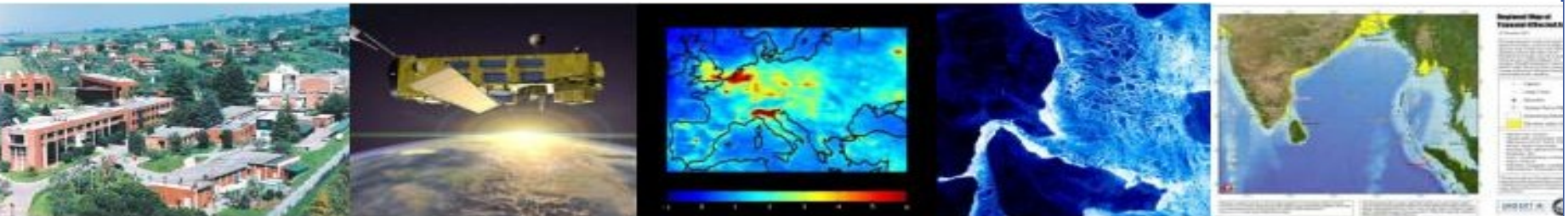


# GMES Sentinel-3



**B. Berruti**  
**M. Drinkwater**  
**ESA- ESRIN**  
**7<sup>th</sup> March 2007**

## Sentinel-3 Mission 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**
- **Sentinel-3 implements 4 core operational missions in continuity of existing ones, delivering:**
  - **Sea surface topography (SSH) and, significant wave height (SWH) over the global ocean to an accuracy and precision exceeding that of Envisat RA-2.**
  - **Sea and Land surface temperature (SST, LST), at least at the level of quality of the Advanced Along-Track Scanning Radiometer (AATSR) instrument**
  - **Visible and Infrared radiances (“Ocean Colour”) for oceanic and coastal waters, determined to an equivalent level of accuracy and precision as MEdium Resolution Imaging Spectrometer (MERIS) instrument data with complete Earth coverage in 2 to 3 days, and co-registered with SST measurements.**
  - **Visible, Near Infrared, Short-Wave Infrared, and Thermal Infrared radiances (“Land Colour”) for land surface, with complete Earth coverage in 1 to 2 days, with products equivalent to those derived from MERIS, A/ATSR and Spot VGT, together with those from their combination.**

## Marine Services

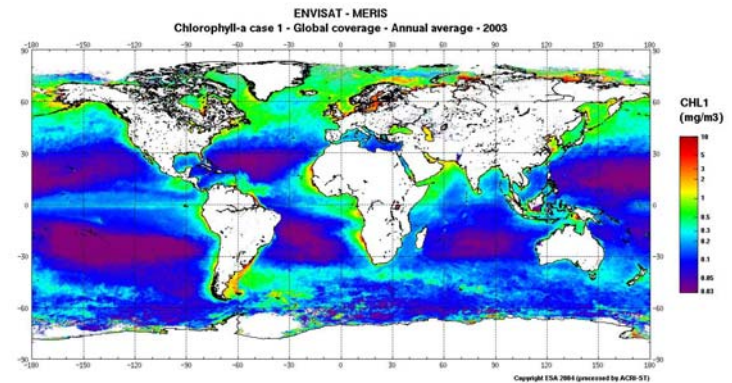
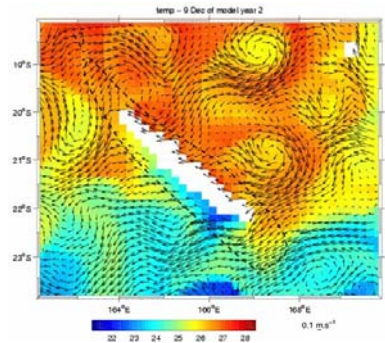
GMES Initial Service	S-3 Requirement
<b>Marine and Coastal Environment</b>	sea-surface topography mesoscale circulation water quality sea-surface temperature wave height and wind sediment load and transport eutrophication
<b>Polar Environment monitoring</b>	sea-ice thickness ice surface temperature
<b>Maritime Security</b>	ocean-current forecasting water transparency wind and wave height
<b>Global Change Ocean</b>	global sea-level rise global ocean warming ocean CO <sub>2</sub> flux

## Land Services

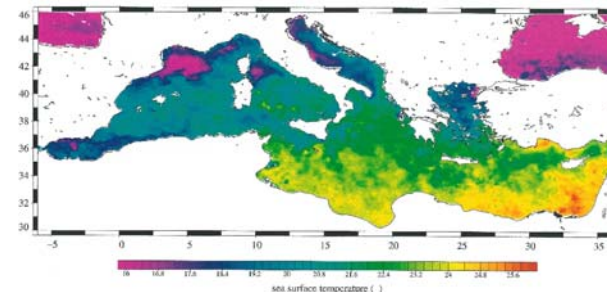
GMES Initial Service	S-3 Requirement
Global Change Land	forest cover change mapping soil degradation mapping
Land cover & Land use change	land use mapping Vegetation indices
Forest Monitoring	forest cover mapping
Food Security early warning	regional land-cover mapping drought monitoring
Humanitarian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

## Products

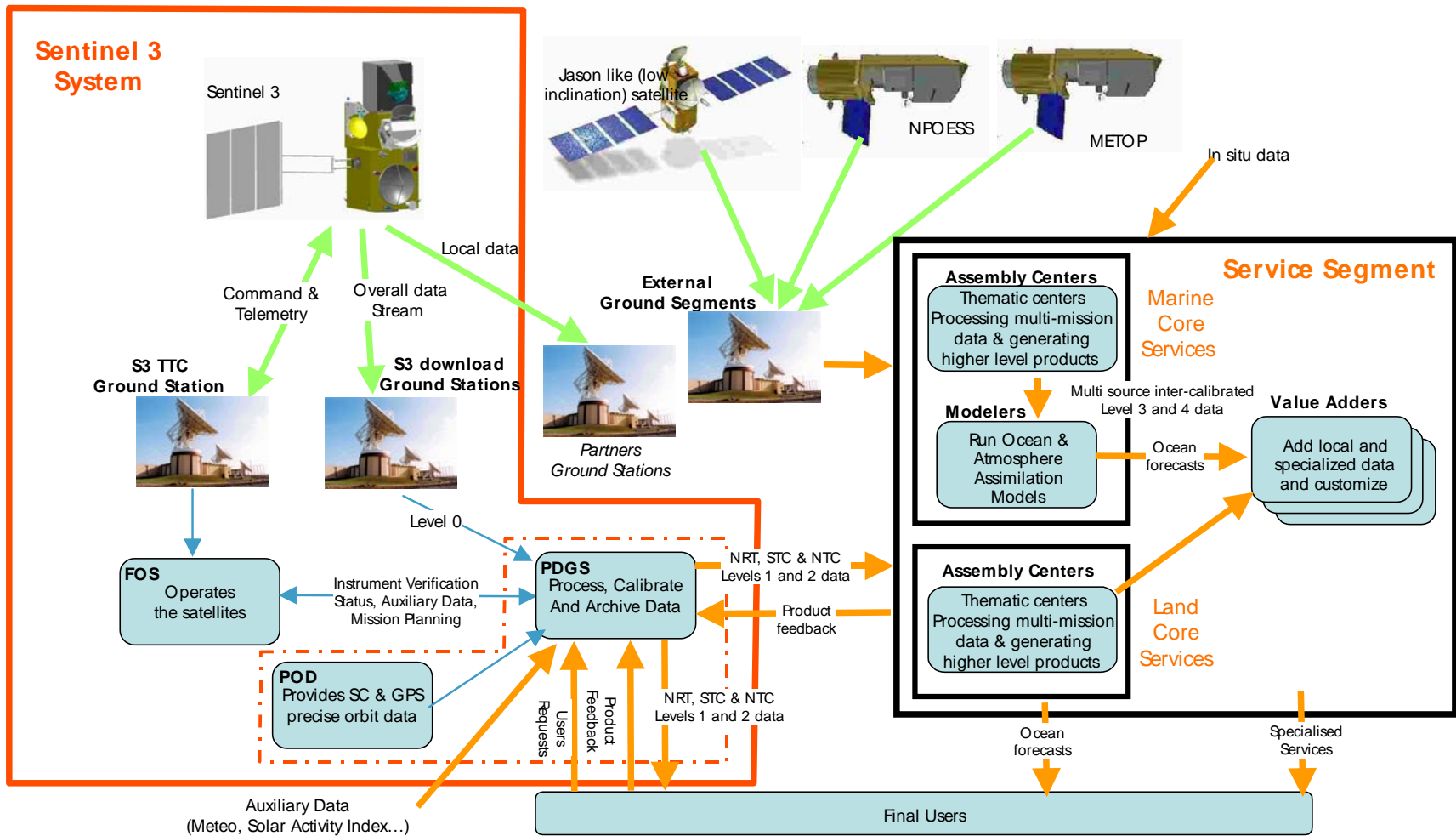
- **Surface Topography:**
  - SSH, SWH, Wind, Geostrophic Currents
  - Sea-ice thickness
- **Ocean Surface Colour**
  - Cla, PFTs, HAB, Transparency, Sediment loading, Turbidity
- **Land Cover and Vegetation**
  - NDVI, MGVI, MTCI, faPAR, LAI
- **Sea Surface Temp**
- **Land Surface Temp**
- **By-products:**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



Objective Analysis result 20041109-EUR-L4UHFnd-MED-v01.nc



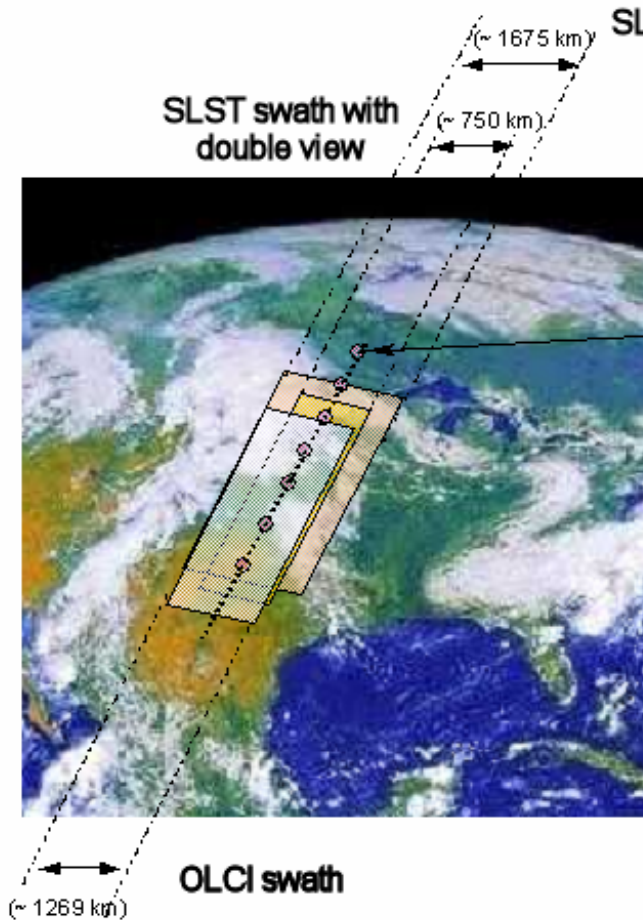
# Mission Context



## Orbit Selection/Coverage

- **Key requirements for orbit selection:**
  - **High-inclination polar sun-synchronous frozen orbit, to achieve near-complete global coverage**
  - **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
    - Off Zenith Angle (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**
  - **Compatible with EPS & NPOESS**

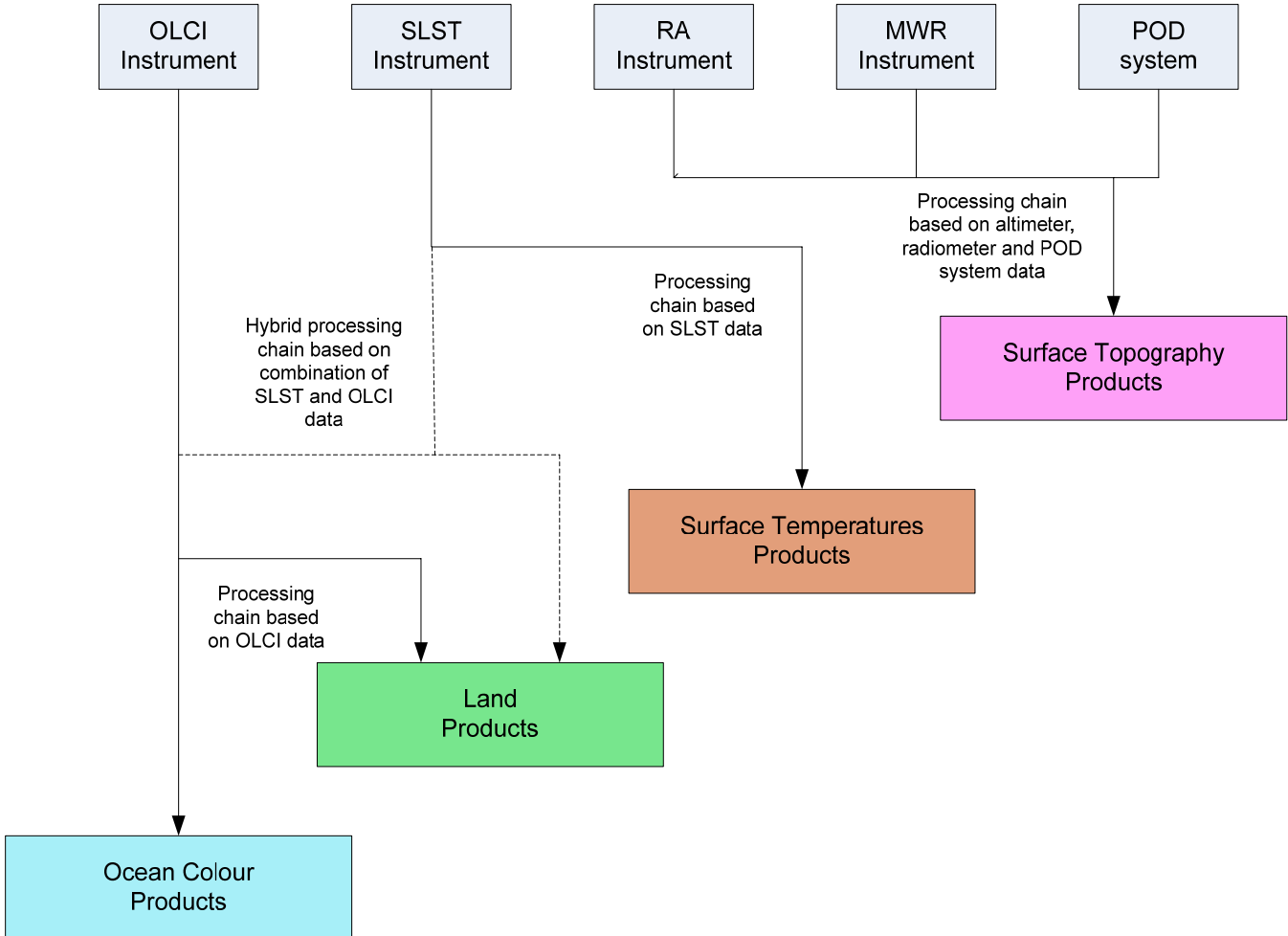
# Payload Complement



- **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 Colour Instrument (OLCI)
  - Sea and Land Surface Temperature (SLST)
- **Optional Payload**
  - FIRE Infrared Element

**NOTE: Final decision to embark FIRE to be taken by PDR.**

# Mission chains summary



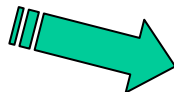
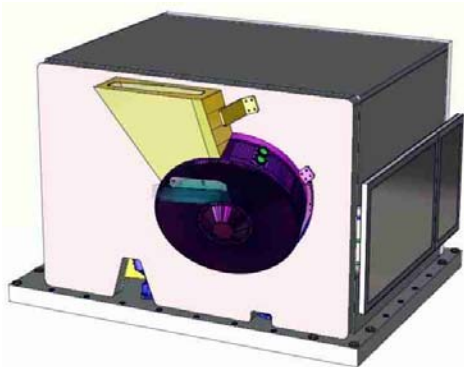
## Revisit time

- 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	

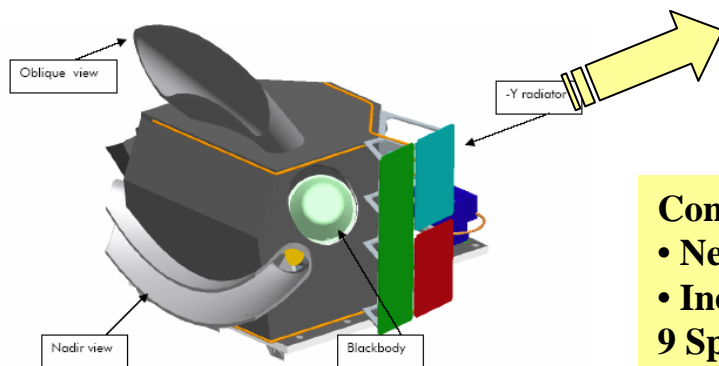
- Near-Real Time (< 3 hr) availability of the L2 products
- Slow Time Critical (STC) (1 to 2 days) delivery of higher quality products for assimilation in models (e.g. SSH, SST)

# Resolution of optical instruments



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

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



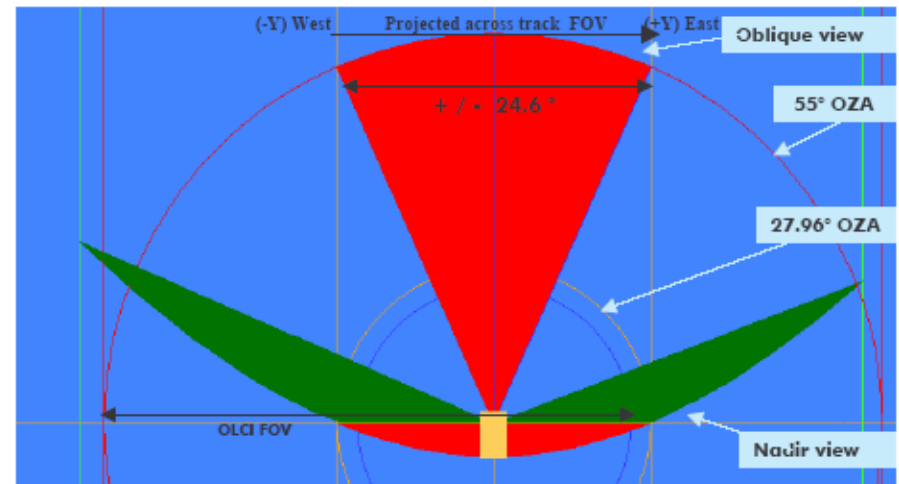
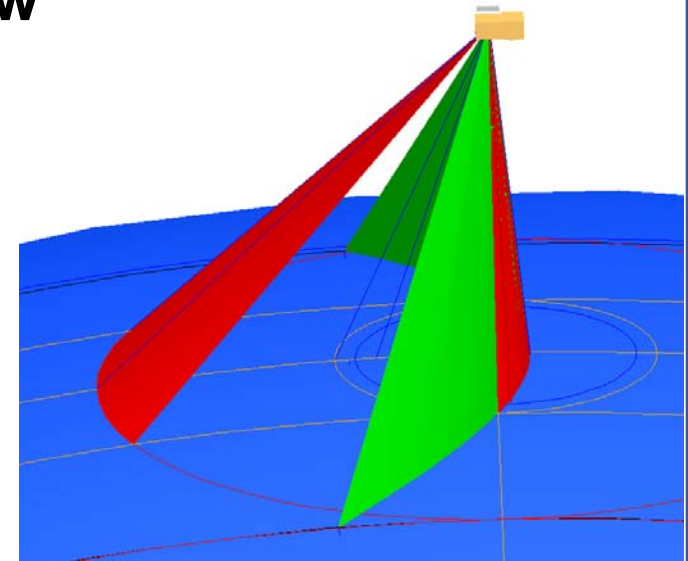
**Conical imaging radiometer with a dual view capability:**

- Near-nadir view
- Inclined view with an OZA of 55°

**9 Spectral Channels + 2 (option) for Active FIRE**

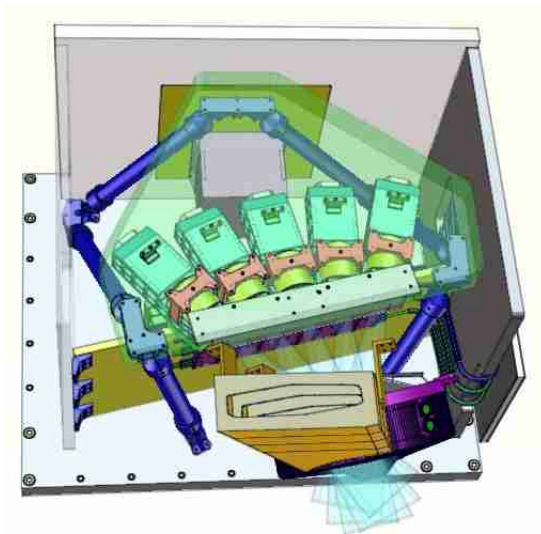
## SLST Overview

- Heritage from AATSR, dual-view (nadir and backward) required for aerosol corrections:
  - Nadir swath  $>74^\circ$  (1300 km min up to 1800 km)
  - Dual view swath  $49^\circ$  750 km
  - Nadir swath covering OLCI
- 9 spectral bands:
  - Visible : 555 – 659 - 859 nm
  - SWIR : 1.38 – 1.61 – 2.25  $\mu\text{m}$
  - TIR : 3.74 – 10.85 – 12  $\mu\text{m}$
- One IR channel used for co-registration with OLCI

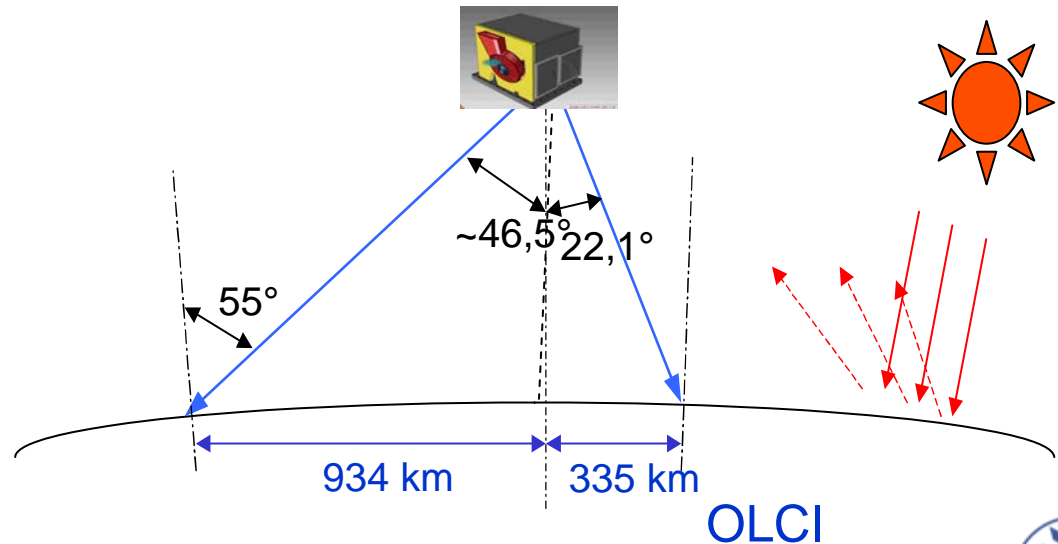


## OLCI Overview

- Heritage from MERIS
- 5 cameras, 16 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



7 March 2007



GMES Services Co-location  
ESA-ESRIN Frascati

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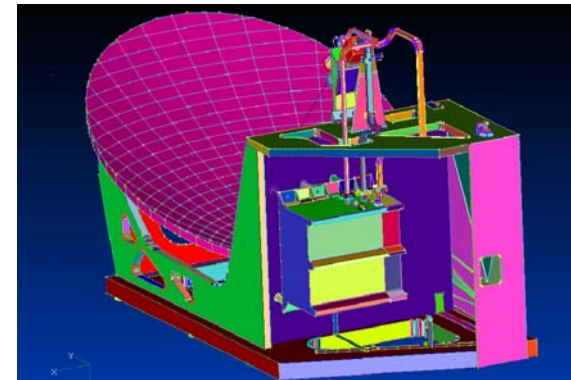
## Accuracy of Microwave instruments

- Radar Altimeter (dual-frequency Ku/C Band SAR)

- Post-processed: 1.6 cm

- MWR (3 or 2 frequencies concept)

- Wet Troposphere correction:
  - 1.4 cm



- GNSS (dual frequency GPS + dual frequency Galileo)

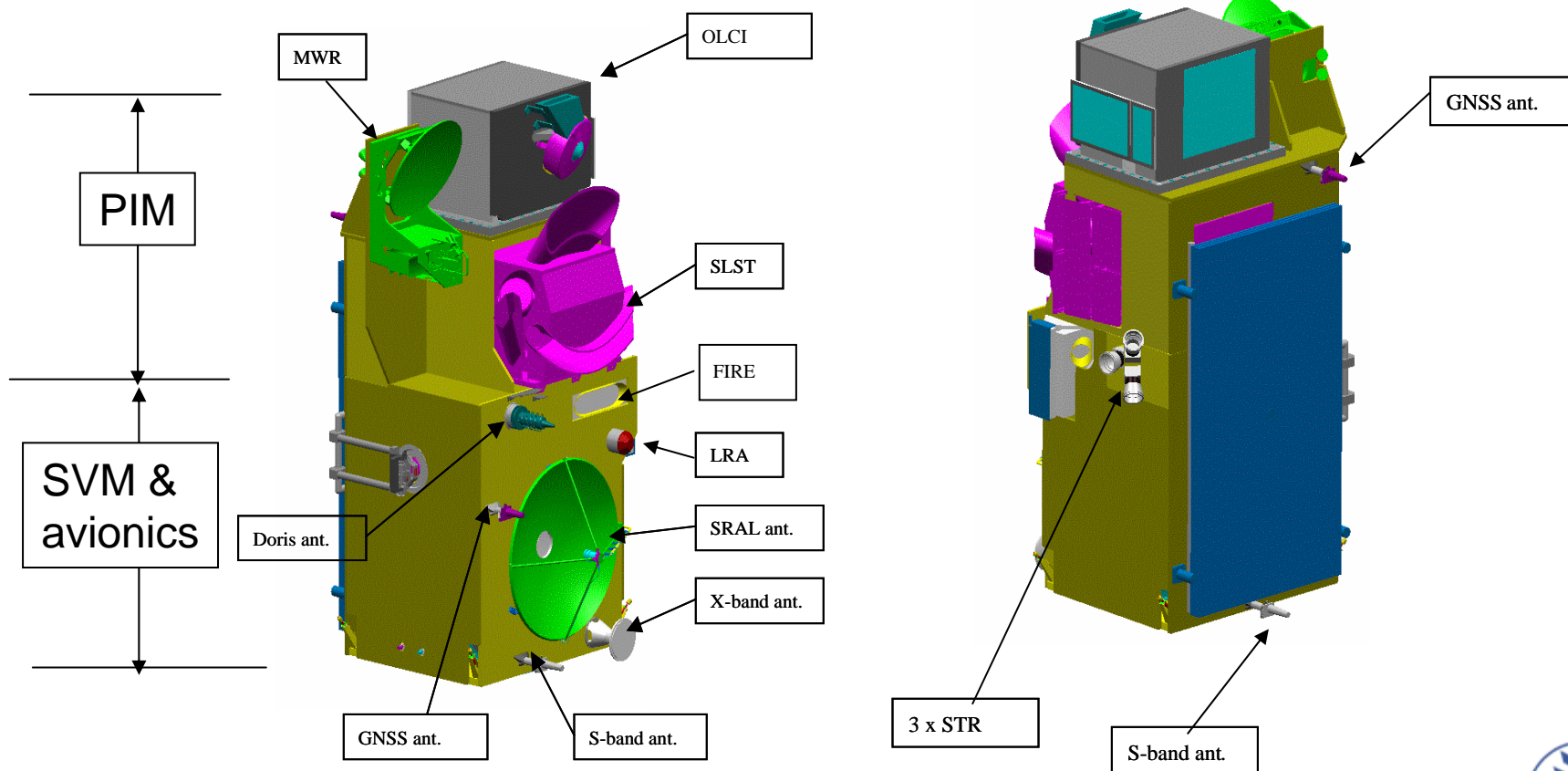
- Real time navigation: 3 m

- POD ground processing

- Near real time: 10 cm (radial)
    - 1 month: 2 cm (radial)

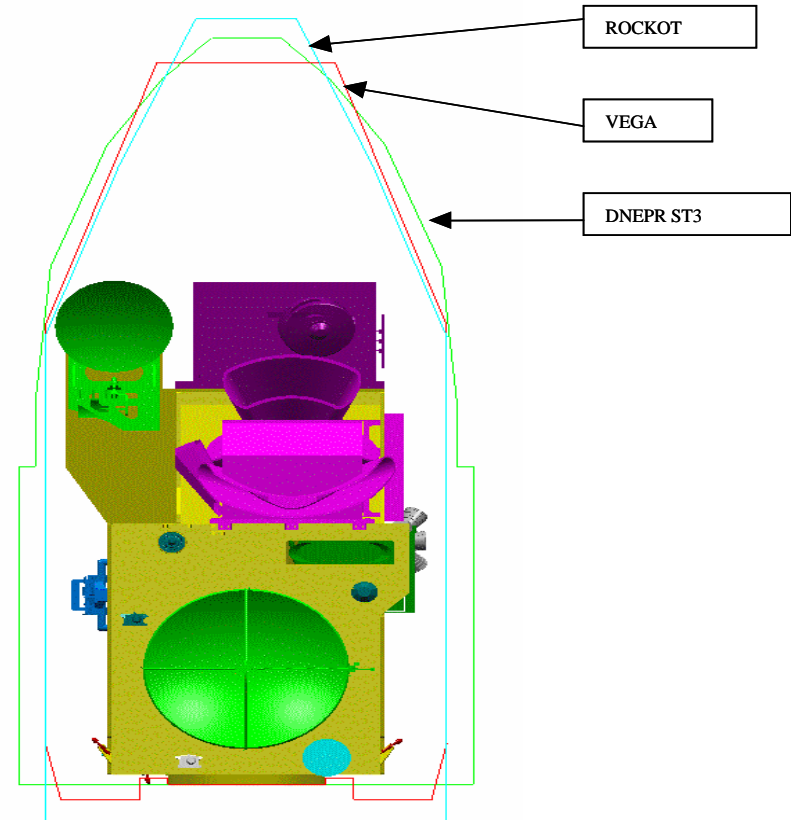
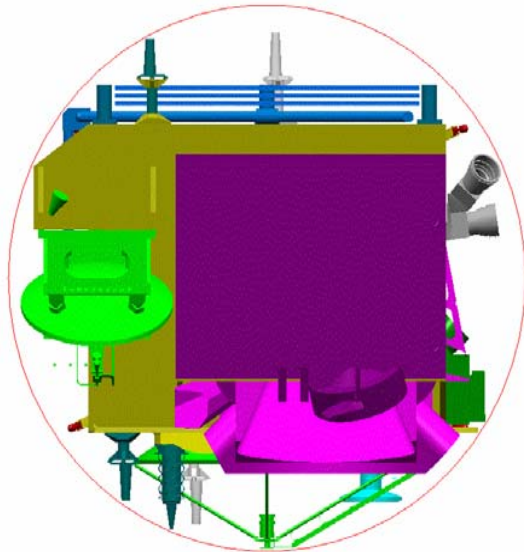
# Sentinel-3 Satellite Configuration Overview

- Configuration driven by Instruments FoV constraints....



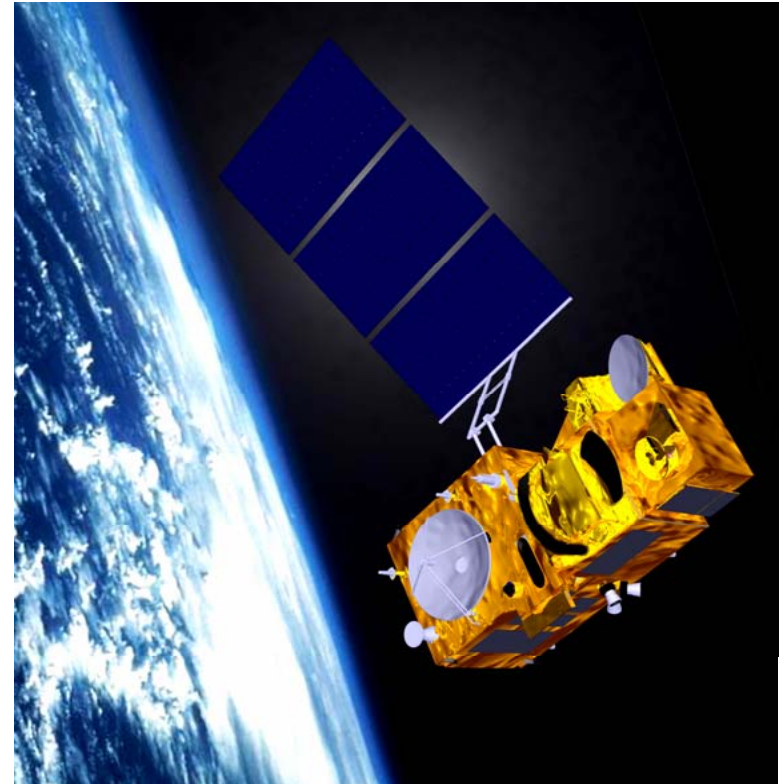
# Sentinel-3 Satellite Configuration Overview

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



## 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 and minimization of programme risks**
- **Enclosed tables summarise Sentinel-3 compliance with User Requirements**

## Ocean Colour

	User Requirements	Sentinel-3 Implementation
<b>Spectral Bands</b>	<p>Minimum of 15 bands from 400-1050 nm. The role of the bands for Case 1 (open ocean) and Case 2 (coastal) waters is:</p> <ul style="list-style-type: none"> <li>• 413 nm: <i>CDOM</i> discrimination in open ocean</li> <li>• 443, 490, 510, 560 nm: <i>Chl</i> retrieval from blue-green ratio algorithms</li> <li>• 560, 620, 665 nm + ...: Retrieval of Case 2 water column properties using red-green algorithms</li> <li>• 665, 681, 709 nm + ...: Use of fluorescence peak for <i>Chl</i> retrieval</li> <li>• 779, 870 nm for atmospheric correction</li> <li>• additional band required above 1000 nm to improve atmospheric correction over turbid water</li> </ul>	All bands included.
<b>Spatial Resolution</b>	2-4 km (global monitoring) - 0.2-0.5 km (coastal)	1.2 km (open ocean) - 0.3 km (coastal)
<b>Revisit time</b>	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)
<b>Observation time</b>	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 10:300

# Land

	User Requirements	Sentinel-3 Implementation
<b>Spectral Bands</b>	<p><b>Vegetation</b> Minimum of 15 bands spanning spectral range from 443-1085 nm for Land surface and vegetation properties, and atmospheric corrections:</p> <ol style="list-style-type: none"> <li>1. -0.443 <math>\mu\text{m}</math> (Blue): for MGVI, aerosol optical depth</li> <li>2. -0.560 <math>\mu\text{m}</math> (Green): for Chl, NDVI</li> <li>3. -0.665, 0.681, and 0.709 <math>\mu\text{m}</math> (Red): for Chl absorption peak, fAPAR, fCover</li> <li>4. -0.753, 0.779 and 0.865 <math>\mu\text{m}</math> (NIR): Chl, fCover MGVI, MTCI, fAPAR</li> <li>5. -1.61 <math>\mu\text{m}</math> (SWIR): cloud clearing, cloud/snow discrimination</li> <li>6. -Additional SWIR bands required at 1.375 <math>\mu\text{m}</math> &amp; 2.25 <math>\mu\text{m}</math> for cirrus cloud clearing and aerosol corrections</li> <li>7. -865 <math>\mu\text{m}</math> common band requirement for OLC-SLST pixel co-registration</li> </ol> <p><b>Temperature</b></p> <ol style="list-style-type: none"> <li>1. -3.74 <math>\mu\text{m}</math> (Mid-Wave IR): for Active Fires</li> <li>2. -10.85 and 12.0 <math>\mu\text{m}</math> (ThIR): for Land Surface Temperature, Active Fires</li> </ol>	<p><b>Vegetation</b> All covered by combining OLCI and SLST measurements:</p> <ol style="list-style-type: none"> <li>1. - 0.443 (OLCI), missing (SLST)</li> <li>2. - 0.560 (OLCI), 0.555 (SLST)</li> <li>3. - 0.665, 0.681, 0.709 (OLCI), 0.659 (SLST)</li> <li>4. - 0.754, 0.774, 781, 0.863, 0.872 (OLCI), 0.865 (SLST)</li> <li>5. - missing (OLCI), 1.61 (SLST)</li> <li>6. - 1.375, 2.25 (SLST)</li> <li>7. - 863 (OLCI), 865 (SLST)</li> </ol> <p><b>Temperature</b></p> <ol style="list-style-type: none"> <li>1. - 3.74 (SLST)</li> <li>2. - 10.85 and 12.0 (SLST)</li> </ol>
<b>Spatial Resolution</b>	0.25 - 0.5 km (global)	0.3km (OLCI), 0.5 (SLST solar channels), 1km (SLST thermal channels)
<b>Revisit time</b>	1 day (coastal) – 2-3 days (global)	Spec: 2 days (colour), 1 day (temp) with 2 satellites Achieved: 1.1 day (colour), <1day (temp)
<b>Observation time</b>	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 16<sup>th</sup> of February 2007**
  - Bidding period close 4<sup>th</sup> of May 2007
  - Contractor selection by End of June 2007

**S3 Phase B2/C/D/E1 Contract Proposal to IPC with the goal to start B2 before end September 2007**

# S3 Project Development Schedule (at SRR)

