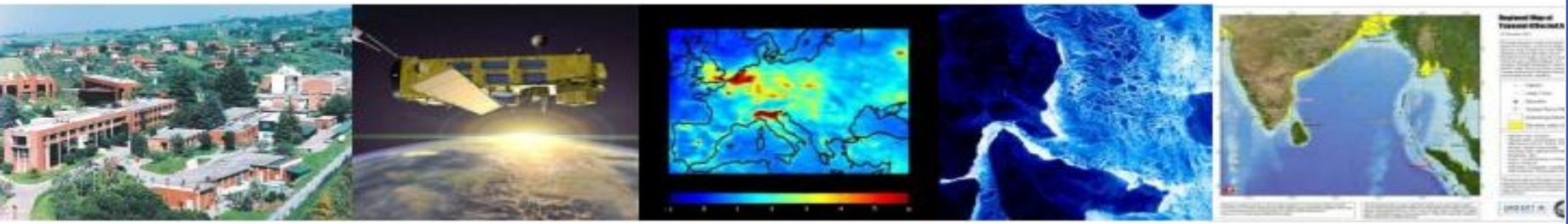


GMES Sentinel-2

The Optical High Resolution Mission for GMES Operational Services

16 July 2007, FAO, Roma

P. Martimort, F.Spoto, B. Koetz and O. Arino and M. Rast

Global Monitoring for the Environment and Security

European independence in critical data sources for environmental monitoring and security

and

the European contribution to the Global Earth Observation System of Systems (GEOSS)

Sentinel-1, Sentinel-2, Sentinel-3

Sentinel-2 Geographical Coverage

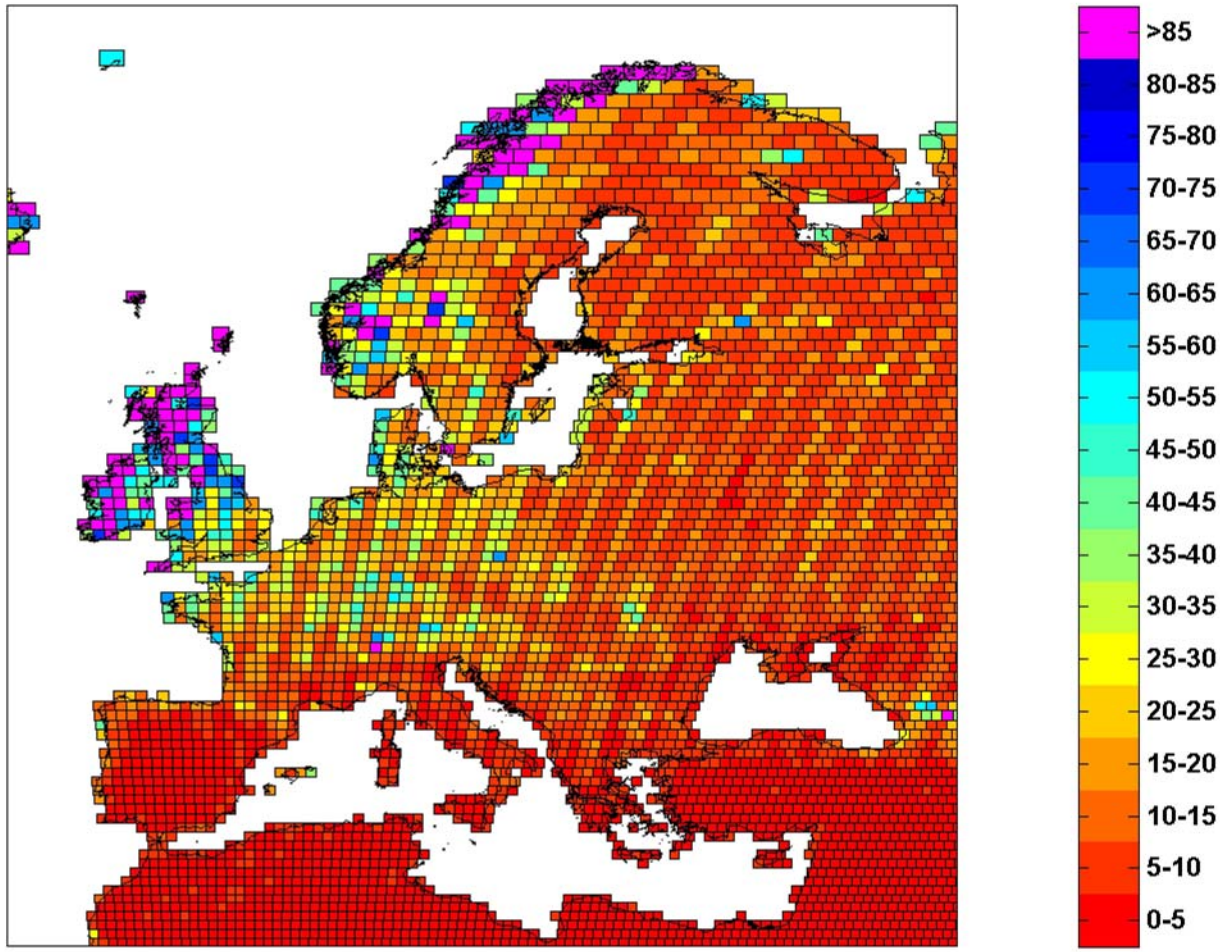
- **Full and systematic coverage of land surface (including major islands) globally from -56° (Southern America) to +83° (Northern Greenland) latitude. To achieve this objective and to provide high mission availability, a constellation of 2 operational satellites is required, allowing to reach a 5 day geometric revisit time. The revisit time with only one operational satellite as it will be the case at the beginning of the deployment of the system is 10 days.**

- **Additionally, the capability to access more rapidly (within 1 to 3 days) some limited geographical areas in emergency mode by performing a roll-tilt manoeuvre of the spacecraft has been included in the design to fulfil emergency services and will be used to observe major disaster (e.g. floods, earthquakes) at their occurrence.**

Sentinel-2 Revisit Time Capability

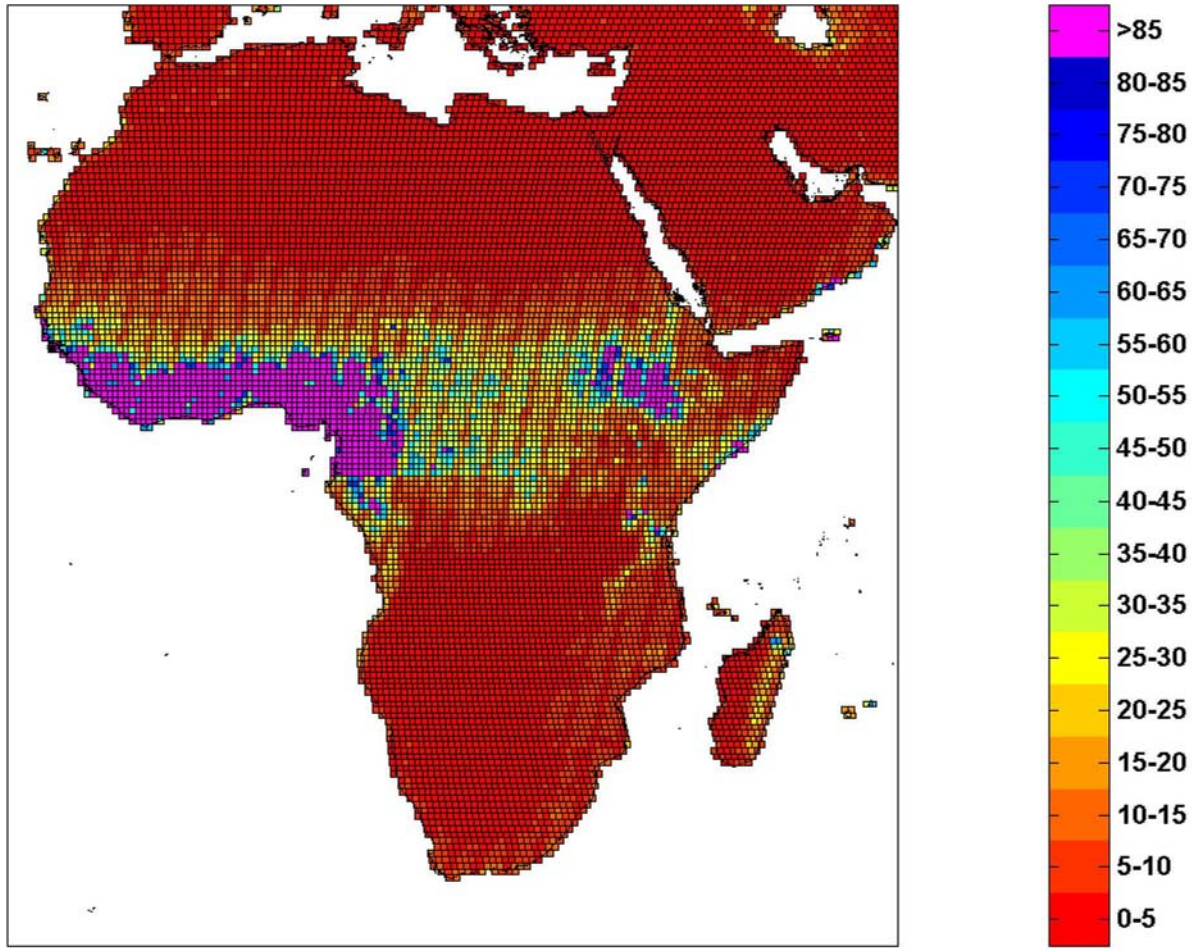
Revisit time over Europe in summer with 2 satellites

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

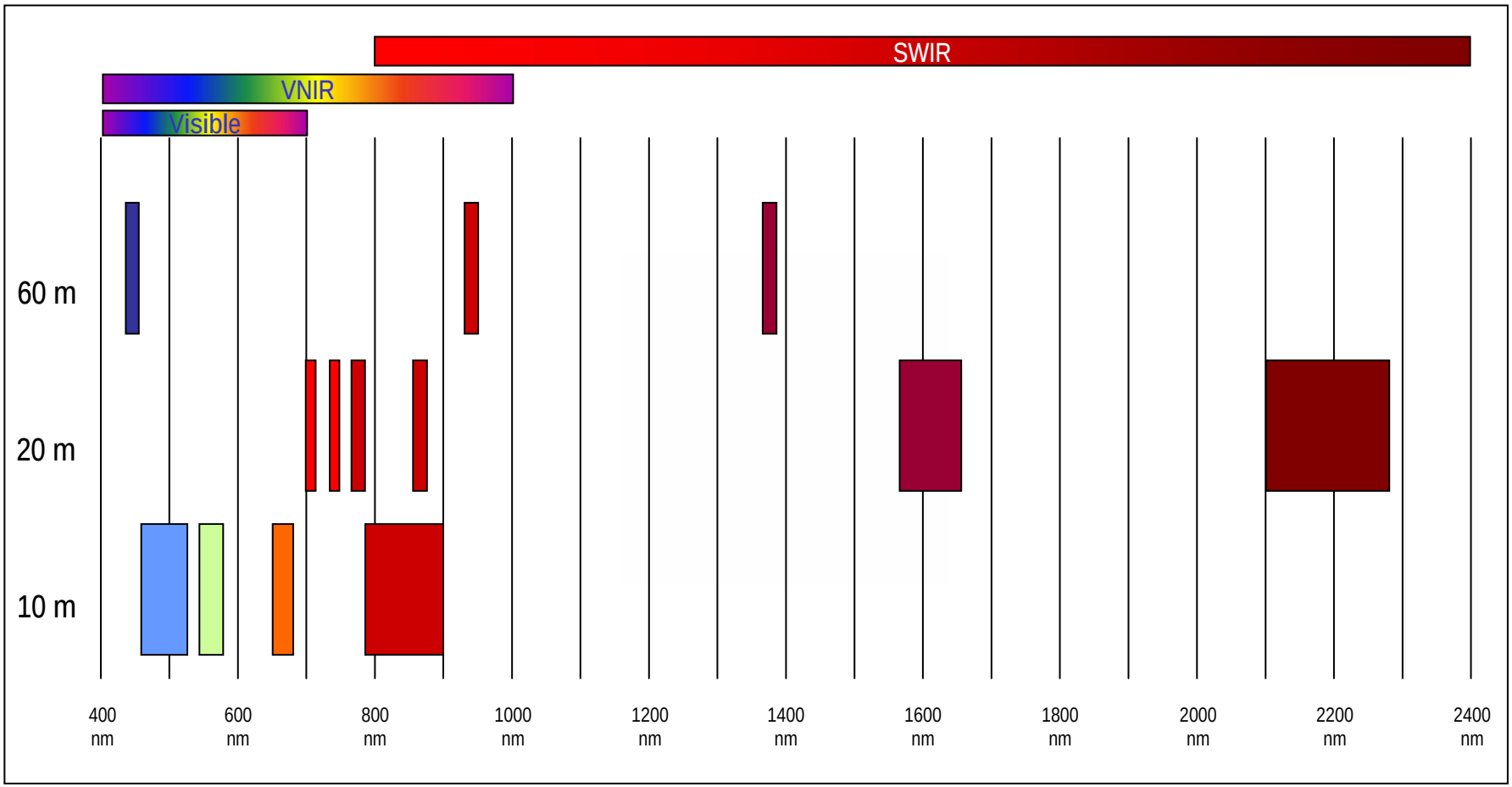


Revisit time over Africa in summer with 2 satellites

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



Sentinel-2 Spectral Bands

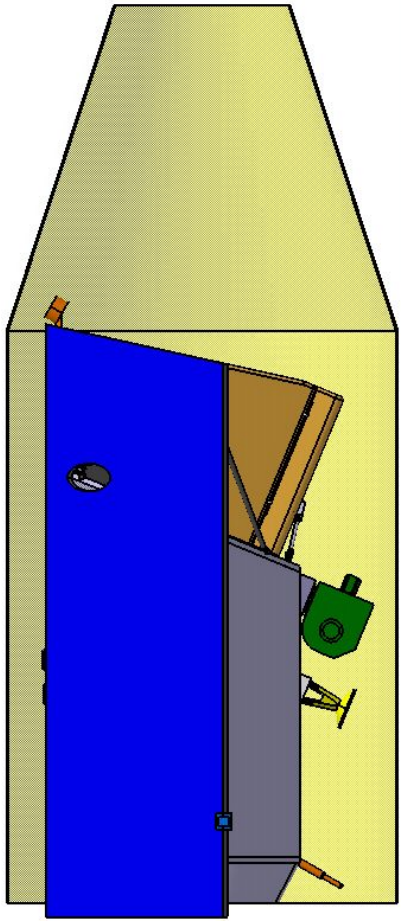


13 spectral bands versus spatial sampling distance

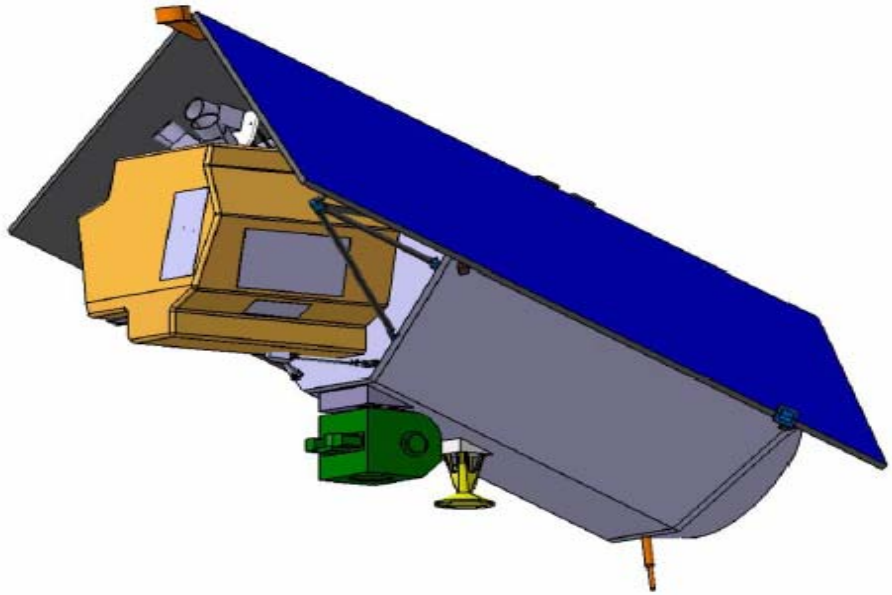
Sentinel-2 Spacecraft Design

- Compact satellite with about 1 ton mass.
- 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, leads to a simple mechanical design.
- 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.

Sentinel-2 Spacecraft View

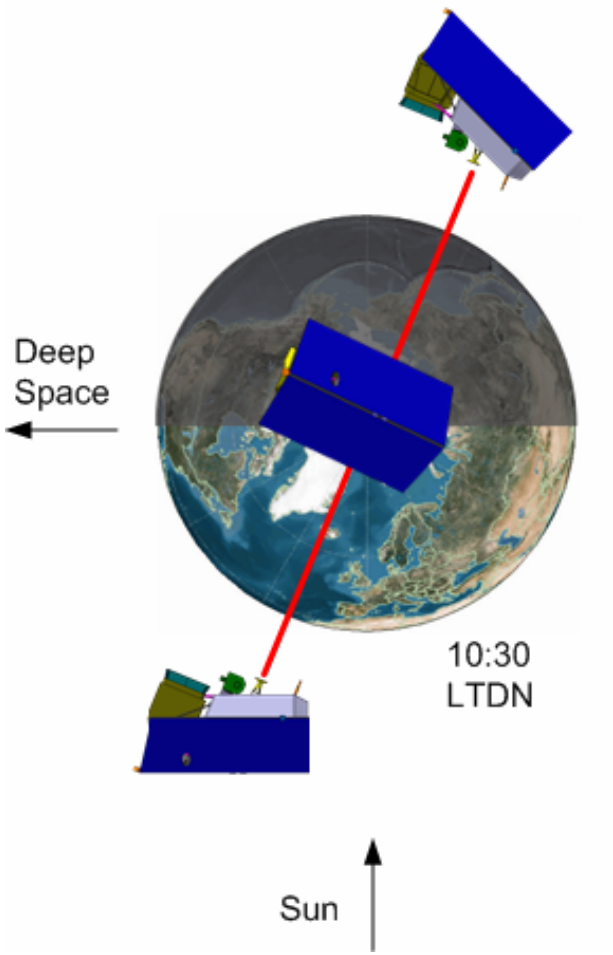


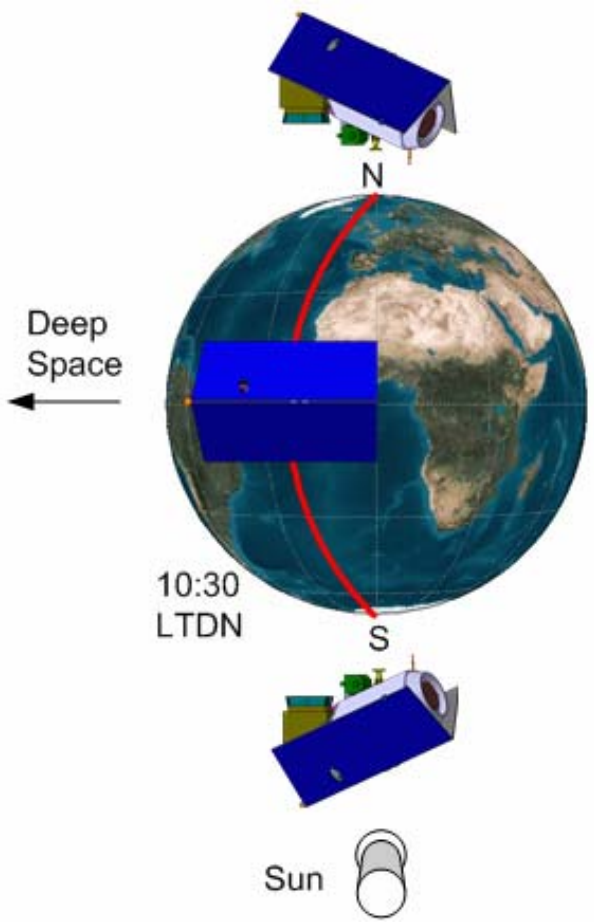
Satellite within VEGA fairing



Satellite in-orbit configuration

Sentinel-2 Satellite in-orbit Configuration



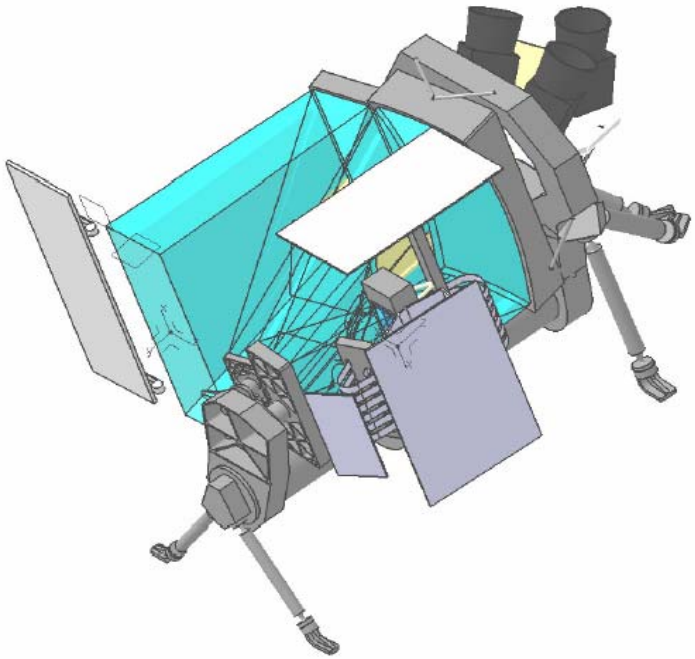


In its orbital configuration, the satellite is tilted by 22.5° with respect to the roll axis in order to maximize the solar energy collected by the solar array.

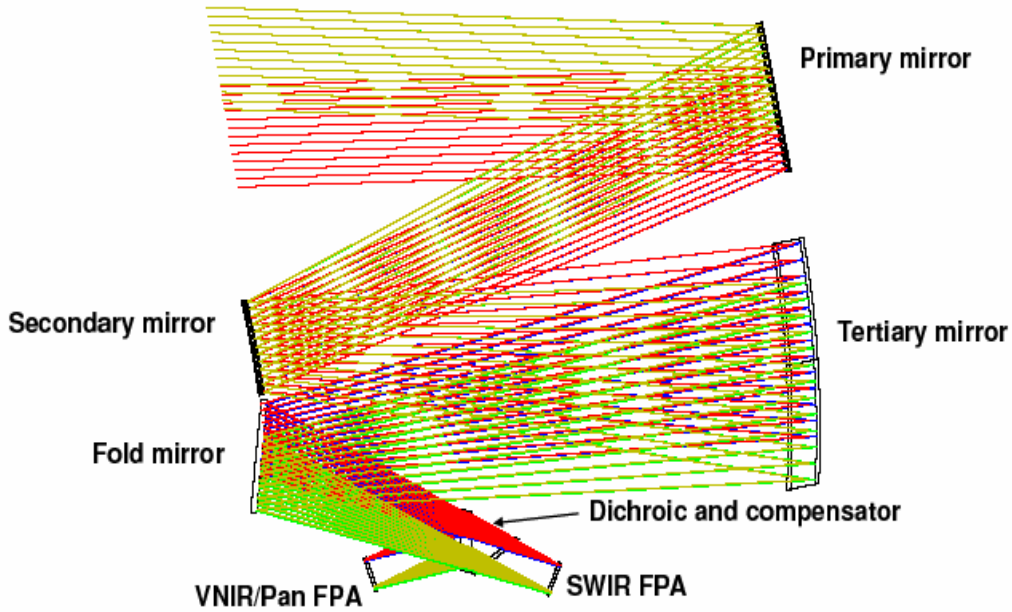
Sentinel-2 Multi-Spectral Instrument Design

- 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.
- A shutter mechanism is implemented to prevent the instrument from direct viewing the sun in orbit and from contamination during launch.
- The average observation time per orbit is about 16 minutes, while the peak value is 31 minutes.

Sentinel-2 Multi-Spectral Instrument View



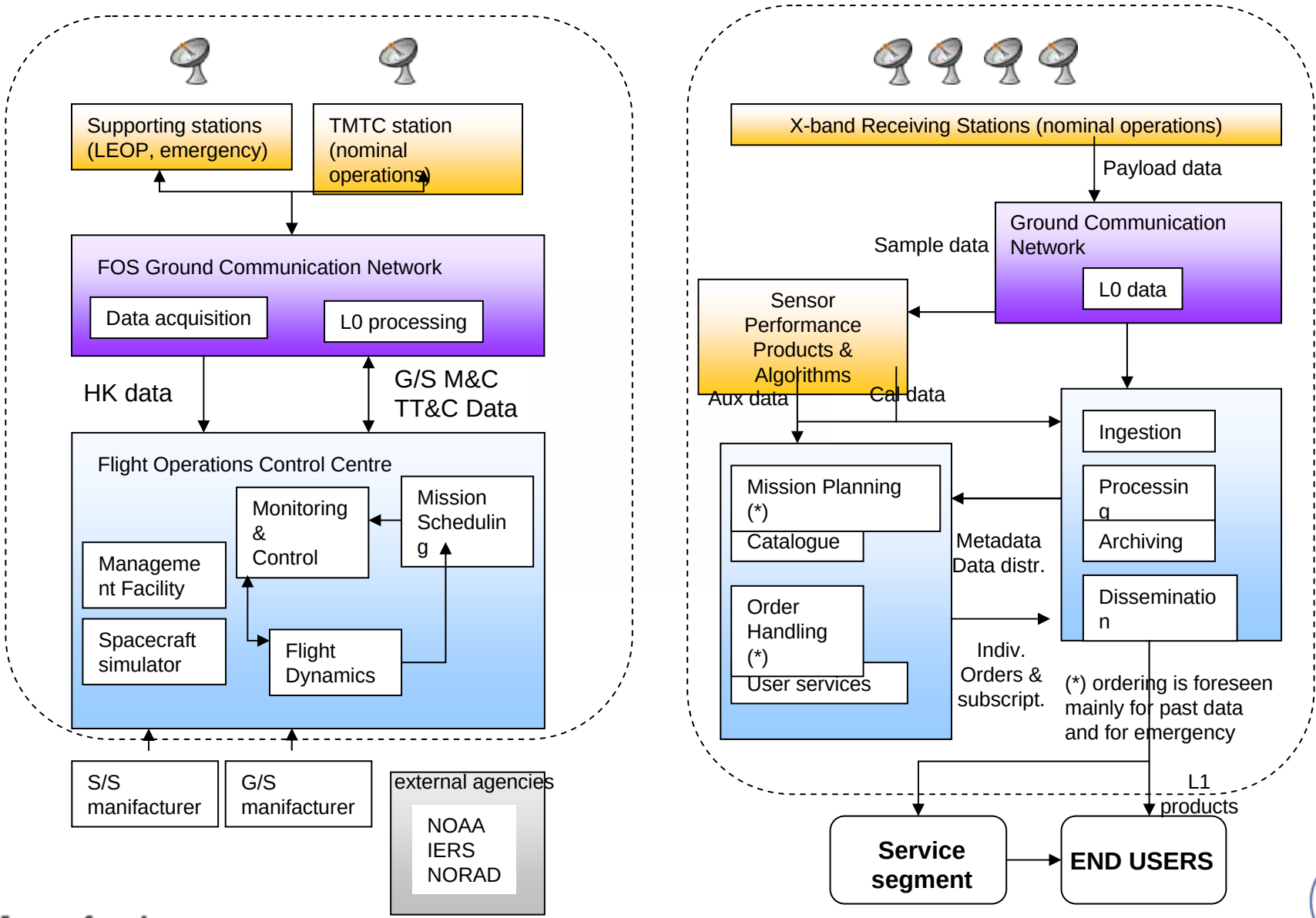
Multi-Spectral Instrument View



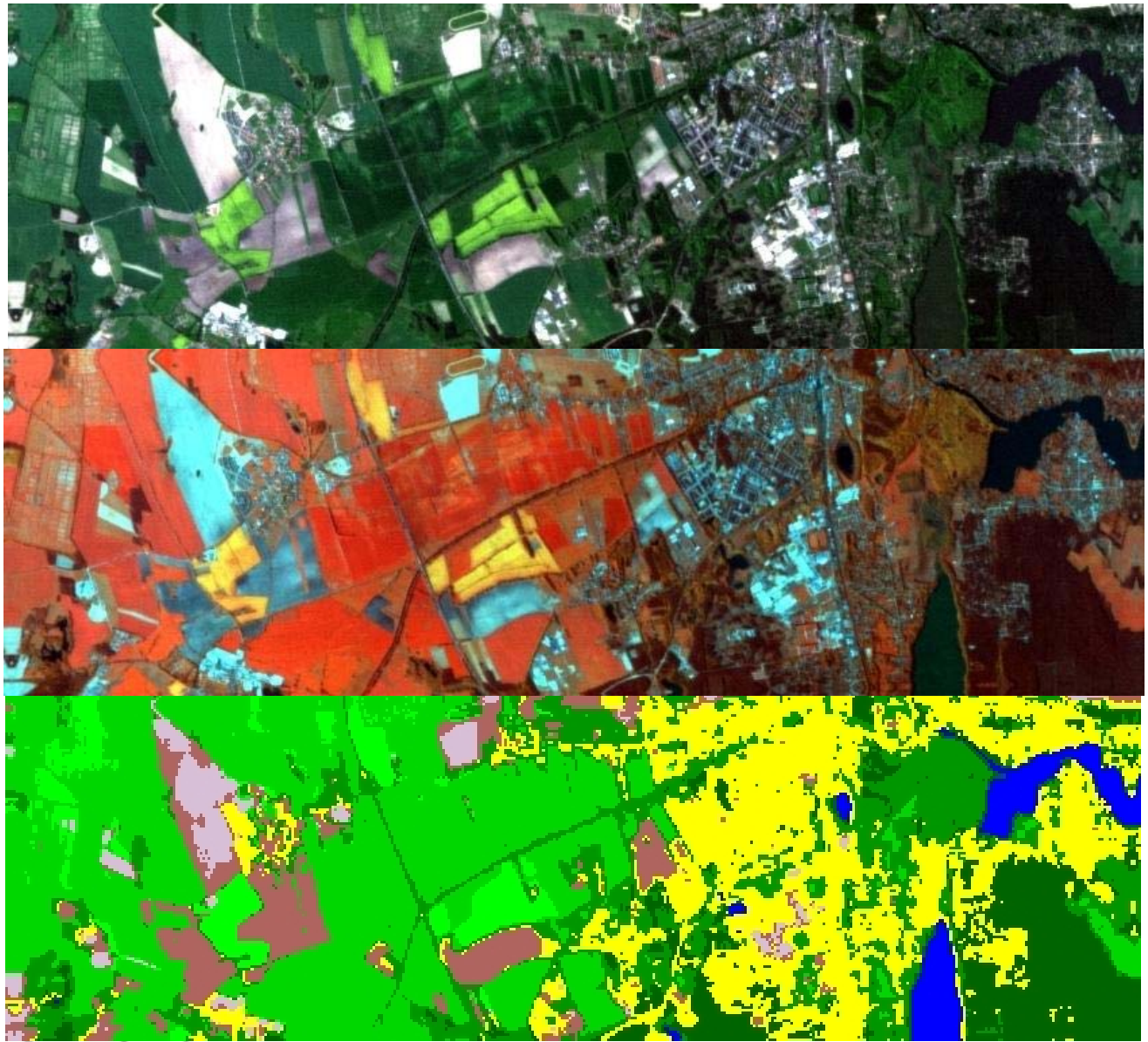
MSI optical design across view

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.

Sentinel-2 Ground Segment



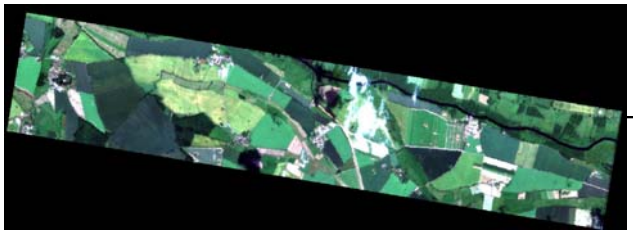
Sentinel-2 land cover/land use products



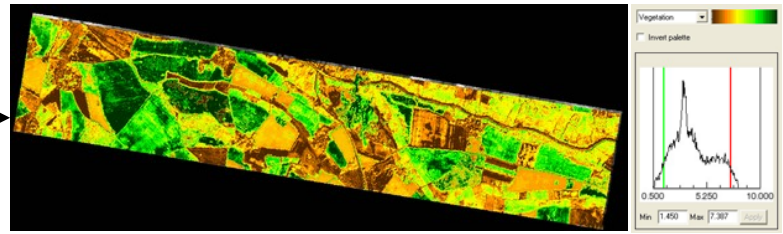
Simulated Sentinel-2 colour composite images using the red/green/blue bands (above) and near-infrared /red/green (below)

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

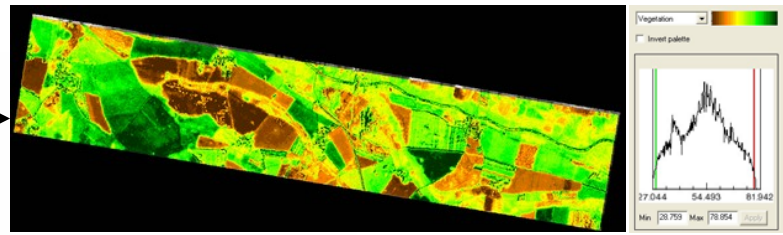
Sentinel-2 geo-biophysical products



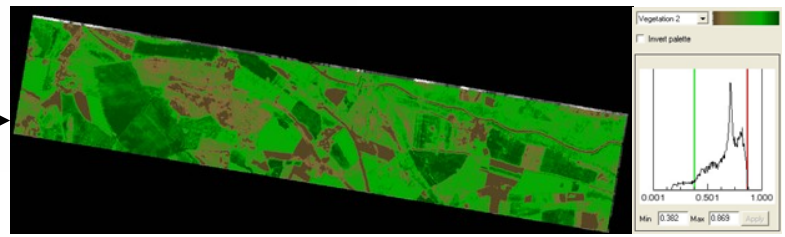
Sentinel-2 simulated Level 1



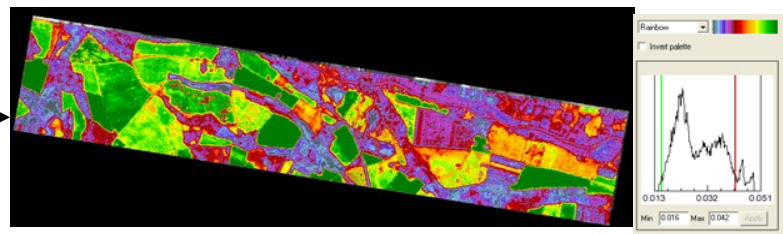
Leaf Area Index



Leaf chlorophyll content

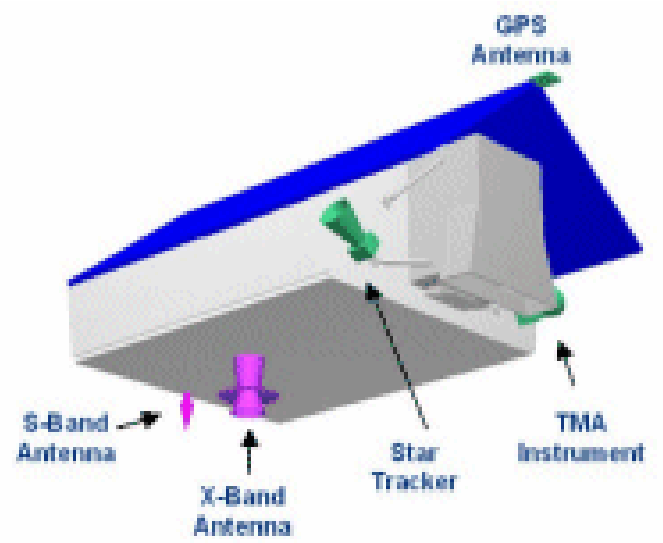


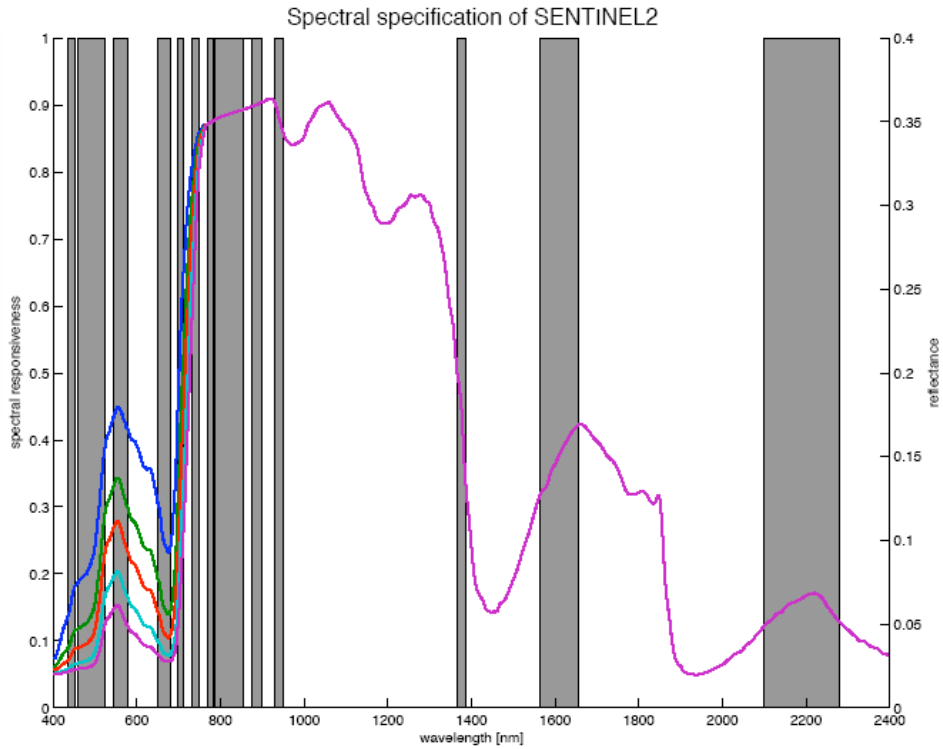
Fractional cover



Leaf water content

Sentinel-2 simulations



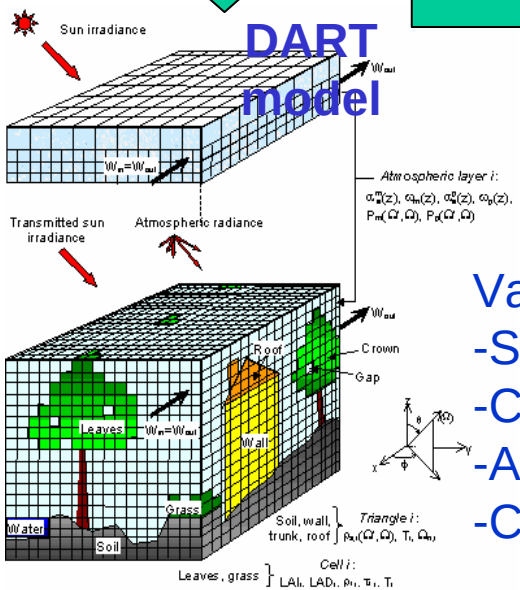


Sentinel-2 simulations objectives

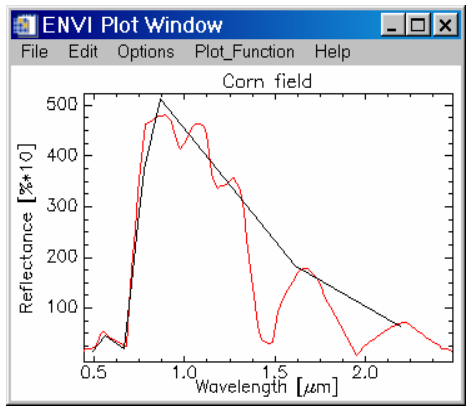
- Evaluation of SENTINEL 2 specifications relevant for level 2 products
  - spectral, geometric, temporal
- Simulation of synthetic scenarios
  - ⇨3D scene reconstruction with the DART model
  - ⇨Changing environmental & atmospheric conditions
  - ⇨Relevant for selected user services
  - ⇨ Validation with real imaging spectrometer data

Sentinel-2 simulations: realistic scene

3D scene parameterization



SENTINEL2 mission simulator



Variable Specifications:
-Sensor specs
-Calib. & instr. Error
-Atmosphere & illumination
-Compression factor

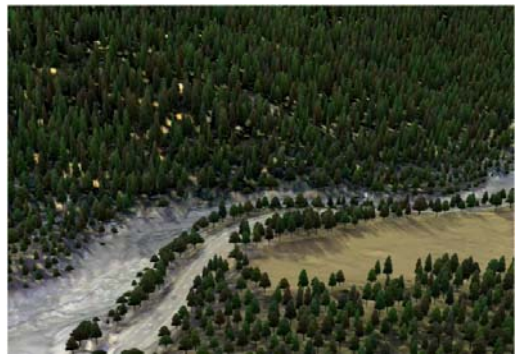
Sentinel-2 simulations: DART scene simulation

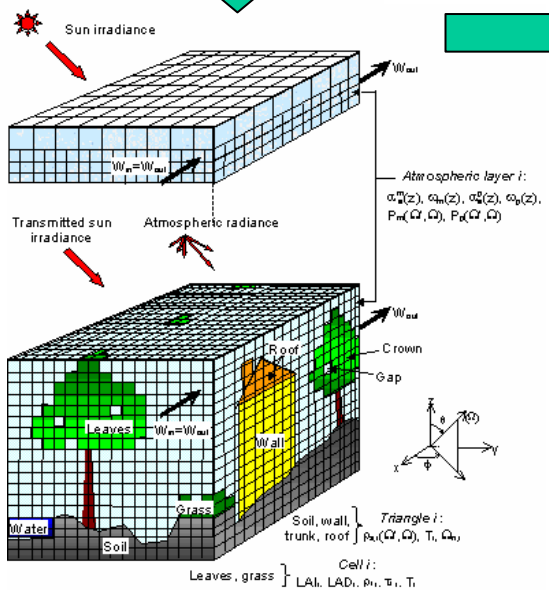
3D landscape:
- -LIDAR
- -Imaging spectrometry

Optical properties:
- -Field spectrometry

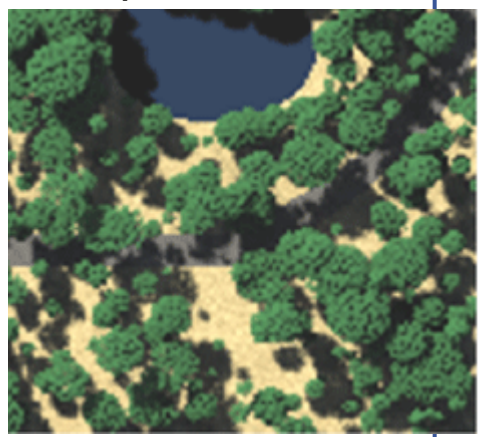
Canopy structure
- -Field measurements

3D scene parameterization





Example: Forest scene



DART model:
-Radiative Transfer Model
-Spatial scene representation
-Natural / urban landscapes

Synthetic scene:
-Top-of-canopy reflectance
-Diff. view angles
-variable atmosphere & illumination

Conclusion

- The Sentinel-2 wide-swath high-resolution multispectral system will provide enhanced continuity to the SPOT- and Landsat-type observations - with improved revisit time, coverage area, spectral bands, swath width, radiometric and geometric image quality.
- In terms of programmatics, ESA has performed the Sentinel-2 Definition Phase A/B1 in 2005 and 2006 with an industrial consortium led by Astrium GmbH. Following the successful completion of this Phase A/B1 in January 2007, the Invitation to Tender for the Implementation Phase 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 and the launch of the first satellite is foreseen for 2012.