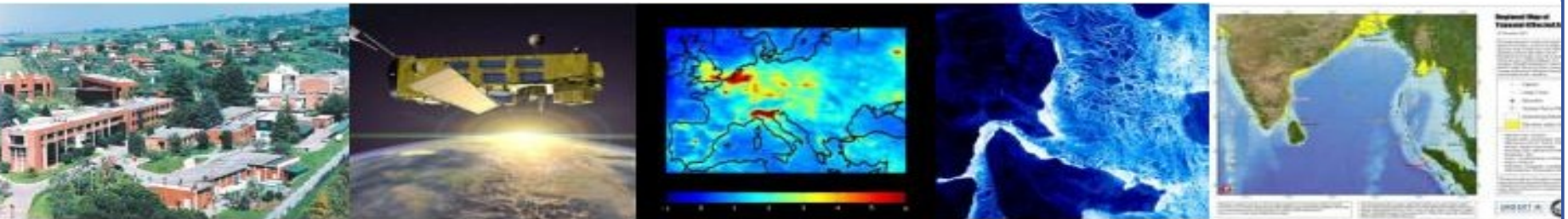


GMES Sentinel-2

The Optical High Resolution Mission
for GMES Operational Services



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- In the framework of the Global Monitoring for Environment and Security (**GMES**) programme, one important development is the **Sentinel-2 system**, providing **global, systematic, high resolution and high revisit** optical imagery.
- Tailored towards the needs of **GMES land and emergency services**.
- The observation capabilities which respond to the gap analysis at the basis of the Sentinel requirements, aim at ensuring **continuity of SPOT- and Landsat-type multispectral data**, with further enhancement to account of future service evolution.
- In order to **support operational services over a long period** (at least 15 years following the launch of the first satellite), it is foreseen to develop a series of four satellites, with nominally two satellites in operation in orbit and a third one stored on-ground as back-up.

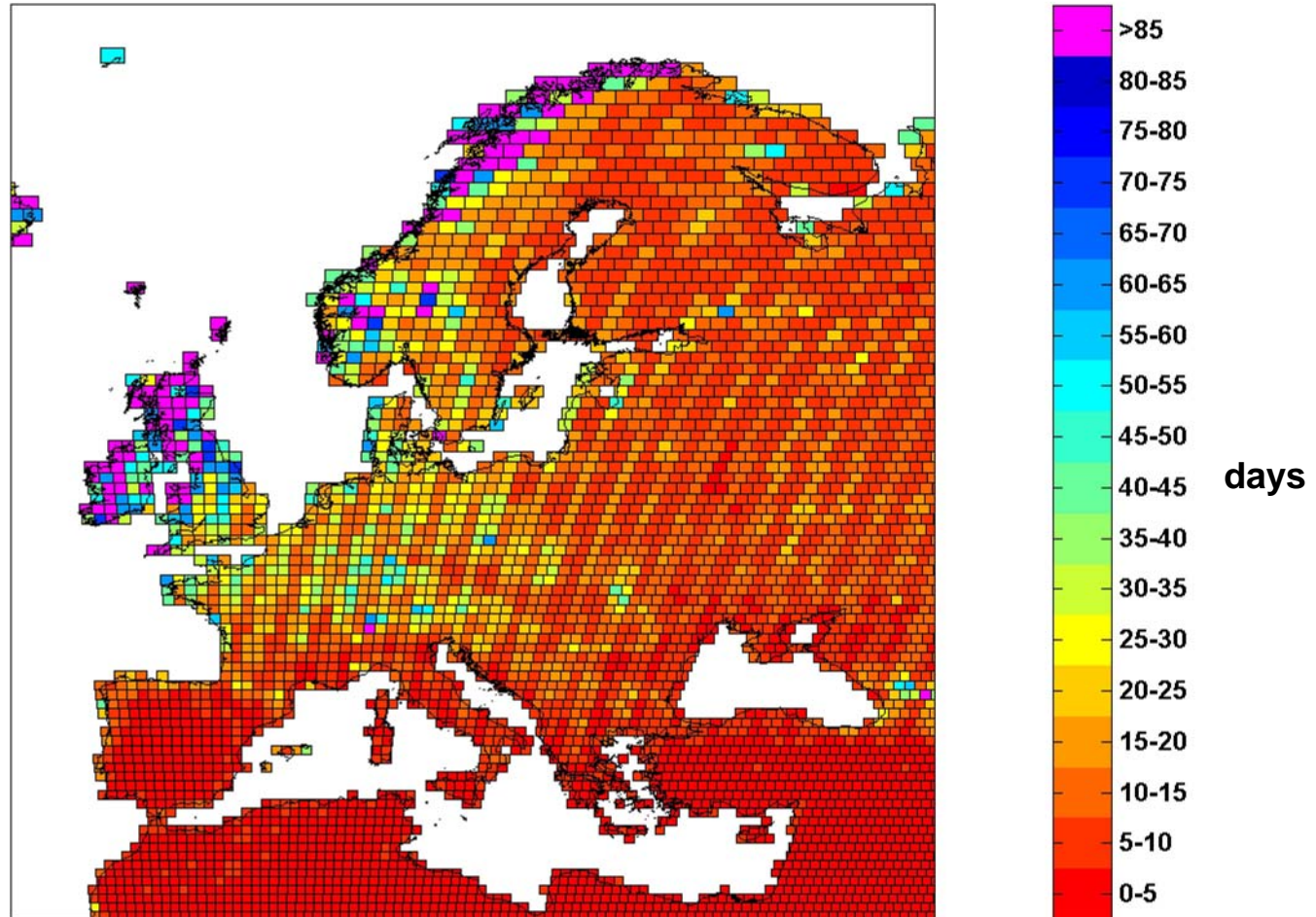
- Sentinel-2 will enable operations of valuable information services to the European Union and its Member States in the frame of the GMES programme, in the areas of **global climate change** (Kyoto Protocol and ensuing regulations), **sustainable development, environmental policies** (e.g. Soil Thematic Strategy, Natura 2000, Water Framework Directive), **risk management, EU Common Agricultural Policy, development and humanitarian aid, and EU Common Foreign & Security Policy.**
- In order to meet the user needs, Sentinel-2 satellite data will support the operational generation of generic **land cover, land use and change detection maps** (e.g. CORINE land cover maps update, soil sealing maps, forest area maps)
- In addition, the evolving data exploitation calls for supporting also the generation of **geophysical variables maps** (e.g. leaf chlorophyll content, leaf water content, leaf area index...).

- Sentinel-2 will be used in GMES together with other satellites to provide complete observations to GMES data consumers.
- Sentinel-2 will contribute to the CEOS Land Surface Imaging constellation, which will coordinate access to the missions of the same type (especially LDCM) to improve the final information for the end users; in this respect it will ensure European independence while at the same contributing to global efforts for improved land imaging observation provision.
- The mission primary aim drives the design towards a dependable multi-spectral Earth observation system that at the same time ensures continuity to Landsat and SPOT observations and improves data availability for users.

- Full and systematic coverage of land surface (including major islands, coastal and inland waters) globally from -56° (Southern America) to $+83^{\circ}$ (Northern Greenland) latitude with the objective to provide cloud-free products typically every 15 to 30 days.
- 2 operational satellites are required, allowing to reach a 5 day geometric revisit (10 days with 1 satellite). Landsat-7 provides 16-day geometric revisit time, while SPOT provides 26-day revisit without systematic coverage of land surfaces.
- Capability to access more rapidly (within 1 to 3 days) some limited geographical areas in emergency mode by performing a roll-tilt manoeuvre to fulfil emergency services (e.g. observe natural disasters at their occurrence).

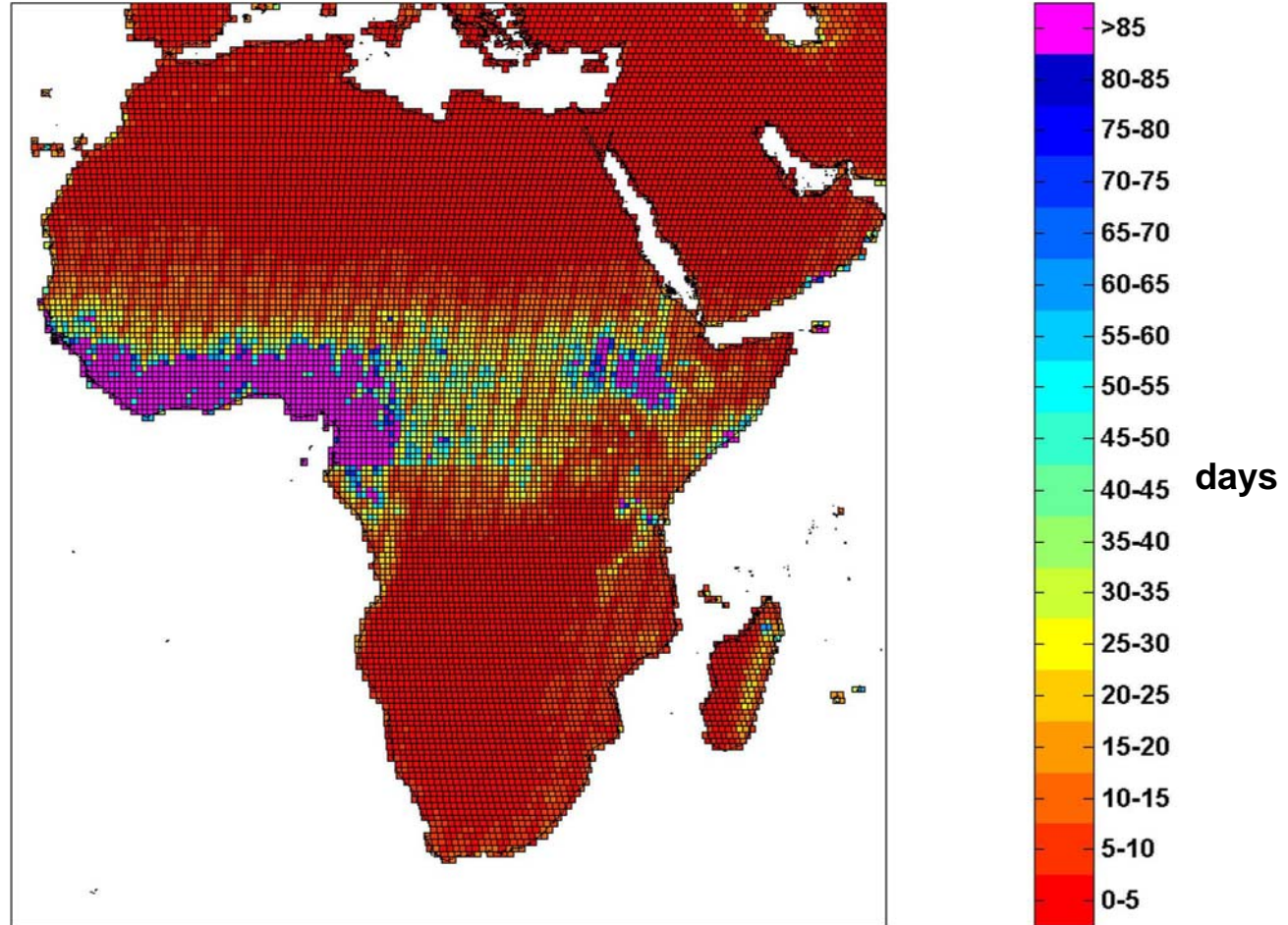
Revisit time over Europe in summer with 2 satellites

Maximum effective coverage time for SC1 & SC2 (days) (<15% cloud cover; 68% confidence)

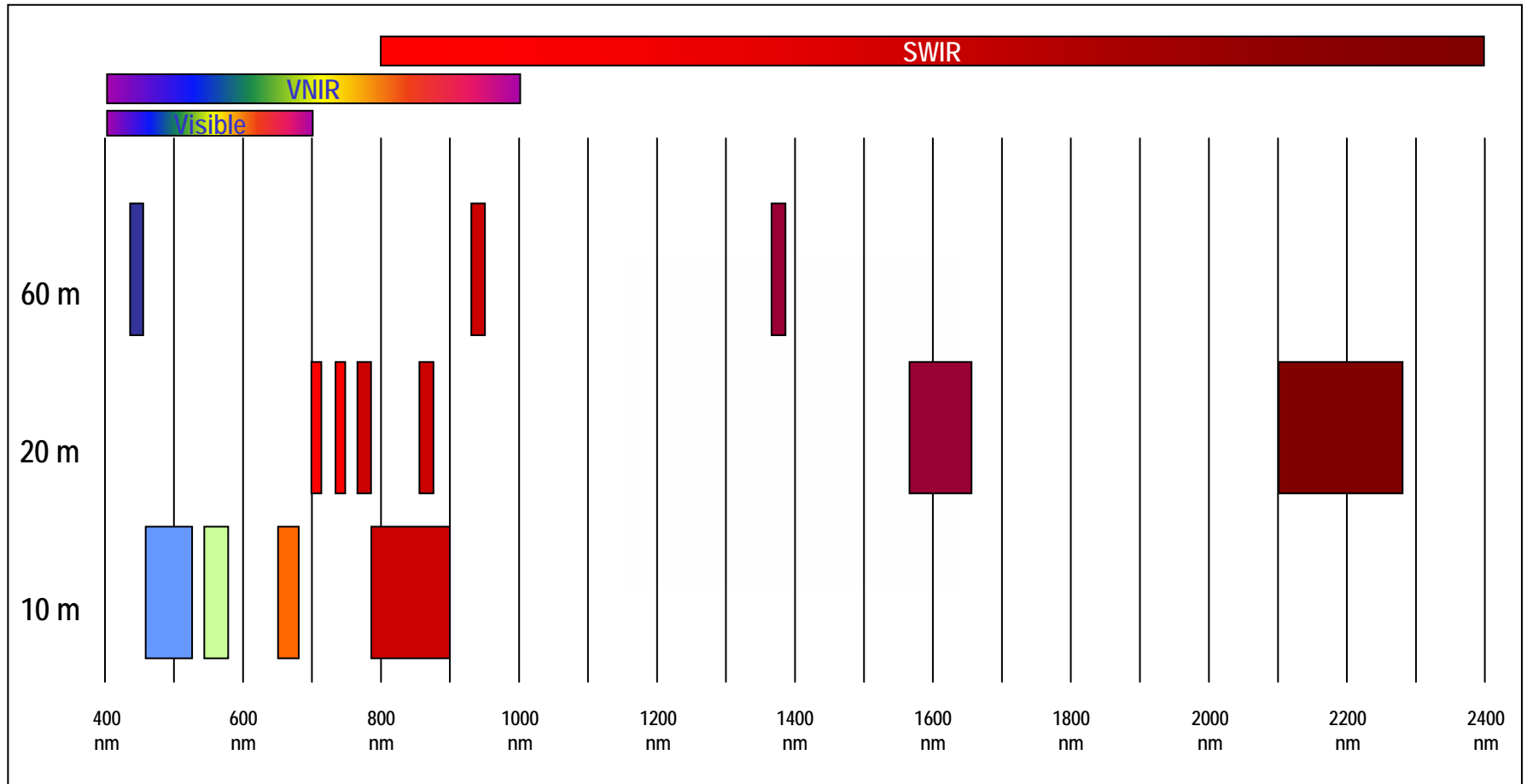


Revisit time over Africa in summer with 2 satellites

Maximum effective coverage time for SC1 & SC2 (days) (<15% cloud cover; 68% confidence)



- The Sentinel-2 Multi-Spectral Instrument (MSI) features **13 spectral bands** from the visible and near infrared (**VNIR**) to the short-wave infrared (**SWIR**), featuring 4 spectral bands at **10 m**, 6 bands at **20 m** and 3 bands at **60 m** spatial resolution.
- This configuration, selected as the best compromise in terms of user requirements and mission performance, cost and schedule risk, will provide **enhanced continuity to SPOT and Landsat**, with narrower bands for improved feature identification, additional channels in the red edge spectral domain allowing to assess the vegetation status, and dedicated bands for an improved atmospheric correction and cirrus cloud detection.
- To be compared with the VNIR and SWIR channels of:
 - SPOT5 : 4 multi-spectral channels + panchromatic channel
 - Landsat 5/7 : 6 multi-spectral channels + panchromatic channel



13 spectral bands versus spatial sampling distance

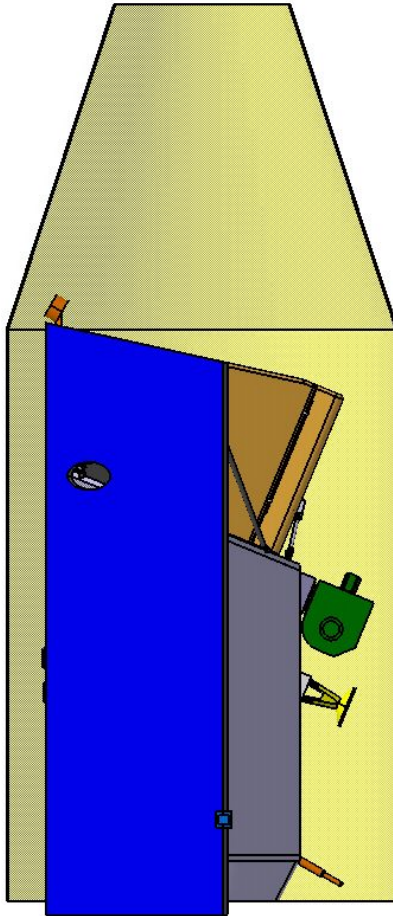
MSI spectral bands	Mission objective	Measurement or Calibration
B1(443/20/60) & B12(2190/180/20)	Aerosols correction	Atmospheric correction bands
B8(842/115/10)/B8a(865/20/20), B9(940/20/60)	Water vapour correction	
B10(1375/20/60)	Cirrus detection correction	
B2(490/65/10), B3(560/35/10), B4(665/30/10), B5 (705/15/20), B6(740/15/20), B7(775/20/20), B8(842/115/10)/B8a(865/20/20), B11(1610/90/20), B12(2190/180/20)	Leaf Chlorophyll Content, LAI, fAPAR, Leaf Water Content, Fractional Vegetation Cover, snow/ice/cloud...	Land measurement bands

(Wavelength [nm] / Width [nm] / Spatial Sampling Distance [m])

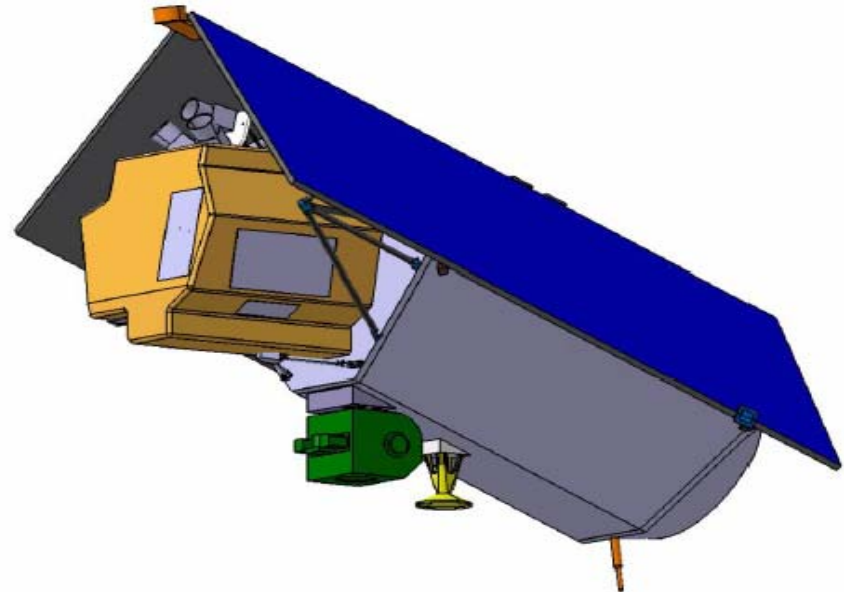
- In order to provide an operational data flow, an **accurate geo-location (better than or equal to 20 m)** is required and shall be produced automatically to meet the timeliness requirements.
- After reception, the **data are processed systematically over pre-defined areas in pre-defined time windows**, selected on the basis of the user requirements, and are made available to **“subscribing” users**, i.e. users having notified their interest for that particular dataset (“subscription”). The dissemination is planned to be performed mostly on-line.
- **On-demand production** and delivery is supported for **specific cases** like disaster management. Mission planning is required only to perform the roll-tilt manoeuvre when needed in support to unpredictable requests.

- Frequent revisit time and high mission availability require 2 spacecraft operating simultaneously, leading to a small cost-effective low-risk spacecraft. The orbit is sun-synchronous at **786 km altitude (14+3/10 revs per day)** with a **Local Time at Descending Node of 10:30 a.m.**, selected as the best compromise between **cloud cover minimisation and sun illumination**. The two satellites will be equally spaced in the orbital plane. Roll-tilt for fast imaging enable **access of any area within 3 days**.
- The ground station network must provide a high contact time to enable full payload observation data downlink so that **4 core ground stations are required**. One polar station for Telemetry, Tracking and Control (TT&C) is shown to be sufficient.
- To a limited extent, the system can also accommodate some direct receiving local user **ground stations for Near-Real Time applications**.

- Compact satellite with about **1 ton mass**, compatible with small launchers like VEGA (baseline) and Rockot (back-up).
- **7 year design lifetime**, with propellant for 12 year operations.
- Roof-shaped configuration with a fixed body-mounted solar array, as considered in phase A/B1 and depicted on the next page, has been changed to a **rotating solar array** configuration for enhanced power and thermal efficiency for phase B2 kick-off.
- **3-axis stabilized** with AOCS based on high-rate multi-head star trackers, gyrometer and GNSS receiver.
- The power subsystem relies on high efficiency solar cells (**GaAs triple junction**) and a **Li-ion battery**.
- **2 Terabit solid state mass memory**, payload data downlink at a rate of **450 Mb/s in X-band** with a high spectral efficiency modulation (8PSK).
- Command and control performed with omni-directional S-band antenna coverage.



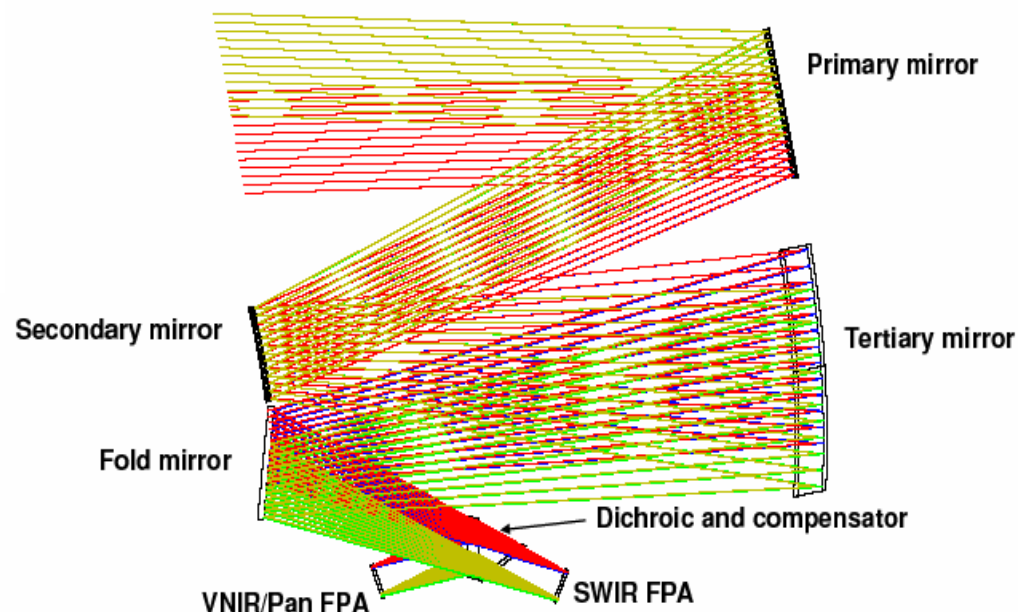
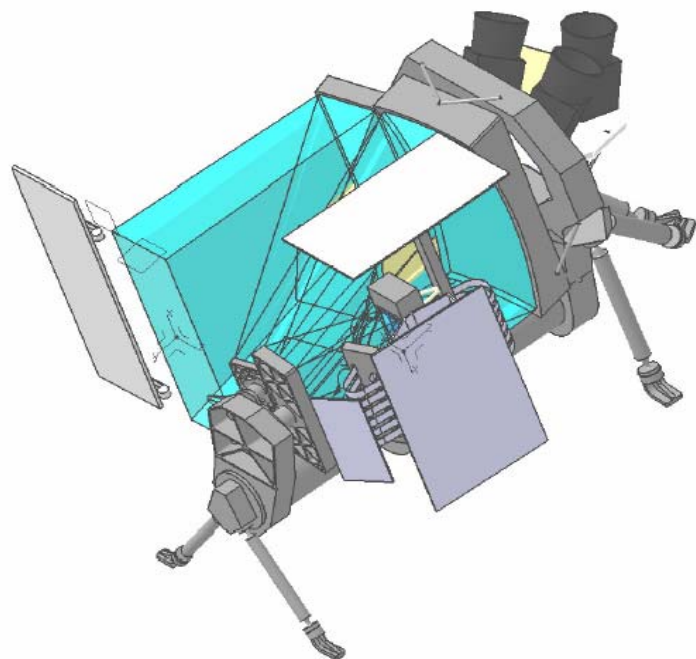
Satellite within VEGA fairing



Satellite in-orbit configuration

(*) Note that the configuration has been changed for phase B2 kick-off to accommodate rotating solar array

- **Push-broom instrument**, 200 kg mass, 170 W power consumption
- **Three Mirror Anastigmat (TMA) telescope with 150 mm pupil diameter**, providing a very good imaging quality all across the wide field of view, corresponding to **290 km swath width**, significantly enlarged with respect to Landsat (185 km) and SPOT (120 km). Telescope structure and mirrors are made of silicon carbide to minimize thermo-elastic deformations.
- VNIR focal plane based on monolithic **CMOS detectors**, SWIR focal plane based on a **mercury cadmium telluride (MCT)** detector hybridised on a CMOS read-out circuit. A dichroic beam-splitter provides the spectral separation of VNIR and SWIR channels.
- A combination of **partial on-board calibration**, using a sun diffuser, and vicarious calibration with ground targets will guarantee a high quality radiometric performance. The detector signals are converted to digital with **12-bit resolution** and state-of-the-art data compression, based on wavelet transform, is applied to reduce the data volume.



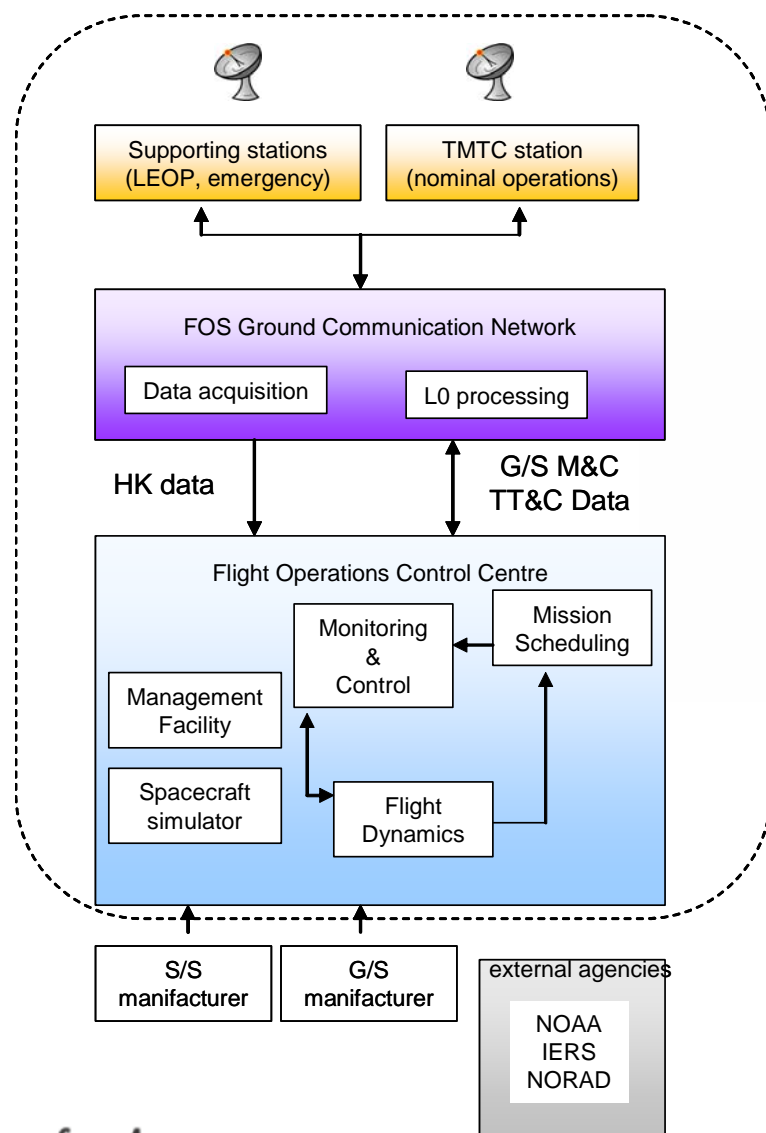
Multi-Spectral Instrument View

MSI optical design across view

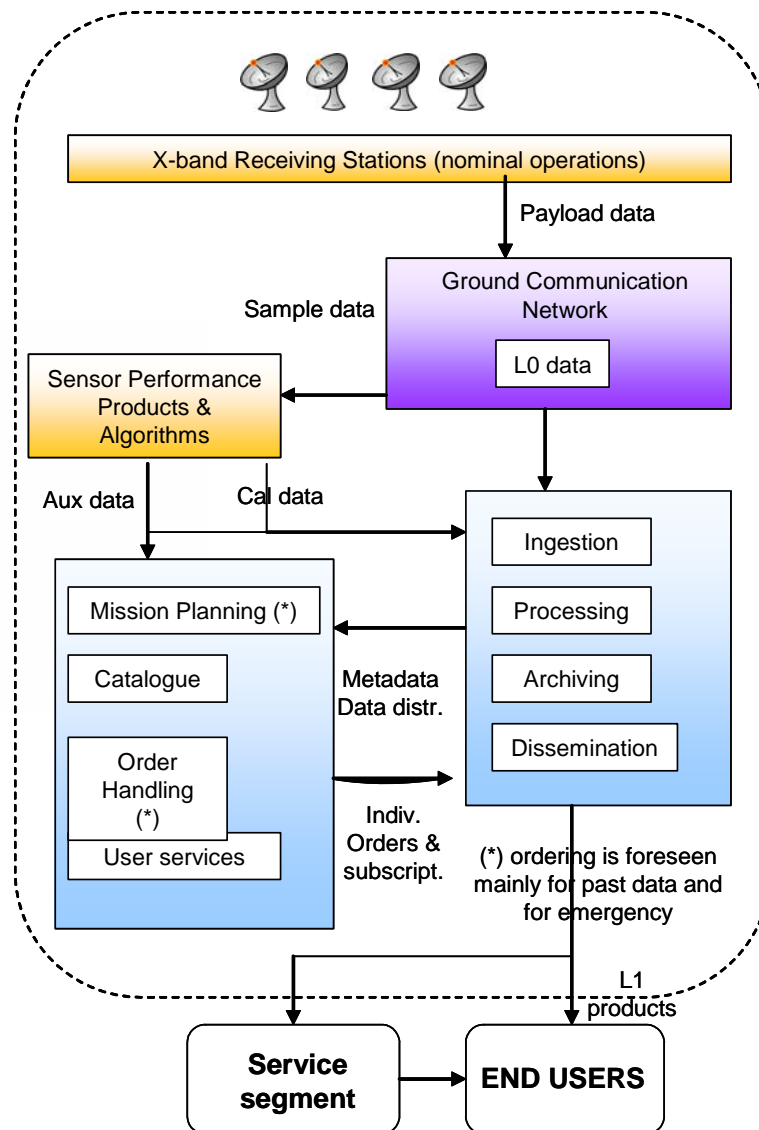
In order to mitigate the development risks and secure the development schedule, technology pre-development activities have been initiated on critical items, namely the **VNIR** and **SWIR** detectors and the **filter assemblies**.

- The Sentinel-2 Ground Segment includes the following elements:
 - a **Flight Operations Segment (FOS)** for satellite command, monitoring and control;
 - a decentralized **Payload Data Ground Segment (PDGS)**, based on an evolving multi mission infrastructure, for mission planning, payload data reception, processing, archiving, quality control and dissemination.
- The **Service Segment**, geographically decentralized, will utilise data from different satellites (Sentinels and contributing missions) in combination with non-space data to deliver customised information services to the final users.

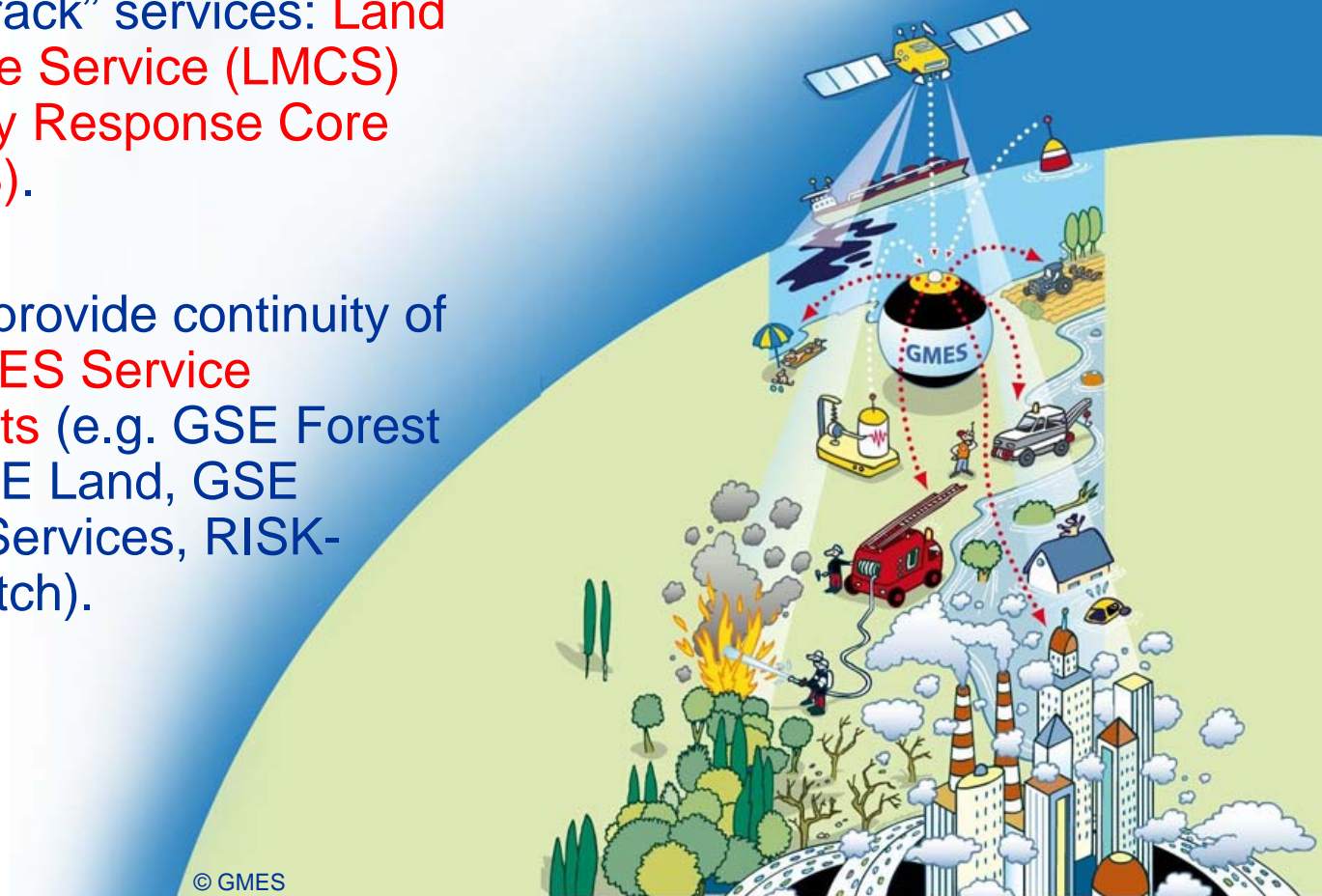
FOS



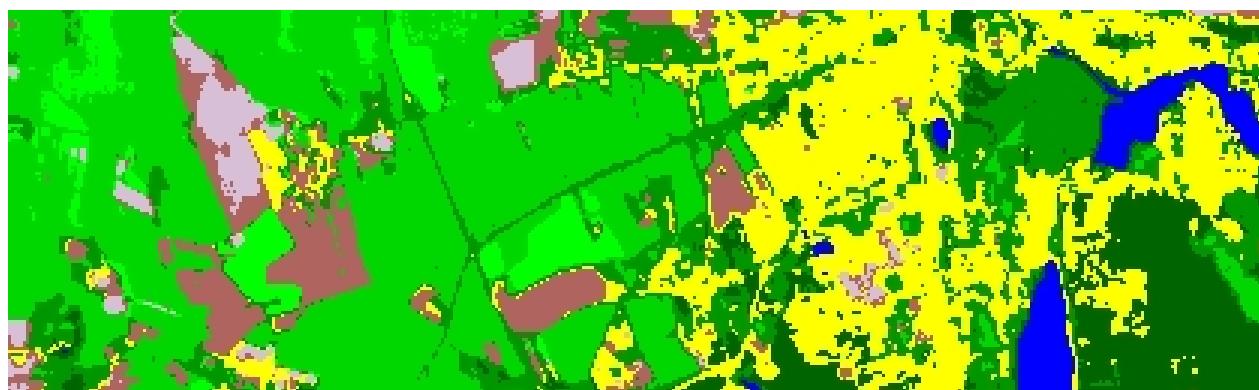
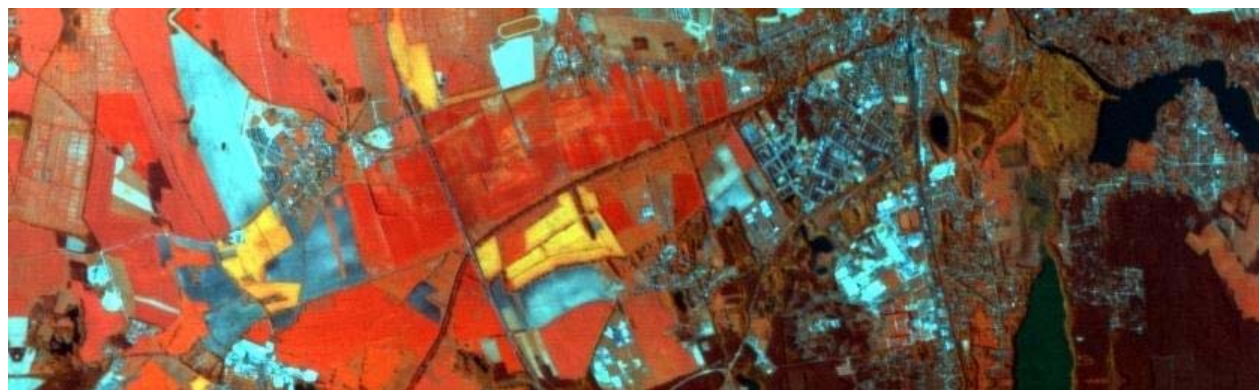
PDGS











- Sentinel-2 will establish a key European source of data for the GMES “Fast Track” services: **Land Monitoring Core Service (LMCS)** and **Emergency Response Core Service (ERCS)**.
- Sentinel-2 will provide continuity of data to the **GMES Service Element projects** (e.g. GSE Forest Monitoring, GSE Land, GSE GMES Urban Services, RISK-EOS, Coastwatch).

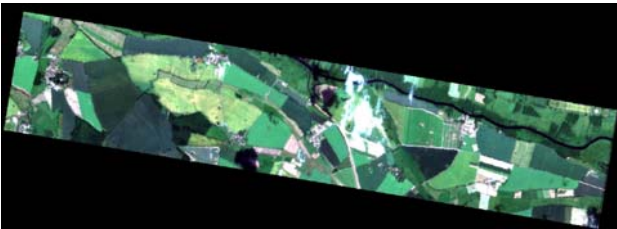


© GMES

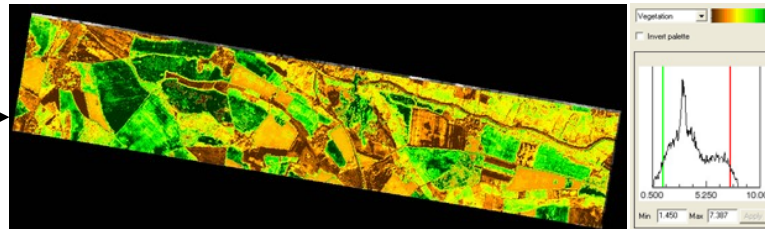


Simulated
Sentinel-2 images
(red/green/blue
bands (above) and
near-infrared
/red/green (below))

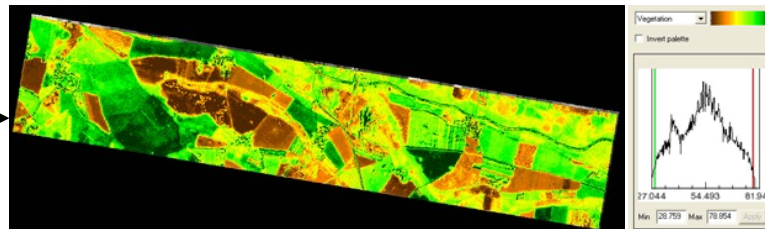
	Urban
	Water
	Forest 1
	Forest 2
	Bare soil1
	Bare soil 2
	Cultivated field 1
	Cultivated field 2



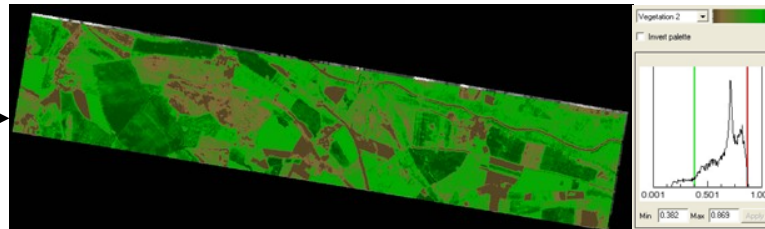
Sentinel-2 simulated Level 1



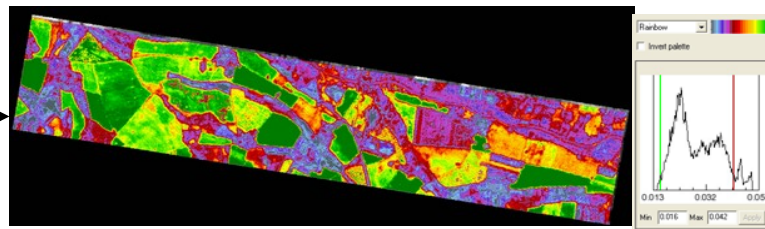
Leaf Area Index



Leaf Chlorophyll Content



Fractional Vegetation Cover



Leaf Water Content

Sentinel-2 simulated Level 2

- Sentinel-2 wide-swath high-resolution multispectral system will provide **enhanced continuity to the SPOT- and Landsat-type** observations - improved revisit time, coverage area, spectral bands, swath width, radiometric and geometric image quality.
- Sentinel-2 will significantly contribute to the **fulfilment of GMES user needs** in terms of delivery of operational land and emergency services.
- In terms of programmatics, following the successful completion of this Phase A/B1 in January 2007, the Invitation to Tender for the **Implementation Phase B2/C/D/E1** was released in February 2007 and proposal received in May 2007.
- The Implementation **Phase B2/C/D/E1** is expected to start in **October 2007** with an industrial consortium led by **Astrium GmbH** (mission prime, platform, system engineering) with **Astrium SAS** as major subcontractor (Payload, system support) and the **launch of the first satellite is foreseen for 2012**.