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

Meeting with Austrian Partners

27 May 2014, Vienna
Copernicus Components

Overall Programme Coordination

- Space Component
- Services Component
- In-Situ Component

Coordinators:
- ESA
- EEA

Partners:
- Industries
- Private companies
- National Space Agencies
- Eumetsat
- Service operators
- National environmental agencies
- European Space Agency

Copernicus Components
Sentinel Deployment Schedule

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
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.
Sentinel-1: a wide range of applications in very different thematic domains...
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
Sentinel–1 Technical Facts

• 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
Satellite External Views

Deployed Configuration
21 m
12.3 m
Stowed Configuration
3.4 m

Soyuz ST
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**

- **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

*European Space Agency*
Launch Sentinel-1A

- 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.
Weekly Mission Status Reports

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, 21:42 UTC
- The Launch and Early Orbit Phase (LEOP) was successfully performed according to the planned timeline and declared closed on 6 April at 10:00 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 Global Navigation Satellite System (GNSS) through injection
- Switch off and initial check of the spacecraft subsystems
- First operations of the X-band Transmitter and the SAR instrument (3 min of Wavenet mode)
- In addition, a collision avoidance manoeuvre was performed on 5 April

Ground Segment

- The Flight Operations Segment performed normal during the complete 3 days of LEOP
- First SAR data acquisition took place at the Main ground station on 6 April, early morning
- First SAR calibration data acquisition was performed on 7 April. The relevant measurement was successfully processed at UK/NOA
- The PDS 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

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

Mission Status Report 4
Reference Period: 23 April - 30 April 2014

Mission Status

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

Satellite and Ground Segment

- The Commissioning Phase activities are ongoing, with the main activities associated to the injection orbit (7.8 km) and to the necessity of longer duration of the reference orbit acquisition phase
- The commissioning of the propulsion subsystem has continued based on the commissioning of both in-orbit and ground propulsion systems
- The satellite is in a Very Low Earth Orbit (VLEO) with all subsystems working in principal and with the Attitude and Orbit Control System (AOCS) in the operational normal Mode (NPM) and the Orbit Determination System (ODS) in the operational Mode (DPM) in operation, except during critical manoeuvres
- An unsuitability of the SAR occurred on 26 April. SAR operations were in stand-by mode on 27 April
- The SAR payload is planned through the PDGS mission planning system. Provisions outside of the plans are performed based on the availability of orbital parameters and on the optical subsystems
- The overall PDGS, PDS and PDGS status and performance are normal

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
Sentinel–2: Superspectral imaging mission

✓ 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
A variety of applications will be served by Sentinel-2

Optical observations with 13 spectral bands at 10-60m resolution
Support a wide range of applications

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)

Global Land cover
Land use
(Credit: GLOBCover ESA)

Emergency management: flooding
(Credit: SAFER, DLR)

Geology
(Credit: USGS)

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

Glaciers and ice
(Credit: LIMA Project)
Sentinel-2 swath

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

High revisit time assured by twin satellite observations performed over a very large swath.
Sentinel-2 Observation scenario

• Baseline in full operations is systematic acquisition of:
  ✓ All land surfaces (-56° and +84° latitude);
  ✓ Major (greater than 100 km² 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.

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

End of ramp-up
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

**VNIR FPA**

**VIS**
- B1

**NIR**
- B9

**SWIR FPA**

**SWIR**
- B10

**Atmospheric correction channels**
- Aerosols
- Water-vapour
- Cirrus

**Continuity with SPOT5 multispectral**
- Vegetation
- Red-edge
- Snow / ice / cloud discrimination

**Vegetation status**
- B11
- B12

Wavebands and resolutions:
- 400 nm
- 600 nm
- 800 nm
- 1000 nm
- 1200 nm
- 1400 nm
- 1600 nm
- 1800 nm
- 2000 nm
- 2200 nm
- 2400 nm

- 10 m
- 20 m
- 60 m
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).
Sentinel-2A: 1 year to launch

**Sentinel-2A**

- **MSI PFM integration**:
  - 21 May 14

- **Satellite arrival at IABG(D)**:
  - 8 Aug. 14

- **OCP FM integration**:
  - 30 Nov. 14

- **QAR Board**:
  - 15 Mar. 15

- **Launch readiness (VEGA)**:
  - 30 Apr. 15

- **System IOCR**:
  - 30 Jul. 15

**Sentinel-2B**

- **MSI integration, Satellite final functional tests**

- **Satellite environmental qualification tests**

- **FAR Board**:
  - 15 Mar. 16

- **Launch readiness (ROCKOT)**:
  - 30 Apr. 16
Sentinel-2 development status

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

- Ocean colour products (Credit: MyOcean)
- Sea Surface Height products (Credit: CLS)
- Sea Surface Temperature products (Credit: Met Office)
- Land cover products (Credit: ESA)
- Atmospheric aerosol products (Credit: GlobAerosol)
- Along track wind and wave products (Credit: AVISO)
- Sea Ice products (Credit: UCL)
- Fire products (Credit: ESA World Fire atlas)
- User parameters derived from L1b products (Credit: GEO)
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
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

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

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

On the web:
Sentinel Online web site: http://sentinel.esa.int
Sentinel-1 sample products: https://senthub.esa.int/