

# UMISAS: NEXT GENERATION SYNTHETIC APERTURE SONAR FOR UxV MINEHUNTING

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EXAIL ROBOTICS

# OUTLINE

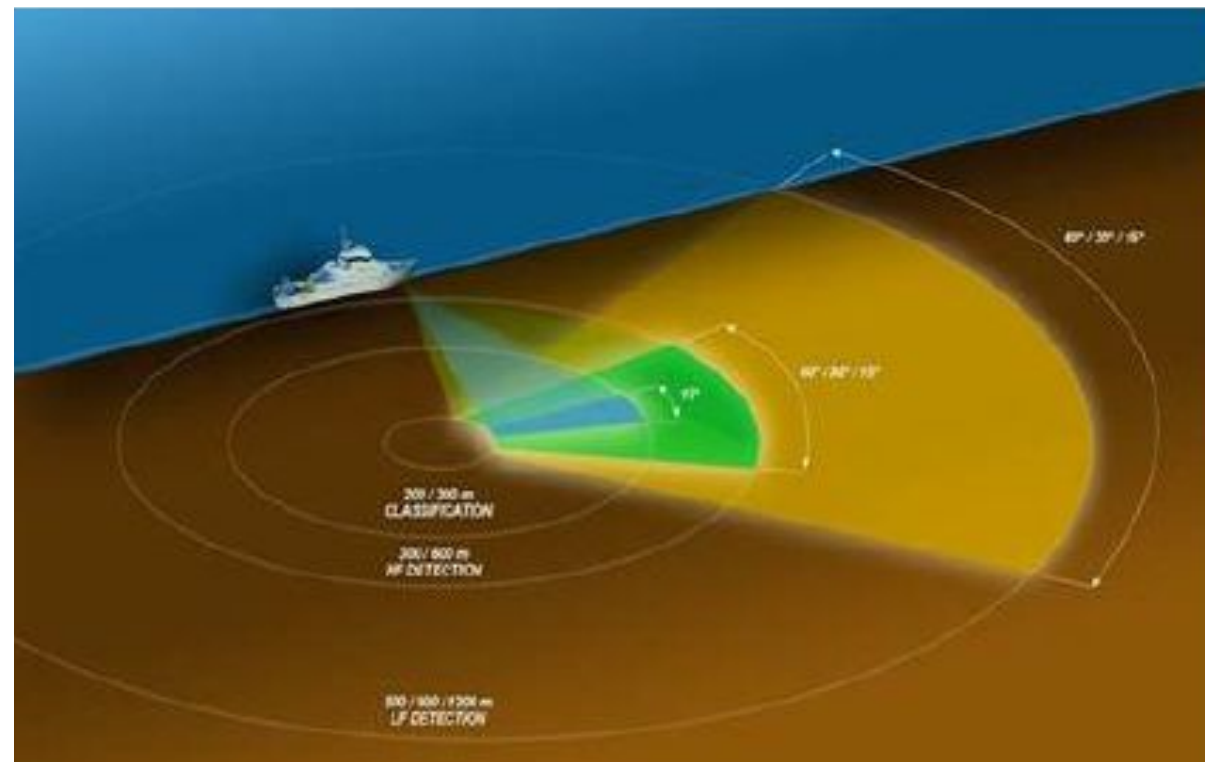
1. Transformation of MCM sonar

2. UMISAS design features & qualification tests results

3. UMISAS dataflow

4. Conclusion

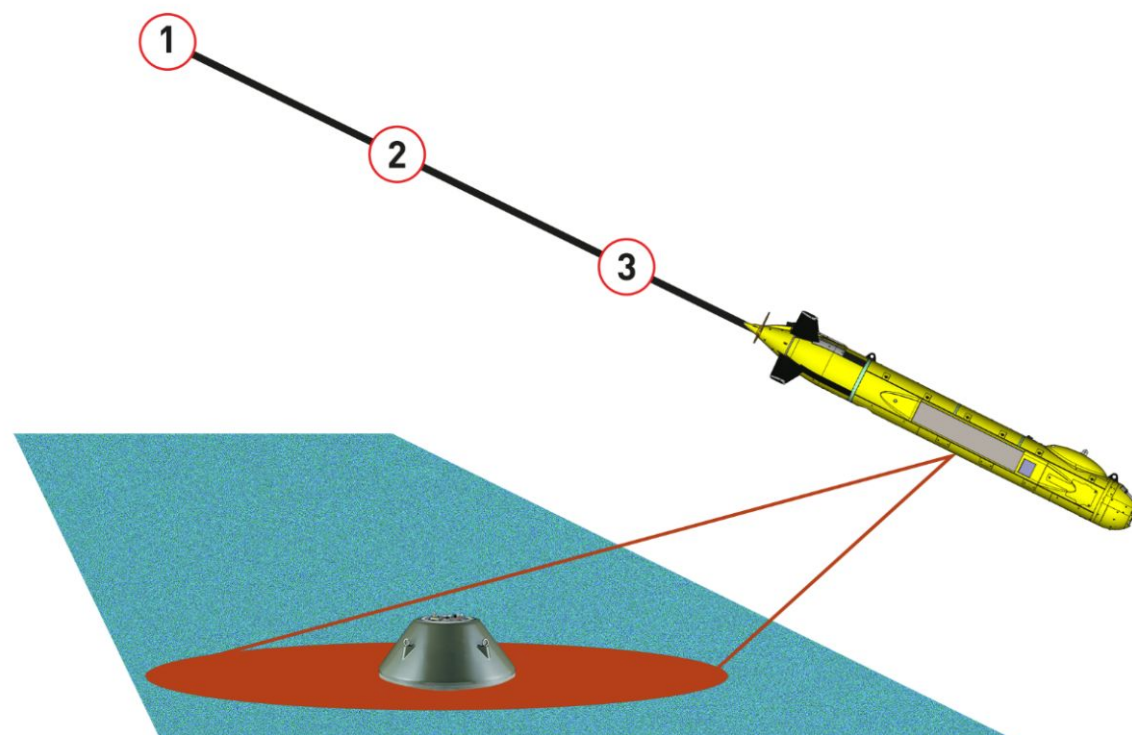
# TRANSFORMATION OF MCM SONAR



## Yesterday: Dedicated forward-looking sonars on MCMVs

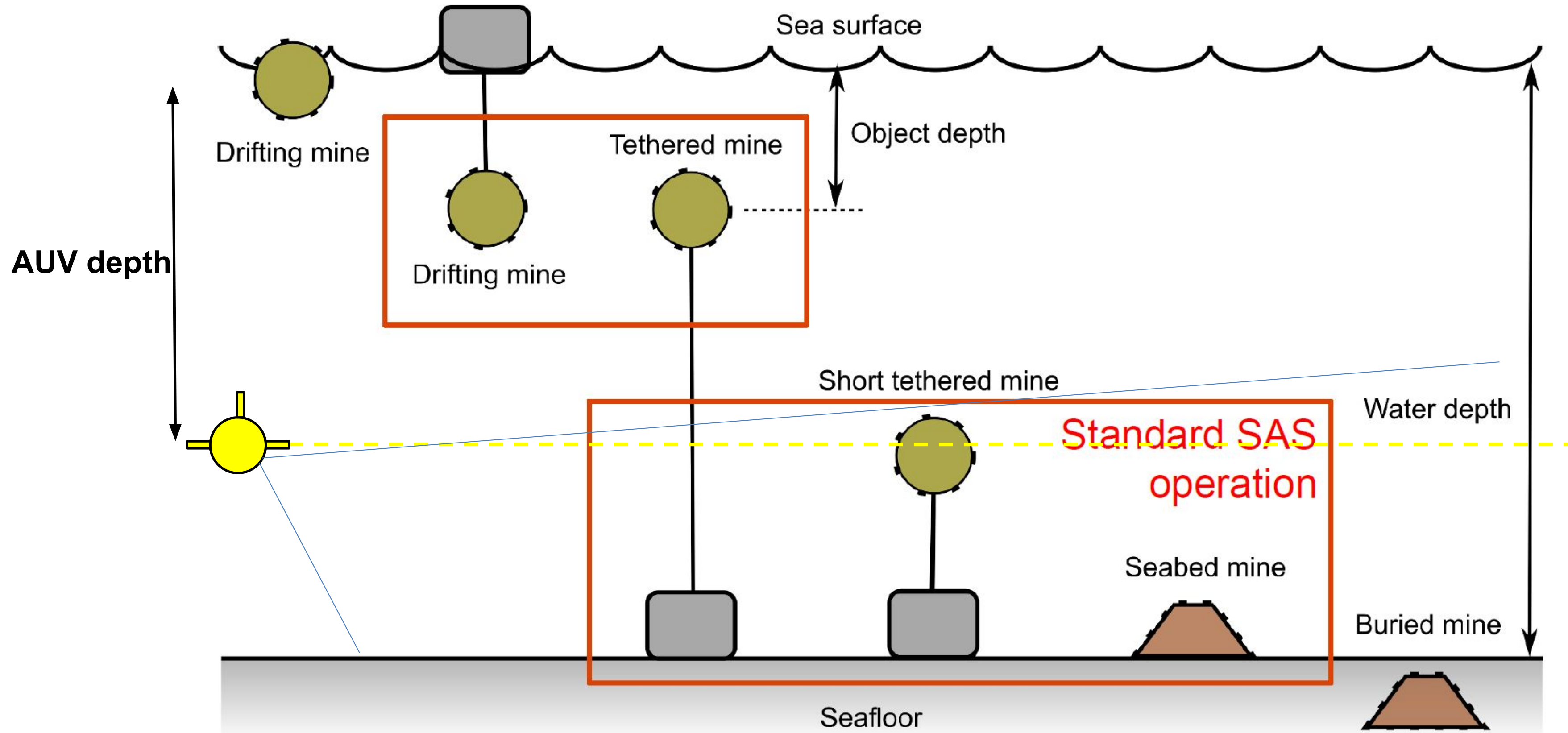
- Strong dependency on sea state, water depth, sound propagation conditions, need for mechanical hoist/stabilisation...
- Very complex and expensive sonars, nevertheless rather coarse resolution (limited by the physics).

## Today: Variable Depth Side-Looking Sonars on AUVs (or TUVs).

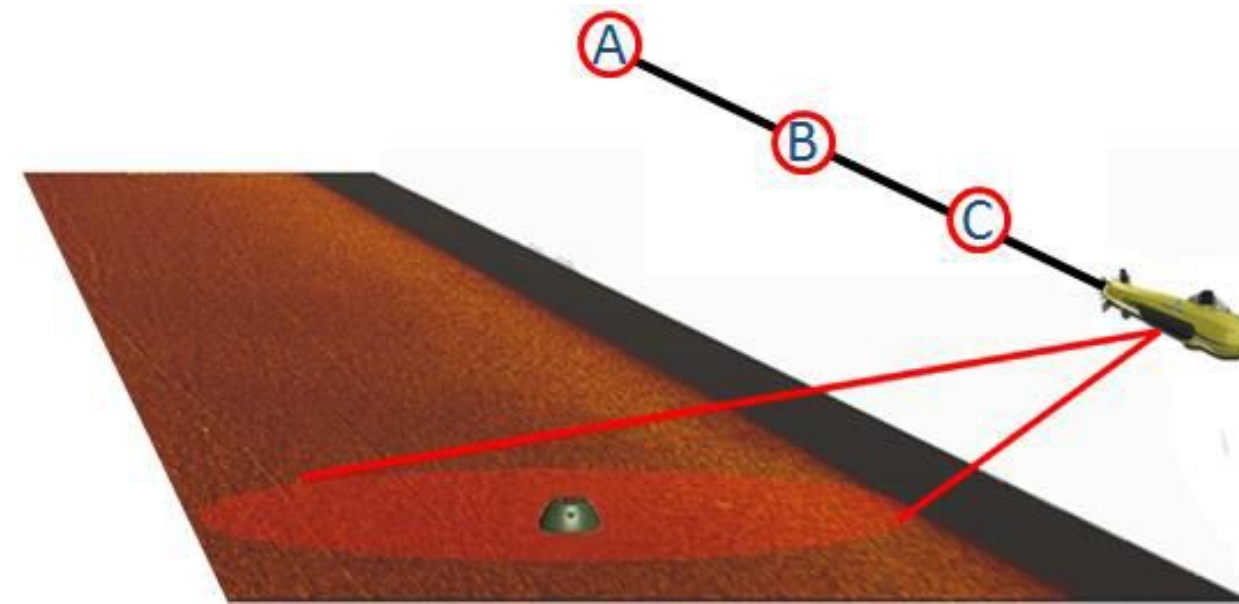
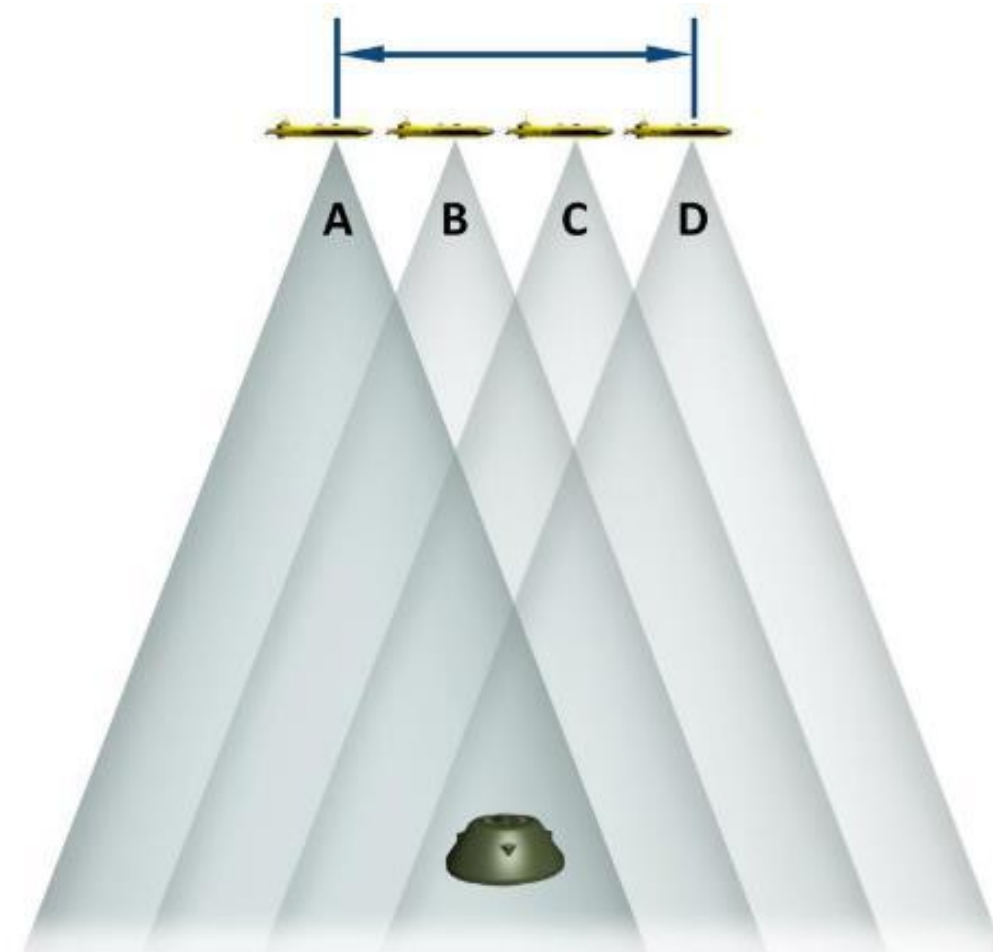


- Optimises depth in water column, thus reduce dependency on sea state, sound speed profile.
- Naturally stable platform equipped with high performance motion sensing.
- Exploit the platform displacement to form very high resolution via synthetic aperture sonar.
- Gain in resolution and cost by a factor 20x or more.
- Multiple uses (MCM, Survey, Seabed Warfare,...).

# MINE THREAT ADDRESSED BY SAS



# WHAT IS SYNTHETIC APERTURE SONAR?



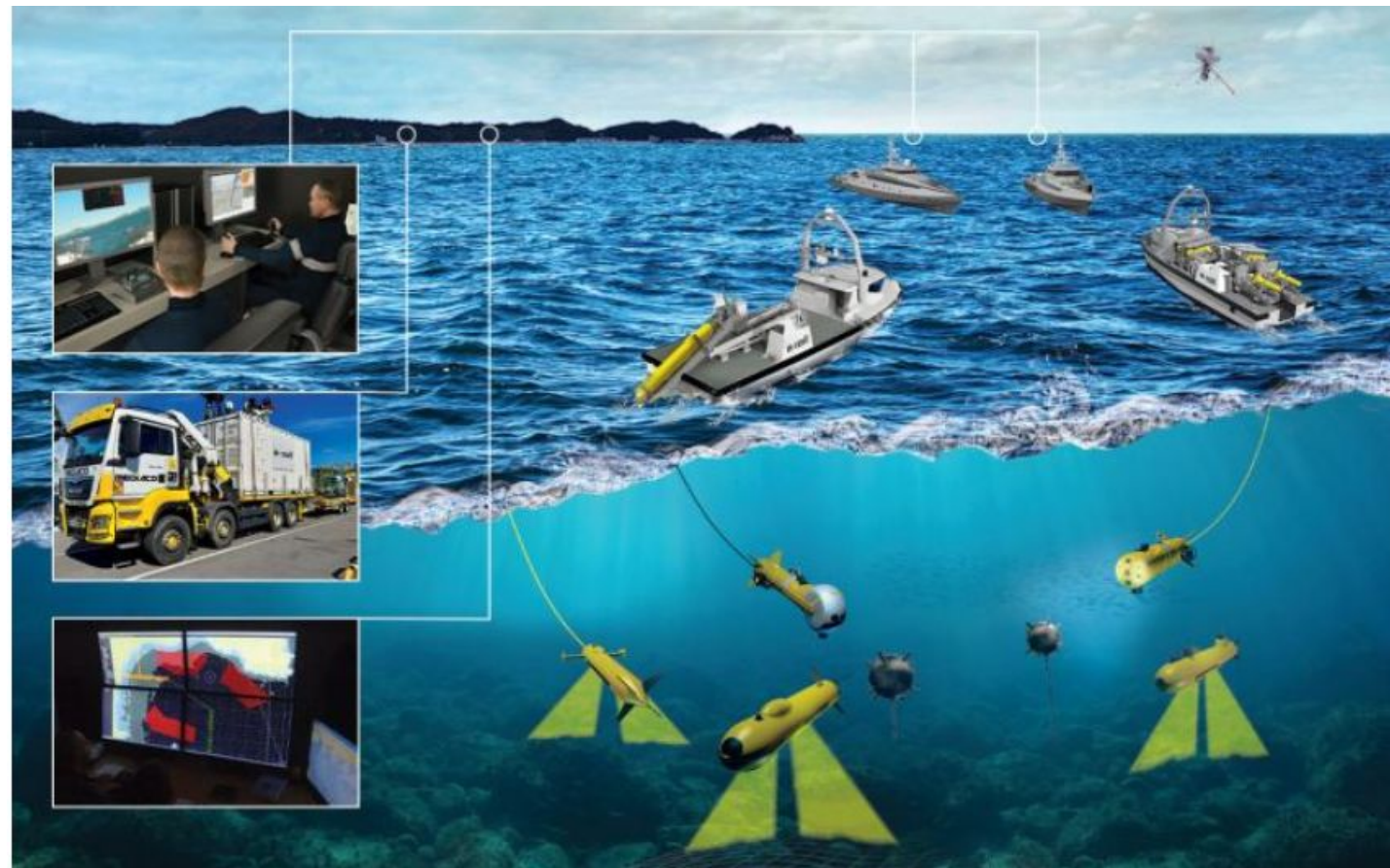
Principle: Form an extended array by displacing a smaller one // to itself.

Processing consists of

- Array Shape Estimation/Platform Positioning using INS+Interferometry
- Wideband Near Field Beamforming



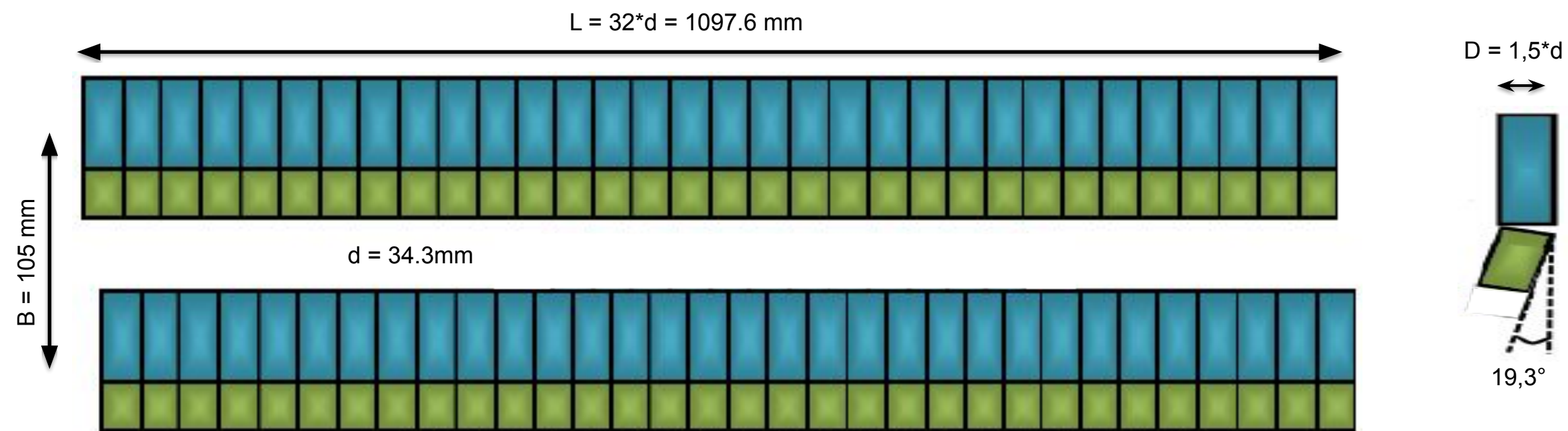
# UMISAS 120 FOR A18-M MID-SIZE AUV



- A key component of the UMIS EXAIL Unmanned MCM solution.
- SAS designed specifically for A18-M in a tight coupling approach.
- Will equip the Navies from BEL, NLD, LAT (over 45 units sold in 120 and 240 configurations).
- **Best level of performance:**
  - Near ID resolution (1.5cm x 3cm) for optimized D&C in harsh environments.
  - High Area Coverage Rate 0.5nm<sup>2</sup>/h including nadir gap-fill with track overlap:
    - 3-4 knots typical.
    - 220-180m range.
  - High resolution co-registered bathymetry.

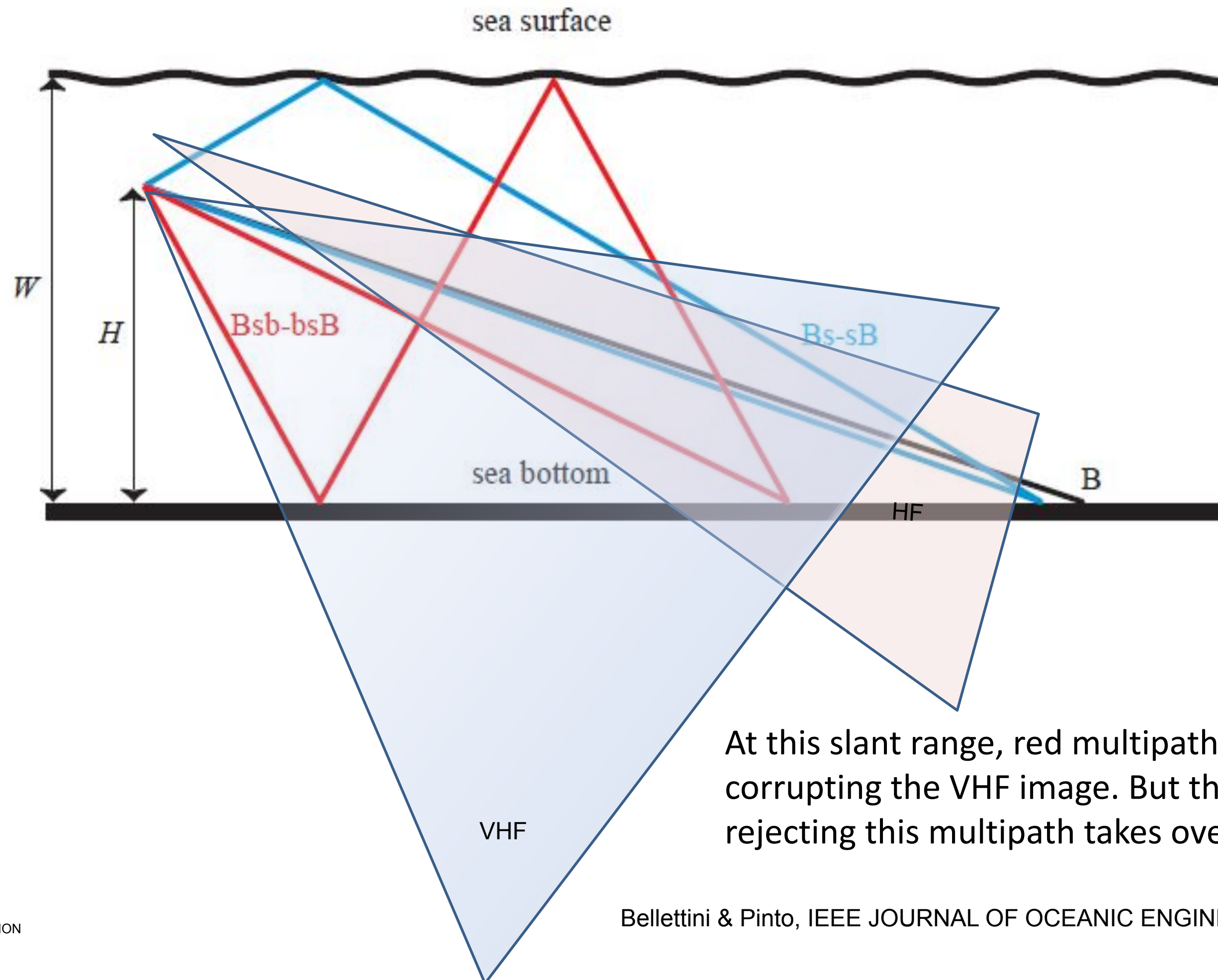


# ARRAY DESIGN OPTIMIZED FOR HARSH ENVIRONMENTS



- Dual frequency HF 250kHz/ VHF 330kHz dual row array design
  - High resistance to multipath
  - 220dB HF source level for SNR in warm waters due to directivity gain
- Ultra-wideband sonar (60kHz Bandwidth for both HF and VHF)
- Interferometric array with  $20\lambda$  baseline for high accuracy depth finding.

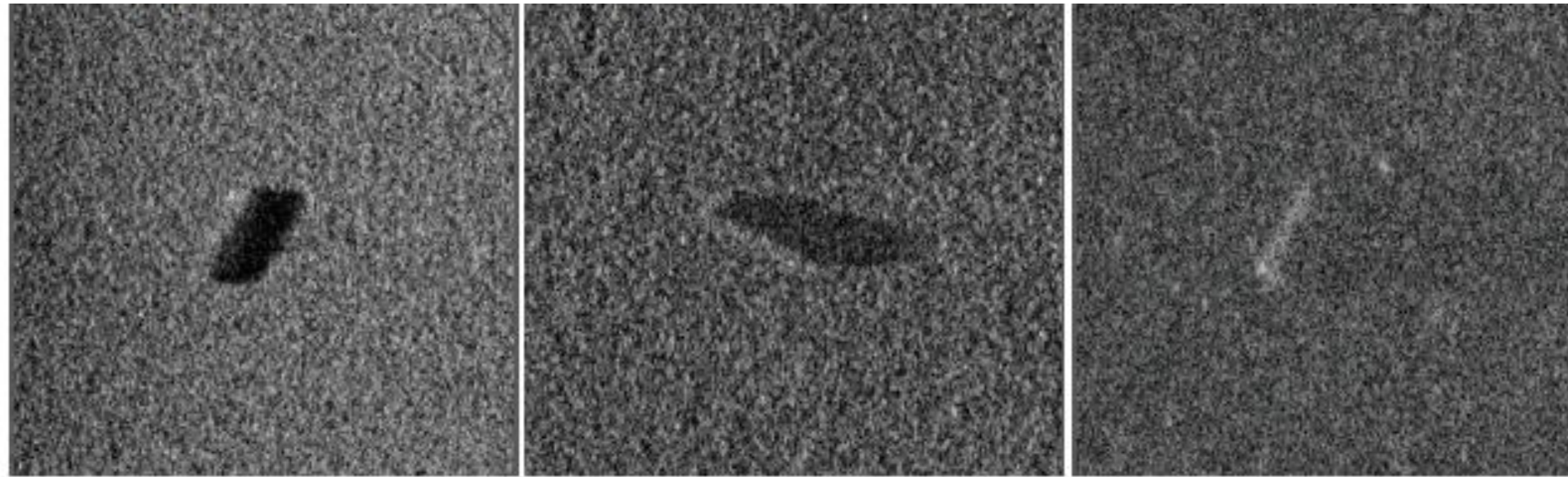
# MULTIPATH REJECTION



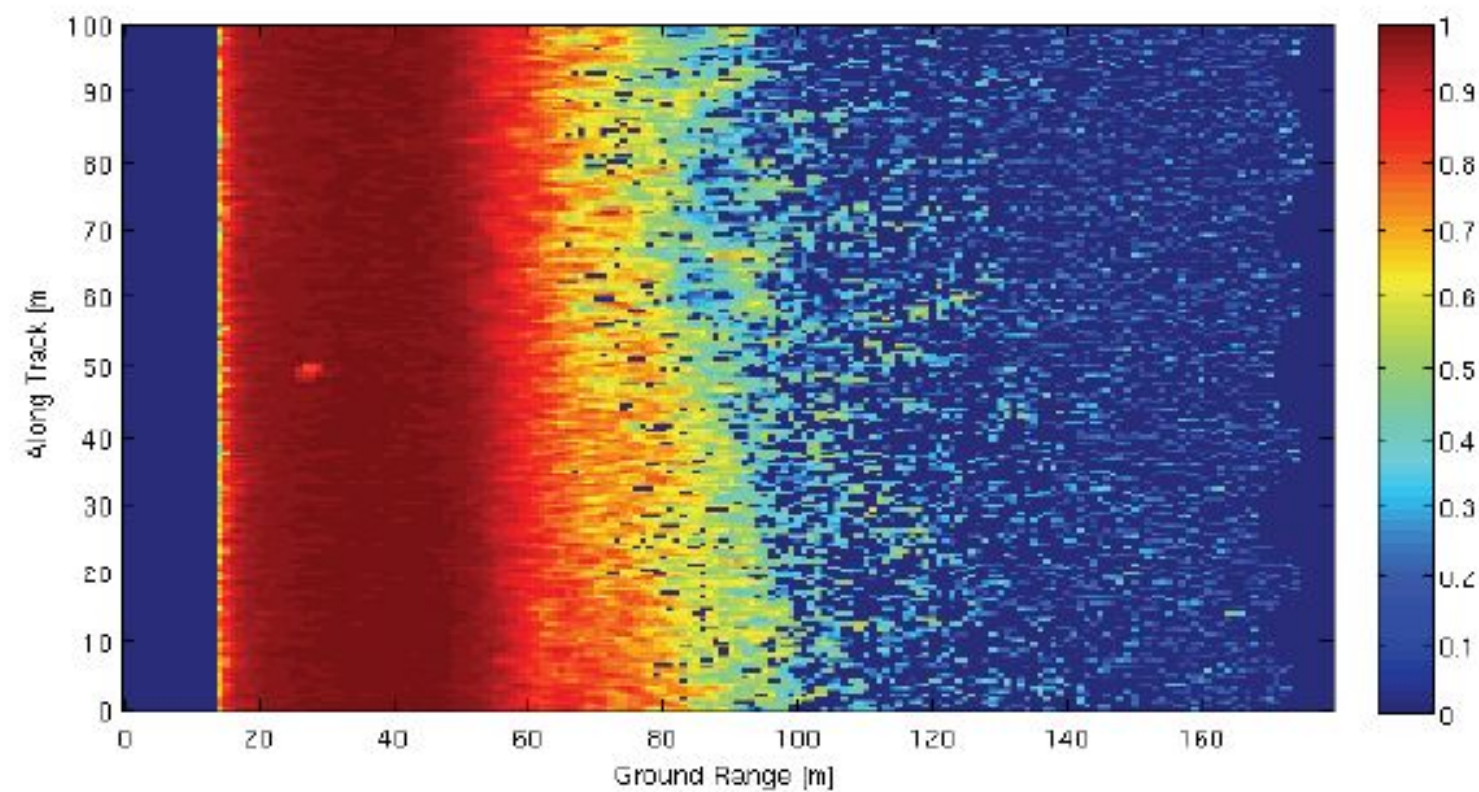
At this slant range, red multipath enters the VHF beam, corrupting the VHF image. But the HF sonar which is capable of rejecting this multipath takes over.



# USE OF INTERFEROMETRIC COHERENCE



*Fig.2: 10 m x 10 m sonar mug shots of MP80 target in shallow water (24 m depth).  
Target slant range is from left to right: 31 m, 76 m and 121 m.*



*Fig.4: Shallow water interferometric SSS coherence.*

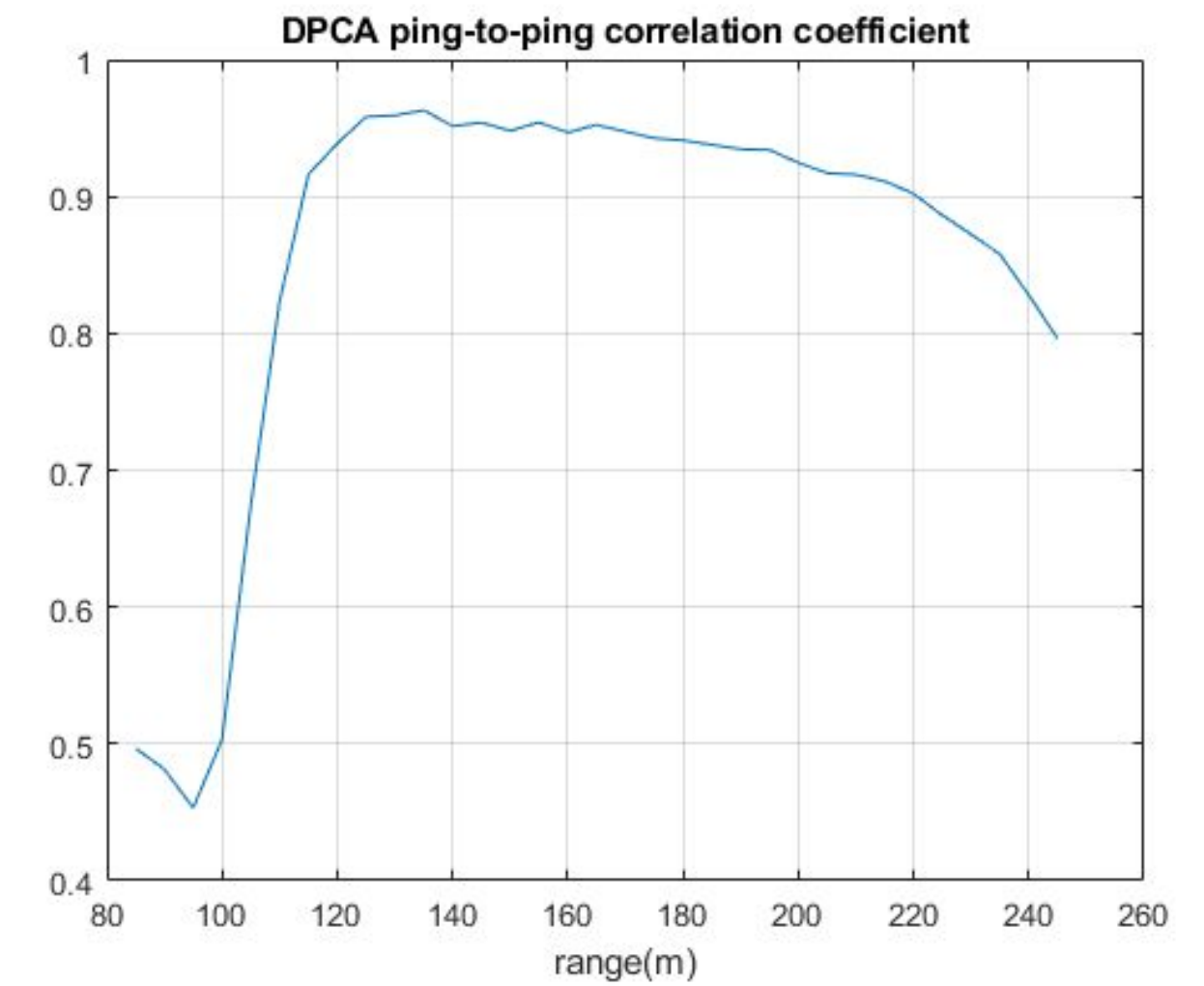
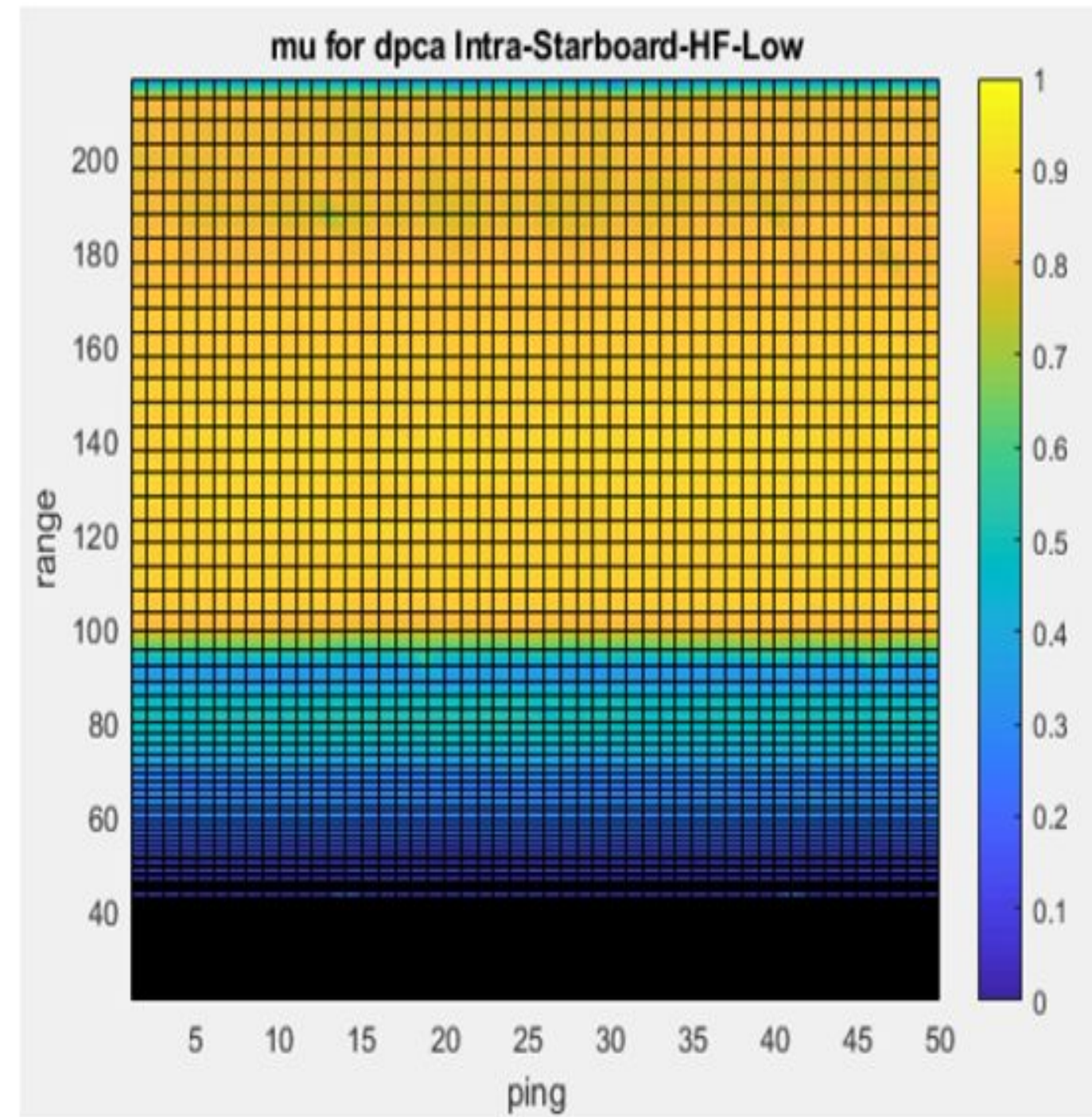
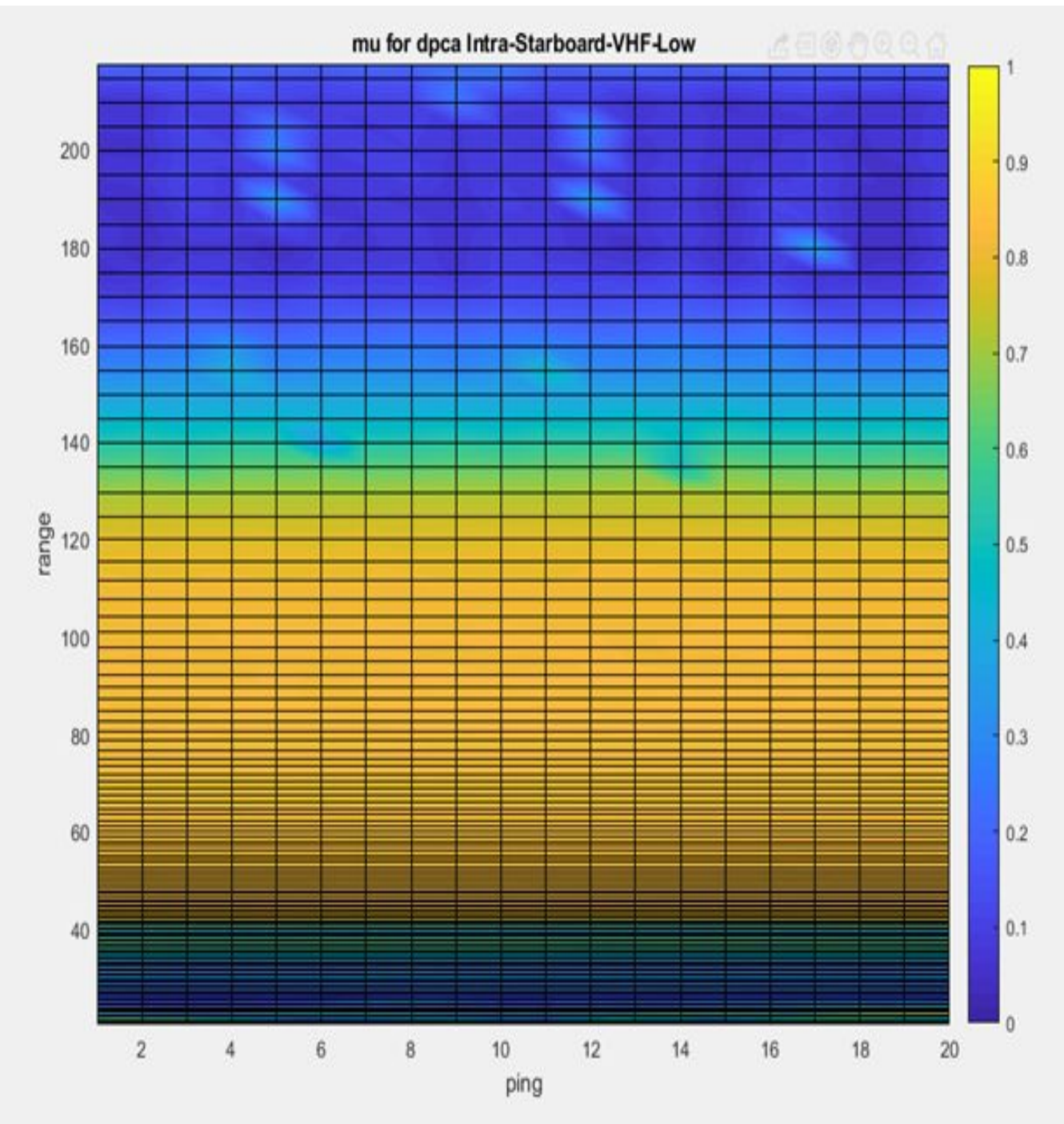
ASSESSMENT OF SHALLOW WATER PERFORMANCE USING  
INTERFEROMETRIC SONAR COHERENCE

Stig A. Synnes, Roy E. Hansen, Torstein O. Sæbø

Norwegian Defence Research Establishment (FFI), PO Box 25, N 2027  
Kjeller, UAM 2009



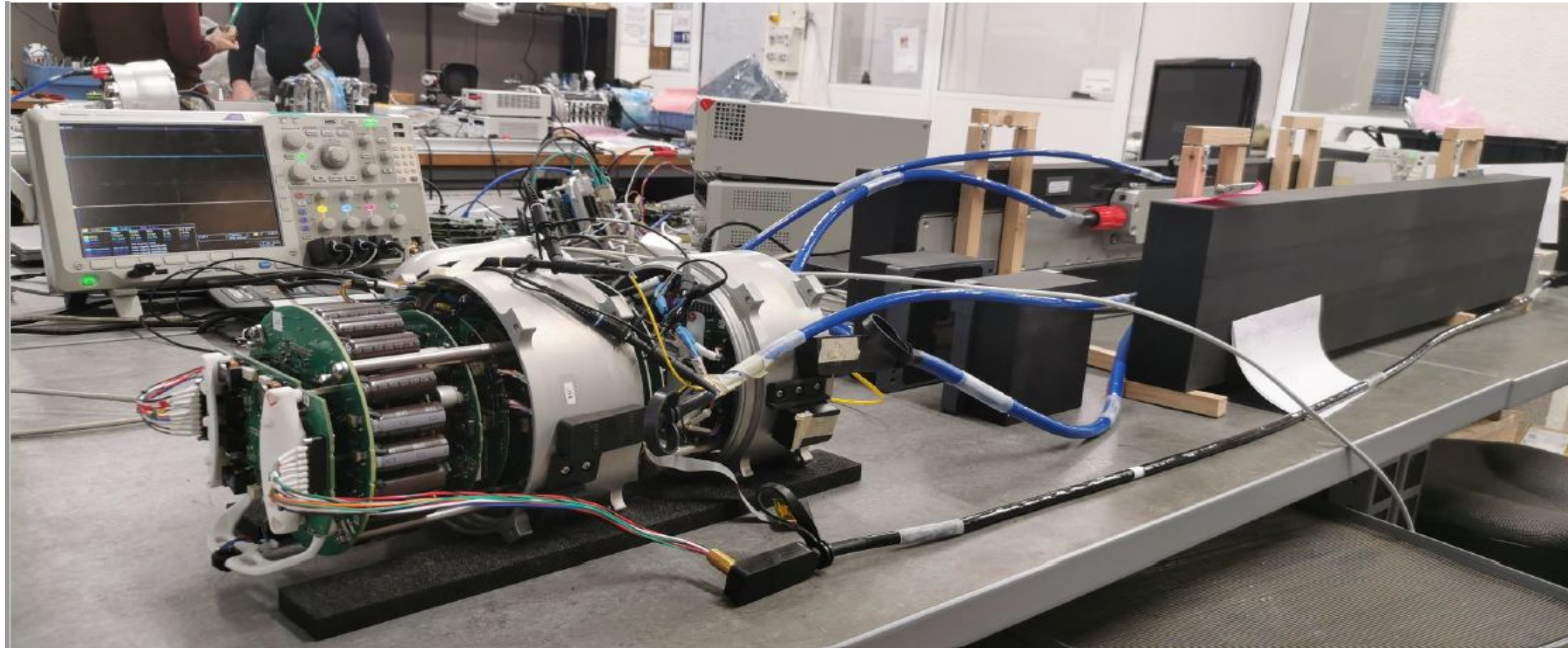
# SHALLOW WATER COHERENCE RESULTS



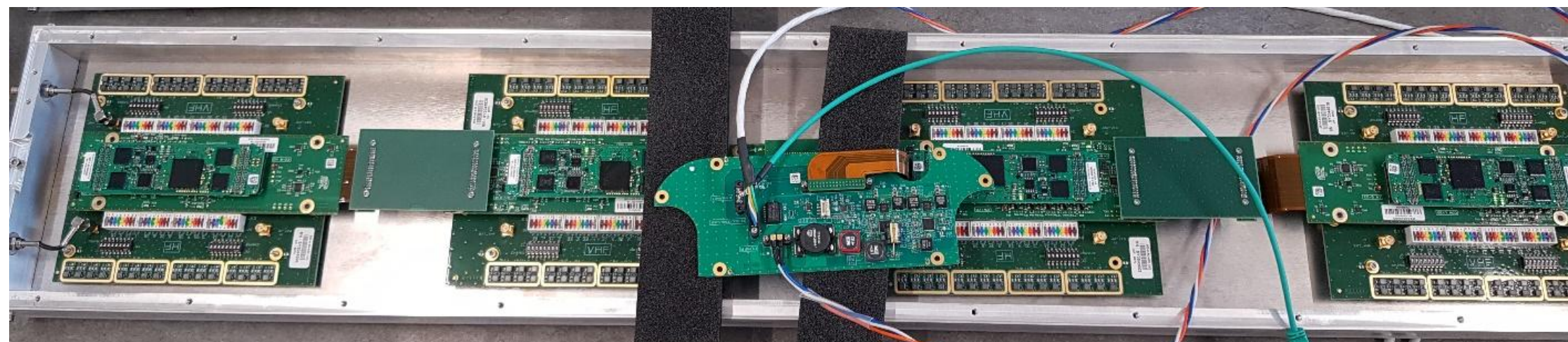
H=20m, W=30m, sandy bottom



# UMISAS DETAILED DESIGN

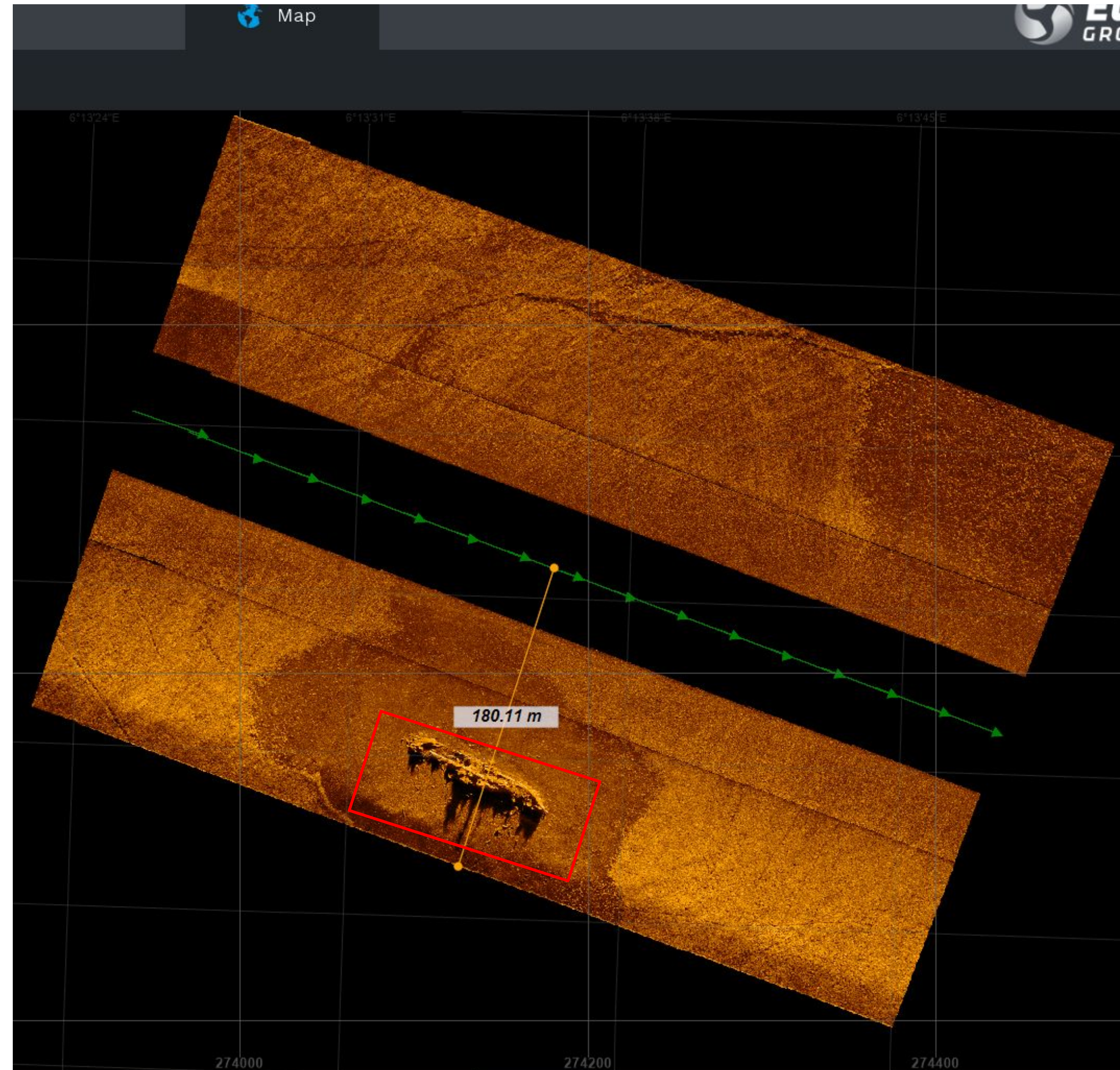


- Wideband piezo-composite acoustic arrays
- Low power electronics integrated directly in the array cavity and miniaturized pressure vessel.
- 150mW/channel ADC.
- Real-time SAS processing on GPU





# QUALIFICATION TESTS HYÈRES, FRANCE

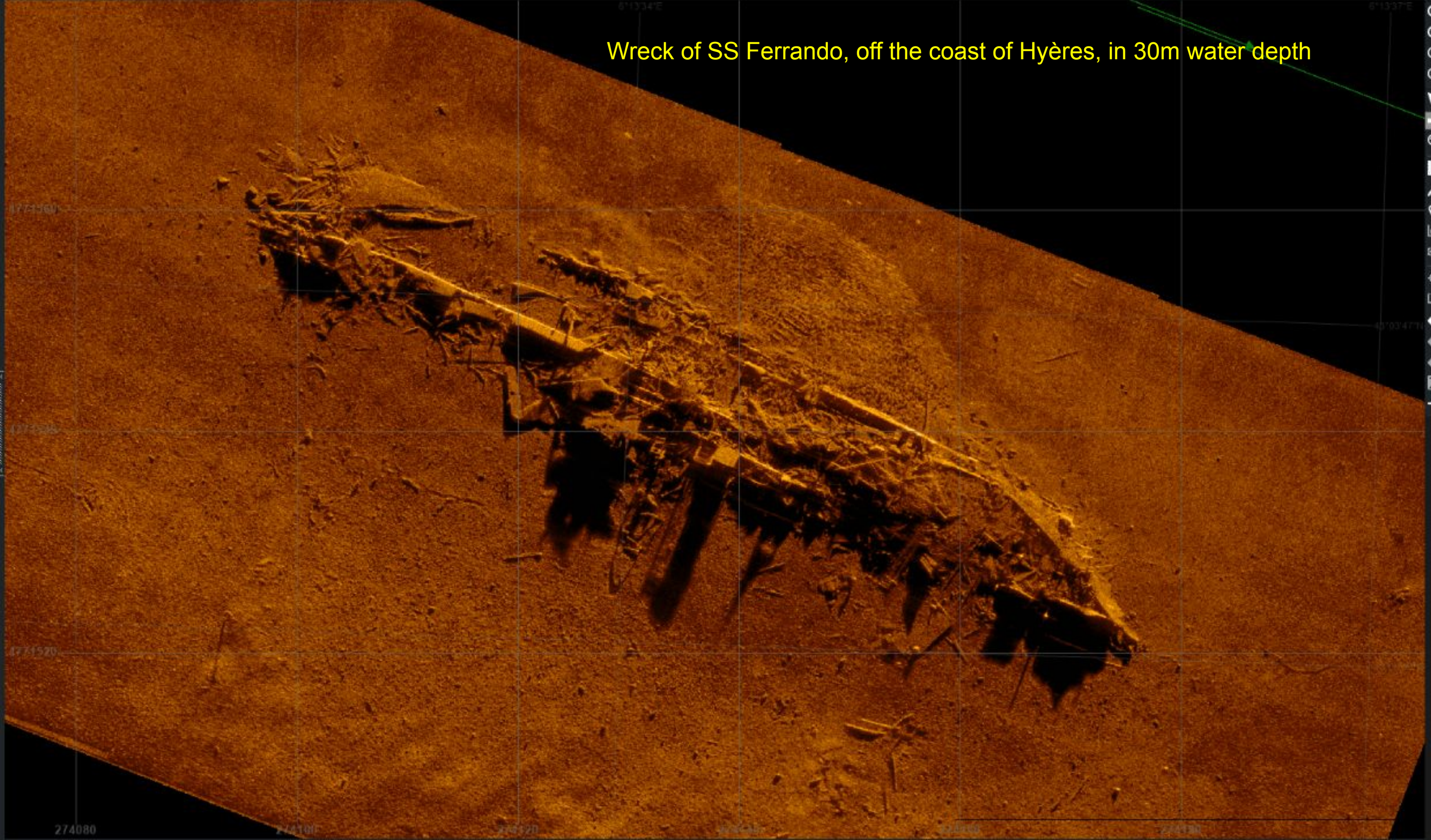




Universal Transverse Mercator  
Zone 32 WGS84 N  
8.2 cm/p

North	4771553.90m N
East	274143.14m E
Lat	43°03'47.08"N
Lon	6°13'34.57"E

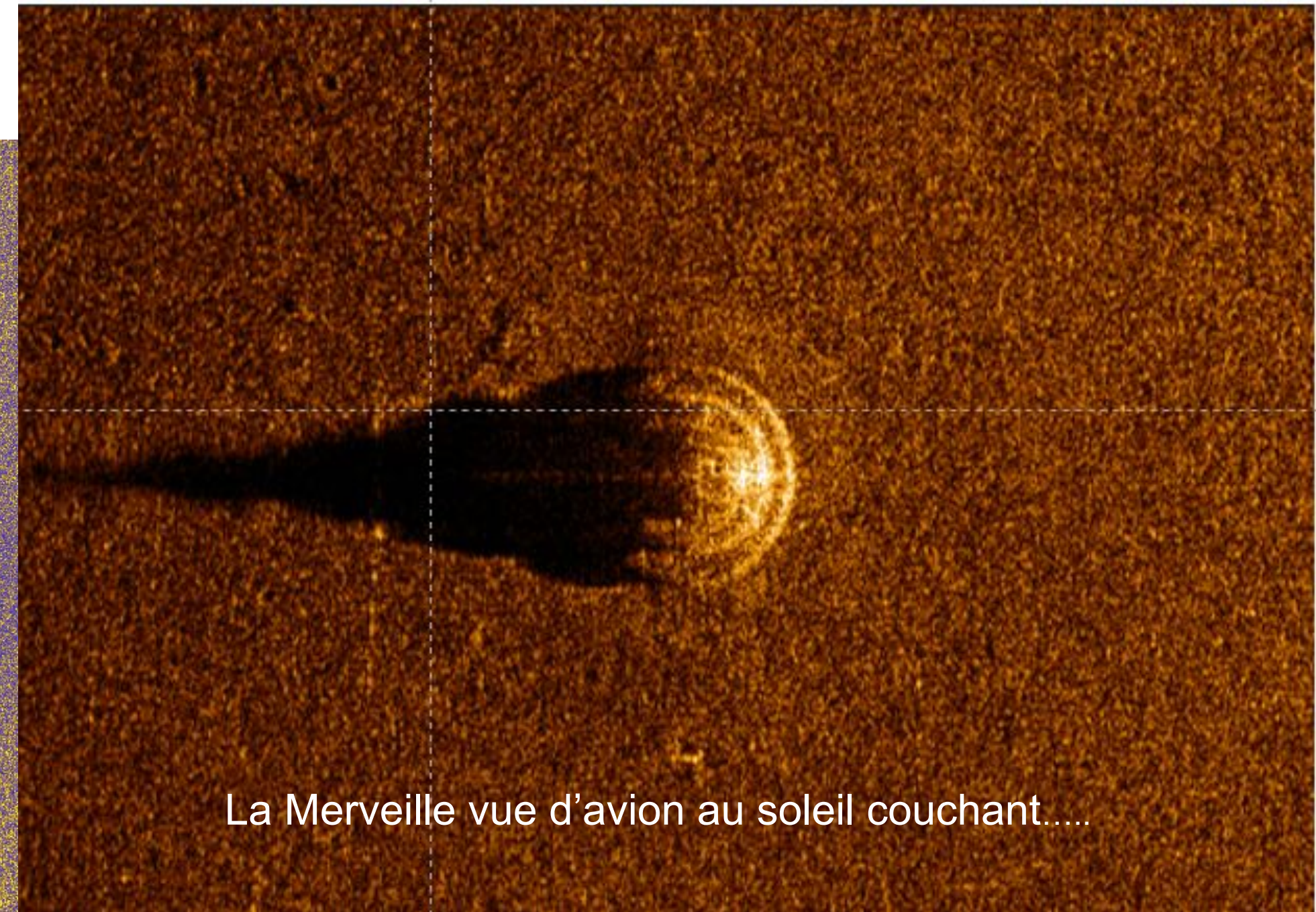
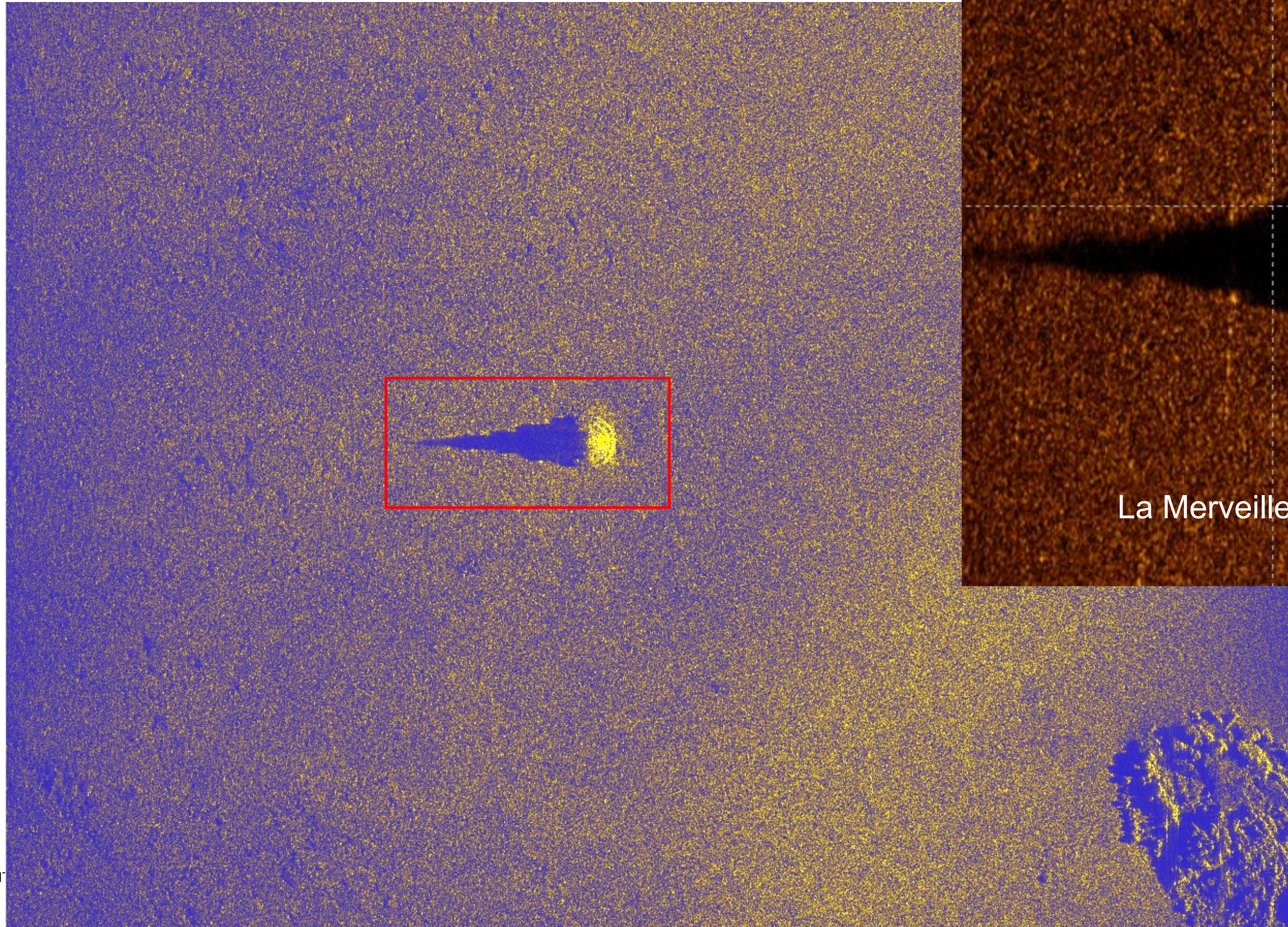
- Map Root
  - Annotation
    - Features
    - SeaClass
    - Contacts
    - Files
      - 103845\_vhf\_starboard\_0000
    - Databases
  - Vectors
  - Mission
  - Navigation
    - Vehicle
      - Extended
  - Sensors
    - Video
    - Sidescan
      - 103845\_vhf\_starboard\_0000
      - 103845\_vhf\_starboard\_00001
      - 103845\_vhf\_starboard\_00002
      - 103845\_vhf\_starboard\_00003
    - Bathymetry
    - Subbottom
  - Imagery Video
  - Imagery Sonar
    - Sidescan (dB)
      - sas5cm\_tvg\_103845\_vhf\_sta
      - sas5cm\_tvg\_103845\_vhf\_sta
      - sas5cm\_tvg\_103845\_vhf\_sta
      - sas5cm\_tvg\_103845\_vhf\_sta
    - Bathymetry DTM (m)
  - Background



Wreck of SS Ferrando, off the coast of Hyères, in 30m water depth



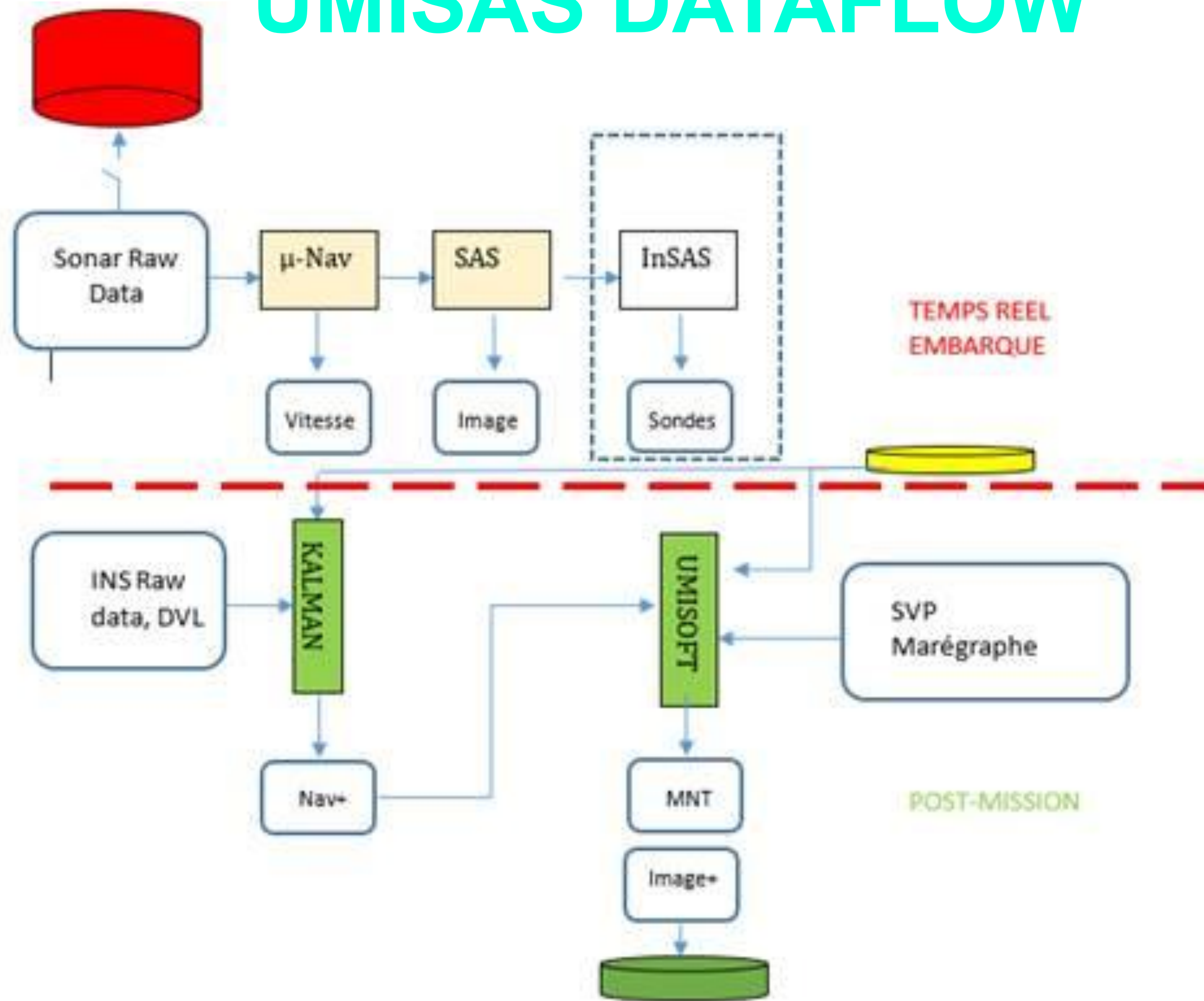
# SHADOW CLASSIFICATION PERFORMANCE



La Merveille vue d'avion au soleil couchant....



# UMISAS DATAFLOW



# CONCLUSION

1. UMISAS is designed on purpose for the A18-M AUV, optimised for harsh environmental conditions. (shallow water, warm water).
2. UMISAS ready for acceptance testing and operational trials
3. EXAIL has already gathered significant operational experience on SAS performance challenging conditions from other programs run with COTS SAS (A18-D, NLD OT&E ).
4. The highly integrated approach will allow to address the still open issues in SAS at the most appropriate place in the system: AUV mission planning, AUV guidance & control & navigation, SAS, ATR, autonomy, ....