SEASTAR

the EE11 ocean mission to observe small-scale ocean surface dynamics and vertical ocean processes in coastal, shelf and polar seas

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EE11 Mission Information Day, 21 Oct 2021

Outline

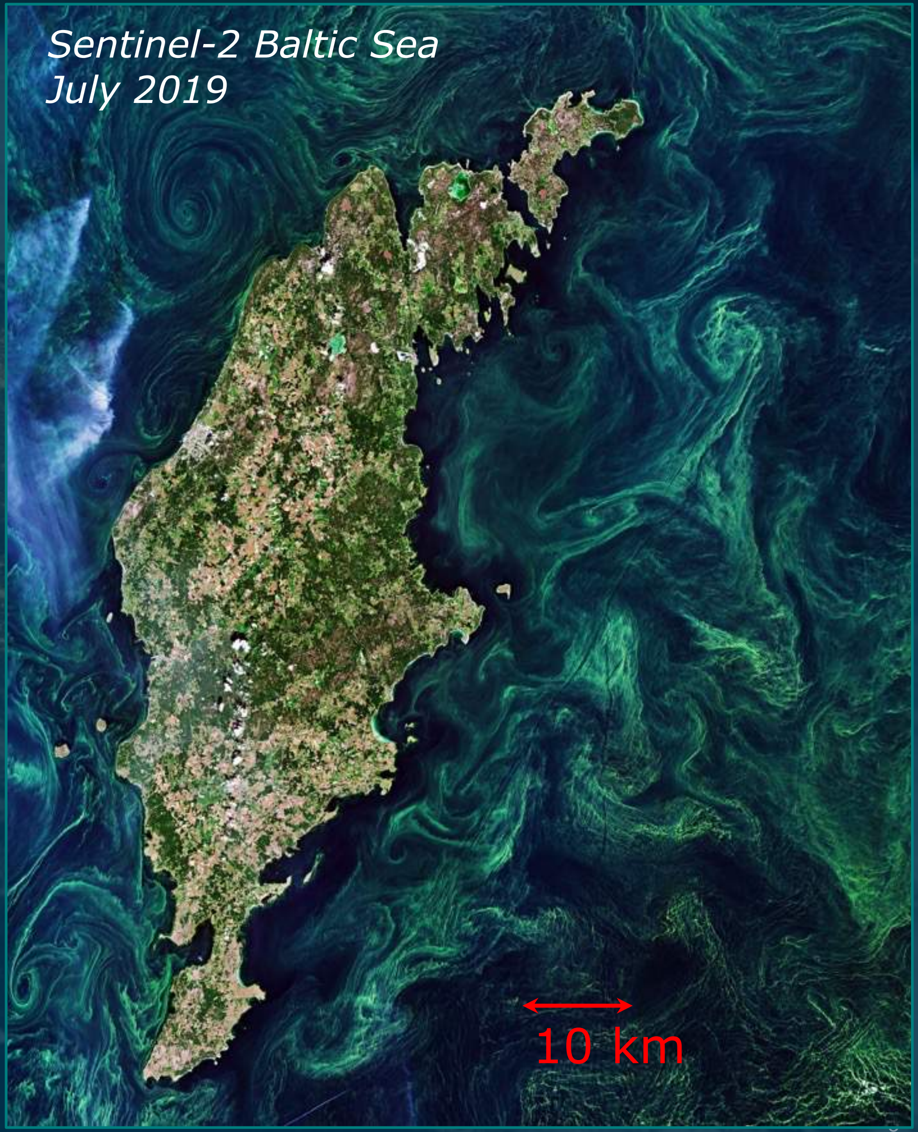
1. SEASTAR Science development: Christine Gommenginger (Lead Investigator, NOC)
    - Primary Science Objectives
    - Level 2 Products and Requirements
    - Coverage & Revisit Requirements
    - Observing principle: Along-track SAR interferometry
    - Main elements of the concept, key challenges

2. SEASTAR System development: Kevin Hall (System Study Manager, ESA)
    - Key System and Payload Specification
    - Technical Challenges
    - Key technologies

3. Your questions: moderated by Paolo Cipollini (Mission Scientist, ESA)

SEASTAR Science drivers

1. High-resolution satellite images frequently show small ocean eddies, swirls, fronts and filaments at horizontal scales below 10 km
   - Frequent near energetic current jets and eddies, in coastal seas and sea ice margins
   - fingerprints of dynamic interactions & vertical exchanges
2. Numerical models suggest these small-scale phenomena play a critical role in the global climate system
   - Impact on vertical exchanges e.g. heat, CO2, nutrients…
   - Impact on horizontal dispersion e.g. debris, oil, pollutants…
3. Very few observations of ocean dynamics at these scales
   - challenging, expensive with traditional means
   - no spaceborne capability from existing or planned missions
   - Little is known about their magnitude, distribution, evolution…



SEASTAR Primary Science Objectives

1 - to measure, for the first time, **2D fields** of **Total Surface Current Vectors** and **Ocean Surface Vector Winds** at **1 km resolution with high accuracy** over **all coastal seas, shelf seas and Marginal Ice Zones** to characterise their magnitude, spatial characteristics, regional extent, and temporal variability on **daily, seasonal to multi-annual time scales**.

2 - to deliver, for the first time, **accurate high-order derivative products** (e.g. vorticity, strain, divergence) to explore the relations between ocean sub-mesoscale/mesoscale circulation, air-sea fluxes and vertical exchanges.

3 - to investigate the relations between small-scale dynamics, air-sea interactions, vertical processes and marine productivity using **synergy with high-resolution satellite data from optical, thermal and microwave sensors**.

4 - to validate high-resolution and coupled models and support the development of new parameterisations to improve operational forecasts and reduce uncertainties in climate projections.

SEASTAR Products and Requirements at Level 2

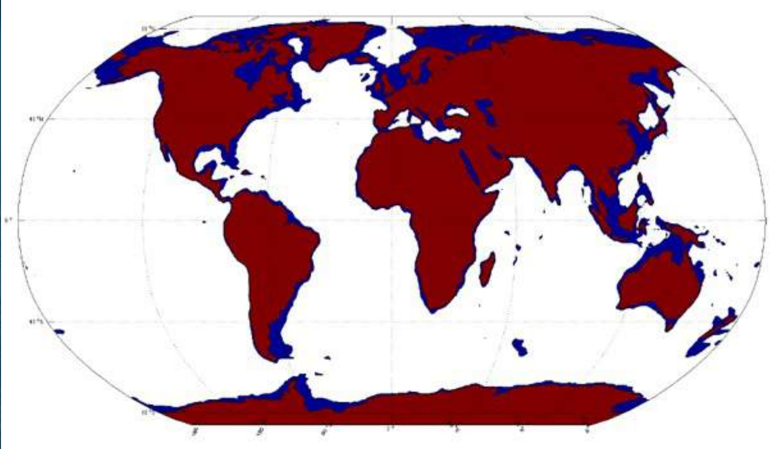
esa

SEASTAR Primary Products (Level 2)		
Total Surface Current Vector (L2-TSCV)		
	One continuous swath:	~100 to 150km
	Horizontal posting (resolution):	≤ 1 km
	TSCV RMSE @ 1km resolution:	≤ 0.1 m/s or 10% (speed) ≤ 20 deg (direction)
Ocean Surface Vector Wind (L2-OSVW)		
	Same swath and posting as TSCV	
	OSVW RMSE:	≤ 1 m/s or 10% (speed) ≤ 20 deg (direction)

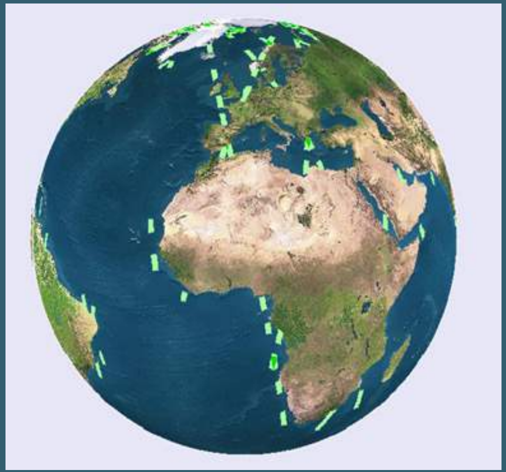
Essential requirements

Coverage & revisit

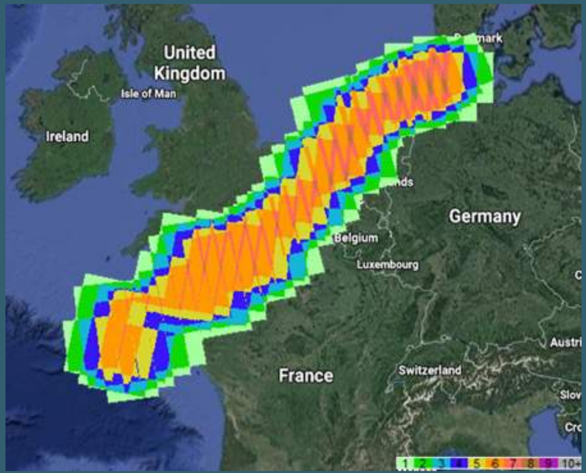
1. **SEASTAR is not a global monitoring mission, but rather a *global coastal* mission**
    - whole coastal ocean, all shelf-seas & MIZ
    - additional vignettes over Sites of Special Interest, even in open-ocean
2. Two mission phases
    - Fast-repeat phase (6 months)
        - 1 day repeat
        - ~150 scenes every day
        - each scene ~250 km long
    - ~30-days drifting orbit (4 years)
        - 1-day sub-cycle
        - swath overlap (~ 50%)



SEASTAR sampling over all coastal/shelf seas and MIZs



Fast-repeat coverage after 1-day



Drifting phase coverage after ~30 days

Observing principle: Squinted Along-track Interferometry

- Unambiguous retrieval of total current and wind vectors requires measurements of NRCS and Doppler shifts in **three azimuth directions**

Two ATI pairs squinted

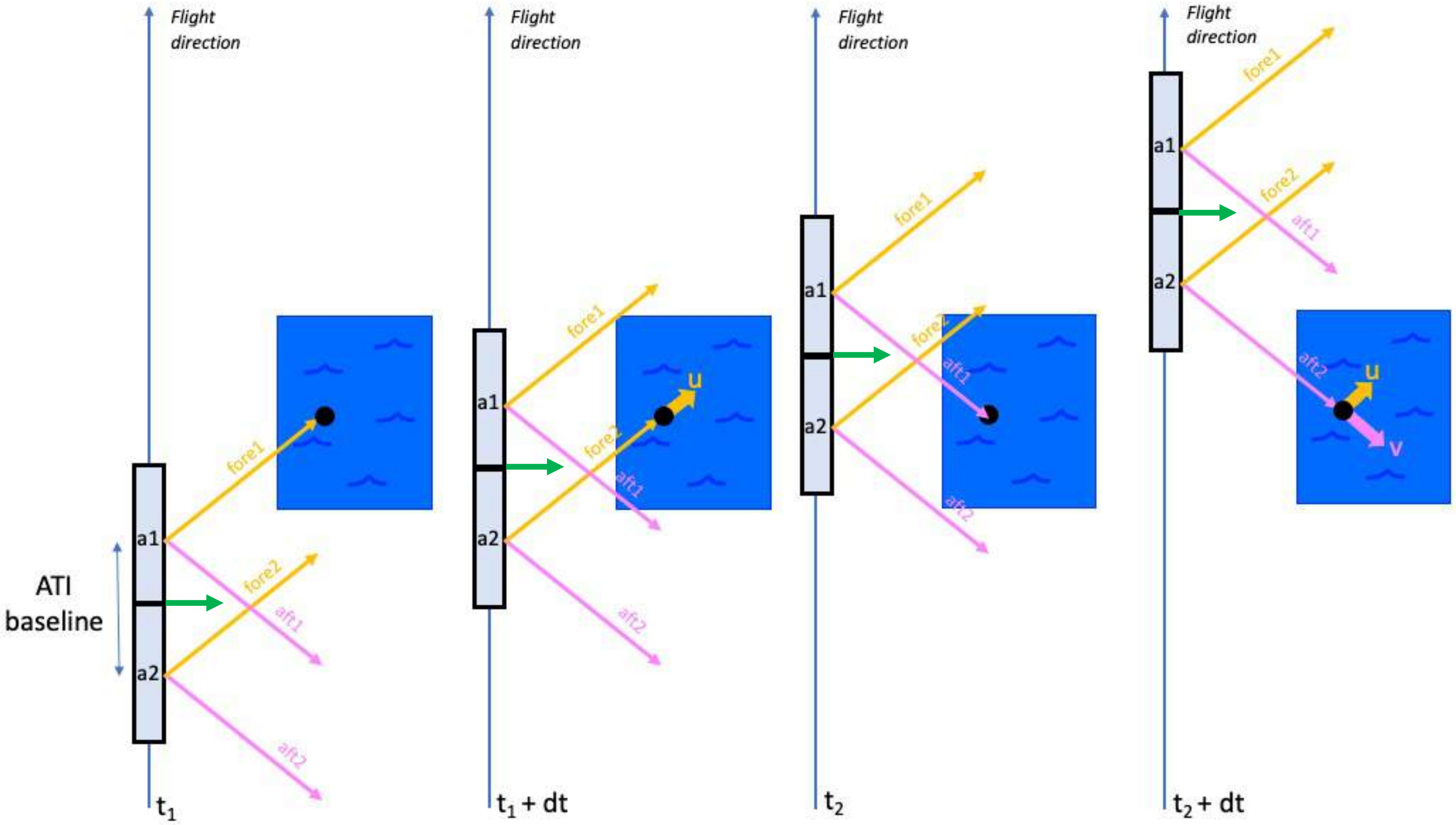
45° forward

45° backward

+ one broadside beam

VV & HH

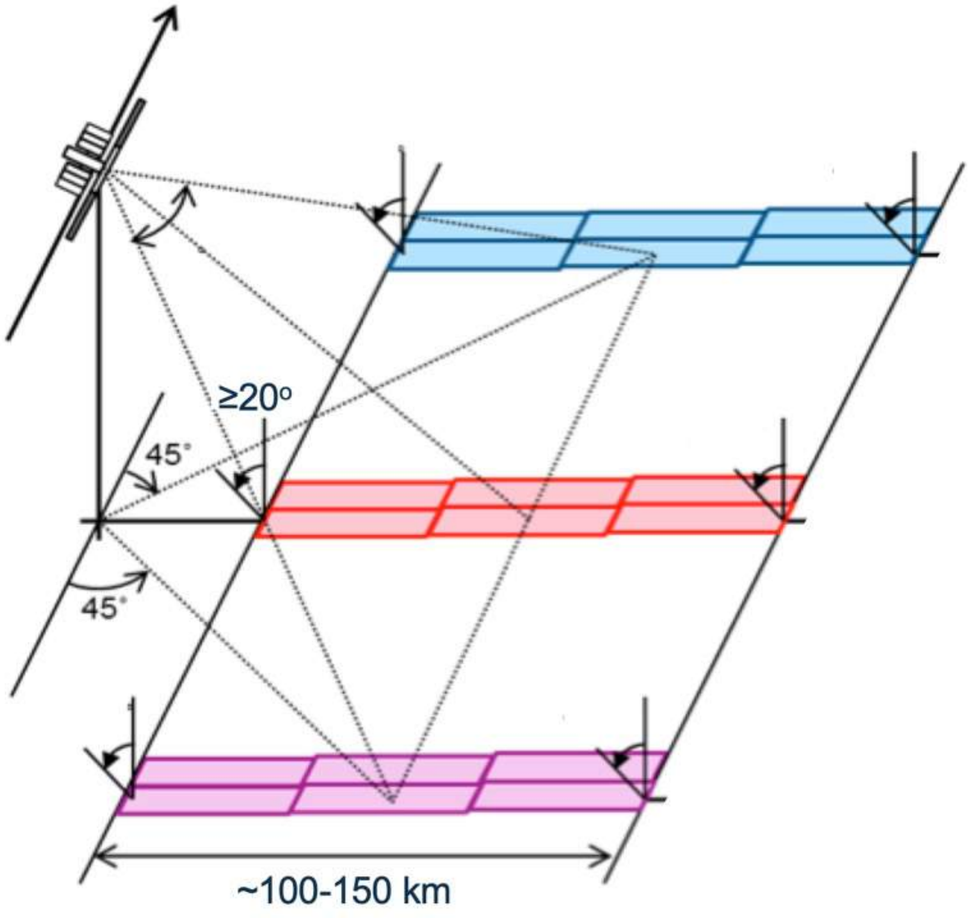
Dual-pol broadside supports L2 inversion of TSCV and OSVW and brings additional information about wave breaking at fronts



Main elements of the concept

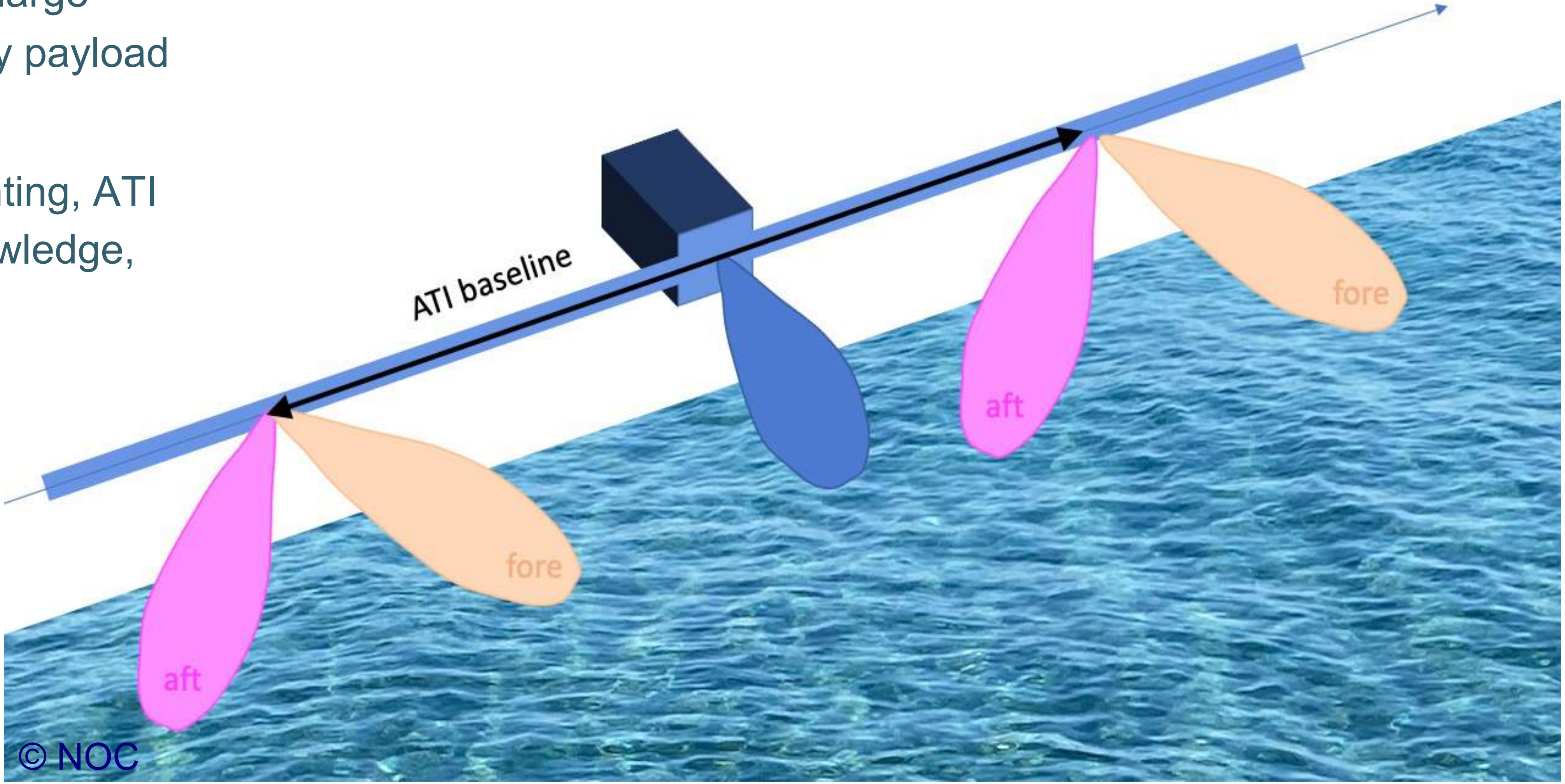
- One payload on a single satellite
- Squinted ATI SAR system, three looks
  - Two squinted beams ± 45° (VV)
  - One broadside beam (VV & HH)
- Ku- or Ka-band
- Broadside SLC (directional wave spectra)
  - ASAR-like
- ~100-150 km swath
- All incidence angles ≥ 20 deg from nadir
  - Greater sensitivity to horizontal motions, less Doppler wave bias, greater benefit of dual-pol
  - But puts greater demand on SNR and coherence to reach target accuracy at far range & low wind
- Strict L1B noise requirement on line-of-sight radial velocity (0.05 m/s)

Essential requirements



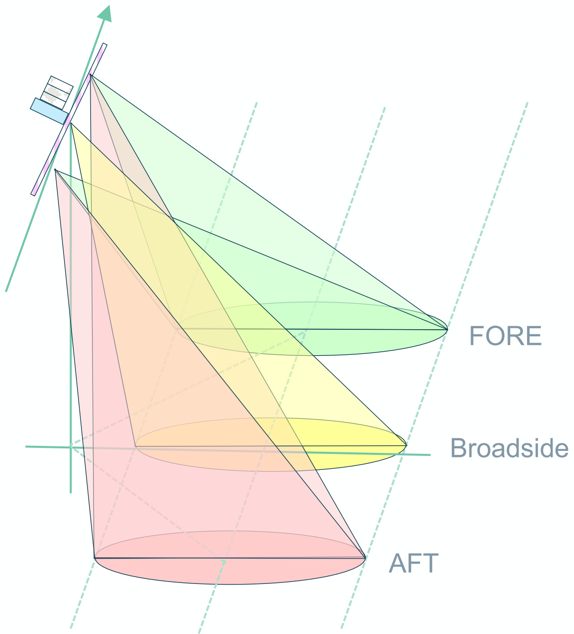
Key challenges

- A potentially large power-hungry payload
- Antenna pointing, ATI baseline knowledge, calibration



Key System and Payload Specification

- **SEASTAR** is a single-platform SAR system performing squinted along-track interferometry.
  - Frequency trade off between Ku and Ka-Band anticipated
- Operating a dedicated instrument to observe **sub-mesoscale** ocean surface dynamics:
  - Total Surface Current Vector (TSCV): error ≤0.1 m/s @ 1km resolution.
  - Ocean Surface Vector Winds (OSVW): error ≤1 m/s.
- The payload will implement **three beams** (2 squinted + 1 broadside)
  - Up to 15m interferometric baseline and ~100 to 150km swath
  - With a High Power Pulsed Operation with a duty cycle of 15-20%
- A **flexible mission profile** currently planned in two phases:
  - **Phase 1**: daily revisit on selected coastal and polar regions (6 months).
  - **Phase 2**: coverage of whole world coastal and polar regions with ~30 days revisit (4 years).
- SEASTAR will also benefit from the on-going airborne demonstrator **OSCAR**.
  - An ESA funded activity currently planned to fly early 2022
- **Re-use of heritage platform** encouraged and must be compatible with **VEGA-C or Ariane-6.**



Mission Technical Challenges

- **SEASTAR** is a SAR mission where pointing will be a key system driver
    - APE(Absolute Performance Error) and AKE(Absolute Knowledge Error) considered challenging
    - Antenna implementation expected to be a key contributor to both error budgets

- **Antenna design and implementation**
    - Antenna technology selection a critical step for the squinted beams
    - Antenna length could be up to 22m depending on operating frequency
    - Stowage and deployment system will drive the accommodation
    - Accurate antenna deformation monitoring might be required

- **External calibration** required to ensure an adequate interferometric baseline estimation.

Key technologies

- **Antenna sub-system**
    - Antenna technology trade off
        - Stability of the structure which will dictate both pointing and baseline, that are critical parameters for the instrument.
        - Manufacturing, assembly, deployment and thermal/structural behaviour which will drive the antenna performance.
    - Metrology system to measure the beam pointing and interferometric baseline may be required.

- **Power amplifiers + Electronic Power Conditioning**
    - Capable to handle high peak and average power at the chosen frequency
    - Maturity of available technology

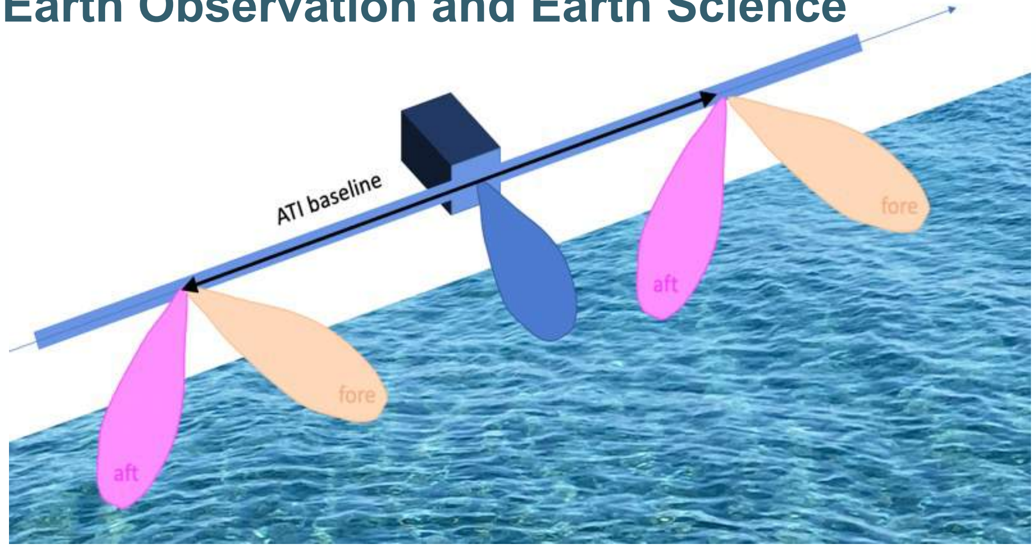
- **High power and low losses ferrite parts** (switches, circulators)
    - Capable to withstand the multipactor high power discharge and average power requirements.

Summary

A science-driven mission with a solid science case to deliver unique new ocean observing capability and address the needs of a large and growing community of Ocean, Earth and Climate scientists and users

A 'quantum leap in knowledge' for Earth Observation and Earth Science

Demanding requirements for high spatial resolution (1 km or finer) and high accuracy (0.1 m/s at Level 2) over a wide swath



A highly innovative concept, never flown in space before, with some challenging elements but high levels of European know-how and technology readiness.

Your chance to make history and build the first mission of its kind!

Thank you for your attention

Your questions please