with other EPS satellites is essential)	LTDN 10:00 to 10:30

Land

	User Requirements	Sentinel-3 Implementation
Spectral Bands	**Vegetation** Minimum of 15 bands spanning spectral range from 443-1085 nm for Land surface and vegetation properties, and atmospheric corrections: 1. -0.443 µm (Blue): for MGVI, aerosol optical depth 2. -0.560 µm (Green): for Chl, NDVI 3. -0.665, 0.681, and 0.709 µm (Red): for Chl absorption peak, fAPAR, fCover 4. -0.753, 0.779 and 0.865 µm (NIR): Chl, fCover MGVI, MTCI, fAPAR 5. -1.61 µm (SWIR): cloud clearing, cloud/snow discrimination 6. -Additional SWIR bands required at 1.375 µm & 2.25 µm for cirrus cloud clearing and aerosol corrections 7. -865 µm common band requirement for OLC-SLST pixel co-registration **Temperature** 1. -3.74 µm (Mid-Wave IR): for Active Fires 2. -10.85 and 12.0 µm (ThIR): for Land Surface Temperature, Active Fires	**Vegetation** All covered by combining OLCI and SLST measurements: 1. - 0.443 (OLCI), missing (SLST) 2. - 0.560 (OLCI), 0.555 (SLST) 3. - 0.665, 0.681, 0.709 (OLCI), 0.659 (SLST) 4. - 0.754, 0.774, 781, 0.863, 0.872 (OLCI), 0.865 (SLST) 5. - missing (OLCI), 1.61 (SLST) 6. - 1.375, 2.25 (SLST) 7. - 863 (OLCI), 865 (SLST) **Temperature** 1. - 3.74 (SLST) 2. - 10.85 and 12.0 (SLST)
Spatial Resolution	0.25 - 0.5 km (global)	0.3km (OLCI), 0.5 (SLST solar channels), 1km (SLST thermal channels)
Revisit time	1 day (coastal) – 2-3 days (global)	Spec: 2 days (colour), 1 day (temp) with 2 satellites Achieved: 1.1 day (colour), <1day (temp)
Observation time	optimised to minimise sun-glint and cloud cover	LTDN 10:00 to 10:30

Sentinel-3 Programme Overview

- Competitive Tender issued at beginning of 2005
- Kick-Off Phase A in Sept. 2005
- Preliminary Concept Review (PCR) in February 2006
- Preliminary Requirement Review (PRR), marking the end of Phase A and the start of Phase B1, in July-August 2006
  - Performance of Payload Instruments re-assessed and baseline Instrument configurations selected.
  - Mission requirements confirmed based on preliminary Fast Tracks reports
- System Requirement Review January 2007
  - Confirmed satisfactory definition of Platform and Instrument, in line with mission requirements
- ITT for Phase B2/C/D/E1 issued on 16th of February 2007
  - Bidding period close 4th of May 2007
  - Contractor selection by End of June 2007

S3 Phase B2/C/D/E1 Contract Proposal to IPC (next week) with the goal to start B2 before end September 2007

S3 Project Development Schedule (at SRR)

N°	Nom de la tâche
1	KO Implementation phase
2	satellite PDR
3	satellite CDR
4	satellite AR
5	PFM launch
6	**OLCI instrument**
12	**SLSTR instrument**
20	**altimeter**
28	**radiometer**
34	**mechanical subsystems**
41	**electrical subsystems**
51	**On board software**
57	**STM AIT**
60	**PFM & EFM AIT**
63	**launch campaign**
64	launch campaign
65	margin