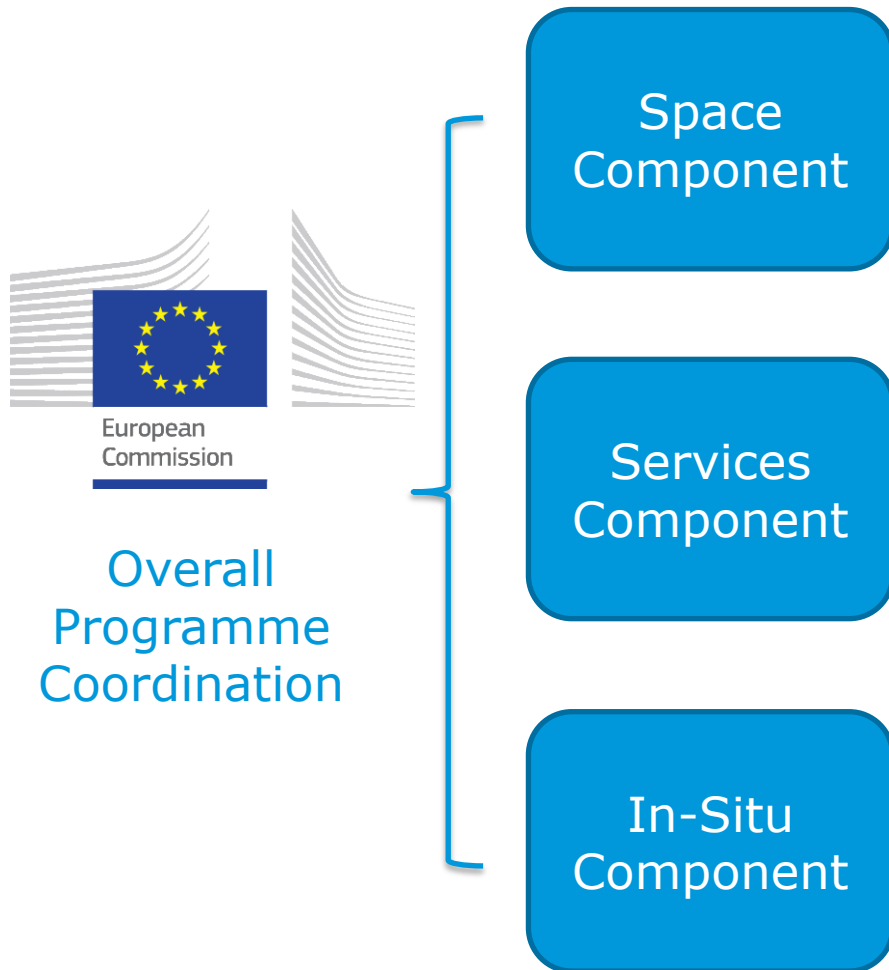# Sentinel-1/-2/-3 Overview and Status

Meeting with Austrian Partners

27 May 2014, Vienna
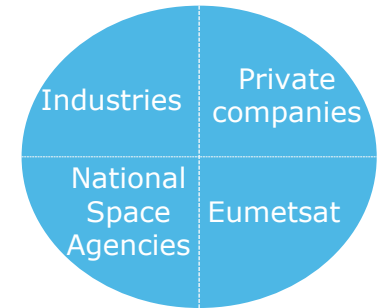
Copernicus Components

Coordinators:

Partners:

Space Component

Services Component

In-Situ Component

Overall Programme Coordination

Industries | Private companies
National Space Agencies | Eumetsat

Service operators

National environmental agencies

European Space Agency

Sentinel Deployment Schedule

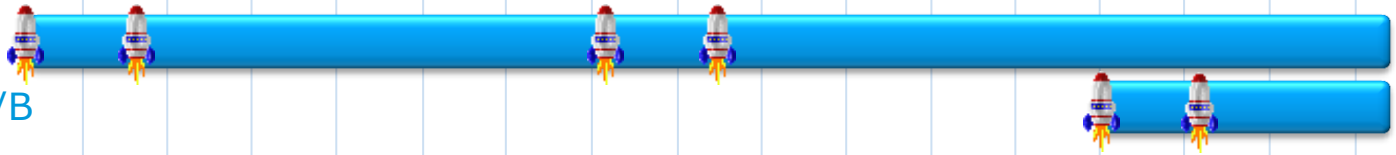**2011**   **2014**   **2020**   **2030**
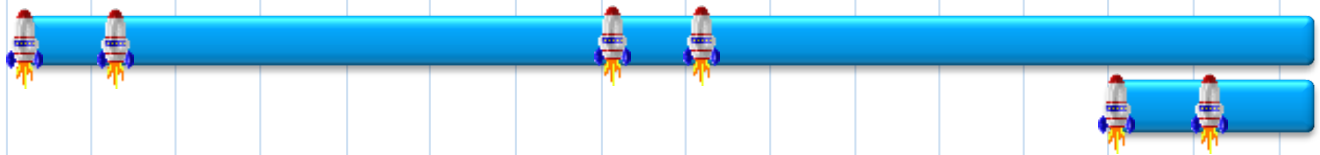
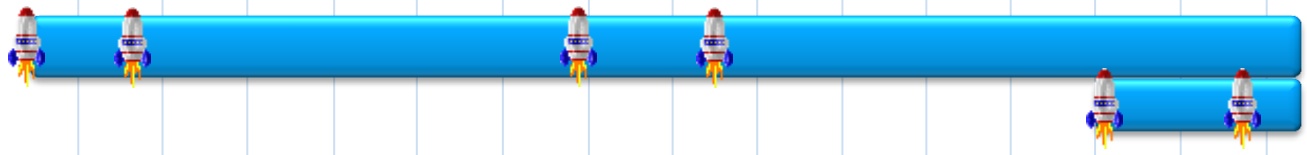Access to Copernicus Contributing Missions data

Sentinel-1 A/B/ C/D

Sentinel-1 SG A/B

Sentinel-2 A/B/C/D

Sentinel-2 SG A/B

Sentinel-3 A/B/C/D

Sentinel-3 SG A/B

Sentinel-4 A/B

Sentinel-5 Precursor

Sentinel-5 A/B/C

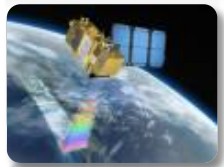Sentinel-6 [Jason-CS] A/B

Sentinel-6 [Jason-CS] Next Generation

European Space Agency

Copernicus Space Component: Dedicated Missions

Sentinel-1 (A/B/C/D) – SAR imaging
All weather, day/night applications, interferometry

Sentinel-2 (A/B/C/D) – Multi-spectral imaging
Land applications: urban, forest, agriculture,…
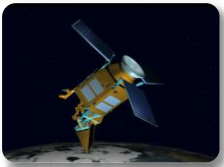Continuity of Landsat, SPOT

Sentinel-3 (A/B/C/D) – Ocean and land monitoring
Wide-swath ocean color, vegetation, sea/land
surface temperature, altimetry

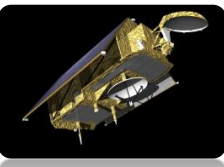**Sentinel-4 (A/B) – Geostationary atmospheric**
Atmospheric composition monitoring, trans-
boundary pollution

Sentinel-5 precursor – Low-orbit atmospheric
Sentinel-5 (A/B/C)   – Low-orbit atmospheric
Atmospheric composition monitoring

**Sentinel-6 - Jason-CS (A/B) – Low inclination Altimetry**
Sea-level, wave height and marine wind speed

Sentinel–1: C-band SAR mission

✓ **Data continuity of ERS and ENVISAT missions**

✓ **Copernicus radar imaging mission for ocean, land, emergency**

✓ **Applications:**

- monitoring sea ice zones and the arctic environment
- surveillance of marine environment (e.g. oil spill monitoring)
- maritime security (e.g. ship detection)
- wind, wave, current monitoring
- monitoring of land surface motion (subsidence, landslide, tectonics, volcanoes, etc.)
- support to emergency / risk management (e.g. flooding, etc.) and humanitarian aid in crisis situations
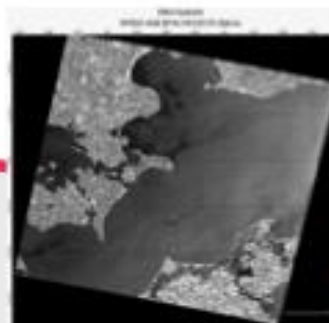- mapping of land surfaces: forest, water and soil, agriculture, etc.
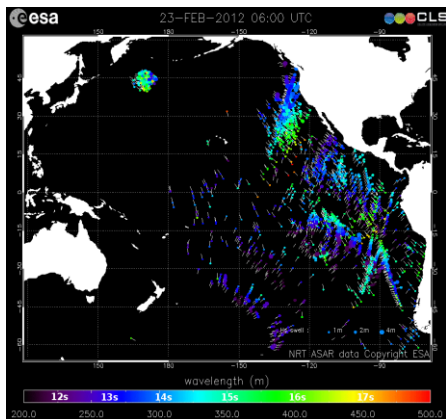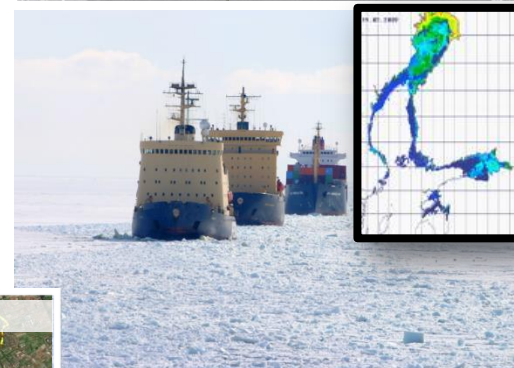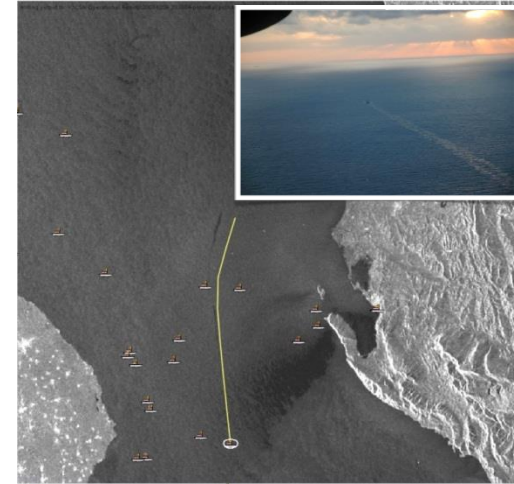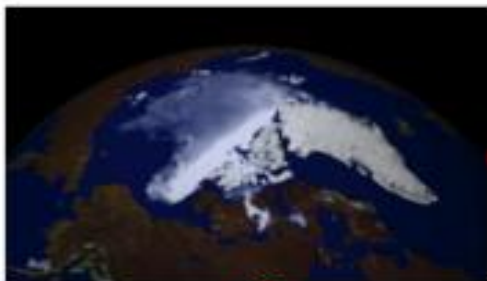
Arctic ice extent
August 2009
(Credit: MyOcean)

Larsen ice shelf loss between
2002 and 2009
(Credit: Polar View)

Oil spill detection
and Surveillance
(Credit: EMSA)

Ship detection
(Credit: ESA)

Acceleration of
Greenland glaciers flow
(Credit: Rignot et Al)

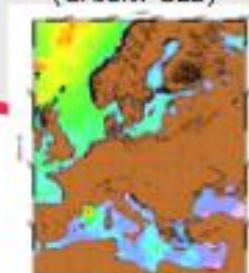**C-band SAR observations to support a wide range of applications**

Land use
(Credit: ESA)

Subsidence map
1992-2006
(Credit: Terrafirma)

Emergency
management: flooding
(Credit: SAFER, DLR)

Mean wind speed
from 2005 to
2009
(Credit: CLS)
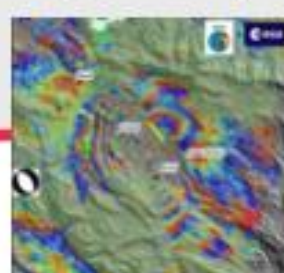
Earthquake
analysis
(Credit: INGV)

Sentinel-1: Mission Profile

- Two satellites

- C-band Radar instrument

- Sun-synchronous orbit at 693 km altitude

- Inclination: 98.18°

- 7 years lifetime

- Consumables for 12 years

- Mean LST: 18:00h at ascending node

- 12-day repeat cycle at Equator (with 1 satellite)

- 96h operative autonomy
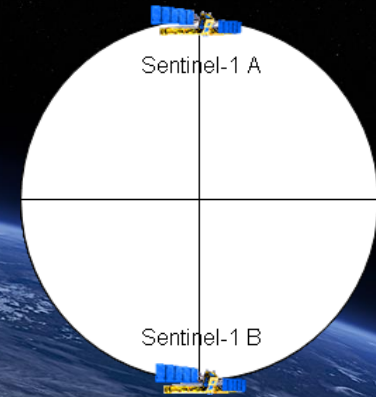
- C-Band SAR instrument operates at centre frequency of 5.405 GHz

- On-board data storage capacity (mass memory) of 1400 Gbit

- Two X-band RF channels for data downlink with 2 X 260 Mbps

- On-board data compression using Flexible Dynamic Block Adaptive Quantization

- Optical Communication Payload for data transfer via laser link with the GEO European Data Relay Satellite (ERDS) system

Deployed Configuration

21 m

12.3 m

Soyuz ST

3.4 m
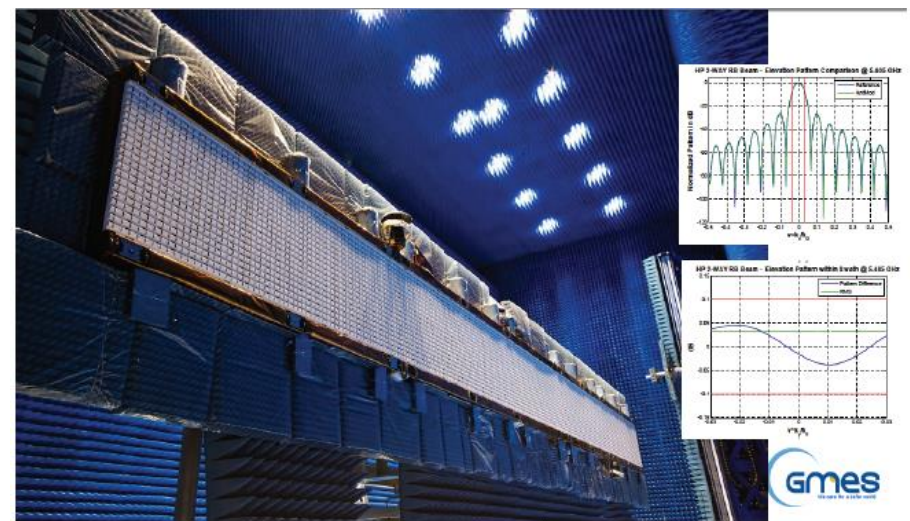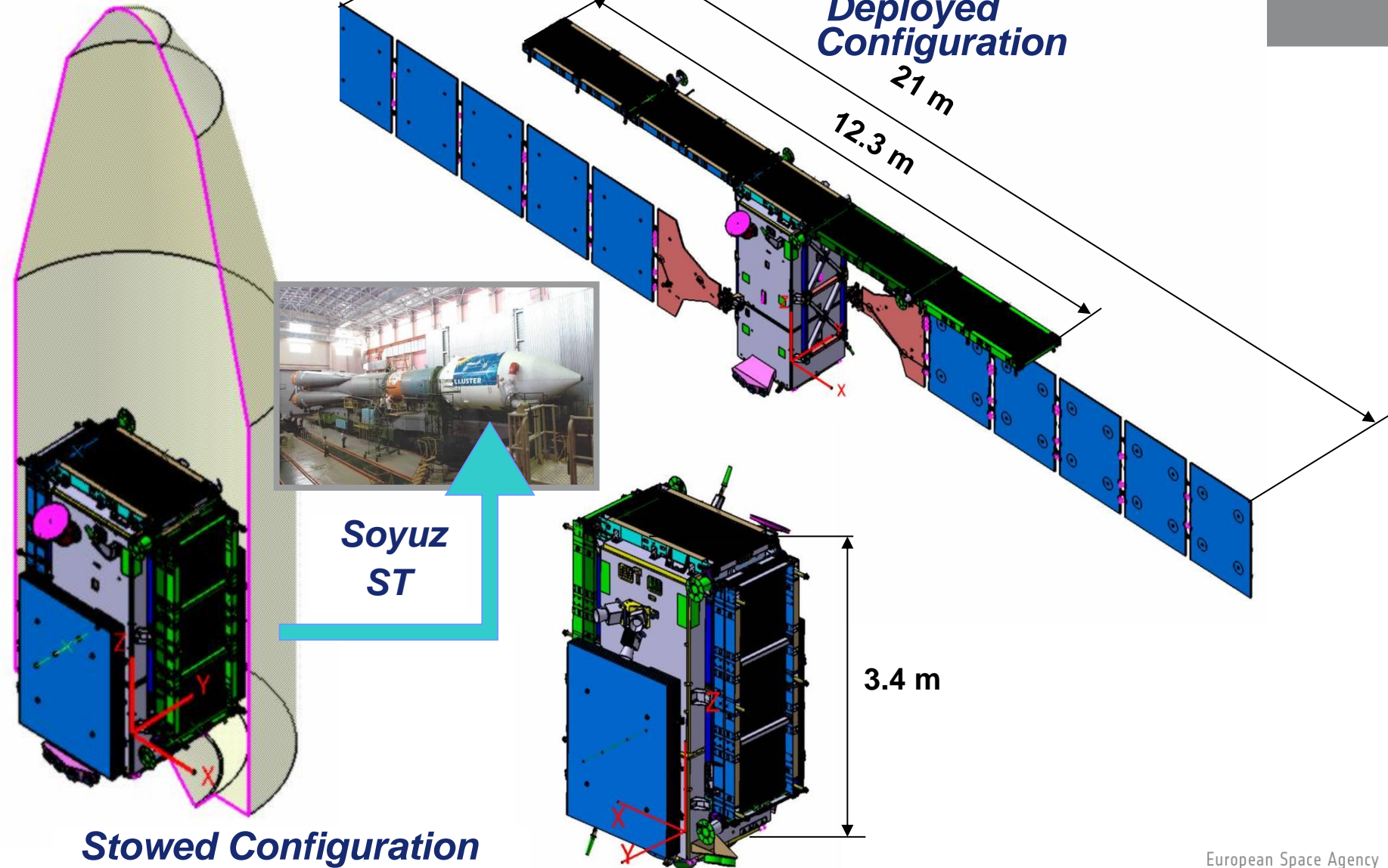
Stowed Configuration

European Space Agency

Sentinel-1 SAR imaging modes

4 mutually exclusive SAR modes with different resolution and coverage
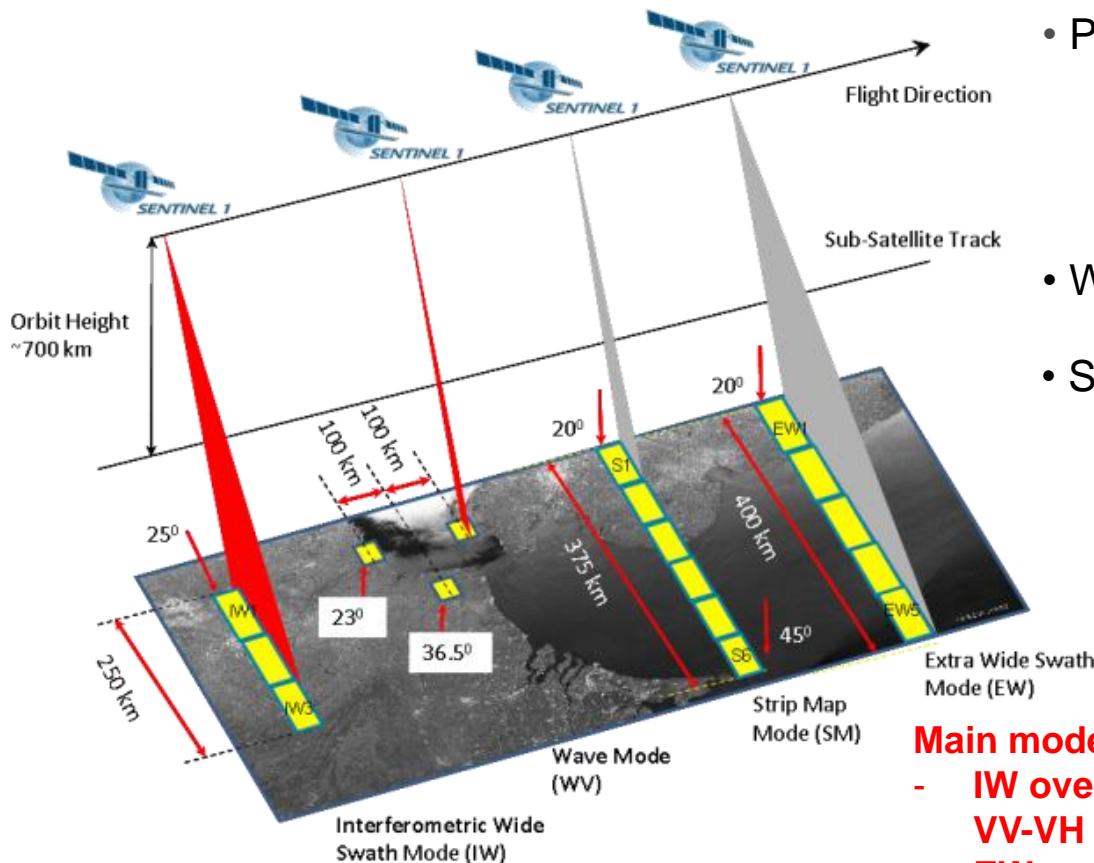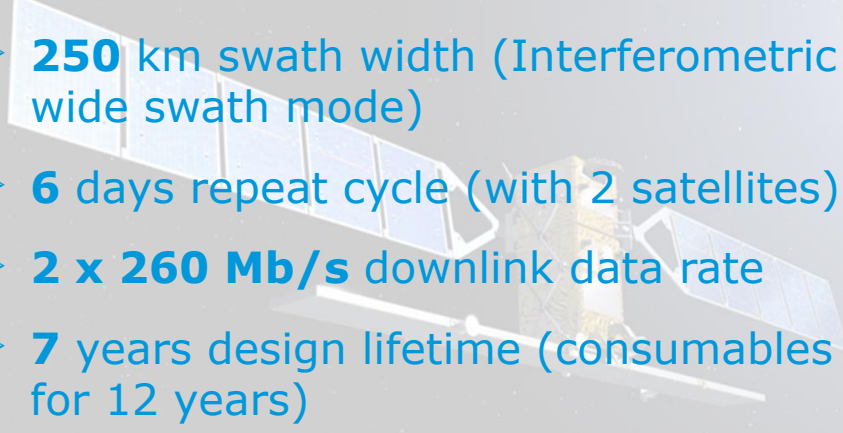
- Polarisation schemes for IW, EW & SM:
  - ✓ single polarisation: HH or VV
  - ✓ dual polarisation: HH+HV or VV+VH

- Wave mode: HH or VV

- SAR duty cycle per orbit:
  - ✓ up to 25 min in any of the imaging modes
  - ✓ up to 74 min in Wave mode
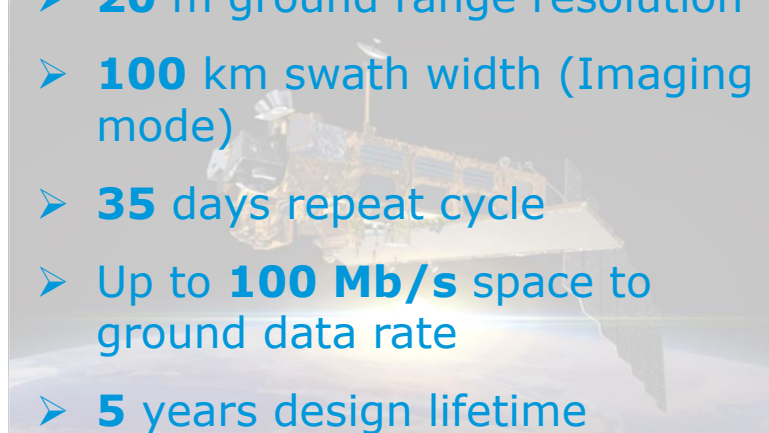
Main modes of operations:
- **IW over land and coastal waters (normally VV or VV-VH polarization)**
- **EW over extended sea (VV or VV-VH) and sea-ice (HH or HH-HV) areas**
- **WV over open oceans**

Sentinel-1 Quantum Leap

Sentinel-1

- **10** m ground range resolution (stripmap mode)

- **250** km swath width (Interferometric wide swath mode)

- **6** days repeat cycle (with 2 satellites)

- **2 x 260 Mb/s** downlink data rate

- **7** years design lifetime (consumables for 12 years)

- Optical link to downlink the data to EDRS.

Envisat ASAR

- **20** m ground range resolution

- **100** km swath width (Imaging mode)

- **35** days repeat cycle

- Up to **100 Mb/s** space to ground data rate

- **5** years design lifetime

Launch Sentinel-1A

esa

- 3 April 2014
- Kourou spaceport
- Soyuz-2 rocket
- New era of Earth observation

Sentinel-1A Satellite Status

- Commissioning Phase on-going

- Not yet in operational orbit

- Lower injection orbit; longer duration of reference orbit acquisition phase

- Calibration for operational data on-going

- Characterisation of propulsion sub-system has been finalised

- Satellite in Nominal Mission Mode

- All sub-systems fully functional /working on prime units

- No major anomalies

- Performance above specifications
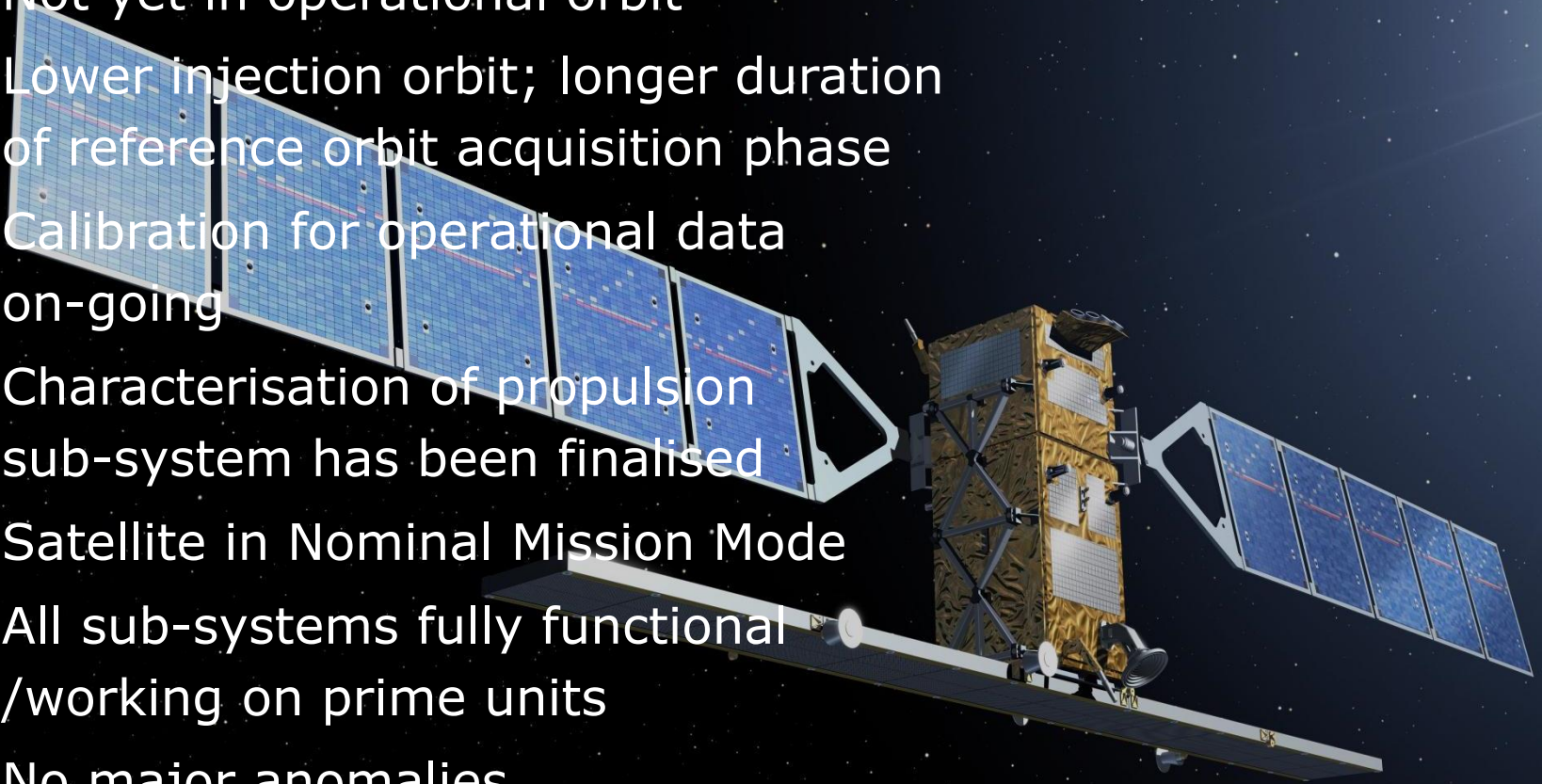
Sentinel-1A GS Status

- Overall PDGS status and performance nominal

- Regular X-band downlink performed via Matera and Svalbard stations since 15 April

- SAR data systematically processed at UK-PAC to Level-1 SLC and GRD products; systematically circulated to German PAC for Long Term Archiving
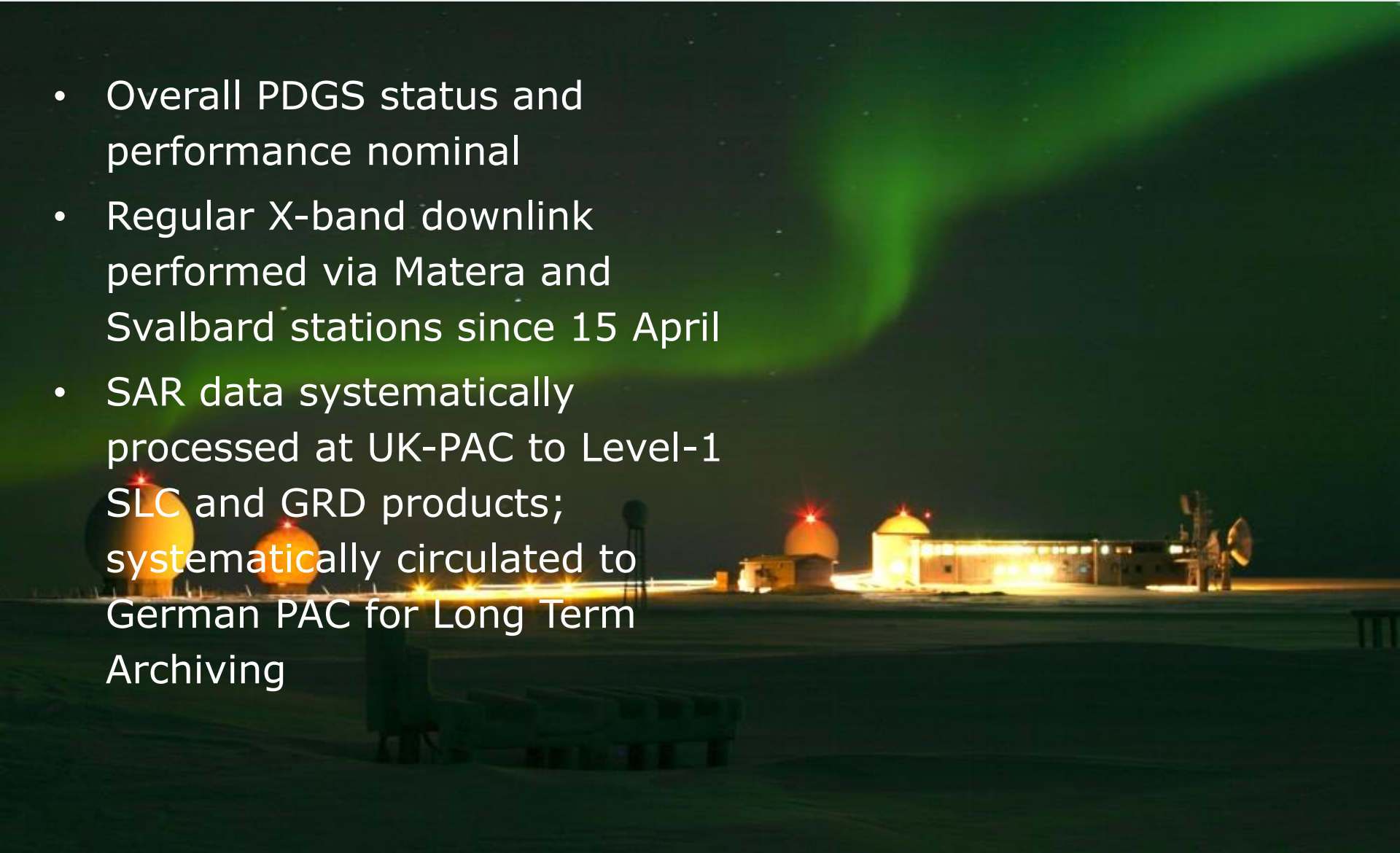
Sentinel-1A Data Access Status

- In routine phase, Sentinel-1A will generate approximately 1.8 Terabytes of products a day

- Users have free and open access to Copernicus dedicated Sentinel products and Copernicus service information

- Initial samples of Sentinel-1A not-yet-qualified products are available to all users since 9 May

- Users can self register online at

    https://senthub.esa.int

- 916 users have self-registered. (This is in addition to the Copernicus core users already registered on CSCDA)

- Since the opening on 9 May, 684 products have been downloaded, corresponding to a volume of 1.4 TB

https://sentinel.esa.int/web/sentinel/missions/sentinel-1/mission-status

Mission Status Report 1

Reference Period: 3 April - 7 April 2014

Mission Status

- Sentinel-1A was successfully launched from Kourou on 3 April 2014, 21:02 UTC
- The Launch and Early Orbit Phase (LEOP) was successfully performed according to the planned timeline and declared closed on 6 April at 16:00 UTC
- The Commissioning Phase has started

Satellite

The LEOP covered the main following key activities:
- Deployments of the solar panels (including. rotation) and of the Synthetic Aperture Radar (SAR) antenna
- Achievement of Satellite Nominal Mode and AOCS Nominal Pointing Mode
- Switch ON and initial checks of the spacecraft sub-systems
- First operations of the X-Band Transmitter and the SAR instrument (3 min of Wave mode)

In addition, a collision avoidance manoeuvre was performed on 5 April

Ground Segment

- The Flight Operations Segment performed nominal during the complete 3 days of LEOP
- First X-band data acquisition took place at the Matera ground station on 6 April, early morning
- First SAR instrument data acquisition was performed on 6 April. The related measurement was successfully processed at UK-PAC
- The FOS and the PDGS were declared ready to support the commissioning phase

Outlook

- Start of platform and payload commissioning activities
- First SAR acquisitions driven by the operational PDGS mission planning system are planned to start on 9 April, as part of the initial verification and calibration activities
- Start of orbit manoeuvre sequence to acquire the target reference orbit.

Report prepared by the ESA Sentinel-1 Team -

Mission Status Report 4

Reference Period: 23 April - 30 April 2014

Mission Status

- The satellite Commissioning Phase is on-going
- The orbit acquisition strategy to reach the reference orbit is under finalisation. The first orbital manoeuvres to raise the orbit altitude started on 29 April

Satellite and Ground Segment

- The Commissioning Phase activities are on-going, with the modifications associated to the lower injection orbit (-7.8 km) and to the consequent longer duration of the reference orbit acquisition phase
- The characterisation of the propulsion sub-system has continued based on the execution of both in-plane and out-of-plane calibration manoeuvres
- The satellite is in Nominal Mission Mode (NMM), with all sub-systems working on prime units, and with the Attitude and Orbit Control System (AOCS) in the operational Nominal Pointing Mode (attitude steering enabled, except during orbital manoeuvres)
- An unavailability of the SAR occurred on 26 April. SAR operations were resumed on 29 April
- The SAR payload is planned through the PDGS mission planning system. Frequent updates of the plans are performed based on the evolution of orbital parameters due to the orbit manoeuvres
- The overall FOS and PDGS status and performance are nominal

Outlook

- Continuation of the satellite commissioning activities
- Continuation of the orbital manoeuvres to reach the reference orbit
- A press event on the 'Sentinel-1A first images with demonstration of applications' is planned on 8 May 2014 in Brussels

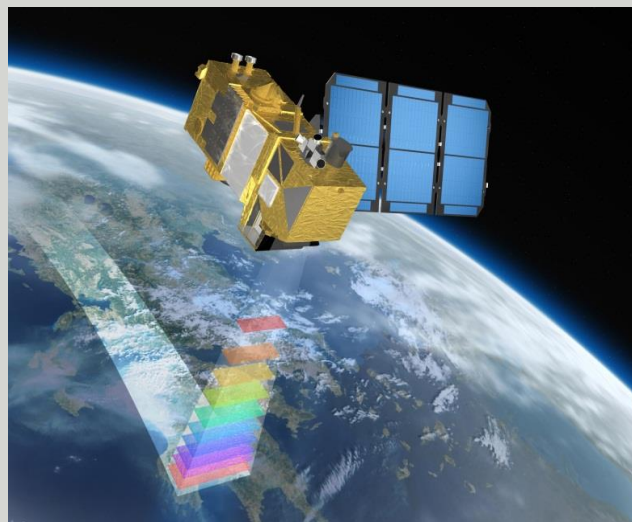*Report prepared by the ESA Sentinel-1 Team -*

✓ **Applications:**

- Land cover, vegetation
- Agriculture
- Forestry
- Inland waters/coastal zones
- Risk mapping
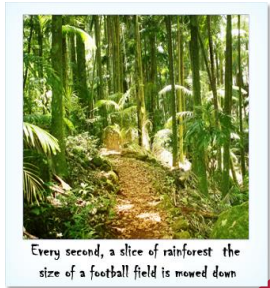
Etc.

✓ **13 spectral bands (VIS, NIR & SWIR)**

✓ **Spatial resolution: 10, 20 and 60 m and 290 km swath**

✓ **5 days repeat cycle at Equator with 2 satellites**

  (10 days with 1)

✓ **Sun synchronous orbit at 786 km mean altitude**

✓ **7 years design life time, consumables for 12 years**

European Space Agency

Forests & Carbon, Vegetation monitoring/change (Credit: GEO-FCT/Tropforest project)

European, African coverages for land cover classification/CORINE IMAGE2006, IMAGE2009 etc. (Credit: Euromap, DMCii-Deimos, USGS)
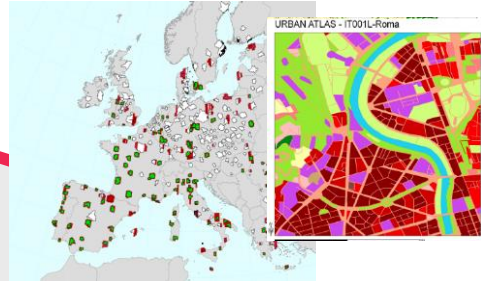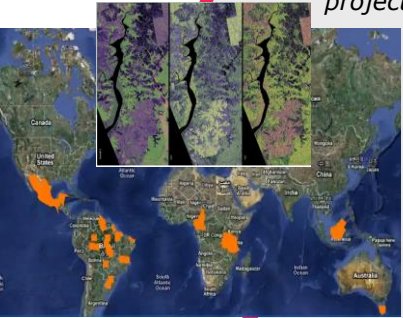
Repetitive coverages/change detection: Urban Atlas (Credit: EUSI, SIRS)

URBAN ATLAS - IT001L-Roma

Global Land cover Land use (Credit: GLOBCover ESA)

Optical observations with 13 spectral bands at 10-60m resolution
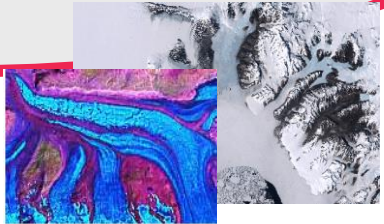
Support a wide range of applications
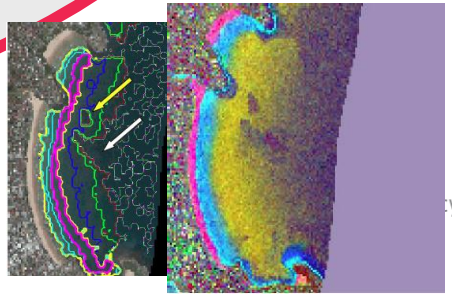
Emergency management: flooding (Credit: SAFER, DLR)

Geology (Credit: USGS)

Coastal zones/bathymetry (Credit: R. Merton et al.)

*Glaciers and ice (Credit: LIMA Project)*

ESA UN

Sentinel-2 swath

SPOT4 60 x 60 km x 2
IRS P6 LISS III 141x141 km
Landsat ETM+ 180 x 172 km
Sentinel-2 290 x 290 km

290Km
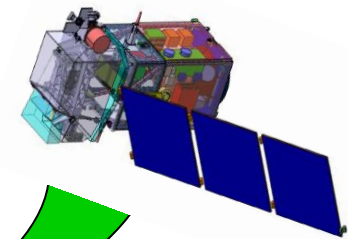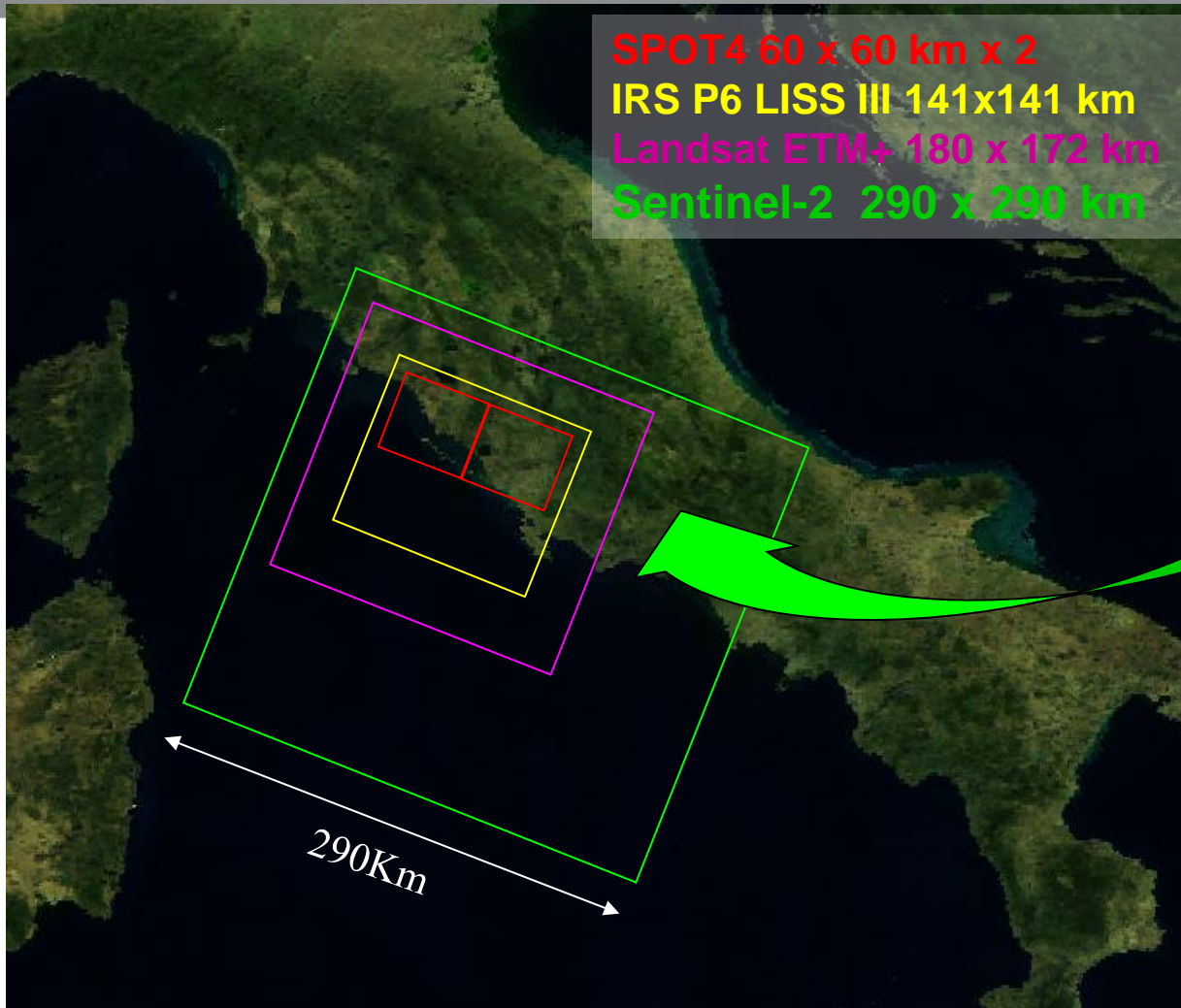
High revisit time → assured by twin satellite observations performed over a very large swath

European Space Agency

Sentinel-2 Observation scenario

- Baseline in full operations is systematic acquisition of:

  - ✓ All land surfaces (-56° and +84° latitude);

  - ✓ Major (greater than 100 km^2 size) and EU islands;

  - ✓ Coastal (20km off the coast)

  - ✓ inland waters, Mediterranean Sea and all closed seas;

  - ✓ Cal/Val sites.

- Like for Sentinel-1, a gradual ramp-up will be defined for Sentinel-2, increasing/improving gradually the service to users in a stepwise approach
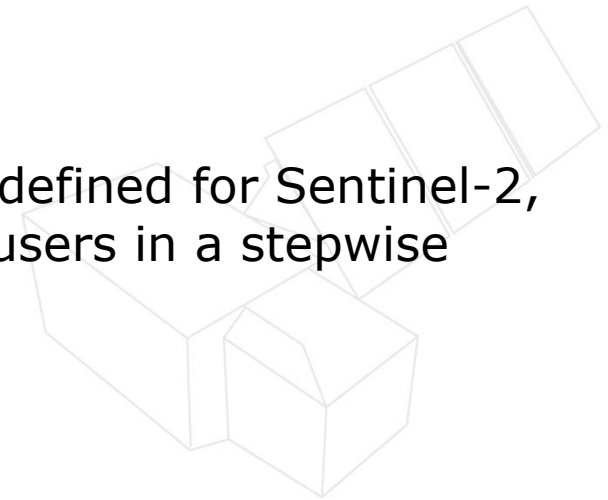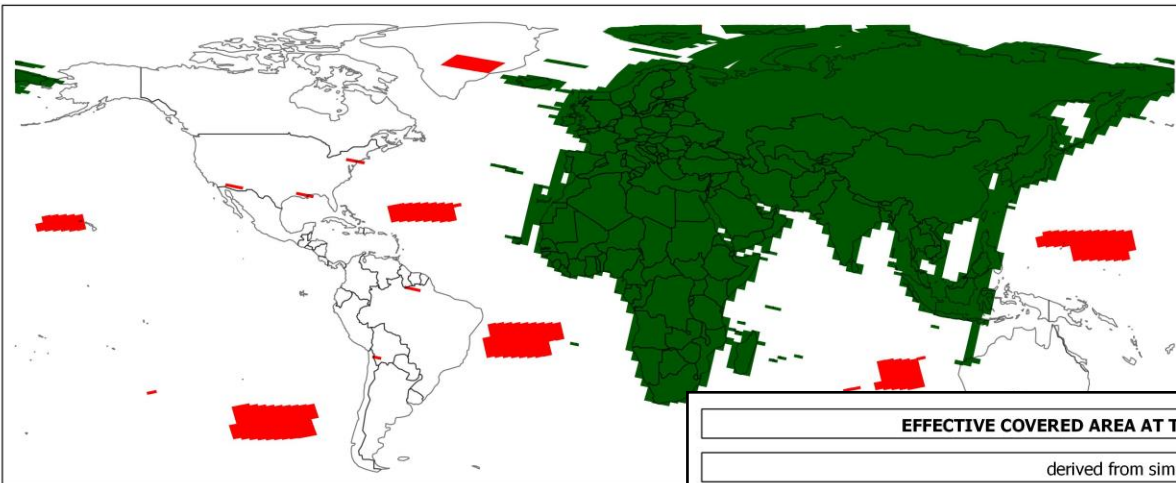
There will be gradual ramp-up until the Full Operational scenario is reached

EFFECTIVE COVERED AREA AT THE BEGINNING OF RAMP UP PHASE 1

derived from simulated swath - cleared for lead in/out datatakes

Start of ramp-up phase

- Assuming availability of 2 downlink stations out of 4
- Ensuring coverage of global Cal/Val needs
- Ensuring COPERNICUS CORE datasets needs for Europe/Africa systematically
- Ensuring maximum coverage/orbit length for GRI generation

EFFECTIVE COVERED AREA AT THE END OF THE RAMP UP PHASE (FULL OPERATIONALITY)

derived from simulated swath - cleared for lead in/out datatakes
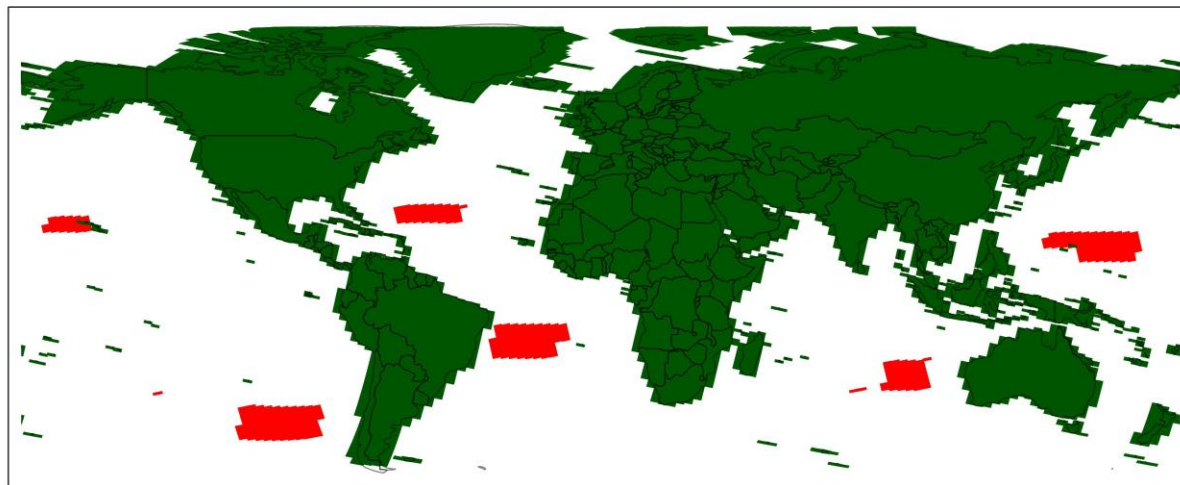
End of ramp-up

Legend

Acquisition Area

- Regular
- Calibration Purposes (outside the regular acquisition area)

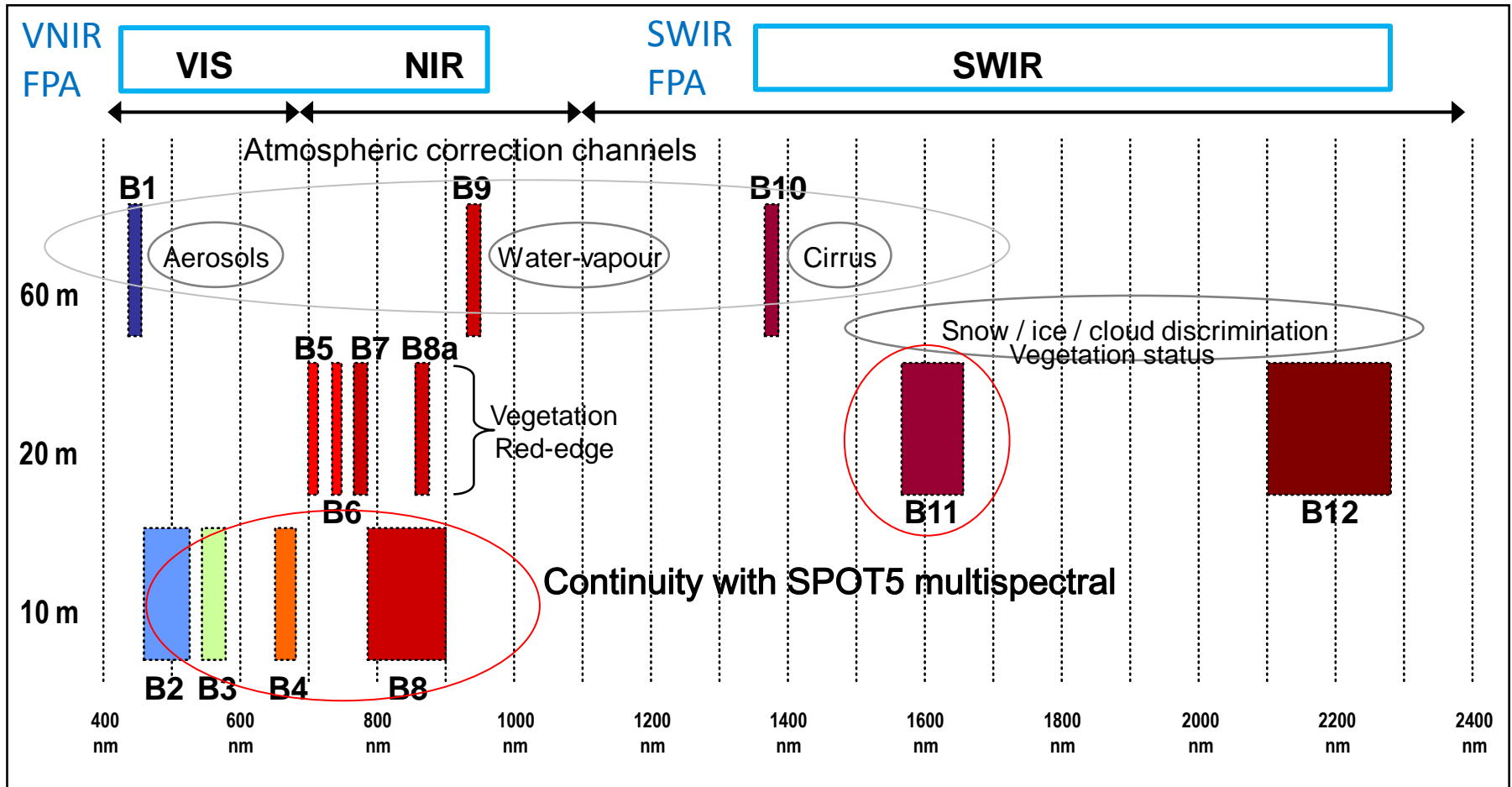# Evolutions of/changes to the Sentinel-2 Observation Plan

Additional observation requirements have been received from Copernicus Services, Member States (collaborative GS), the science community, workshops etc…….e.g.:

- ✓ Coverage of oceans
- ✓ Coverage of coral reefs on global scale
- ✓ Night-time observations
- ✓ Antarctica coverage
- ✓ Coverage of coastal waters (beyond the MRD coast region coverage)

…such requirements are taken onboard for mission planning simulations. ***Their inclusion will follow the process between European Commission and ESA to handle the evolution of the Copernicus Space Component.***

Sentinel-2 Bands and Resolutions

ESA UNCLASSIFIED – For Official Use

European Space Agency
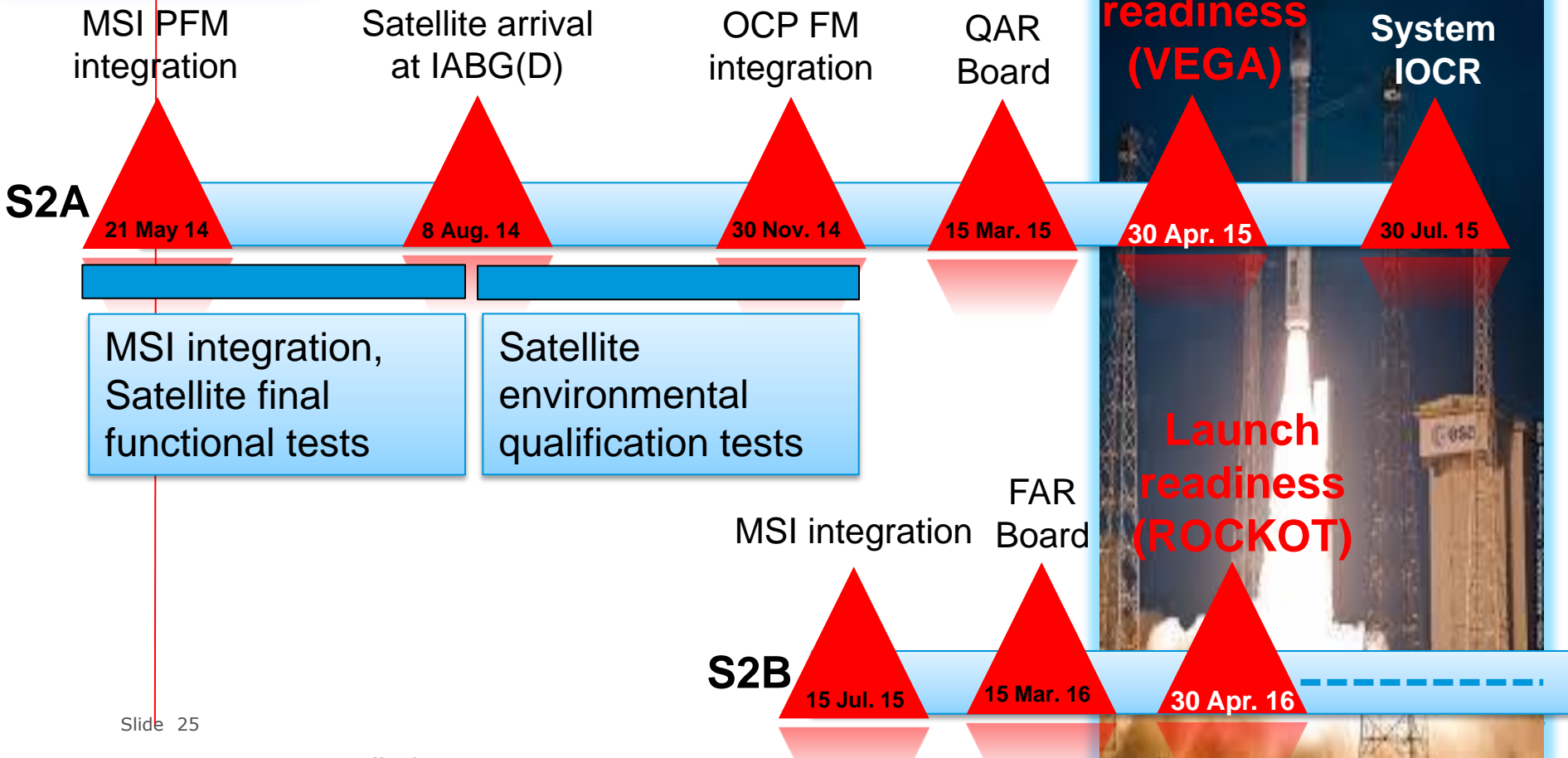
Issues solved & Latest achievements

Some problems:

- Contamination of the SWIR FPA by droplets requiring long & tedious cleaning.

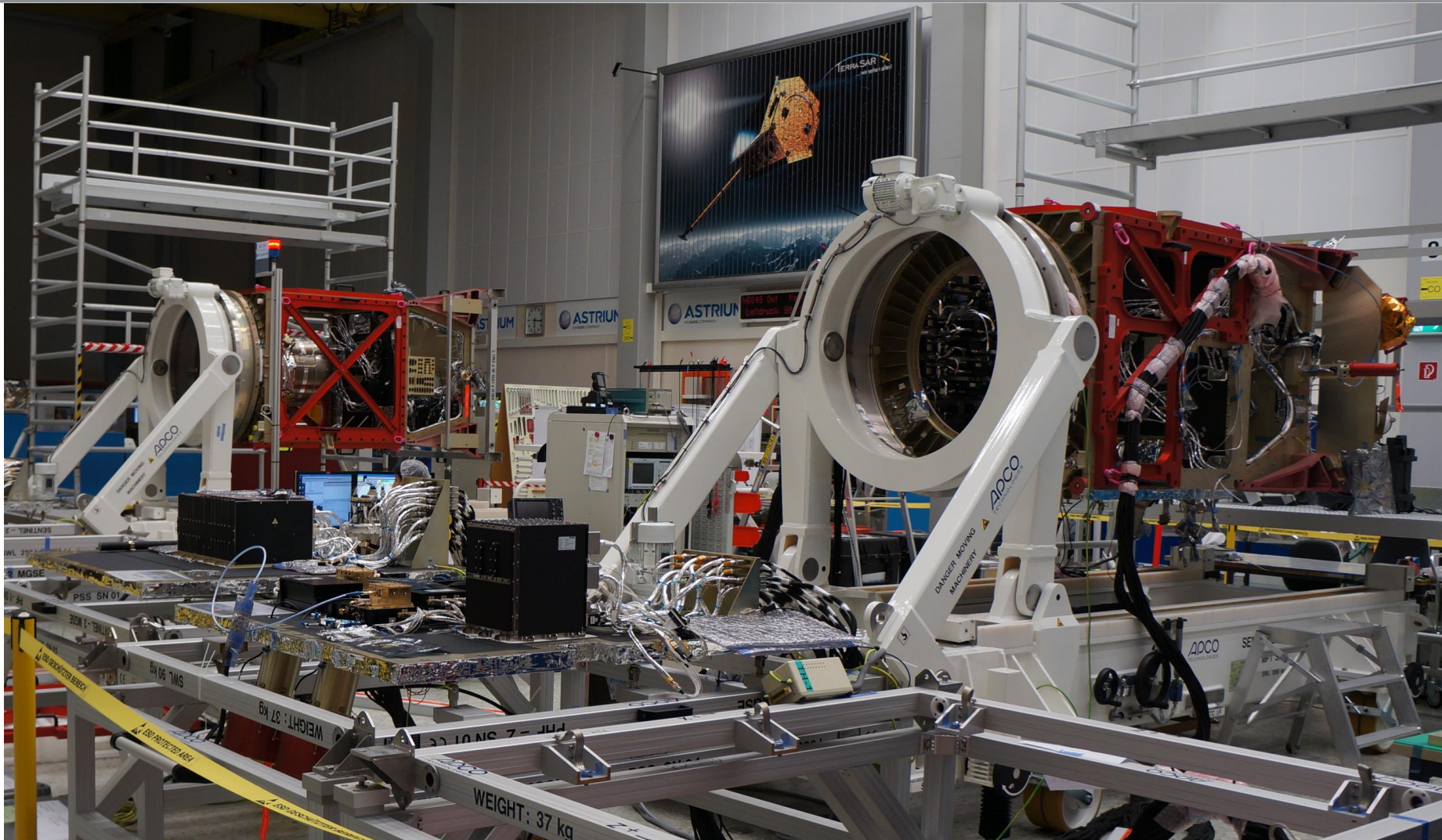- 6 MSI large de-bonded inserts required customised re-enforcement by Titanium flanges.

Significant progress:

- **All MSI performance & qualification tests were successfully completed** in April 2014 by AirbusDS France. **The MSI PFM is on its way** to AirbusDS Germany 6 days ago.

- Platforms integration & test campaign: **all flight hardware integrated** for the environment test campaign. Qualification of flight software & **completion of most subsystem tests**.

- **Decision to launch S2A with VEGA:** PMAR closed, FMA ongoing (satellite-launcher compatibility tests in September 2014).

- The **S2 Ground System Validation & In Orbit Commissioning are being jointly defined** by the ESA Project and Ground System teams (with the support of CNES for Image Quality).

S2A

MSI PFM integration	Satellite arrival at IABG(D)	OCP FM integration	QAR Board	**Launch readiness (VEGA)**	**System IOCR**
21 May 14	8 Aug. 14	30 Nov. 14	15 Mar. 15	30 Apr. 15	30 Jul. 15

MSI integration, Satellite final functional tests

Satellite environmental qualification tests

Launch readiness (ROCKOT)

S2B

MSI integration	FAR Board	
15 Jul. 15	15 Mar. 16	30 Apr. 16

Sentinel-2A and 2B platforms at AirbusDS Germany
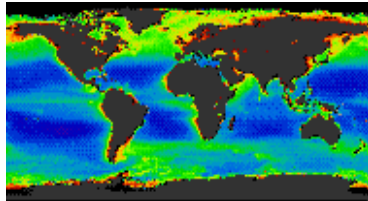
Sentinel–3: Ocean & global land mission

✓ **Applications:**

- Sea/land colour data and surface temperature
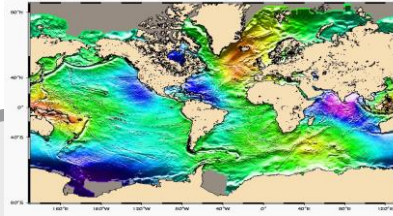
- sea surface and land ice topography

✓ **Sun synchronous orbit at 814.5 km mean altitude over geoid**

✓ **27 days repeat cycle for the topography package, < 3 days for OLCI and < 2 days for SLSTR**
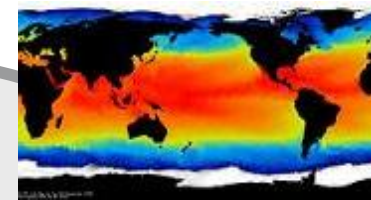
✓ **7 years design life time, consumables for 12 years**
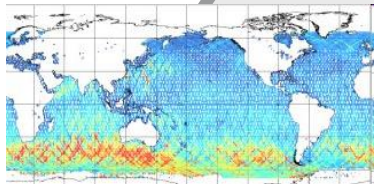
S3 Background: Primary Objectives

Sea Surface Height products
(Credit: CLS)

Ocean colour products
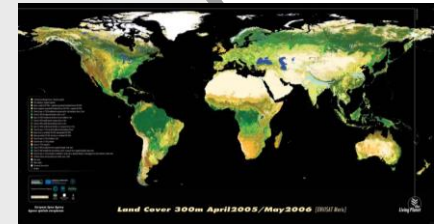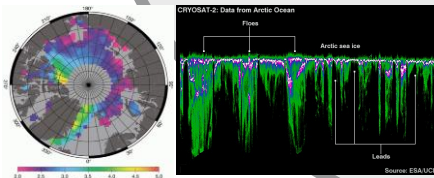(Credit: MyOcean)

Sea Surface Temperature products
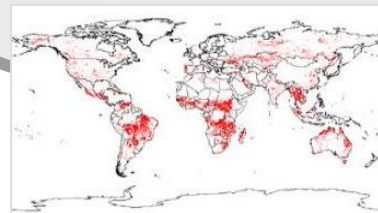(Credit: Met Office)

Along track wind and wave
products
(Credit: AVISO)

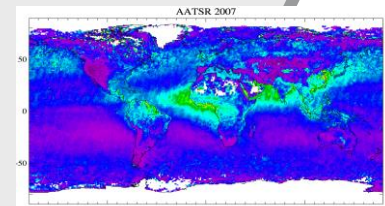Land cover products
(Credit: ESA)

Sea Ice products
(Credit: UCL)

Fire products
(Credit: ESA World Fire
atlas)

User parameters
derived from L1b
products (Credit: GEO)

Atmospheric aerosol
products
(Credit: GlobAerosol)

Sentinel–3 payload

Optical Mission Payload

- Ocean and Land Color Instrument (OLCI) *(continuity of MERIS)*

- Sea and Land Surface Temperature Radiometer (SLSTR) *(continuity of ATSR-AATSR)*

Topography Mission Payload

- Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL)

- MicroWave Radiometer (Bi-frequency)

- Precise Orbit Determination (POD) including
  - GNSS Receiver
  - DORIS
  - Laser Retro-Reflector

SRAL & MWR Track

1420 km (SLSTR nadir)

750 km (SLSTR backward)

1270 km (OLCI)
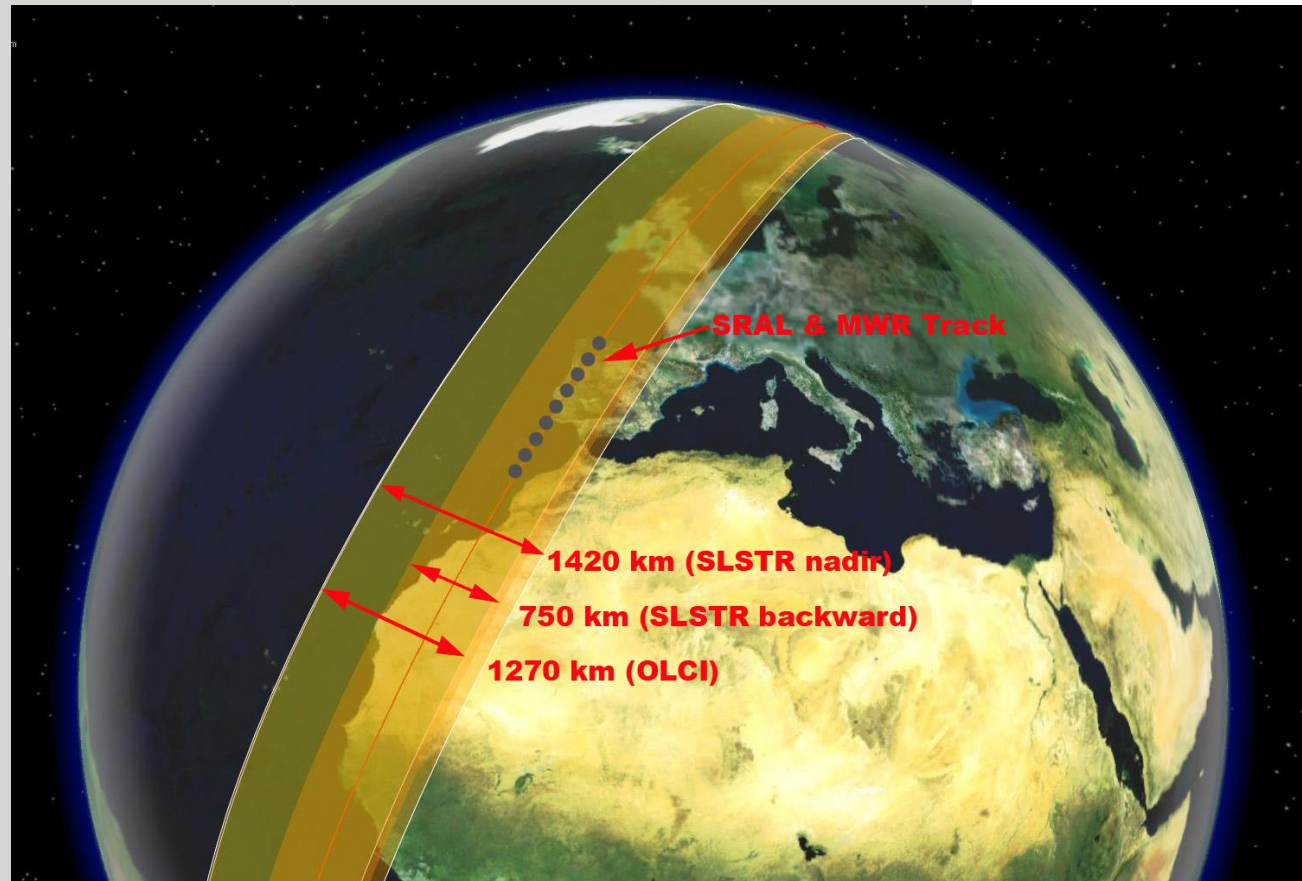
Sentinel-3 Status: General

Development status

- Most equipment required for Sentinel-3A and -3B already delivered

- Sentinel-3A Satellite integration well advanced

- Sentinel-3B Platform integration almost completed

S3A Satellite being prepared at Prime facilities (Cannes-F) for instrument integration

Launch of the Sentinel-3A currently foreseen for June 2015

FAR of the Sentinel-3B satellite planned approx. 1 year after S3A FAR

S3B Platform undergoing electrical integration at Platform Responsible facilities in Rome (I)

European Space Agency

EUMETSAT

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Thank you !

On the web:
Sentinel Online web site:
http://sentinel.esa.int

Sentinel-1 sample products:
https://senthub.esa.int/