National Oceanography Centre

EO Week, 07 September 2021

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

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National Oceanography Centre

& the international SEASTAR team

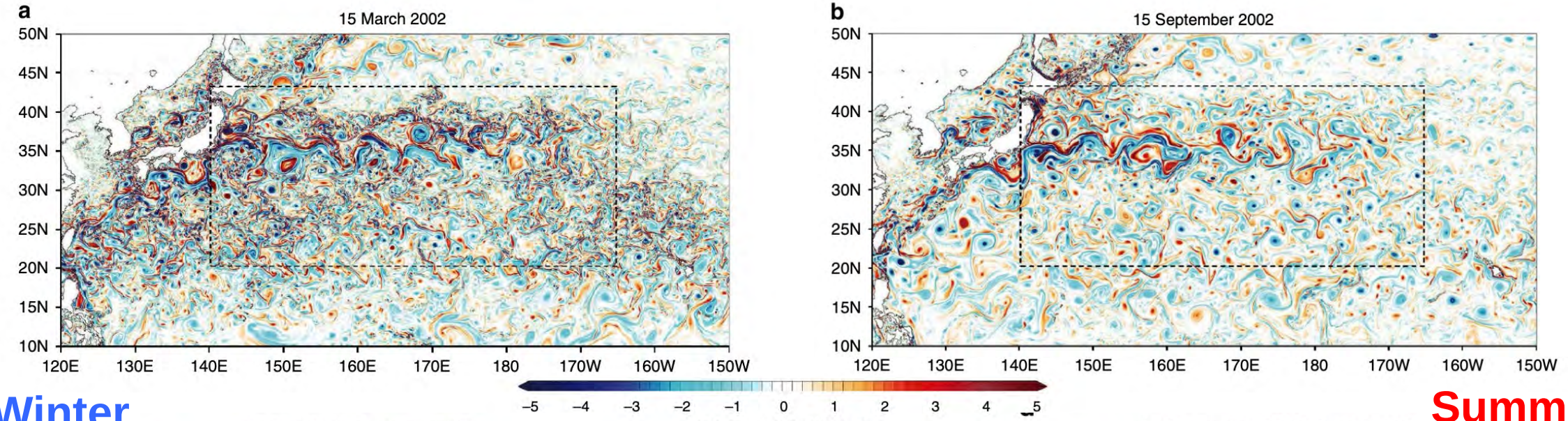
# Outline

- The EE11 SEASTAR mission
  - Science drivers, societal relevance, objectives
  - Key elements of technical concept
  - Issues to address during Phase 0
    - Cost, cost, COST!
- What now ?
- Closing remarks

# Science drivers of the SEASTAR mission

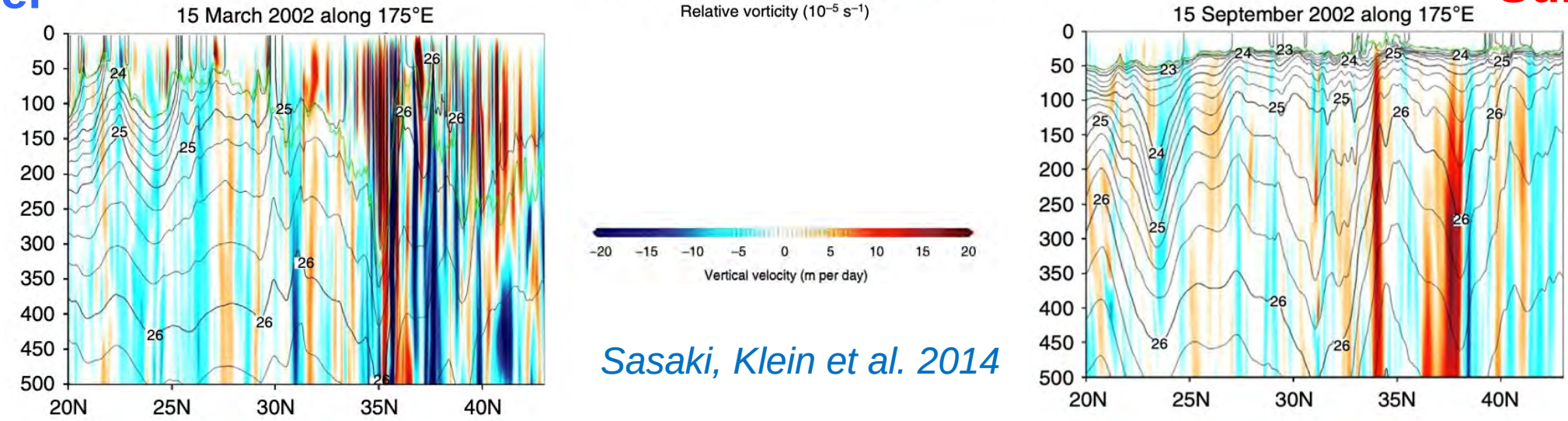
- high-resolution satellite images of sea surface temperature and ocean colour frequently show ocean fronts, swirls, vortices and filaments at horizontal scales below 10 km
  - frequently seen near mesoscale jets and eddies, in coastal seas and close to sea ice margins
  - fingerprints of strong dynamic interactions & vertical exchanges
- observations of small scale dynamics are rare
  - challenging, expensive
  - no spaceborne capability from existing or planned missions
- Numerical models predict major impact of these small scales on many aspects of the Earth and climate system
  - Horizontal and vertical transport of heat, freshwater, gases

# Connecting the atmosphere and the ocean interior




**Winter**

**Summer**

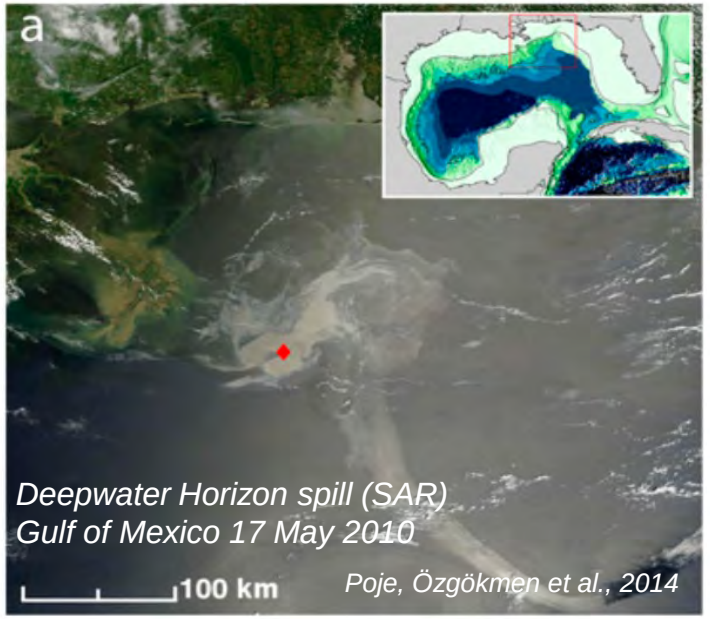



1/30th

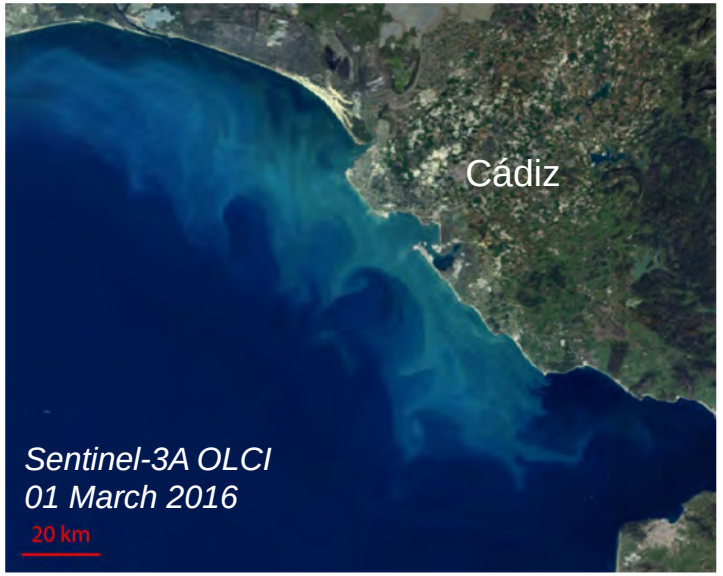
*Sasaki, Klein et al. 2014*

# Impacting horizontal pathways

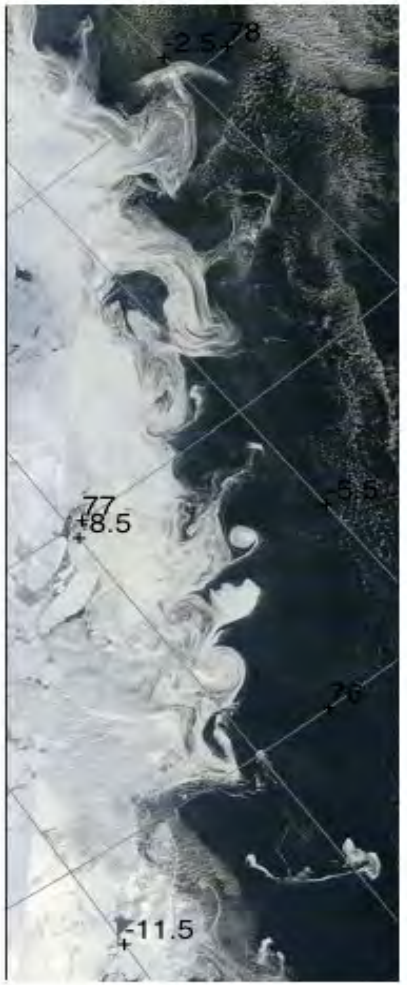
- Poje et al., PNAS, 2014: Deepwater Horizon spill
  - *'the submesoscale-driven dispersion [is] missing in current operational circulation models and satellite altimeter-derived velocity fields'*
  - *'Fundamental questions concerning the structure of the velocity field at the submesoscales (100 m to tens of kilometres, hours to days) remain unresolved due to a lack of synoptic measurements at these scales.'*
- Small scales change the horizontal pathways and fate of floating and suspended materials
  - In the open ocean:
    - Oil spills, plastics, marine debris, marine larvae…
  - At land-ocean interfaces:
    - Freshwater plumes, terrestrial outflows and pollution, suspended sediments…
  - At ice-ocean interfaces:
    - Sea ice melting/formation
- Urgent need for new synoptic observations of fine-scale surface dynamics to validate and improve dispersion, coastal and sea ice models



*Deepwater Horizon spill (SAR)*
*Gulf of Mexico 17 May 2010*
*Poje, Özgökmen et al., 2014*



*Sentinel-3A OLCI*
*01 March 2016*



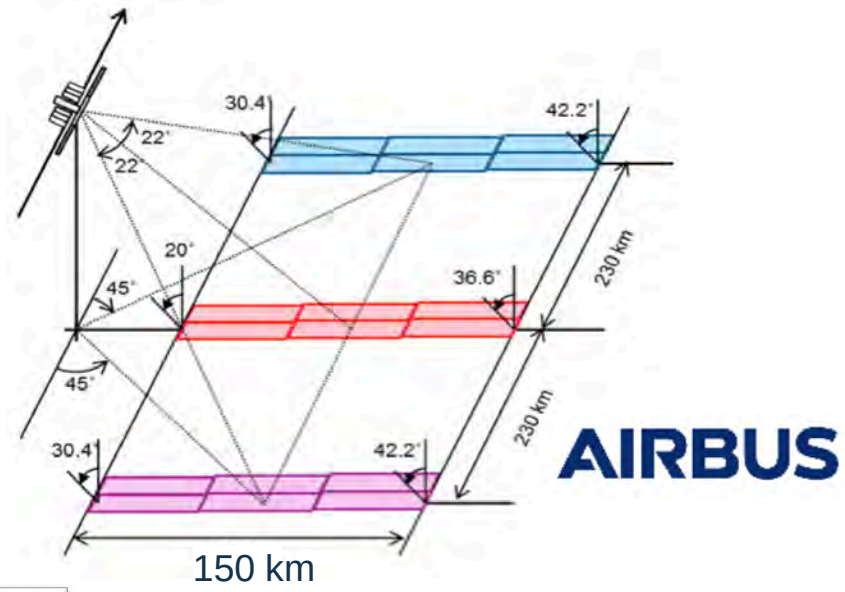
*Aqua/MODIS Fram Strait*
*09 March 2016*
*Manucharyan & Thompson, 2017*

# SEASTAR Science objectives

- Primary Objectives
  - 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, to characterise their magnitude, spatial & regional characteristics and temporal variability on daily, seasonal to multi-annual time scales, over all coastal seas, shelf seas and Marginal ice zones.
  - 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.
  - 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.
  - to validate high-resolution and coupled models and support the development of new parameterisations to improve operational forecasts and reduce uncertainties in climate projections.

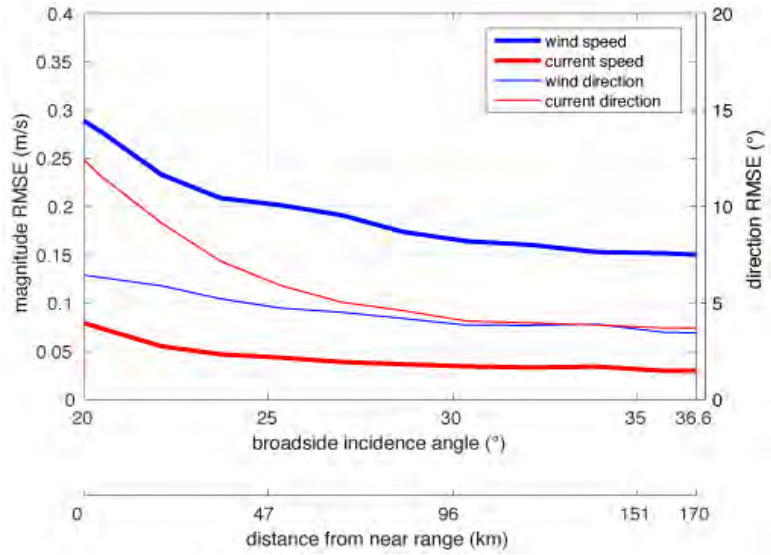
# Key elements of EE11 SEASTAR

- Squinted Along-Track Interferometric SAR
  - Ku-band (active microwave)
  - Three azimuth looks (ASCAT-like)
  - Two squinted beams ± 45º from broadside (VV)
  - One broadside beam (VV & HH)

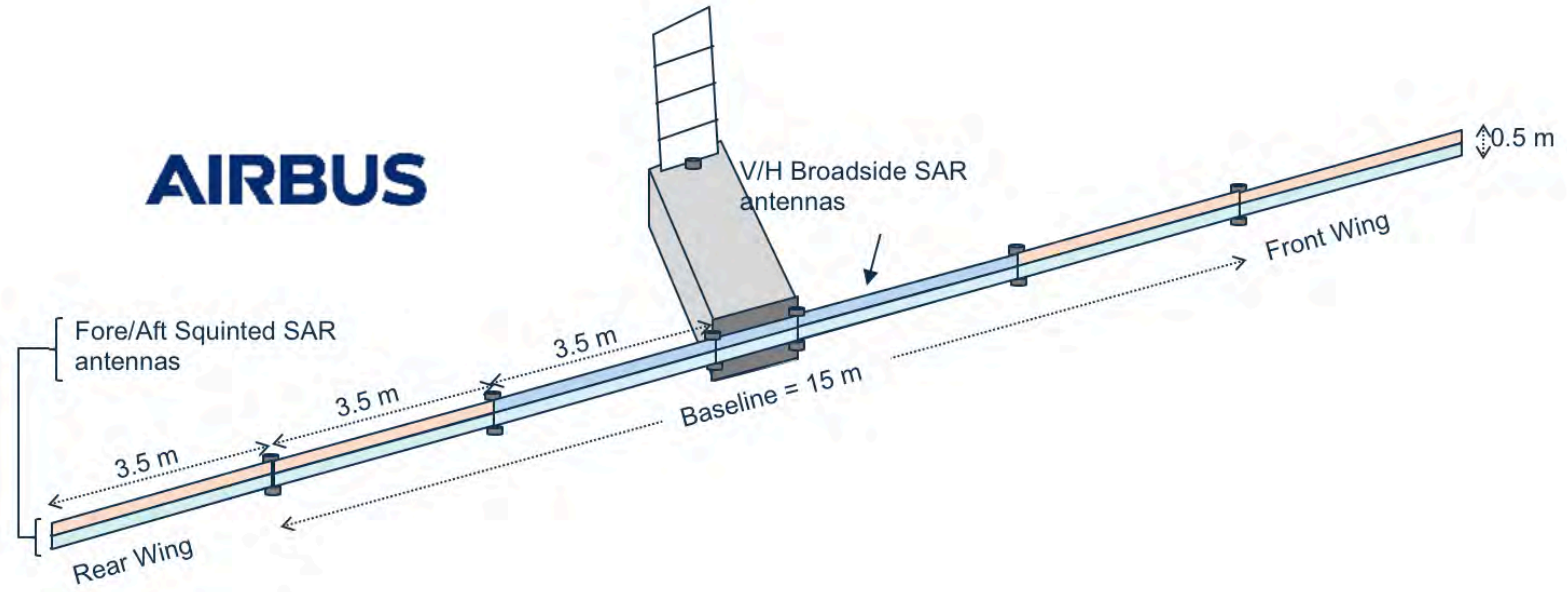


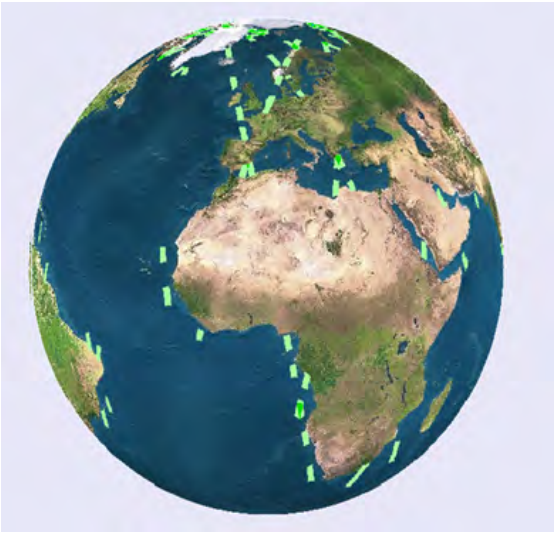

- High Science Readiness Levels
  - Airborne demonstrators & campaigns
    - Wavemill
    - OSCAR
  - L1-L2 inversion algorithm
    - to relate instrument performance

    to L2 errors & science objectives

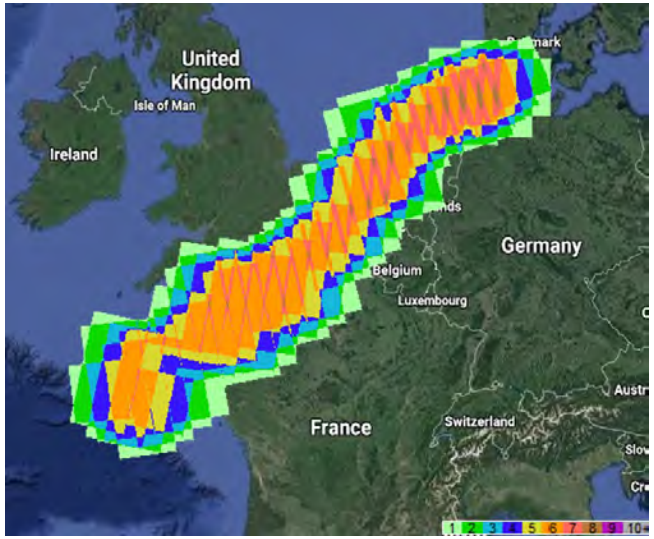
# EE11 technical concept & sampling



SEASTAR Fast-repeat phase (6 months)
Daily coverage after 1-day

- High TRL
- ESA main concern over:
  - Cost, cost, COST !

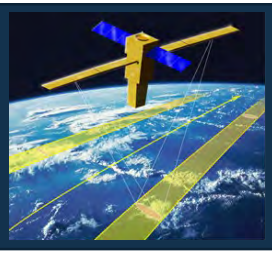


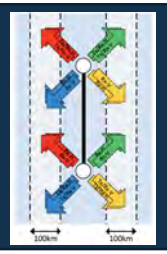

SEASTAR Systematic sampling phase
Coverage after 35 days

# SEASTAR costs ups-and-downs

- Good grasp of cost drivers thanks to:
  - Many years experience
  - Many iterations in response to different calls & constraints
  - Long partnership between academia and industry
    - NOC + Airbus UK
  - Critical support & funding from CEOI and UK Space Agency when needed

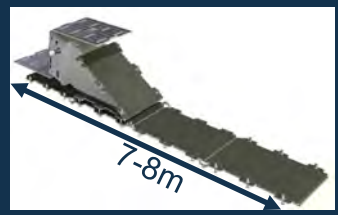
Wavemill concept (2013)
ESA Ocean Surface Current Mission (2015)





'Sentinel-1 class'

EE9
Nov 2015
120M€

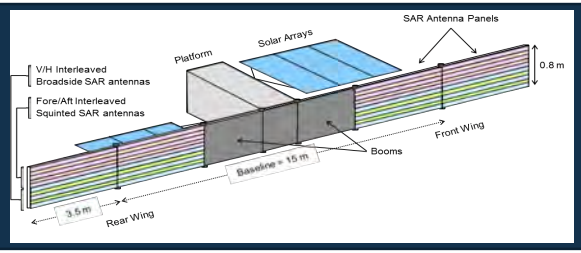



National Oceanography Centre + AIRBUS
Centre for EO Instrumentation

EE9 Revised
Dec 2016
150M€

X

EE10
Sept 2017
400M€




National Oceanography Centre + AIRBUS
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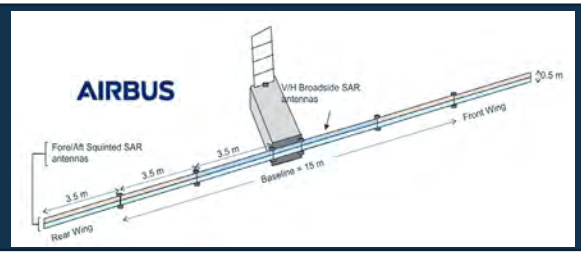
EE11
May 2020
450M€

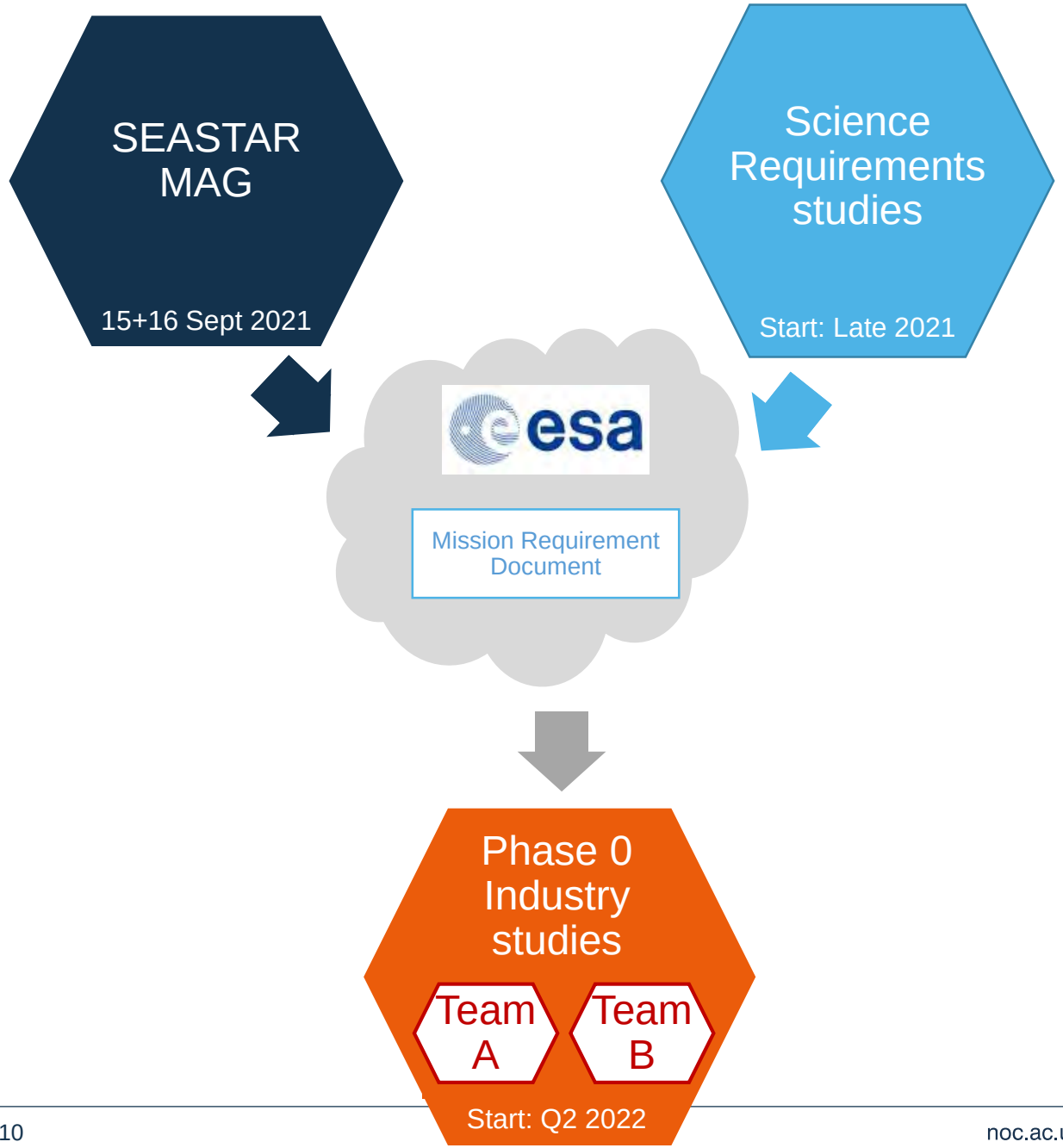



National Oceanography Centre + AIRBUS
Centre for EO Instrumentation

# What now ?

- SEASTAR MAG appointed

- ESA science & industry activities
  - Mission Requirement Document




## Milestones to launch

| | |
|---|---|
| 2023 | End Phase 0 selection<br>2 of 4 go to Phase A |
| July 2025 | End Phase A |
| | User Consultation Meeting<br>1 selected |
| 2031/2032 | Launch |

# Closing remarks

- SEASTAR is one of four candidates selected to enter EE11 Phase 0
  - commonalities & complementarities with EE10 HARMONY
  - the only non-atmosphere mission
    - rallying behind SEASTAR across the ocean, atmosphere, coastal and sea ice communities

- ESA concerns over cost
  - SEASTAR EE11 costs result from **finely tuned trade-offs** between science and industry
  - science/industry **decoupling** within ESA poses a real risk that costs will balloon
    - recognition that current Earth Explorer cost envelop inhibits most innovative concepts

- A long high-risk game
  - 8 years already, 10 more years to go
    - How to sustain a team for so long, especially with current skill shortages ?
- Support and funding from CEOI and UK Space Agency has been critical

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# Thank you – any questions ?

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