The Sentinel 1 missions

Launch: May 2013

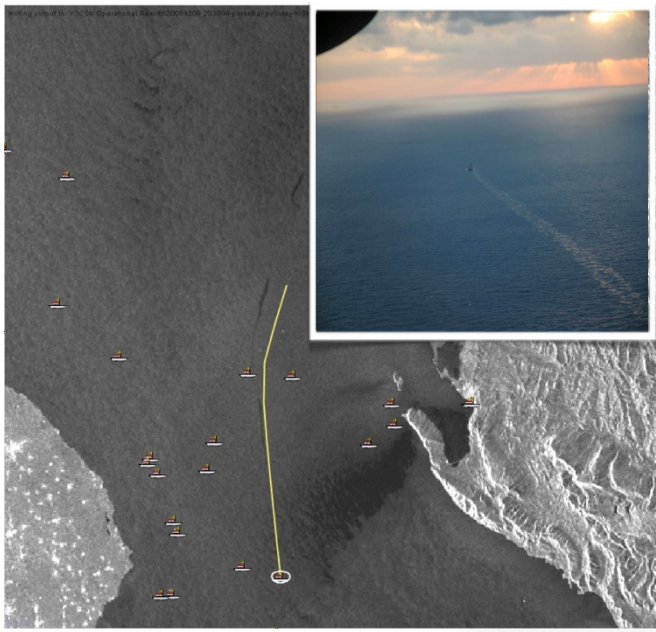
Yves-Louis DESNOS, Ramon TORRES, Pierre POTIN, Betlem ROSICH, Nuno MIRANDA, Dirk GEUDTNER

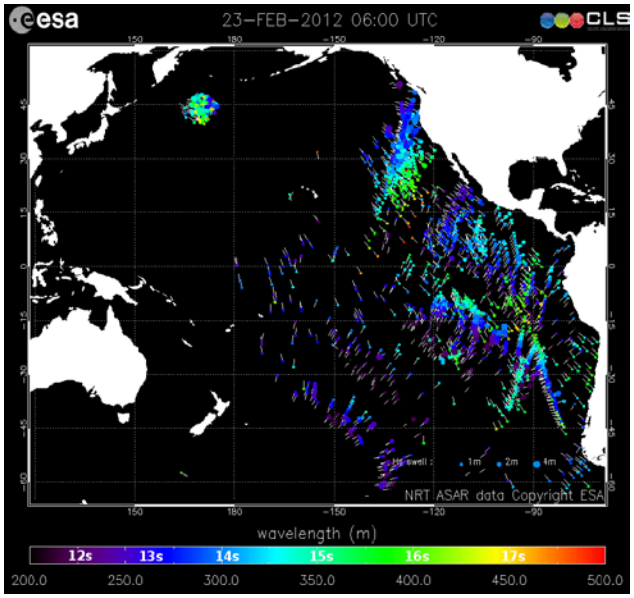
European Space Agency

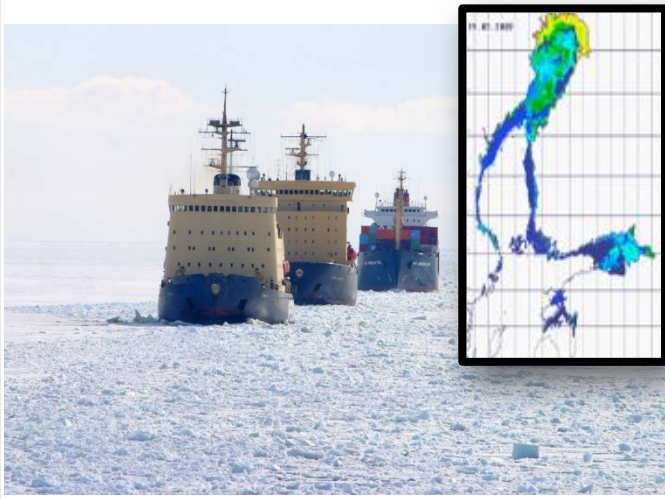
Sentinel-1 Mission Objectives

Provide routinely and systematically SAR data to GMES Services and National services:

- ✓ Marine Monitoring (e.g. oil spill, sea ice)
- ✓ Land Monitoring (e.g. land cover, surface deformation)
- ✓ Emergency Response
- ✓ Climate Change (e.g. Polar caps incl. ice shelves and glaciers)
- ✓ Security (e.g. vessel detection)



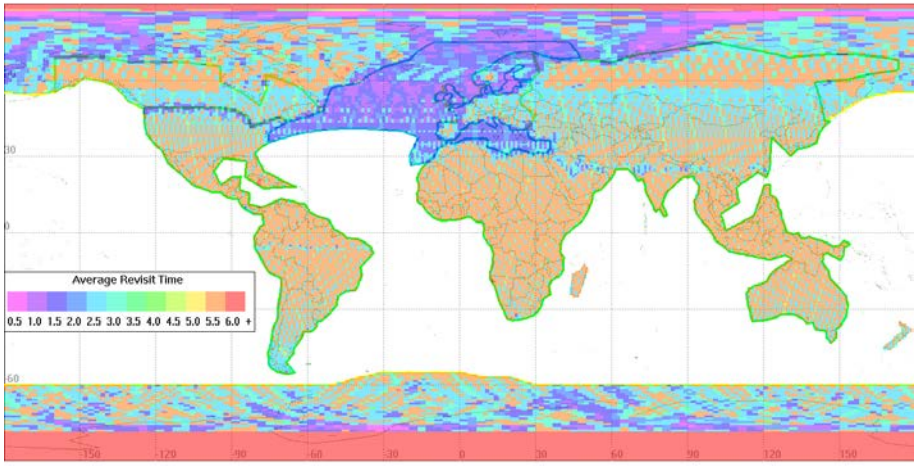


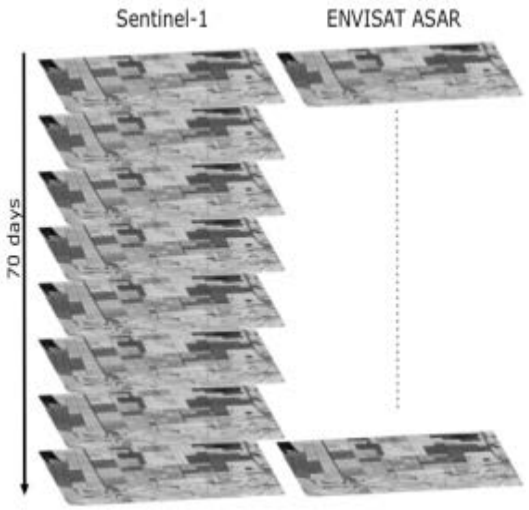


Sentinel-1 Key Requirements

- Provide C-band SAR data continuity of ERS/ENVISAT type of missions at medium resolution (10 m and lower)
- Greatly improved coverage and revisit (i.e. as compared to ENVISAT)
- Conflict-free operations (wide swath and dual-pol modes)
- High system availability (SAR duty cycle and data latency)
- Data quality similar or better than ERS/ENVISAT (e.g. equalized performance across the swath)

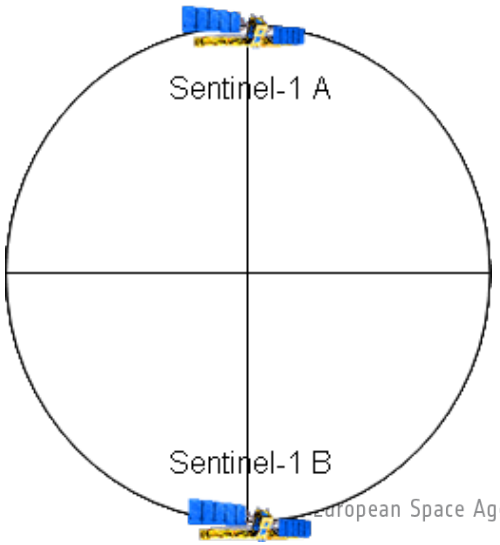
Average Revisit Time with S-1A + S-1B Satellites





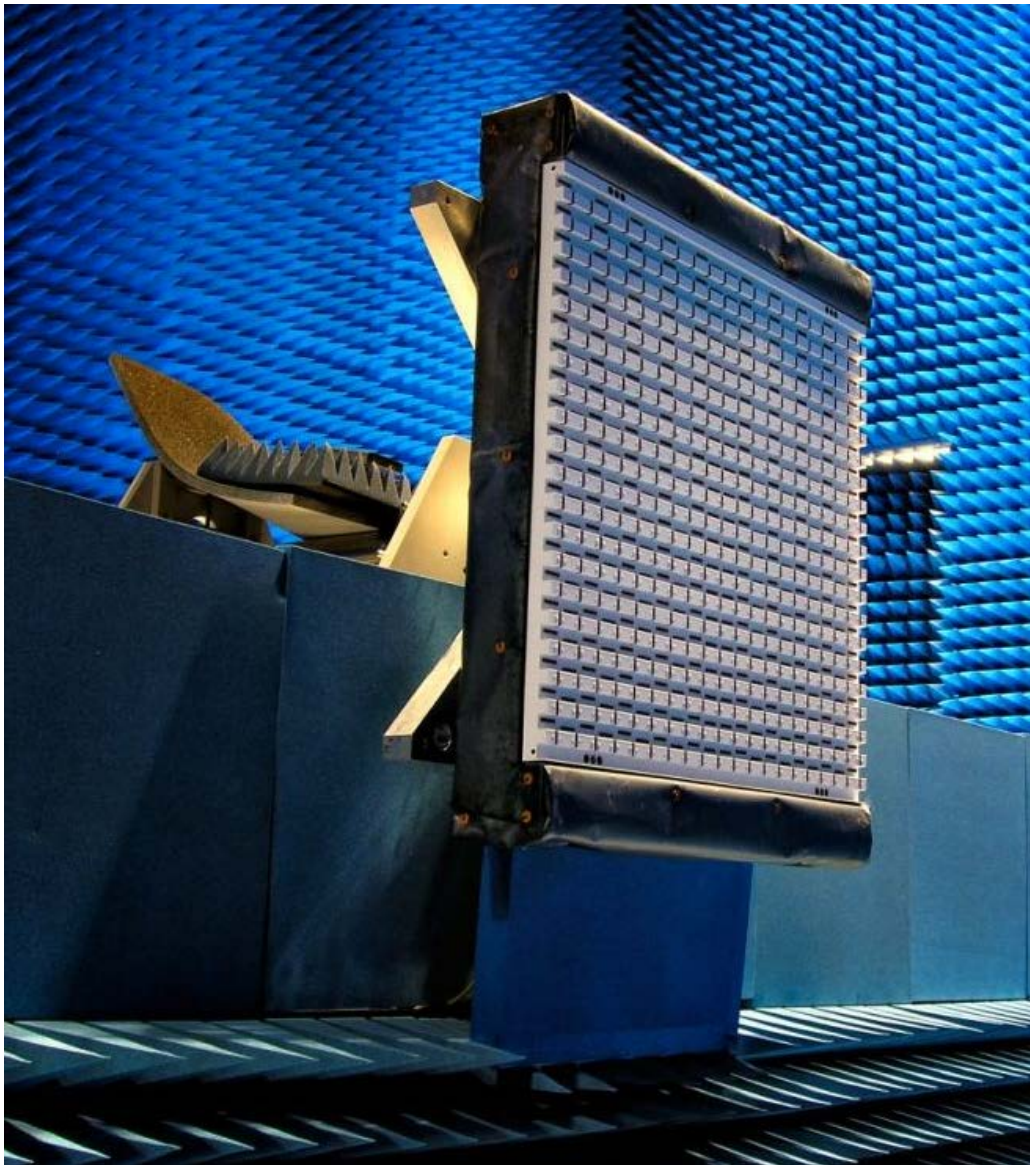
Sentinel–1 Mission Facts

- Constellation of two satellites (A & B units)
- C-Band Synthetic Aperture Radar Payload
- Near-Polar sun-synchronous (dawn-dusk) orbit at 693 km altitude
- Both S-1 satellites are in the same orbit (180 deg. phased in orbit)
- 12 days repeat cycle (1 satellite), 6 days for the constellation
- 7 years design life time with consumables for 12 years
- Launch of Sentinel-1 A scheduled for May 2013 followed by Sentinel-1 B 18 months later



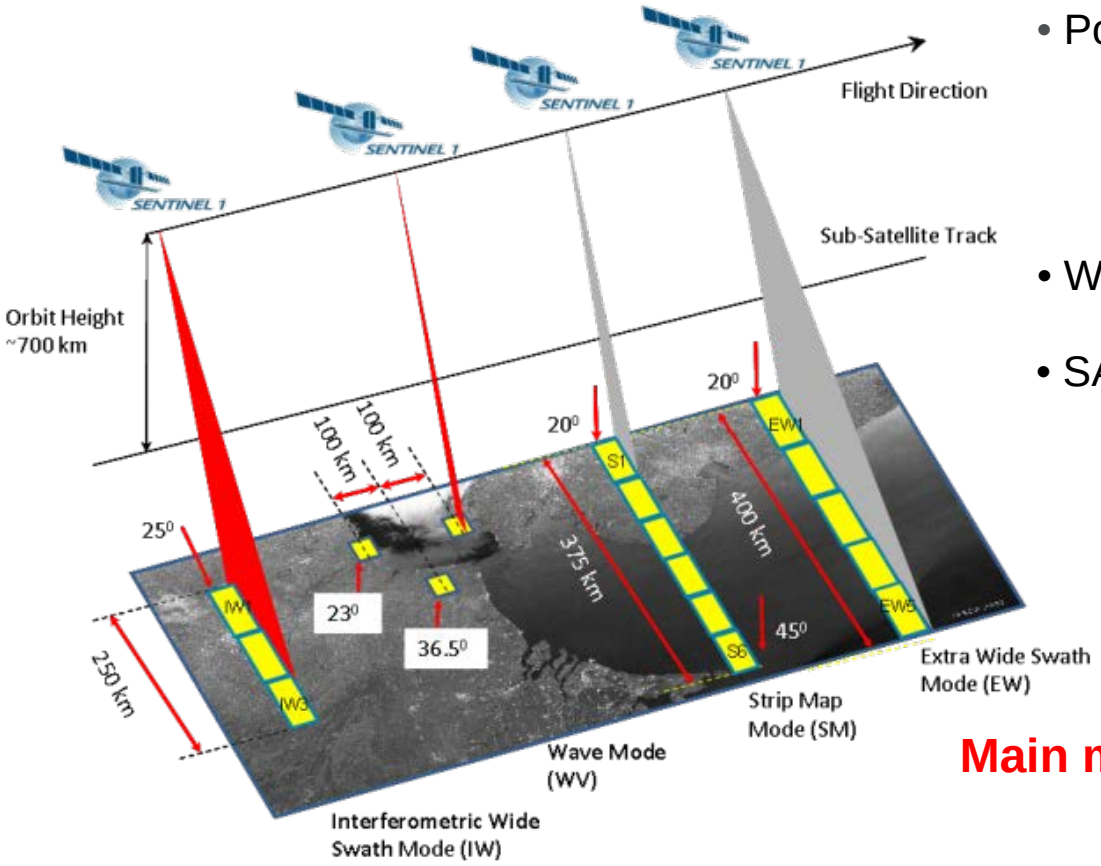
Sentinel–1 Technical Facts

- 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



Sentinel-1 SAR Imaging Modes (1/3)

4 mutually exclusive SAR modes with different resolution and coverage

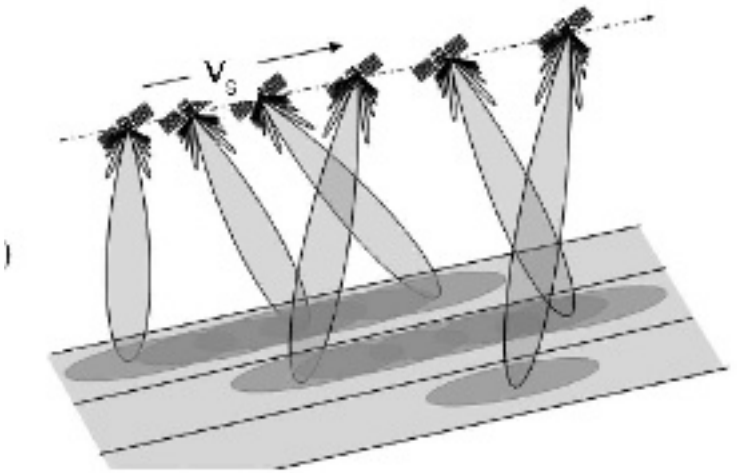


- Polarisation schemes for IW, EW & SM:
  - ✓ single polarisation: HH or VV
  - ✓ dual polarisation: HH+HV or VV+VH
- Wave mode: HH or VV
- SAR duty cycle per orbit:
  - ✓ up to 25 min in any of the imaging modes
  - ✓ up to 74 min in Wave mode

Main modes of operations: IW and WV

S-1 acquisition modes (2/3)

1. SM is the continuation of ERS/ASAR Image modes
2. IW and EW modes relies on TOPS(1) acquisition mode combining electronic steering in elevation and azimuth:
    a. IWS : 3 sub-swath IW1- IW3
    b. EWS : 5 sub-swath EW1-EW5
3. WV is the continuation of ERS/ASAR WV mission but alternates swath between imagettes.
    a. same bandwidth as SM, WV



(1) De Zan, F.; Guarnieri, A.M.; , "TOPSAR: Terrain Observation by Progressive Scans," *Geoscience and Remote Sensing, IEEE Transactions on* , vol.44, no.9, pp.2352-2360, Sept. 2006

Challans: TOPSAR image

Time acquisition: July 9th, 2007 at 6.26 am

Courtesy of DLR

Sentinel-1 SAR Imaging Modes (3/3)

Mode	Access Angle	Single Look Resolution	Swath Width	Polarisation
Interferometric Wide Swath	> 25 deg.	Range 5 m Azimuth 20 m	> 250 km	HH+HV or VV+VH
Wave mode	**23 deg. and 36.5 deg.**	**Range 5 m** **Azimuth 5 m**	**> 20 x 20 km** **Vignettes at 100 km intervals**	**HH or VV**
Strip Map	20-45 deg.	Range 5 m Azimuth 5 m	> 80 km	HH+HV or VV+VH
Extra Wide Swath	**> 20 deg.**	**Range 20 m** **Azimuth 40 m**	**> 400 km**	**HH+HV or VV+VH**

Image Quality Parameters for all Modes (worst case)	
Radiometric accuracy (3 σ)	1 dB
Noise Equivalent Sigma Zero	-22 dB
Point Target Ambiguity Ratio	-25 dB
Distributed Target Ambiguity Ratio	-22 dB

Sentinel-1 observation scenario

High level strategy:

- optimum use of SAR duty cycle (25 min/orbit), taking into account the various constraints (e.g. limitation in the number of X-band RF switches, mode transition times)
- Wave Mode continuously operated over open oceans, with lower priority w.r.t. the other high rate modes
- IW or EW modes operated over pre-defined geographical areas:
  - Over land: pre-defined mode is IWS
  - Over seas and polar areas, and ocean relevant areas: pre-defined mode is either IWS or EWS
- In exceptional cases only, emergency observation requests may alter the pre-defined observation scenario, with e.g. the use of the Strip Map mode

Preliminary observation requirements from MyOcean sea-ice monitoring services

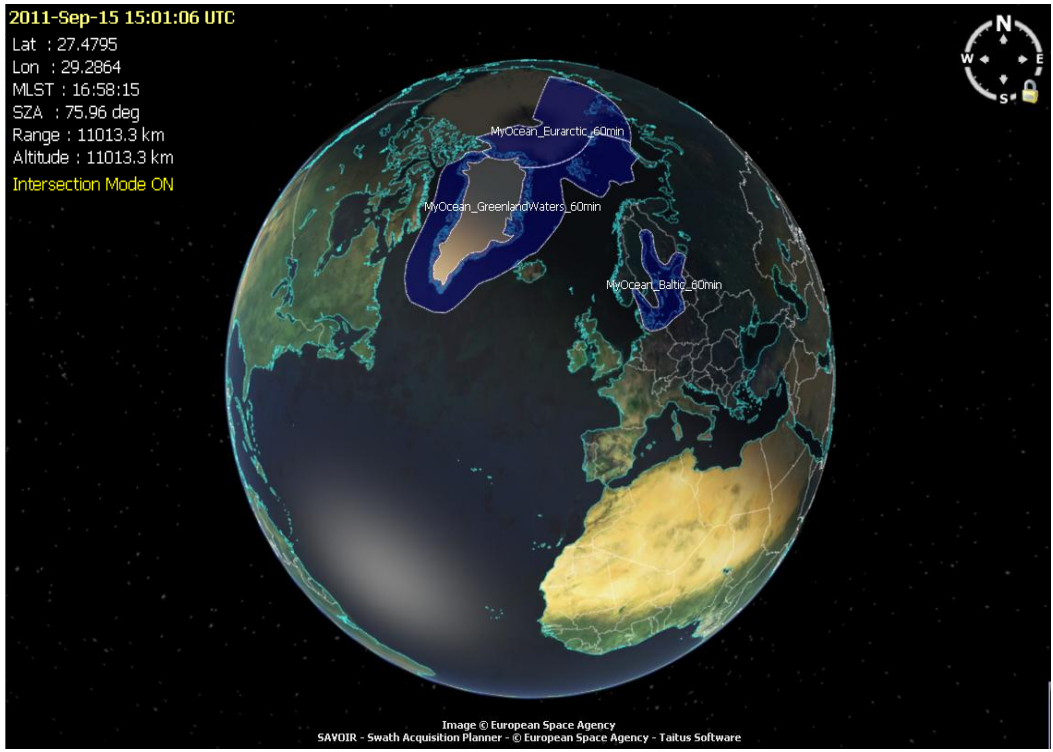
- Areas of interest:
  Eurarctic, Baltic sea, Antarctic

- Data latency from sensing:
  - NRT 1h for Eurarctic, Baltic sea
  - NRT 1h-3h for Antarctica

- Mode / polarisation:
  - EW: 400 km swath, 90m res. (12 ENL)
  - Polarisation:
    - ideally dual-polarisation (HH+HV) for ice charting
    - single polarisation (HH) acceptable for ice drift monitoring in the Arctic Ocean and Antarctic winter season

- Potential conflicts, mainly with:
  - EMSA oil spill monitoring services
  - Ship detection services (Baltic sea)
  - Land requirements regarding coastal zones (mode transition)
  - Other “National” services

North Hemisphere

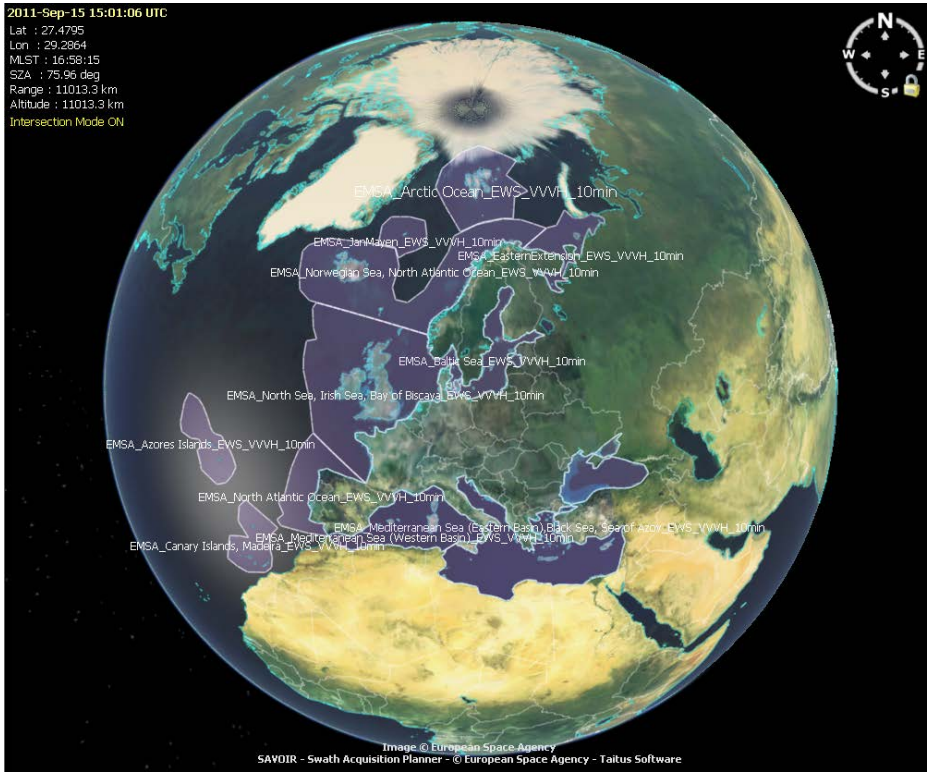


Preliminary observation requirements from EMSA for CleanSeaNet 2nd generation (collaborative)

- Data latency:
  - RT / less than 10 min from sensing
- Mode / polarisation:
  - EW: 400 km swath, 50m res, TBC

  → IW mode may be privileged over specific areas to improve ship detection service (part of CleanSeaNet-2), e.g. Mediterranean Sea
  - Polarisation:
    - ideally dual-polarisation (VV+VH) for oil spill monitoring
    - HH+HV might be acceptable in case of conflicts with other services
    - H polarisation better for ship detection
- Potential conflicts, mainly with:
  - Sea-ice monitoring services (MyOcean and National)
  - Ship detection services (National)
  - Land requirements regarding coastal zones (mode transition)
  - Other “National” services

Sentinel-1 RT (10 min)

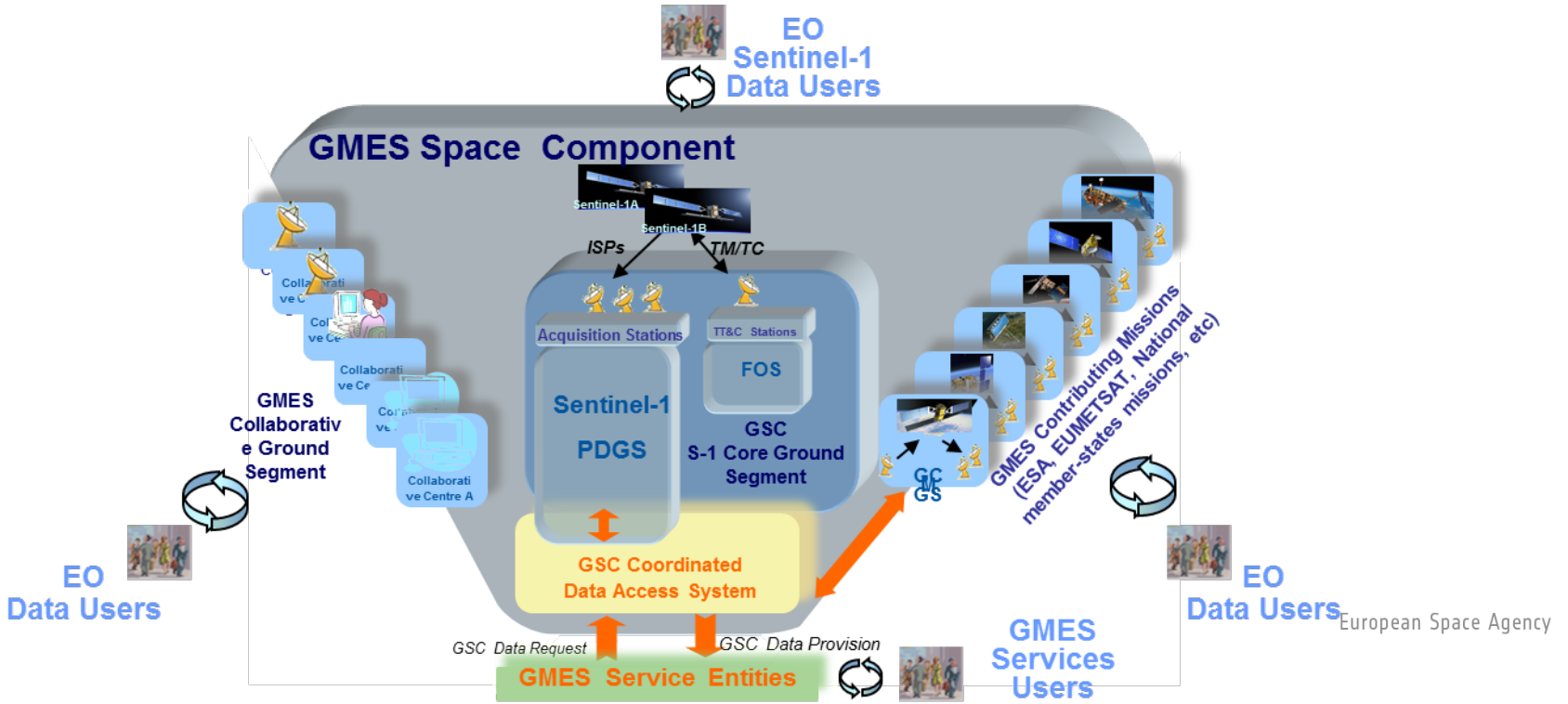


→ Further discussion required with EMSA

Sentinel-1 PDGS Overall Context

GSC Ground Segment consisting of:

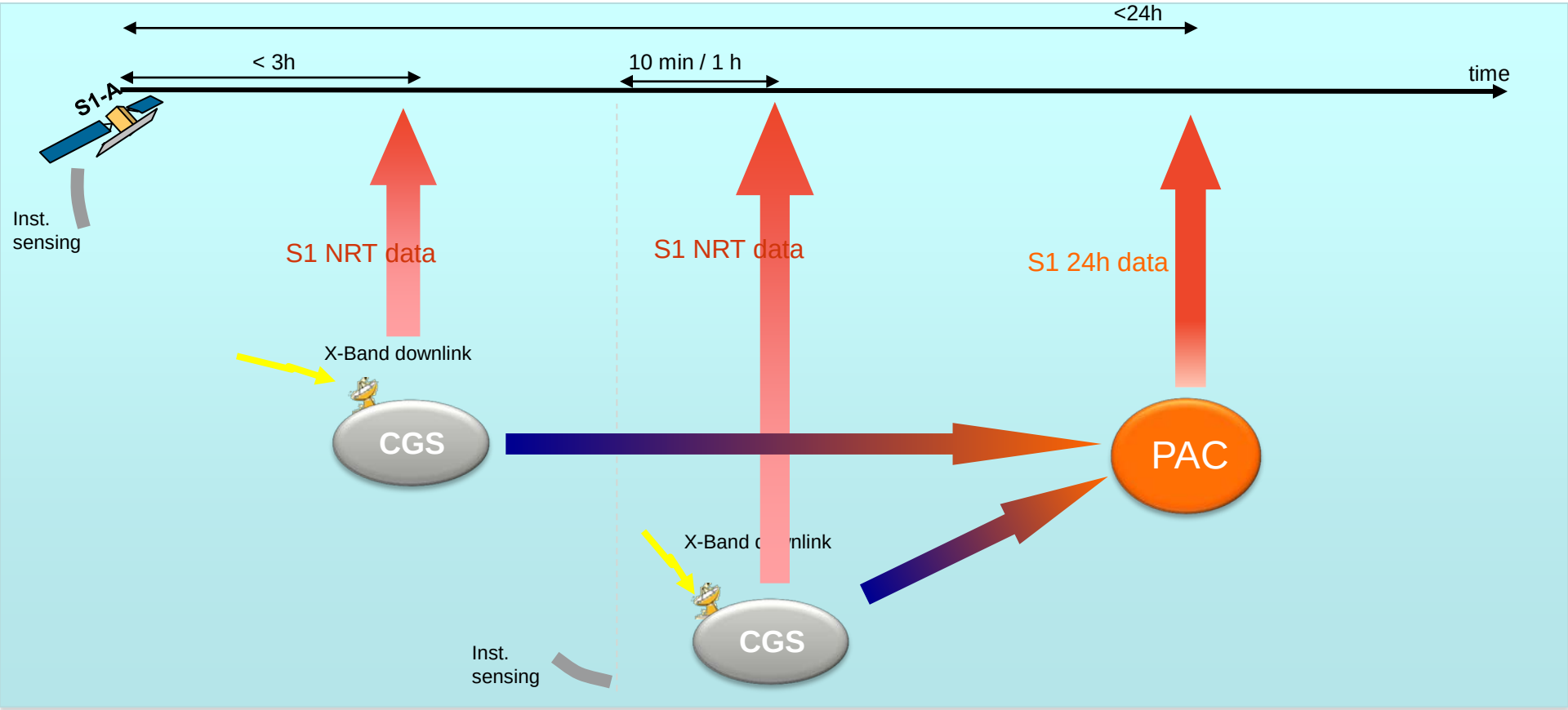
- a GSC Core Ground Segment, with GSC-funded functions and operations, providing:
  - the primary access to all Sentinel Missions core products
  - the coordinating access functions to Contributing Missions and Sentinels data
- a GSC Collaborative Ground Segment, with non GSC-funded operations, providing through dedicated operational interfaces:
  - a supplementary access to Sentinel Missions data, i.e. specific services (e.g. with shorter timeliness), or specific products
  - the frame for international cooperation



Sentinel-1 PDGS Data Timeliness

Data access to systematically generated products is provided according to the following timeliness:

- Standard timeliness: **within 24h from sensing** for all systematic products
- NRT timeliness:
  - < 3h from sensing (**within 1h from downlink**)
  - < **1h from sensing** for data acquired in direct downlink over specific areas (e.g. European waters).



Sentinel-1 PDGS Key Role

X-band raw data

Sentinel-1 PDGS

Data Reception and Ingestion

Mission Planning

Data Processing

Data Archiving

Mission Performance

Precise Orbit Determination

Data Circulation and Dissemination

Configuration, Monitoring and Control

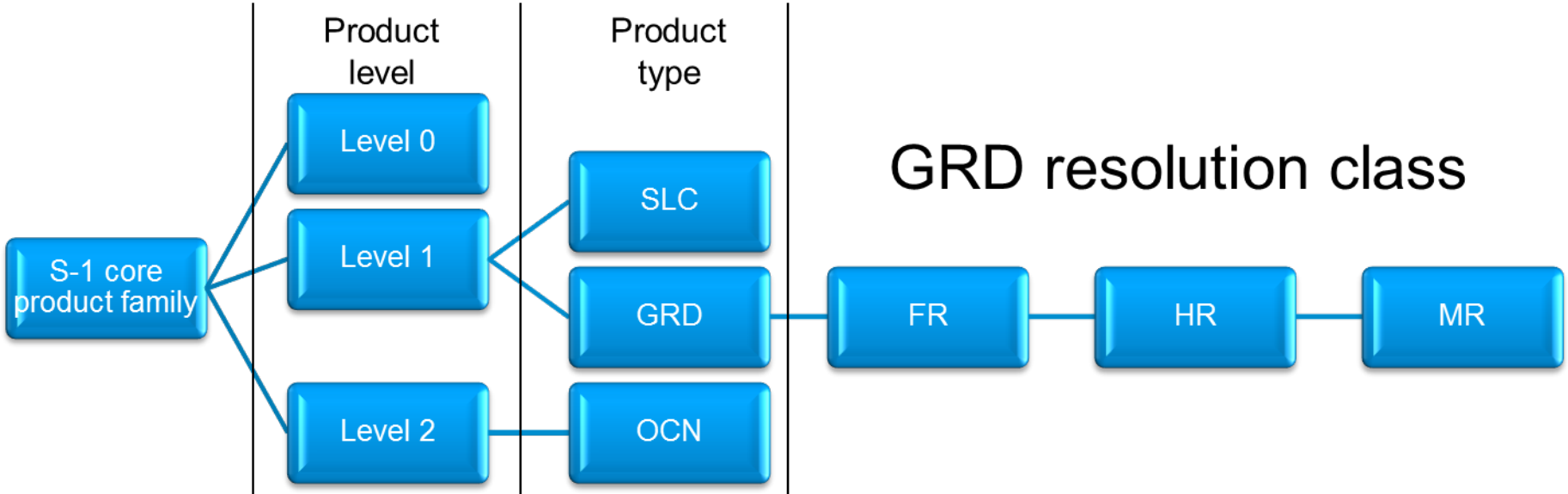
Mission Access User Interface

Products

The Sentinel-1 PDGS as a component of the overall GMES Space Component (GSC) Ground Segment, in charge of the following key activities:

- Implementing the Sentinel-1 mission observation scenario
- X-Band data reception
- Generating the operational core ground segment products
- Reacting to emergency orders with rush instrument tasking and processing
- Providing access to Sentinel-1 data
- Ensuring the long term mission data archiving
- Monitoring the instrument and mission performance
- Ensuring Sentinel-1 core operational user products meet the expected quality, with necessary calibration and validation activities

S-1 Product Family



Acquisition Mode	L0/1/2	Product type	GRD_FR	GRD_HR	GRD_MR
SM	✔	✔	✔	✔	✔
IW	✔	✔		✔	✔
EW	✔	✔		✔	✔
WV	✔	✔			

Sentinel 1 Level 2 products

LEVEL-2 PRODUCT

1. The L2 product family is composed by one **OCEAN (OCN) product** providing up to 3 different components:
    a. **Ocean Swell spectra (OSW)**: providing continuity with ERS and ASAR WV
    b. **Ocean Wind Fields (OWI)**: new compared to ASAR
    c. **Surface Radial Velocities (RVL)**: new compared to ASAR

2. Not all components are applicable to all acquisitions mode

	OSW	OWI	RVL
SM	✔	✔	✔
WV	✔	✔	✔
IW/EW	✖	✔	✔

✖ The current TOPS (IW/EW) instrument settings (not enough overlap between consecutives bursts) doesn't allow to retrieve swell

Sentinel 1 summary

- Sentinel-1 data products maintain data quality of ESA's previous SAR missions (ERS-1/-2, ENVISAT ASAR)
  - Continuity in performance for geophysical products
  - Potential to meet *evolving* GMES service needs
- In response to GMES service needs, substantial improvements are integrated into mission design
  - Revisit frequency
  - Coverage
  - Timeliness and reliability of service
  - Conflict free operations

SEASAR 2012

- SAR Oceanography Science users consultation at SEASAR 2012 -> preparation for future EOEP4 - Support to Exploitation of Operational Missions **(SEOM) -** roadmap for R&D activities

THANKS FOR YOUR ATTENTION

Yves-Louis.Desnos@esa.int
European Space Agency ESRIN