

# OPEN MINDED NAVAL SYSTEMS

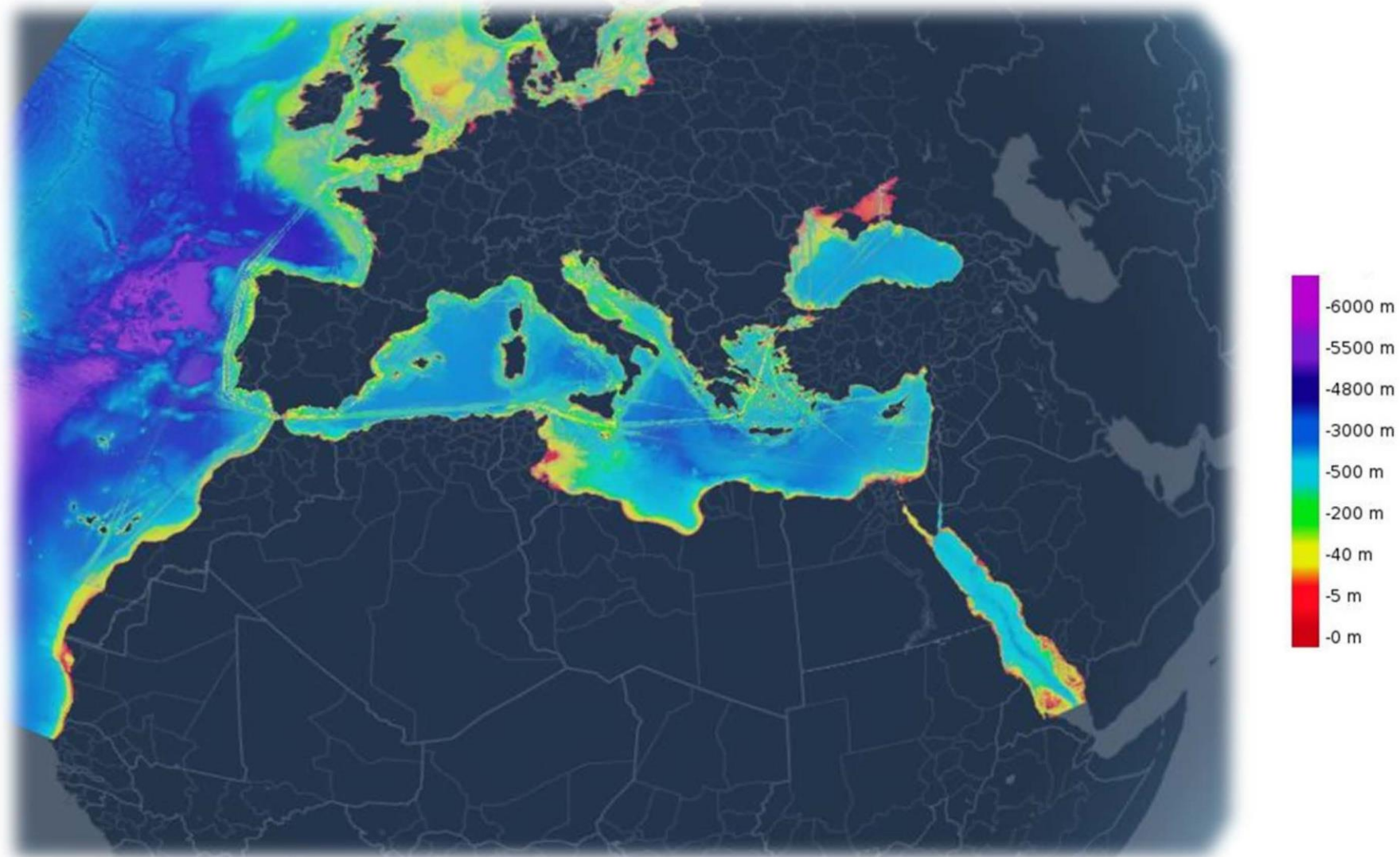
**Sphere® Surveillance  
Integrated Sonar Suite for U212 NFS**

Combined Naval Event – 22 May 2024

**ELAC**   
**SONAR**

A COHORT PLC COMPANY

# RENEWED INTEREST IN THE DEPTHS



## SEA COMMUNICATION LINES

90% of the world's freight traffic travels by sea



# CHALLENGES FOR SUBMARINE SONARS TODAY

Special mediterranean sea environmental conditions

ELAC SONAR – 100 years of experience in submarine sonar systems



- ✓ Heavy traffic condition
- ✓ Warm waters
- ✓ Acoustic Layer
- ✓ Marine Mammal
- ✓ Quieter & Stealthier submarine

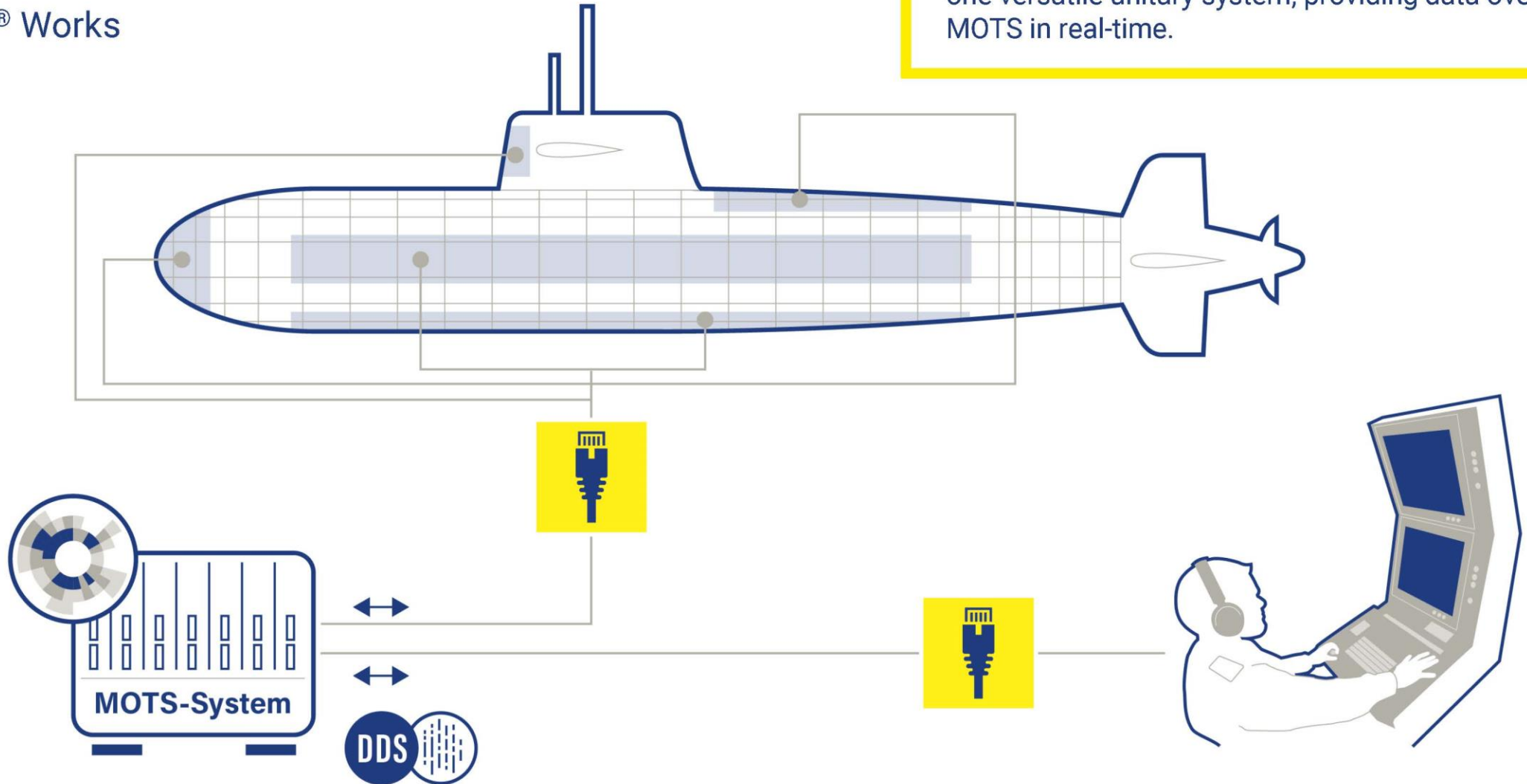
**Sphere® Vertical Aperture Array(VAA)**  
Provides required S/N in complex Env.



# SPHERE® VERTICAL APERTURE ARRAY (VAA)

How Sphere® Works

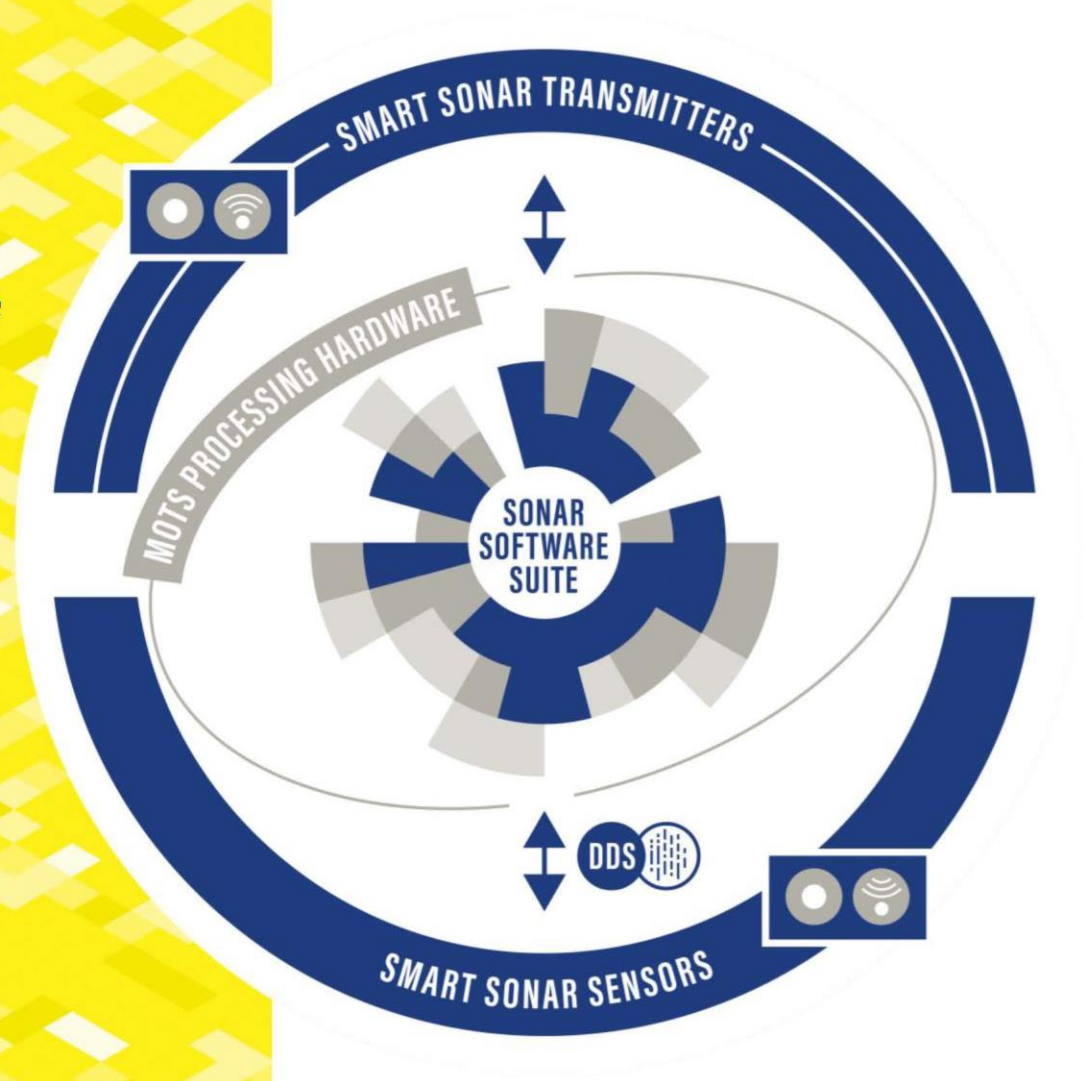
Sphere® by ELAC SONAR integrates – with only one click – formerly separated sonar systems into one versatile unitary system, providing data over MOTS in real-time.



# INTRODUCTION

## The Concept of Sphere®

- ✓ Systems based on middleware Open Architecture
- ✓ Systems Based on Sphere® Software Modules
- ✓ Systems Based on digital Smart RX Modules
- ✓ Systems Based on digital Smart TR Modules



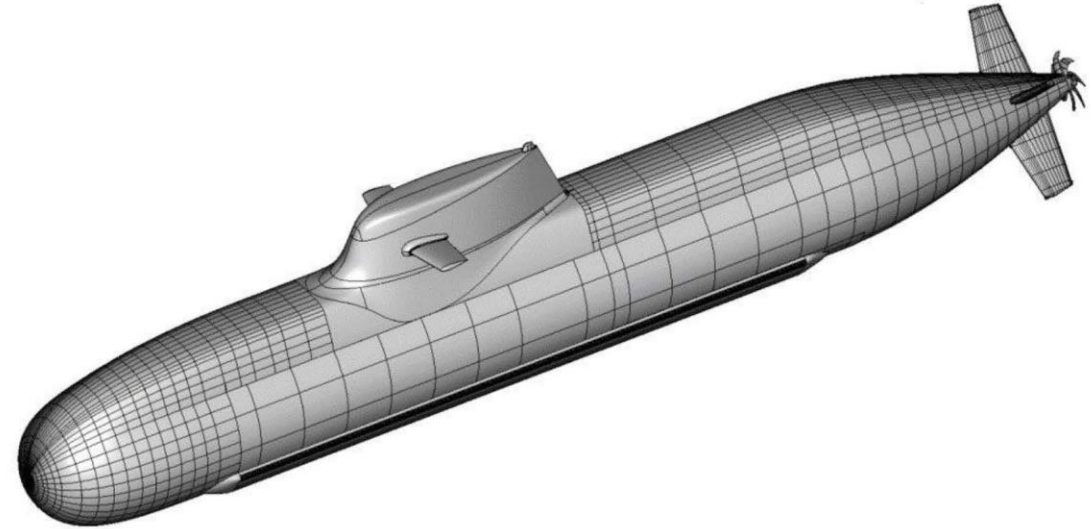
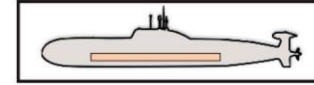
**SPHERE** ®

**SMART TRANSDUCER**



# SMART VERTICAL APERTURE ARRAY (FAS)

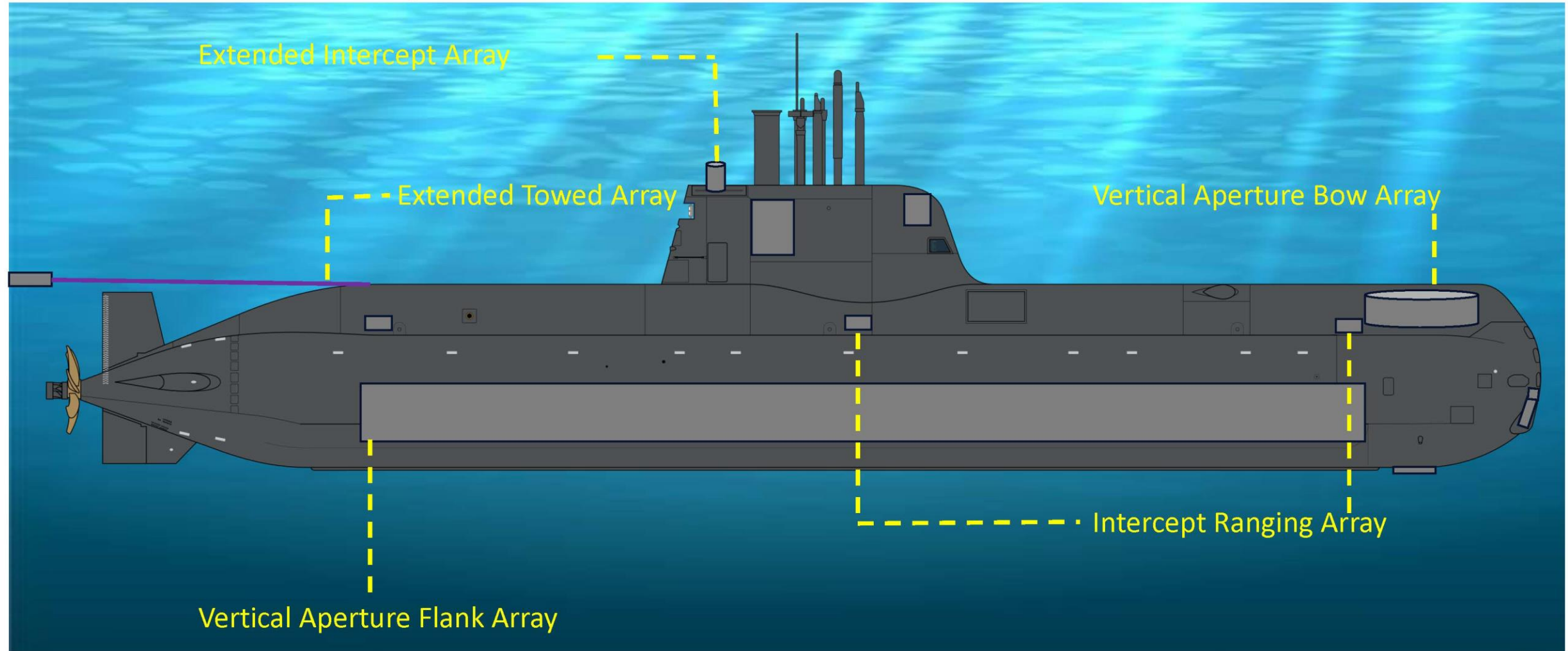
- Easy Installation due to module concept
- Flow optimized module shape (no Acoustic Window)
- Building blocks - number of modules driven by the hull
- Baffling included in Module to Reduce ship own noise





# SPHERE® FULLY INTEGRATED SONAR SUITE

Vertical aperture passive arrays

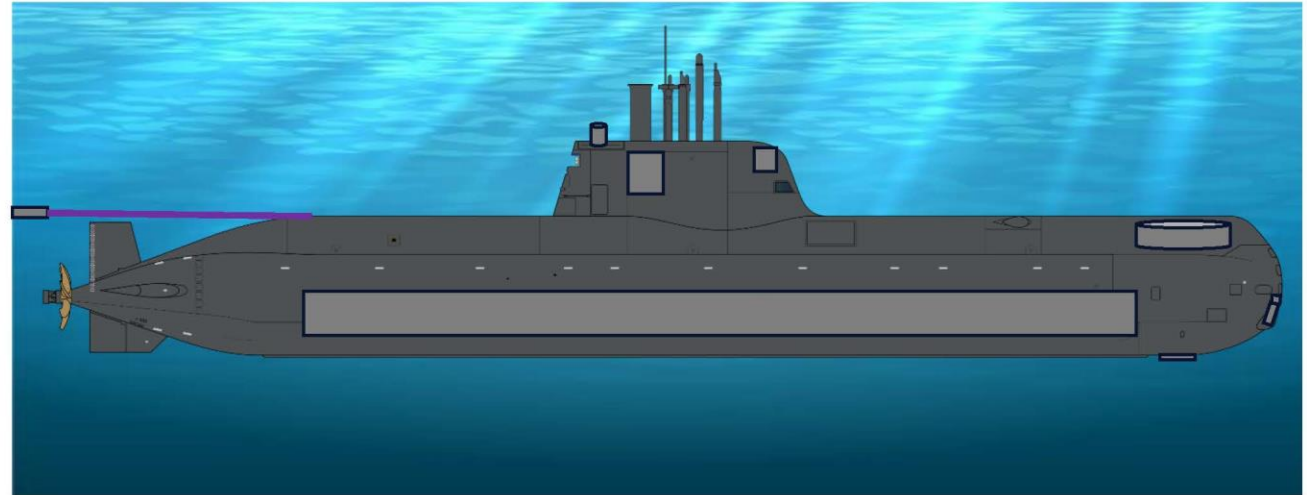


# SPHERE® FULLY INTEGRATED SONAR SUITE

Vertical aperture passive arrays

Vertical Aperture Arrays:

- 360 degree **full spatial coverage**
- 10 Hz – 100 kHz passive **full spectral coverage**
- High level **full dynamic coverage**
- Detection on all beams **full temporal coverage**

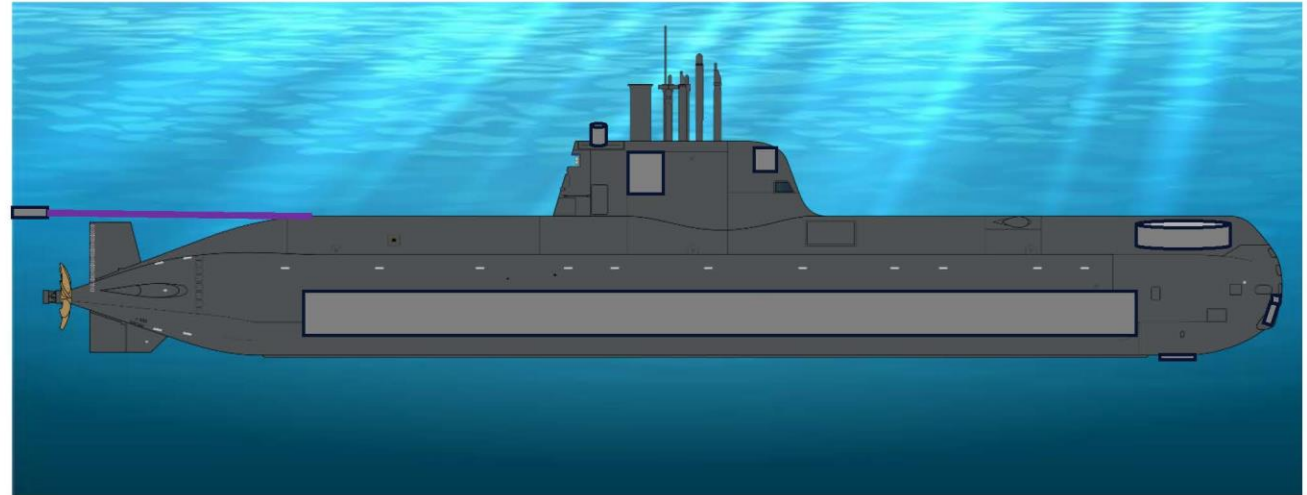


# SPHERE® FULLY INTEGRATED SONAR SUITE

Vertical aperture passive arrays

## Passive surveillance:

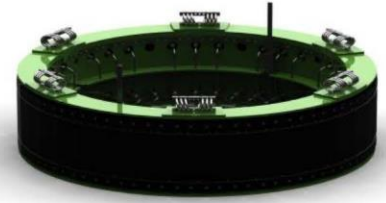
- Broadband, narrowband, DEMON, transient & intercept detection
- Wave curvature ranging (WCR)
- Broadband, narrowband, DEMON & intercept tracking
- LOFAR, DEMON, transient & intercept analysis
- DB based classification
- Target Motion Analysis (Bearing, F-TMA, X-TMA)



# SPHERE® FULLY INTEGRATED SONAR SUITE

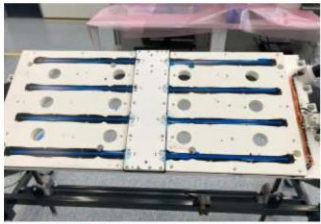
Vertical aperture passive arrays

Bow Array



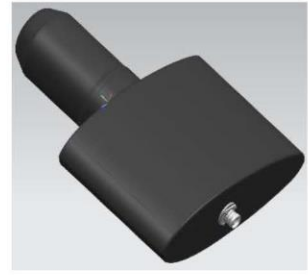
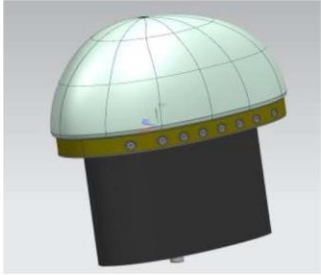
>1000 Channels

Flank Array



>3000 Channels

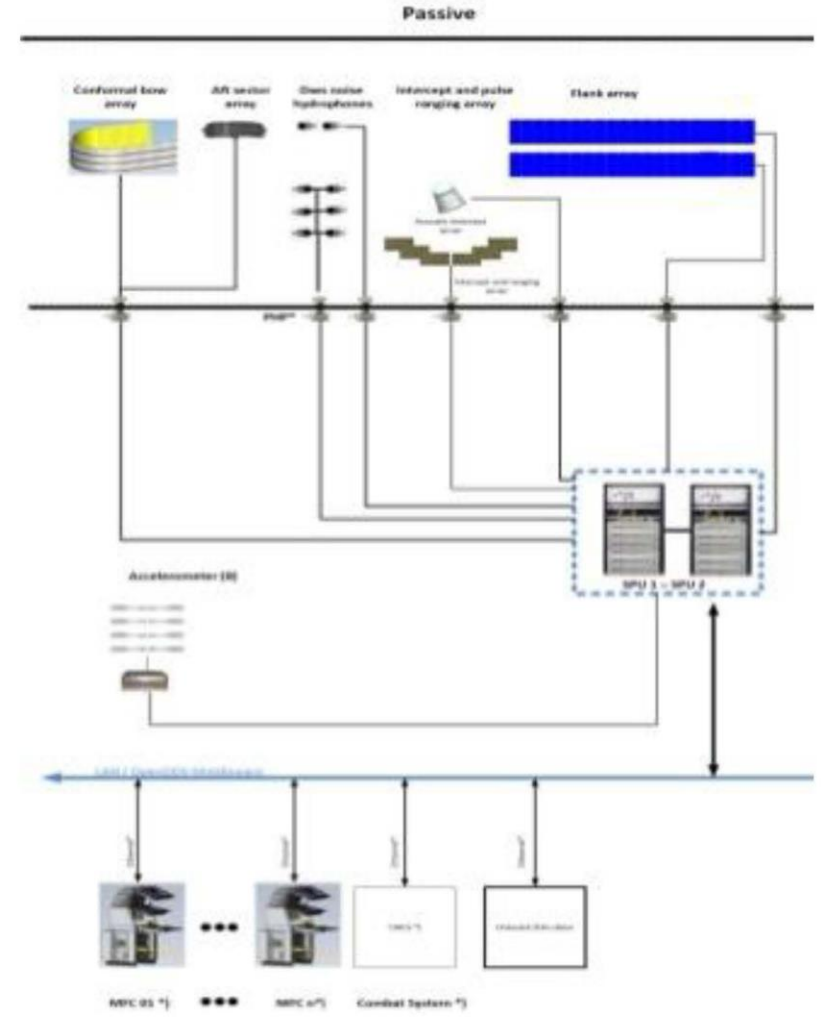
Int. Array



>40 Channels

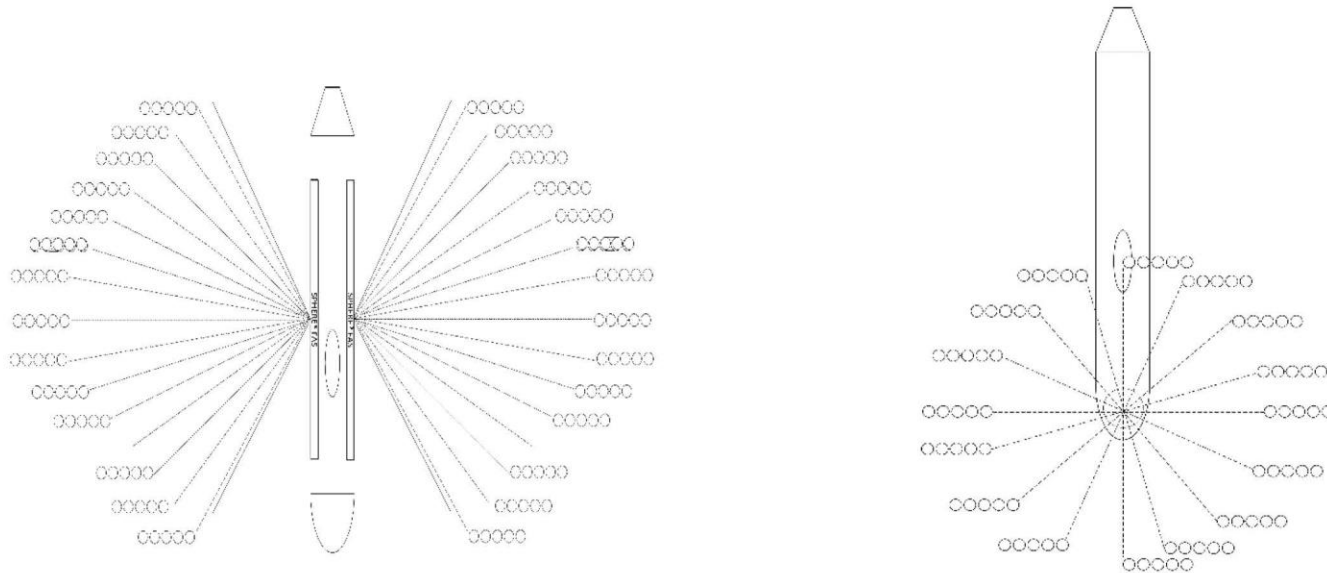
ELAC SONAR GmbH

Company Confidential



# SPHERE® FULLY INTEGRATED SONAR SUITE

Vertical aperture passive arrays



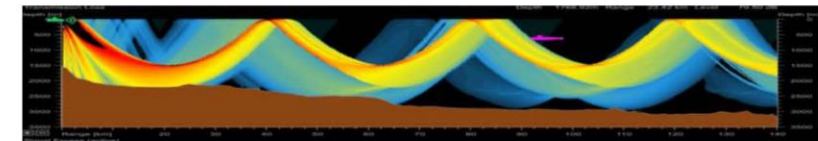
Outstanding ☆

!!! Total Number of FAS Beams > 3000 Beams !!!

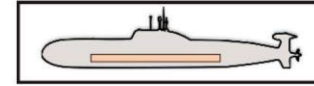
!!! Total Number of CAS Beams > 1000 Beams !!!

!!! Total Number of IAS Beams > 90 Beams !!!

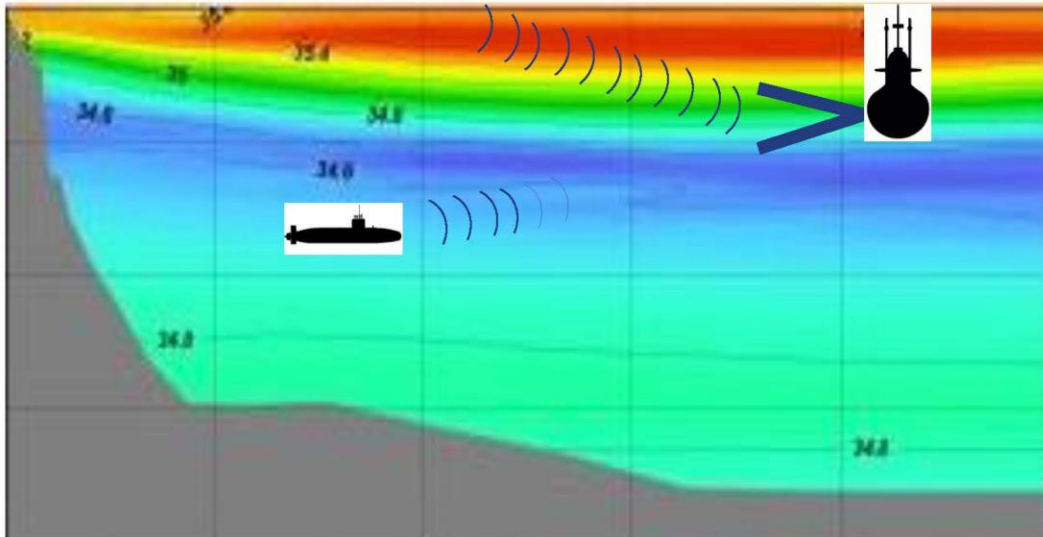
- Full Motion Compensation (Roll Pitch Yaw)
- Always the best S/N
- Multipath resistance
- Detection, Audio, Analysis
- CZ Detection



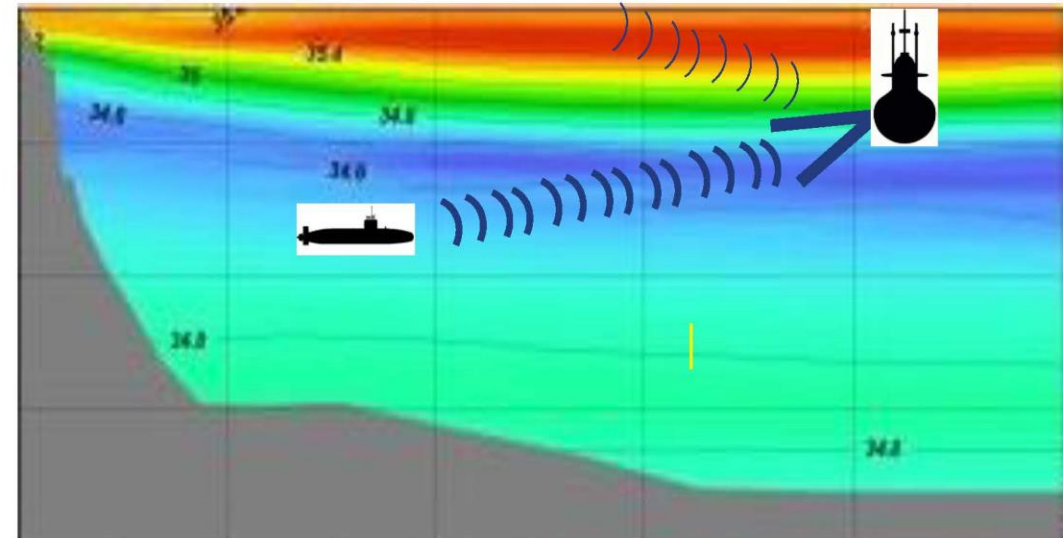
# SMART VERTICAL APERTURE ARRAY (FAS)



Operational Value



No detection due to bad S/N from surface noise

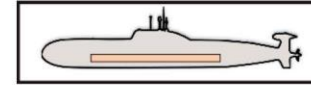


Detection due to reducing surface noise and increase S/N

Vertical beamforming

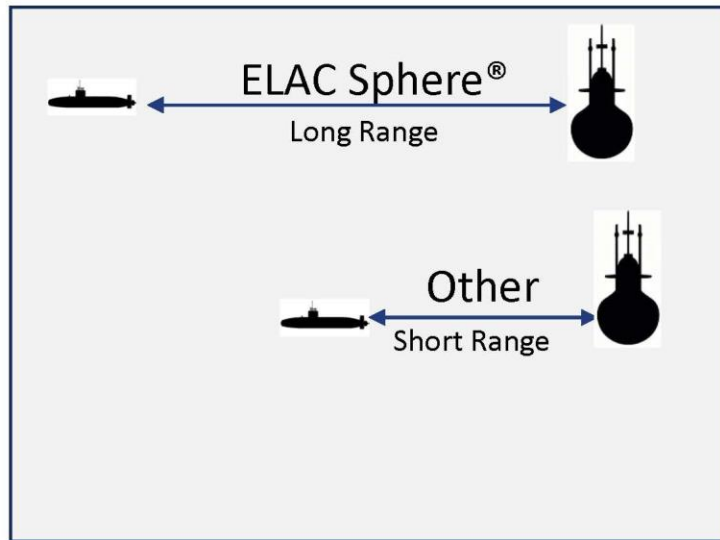


# SMART VERTICAL APERTURE ARRAY (FAS)



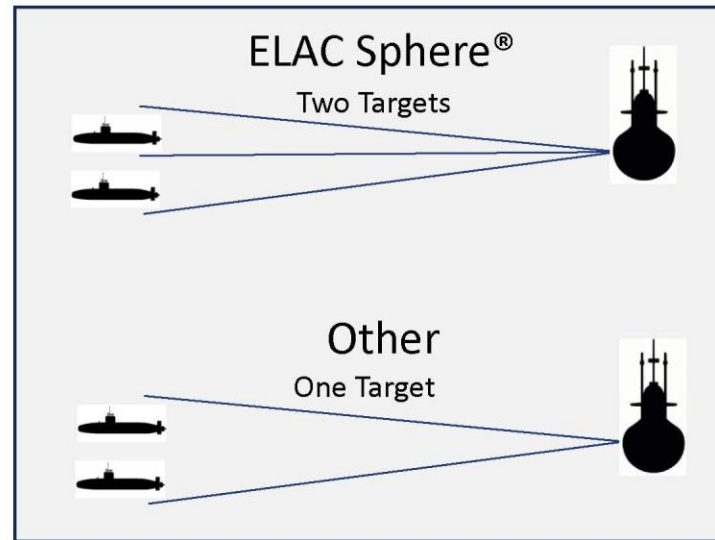
## Operational Value

### Higher Directivity Index



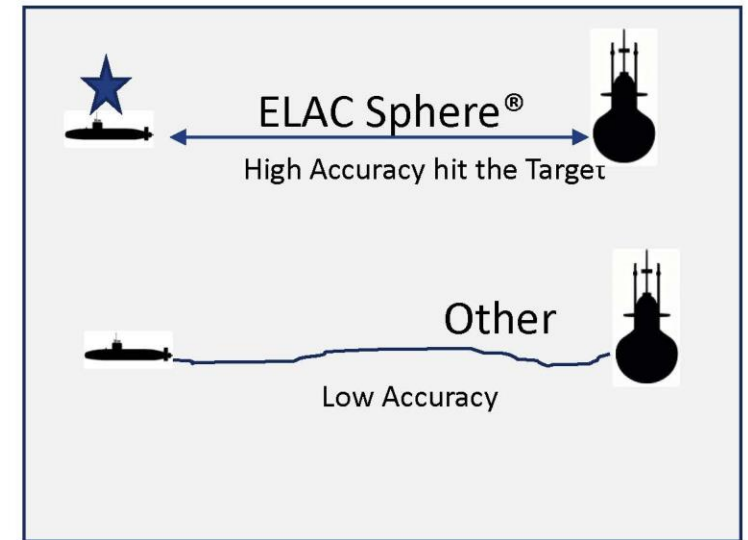
### Longer Detection range

### Narrower Beams



### Better Target Separation

### Narrower beams & higher bandwidth



### Better bearing accuracy

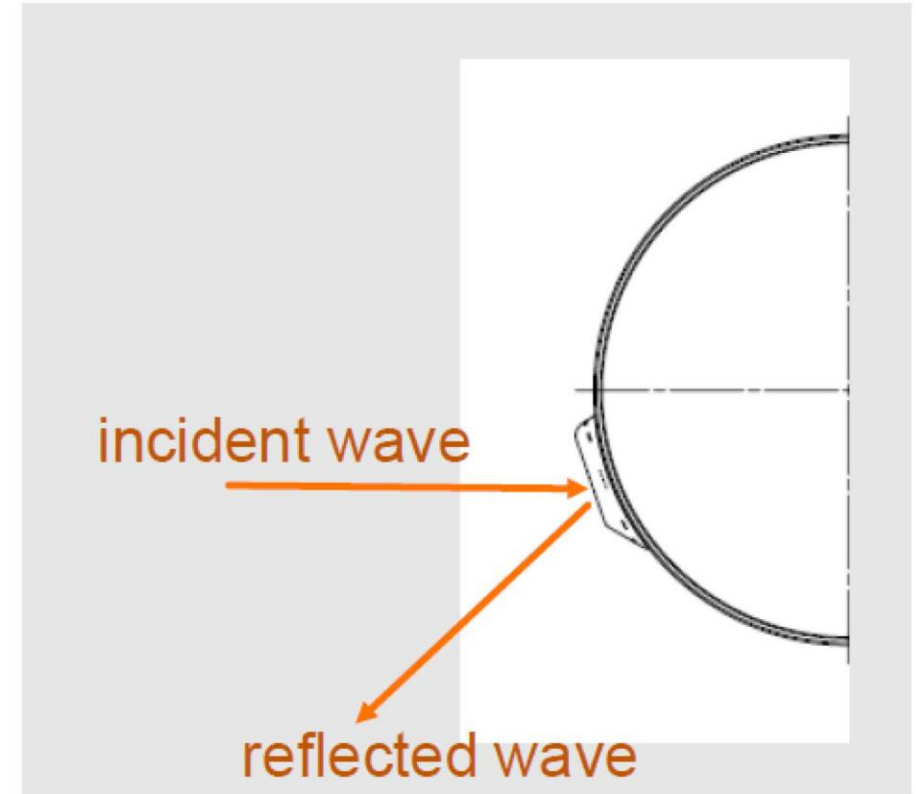
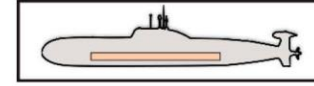
## Wider frequency band



# SMART VERTICAL APERTURE ARRAY (FAS)

## Stealth Design

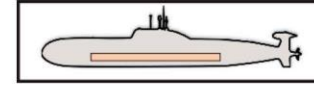
- Stealth Design with low Target Strength based on avoidance of vertical reflecting surfaces
- No reflection in the direction of incident sound waves.
- Significant improved Target Strength compared to a designs with a vertical baffle resp. Signal conditioning plate.





# SMART VERTICAL APERTURE ARRAY (FAS)

Passive Ranging



e.g. Length of PRS Baseline can be customised

**Significant better Ranging**

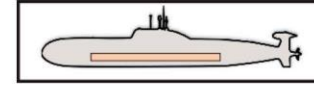


# SMART VERTICAL APERTURE ARRAY (FAS)

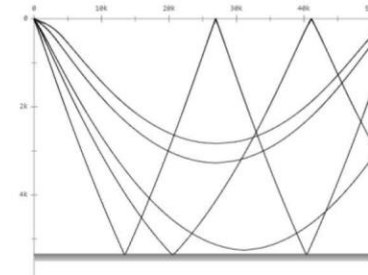
Passive Ranging

## Operational Value

- Longer Ranging due to higher Frequency (Fresnel Range)
- Stable result due to multipath reduction by vertical aperture
- Longer Ranging due to significant better S/N due to panel array



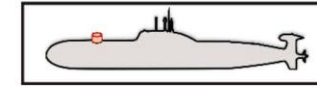
$$Range = \frac{Array\ length^2}{Wavelength}$$



$$Gain = \frac{4 \pi Surface}{Wavelength^2}$$

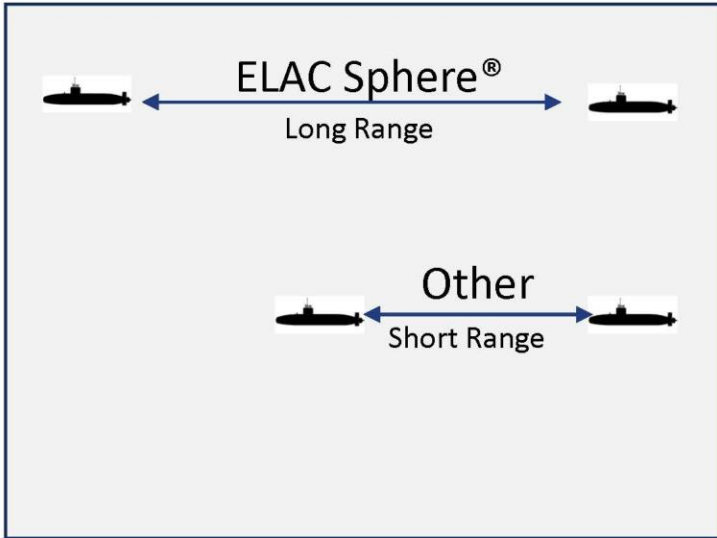


# SMART INTERCEPT ARRAY



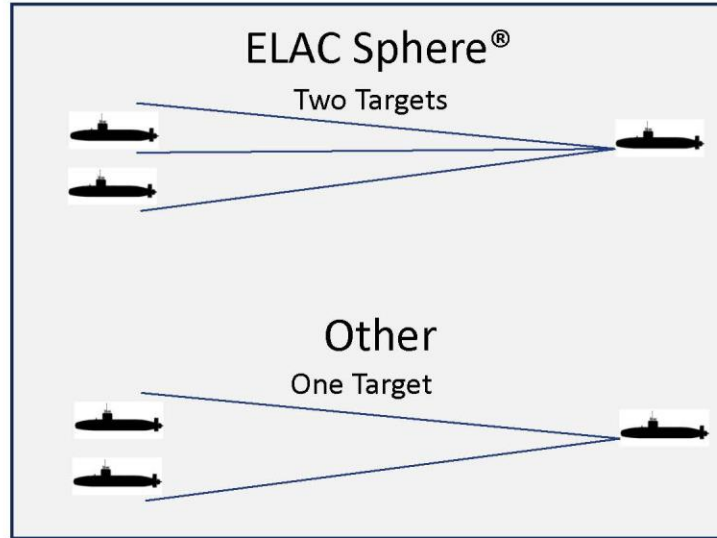
## Operational Value

### Higher Directivity Index



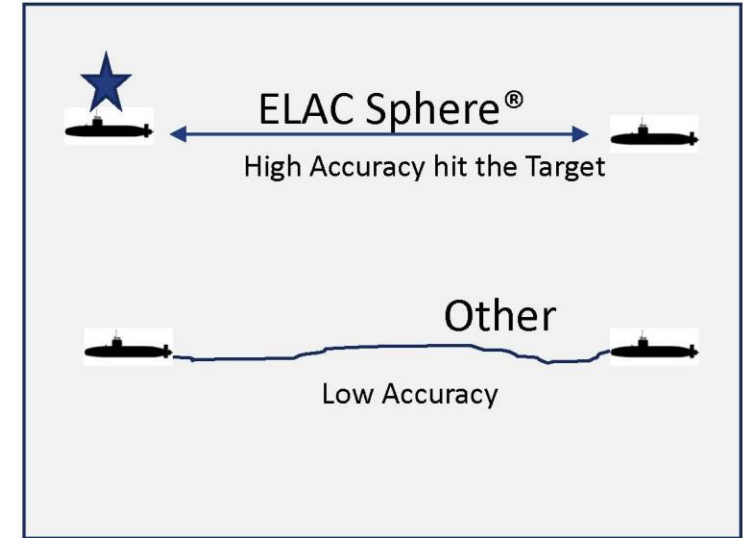
Longer Detection range

### Narrower Beams



Better Target Separation

### Narrower beams & higher bandwidth



Better bearing accuracy

## Wider frequency band



**SPHERE** ®

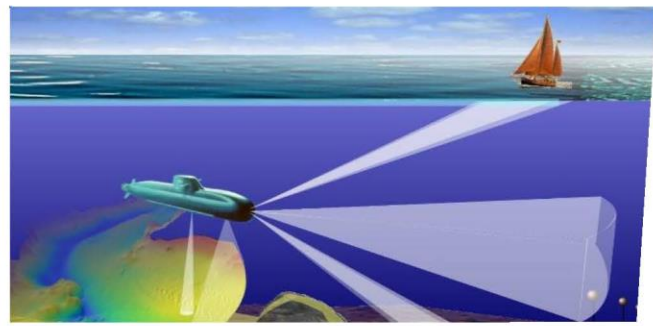
**SMART TX TRANSDUCER**



# SPHERE® FULLY INTEGRATED SONAR SUITE

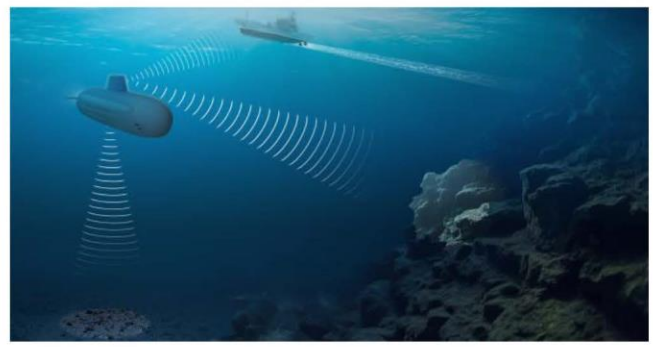
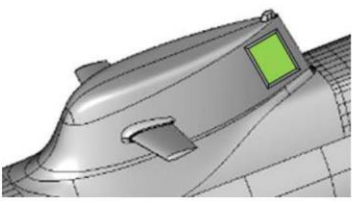
2D active arrays

2D Bow Array



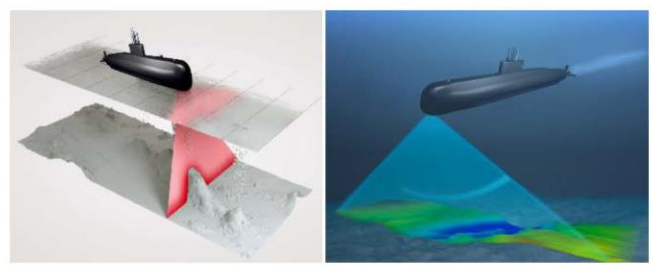
120° Cover.

2D Sail Array

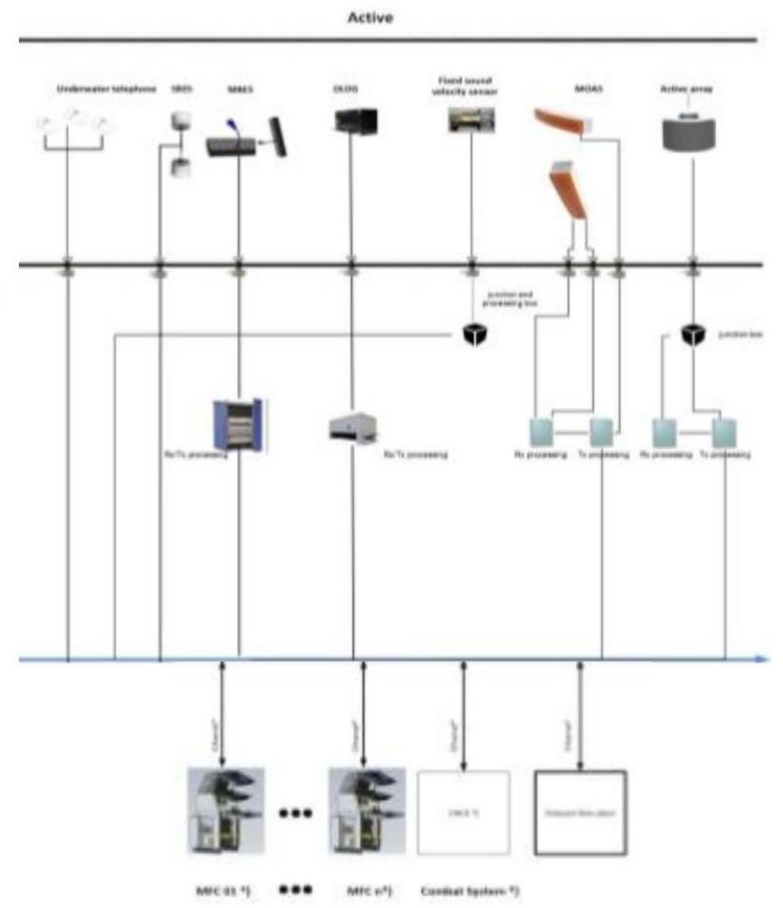


360° Cover.

2D Chin Array



140° Swath



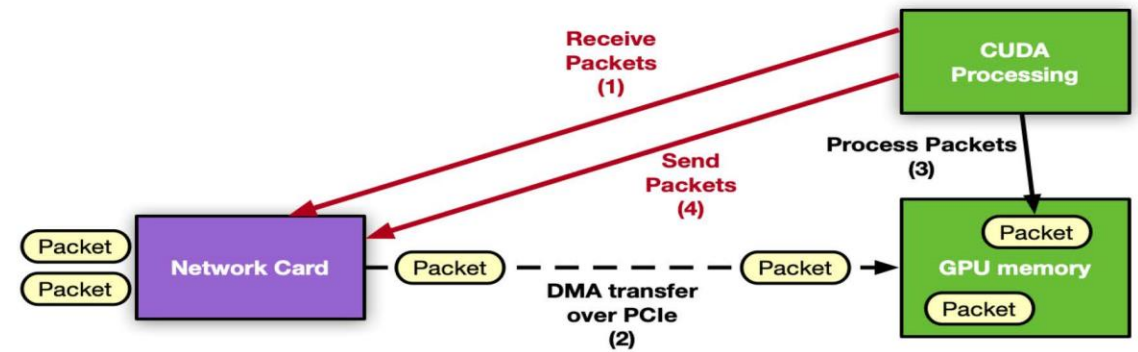
# SPHERE® FULLY INTEGRATED SONAR SUITE

Sonar processing



Measured Running Times						
Array Size	GPU TD(s)	GPU FD(s)	CPU TD(s)	CPU FD(s)	G/C TD(%)	G/C FD(%)
76	0.028	0.027	0.240	0.180	11.6	11.3
152	0.059	0.053	0.490	0.354	12.2	15.0
304	0.114	0.109	0.980	0.691	11.6	15.8
608	0.224	0.213	1.950	1.370	11.5	15.5
1216	0.445	0.423	3.890	2.720	11.5	15.5

GPU for beamforming on off-the-shelf hardware, even for large arrays performs with factor 10



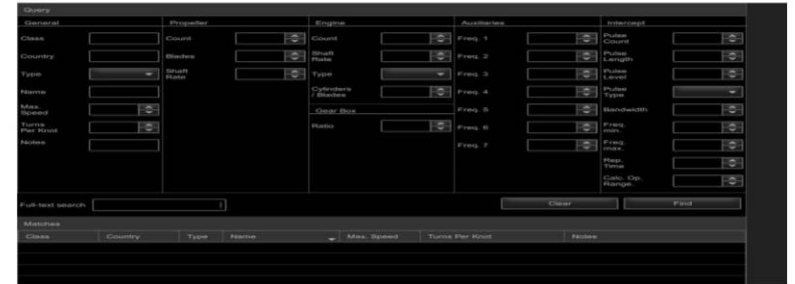
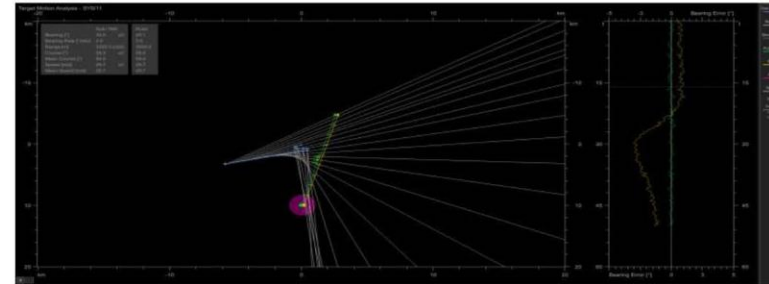
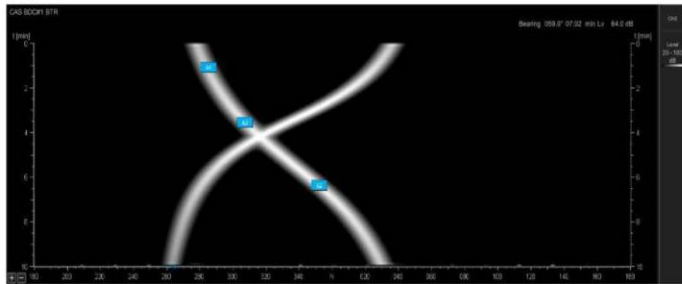
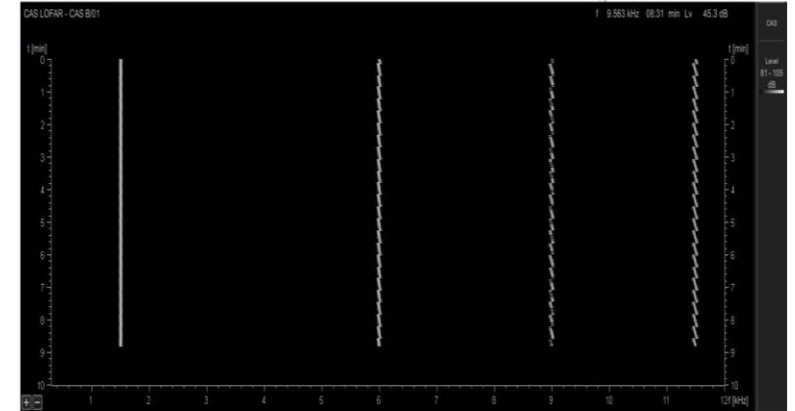
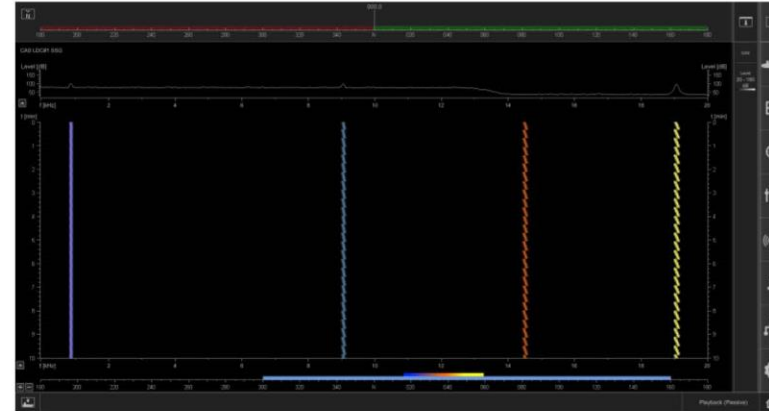
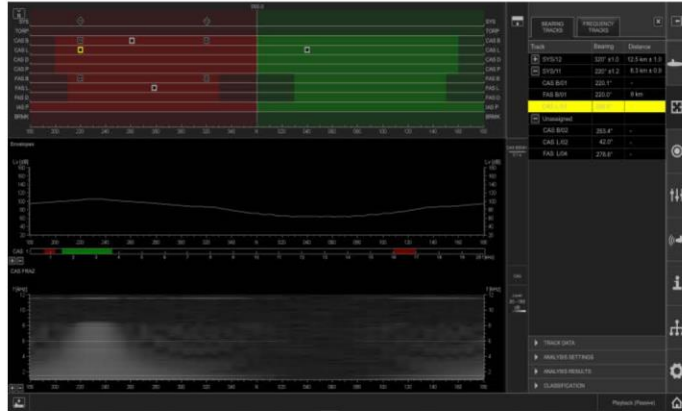
**GPU-centric application**



# SPHERE® FULLY INTEGRATED SONAR SUITE



## Sonar passive HMI



### Broadband HMI:

- CAS
- FAS
- TAS

### TMA HMI:

- CAS
- FAS
- TAS

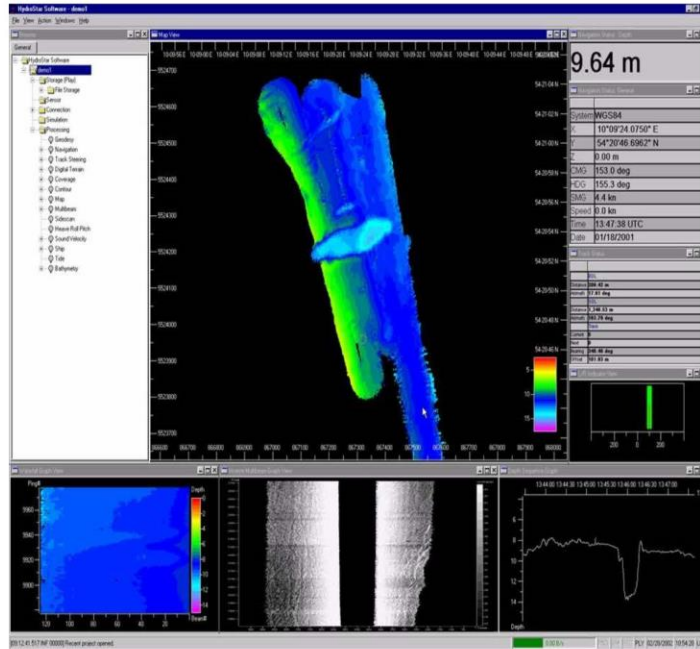
### Analysis HMI:

- CAS
- FAS
- TAS



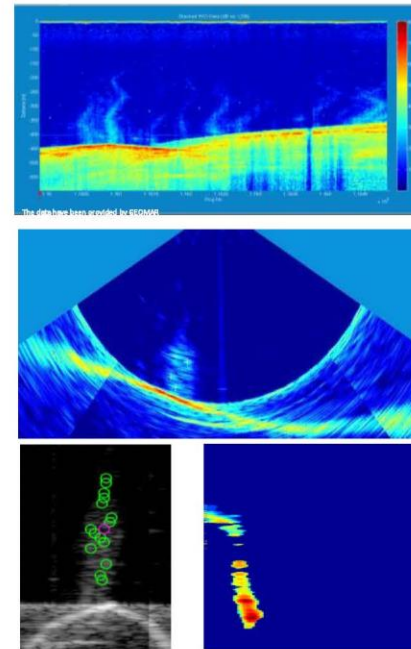
# SPHERE® FULLY INTEGRATED SONAR SUITE

## Sonar active HMI



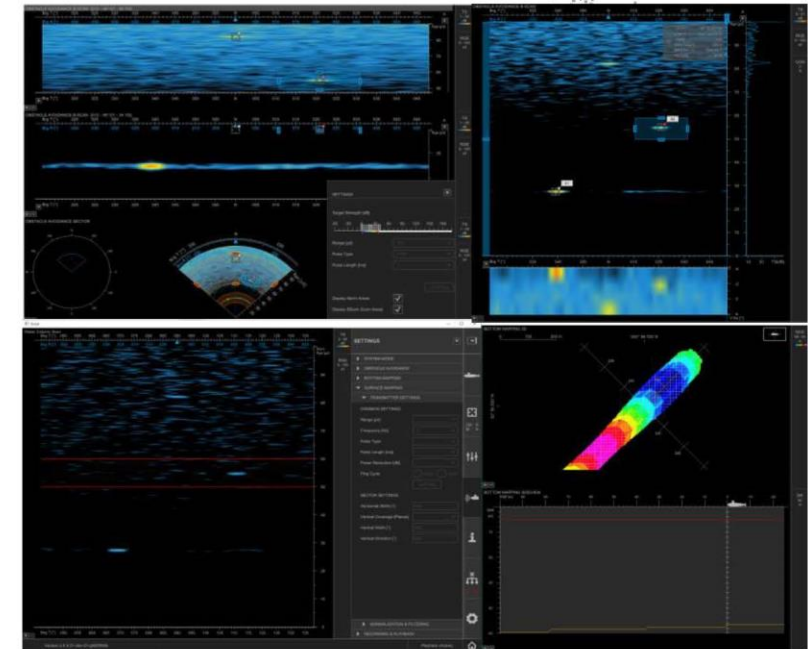
### MBES HMI:

- Depth data
- Side Scan
- Bottom Backscatter
- Position Fix



### WCI HMI:

- Object detection



### MAS HMI:

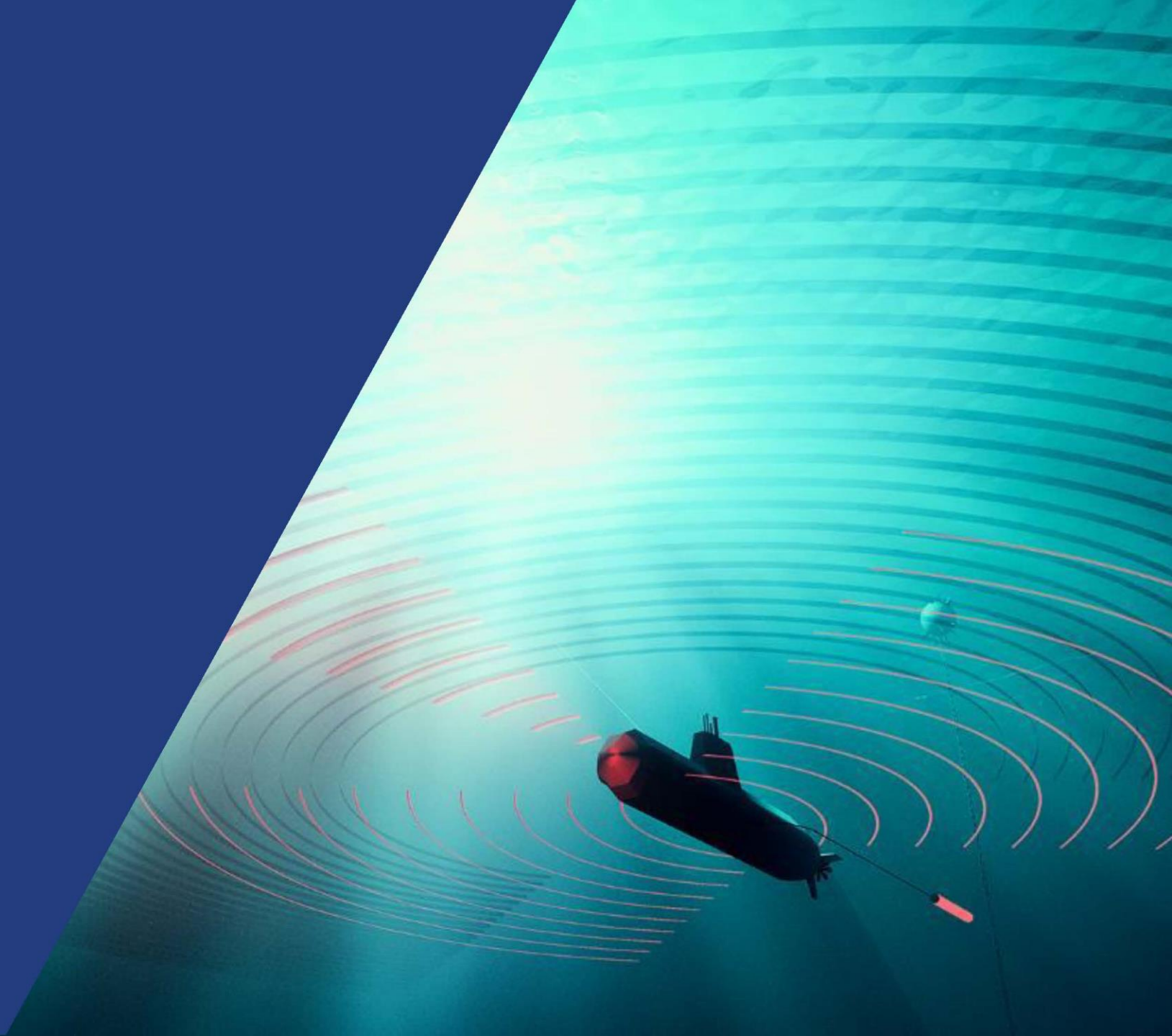
- 3D Object detection
- Forward looking Mapping
- Forward looking surfacing



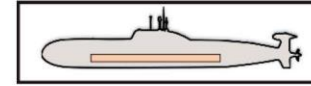


**SPHERE** ®

**WHATS NEXT ?**



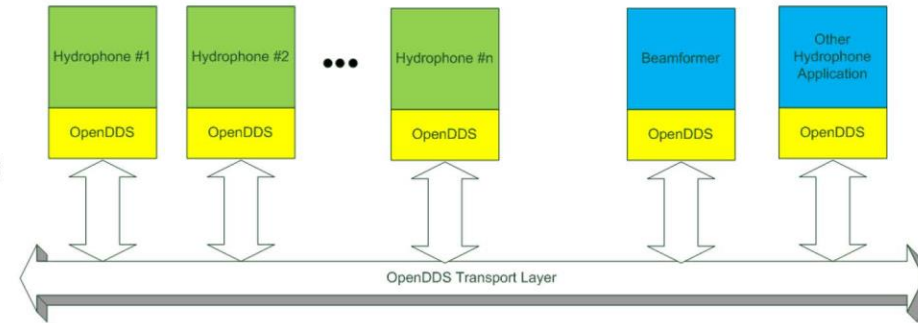
# SMART VERTICAL APERTURE ARRAY (FAS)



Length = ca. 28m

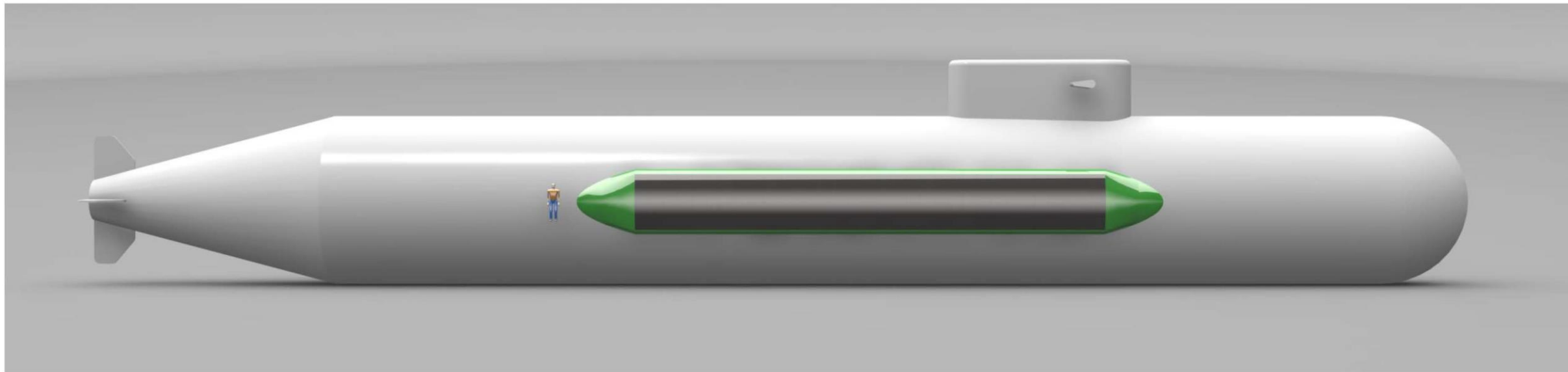
Height = 3.5 m

Channels = 15.000 individual (Stbd&Port)



**Open architecture (middleware)**

- Each application has access to all hydrophones
- Use Hydrophones from different arrays



**THANK YOU  
FOR YOUR ATTENTION.**

**ELAC**   
**SONAR**

A COHORT PLC COMPANY



Leonardo Electronics

# Leonardo new U212 Near Future Submarine (NFS) CMS – ATHENA MK2/U

Technologies and Solutions for Integrated Underwater Operations

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COMBINED NAVAL EVENT (CNE)

Farnborough, 22/05/2024



Electronics



Helicopters



Aircraft



Cyber & Security



Space

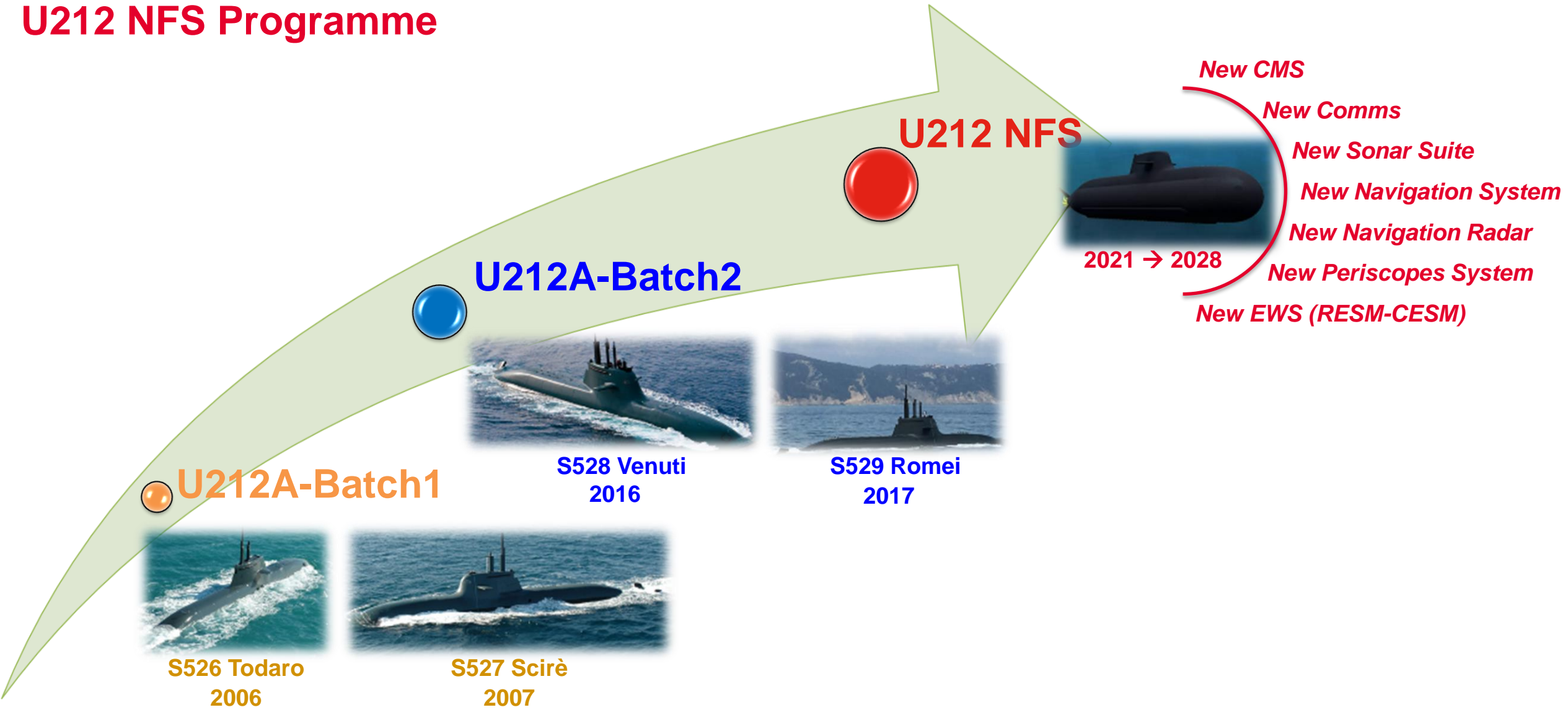


Uncrewed Systems



Aerostructures

# U212 NFS Programme

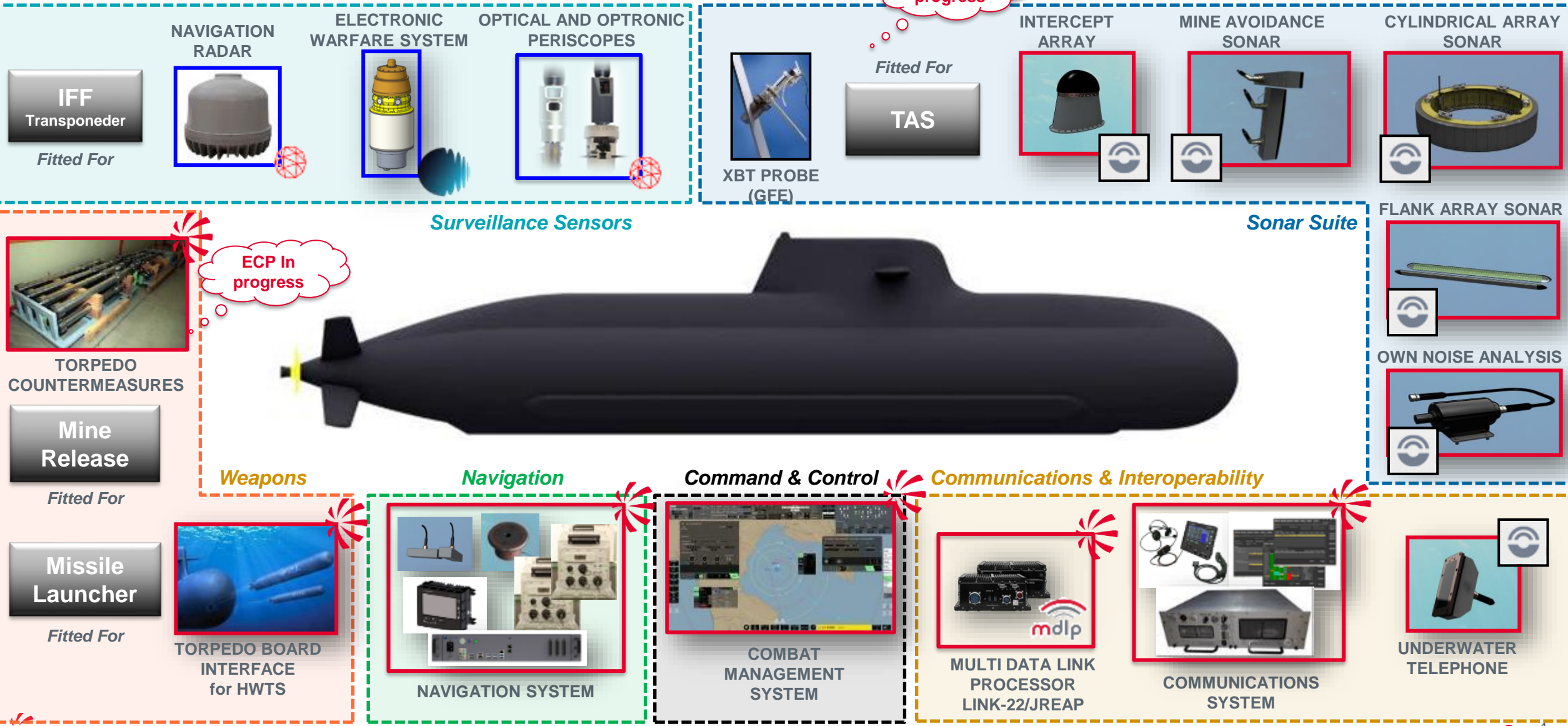


# Combat System Solutions for Submarines

*Leonardo can provide last-generation Systems and System Integration for current and future submarines critical missions*



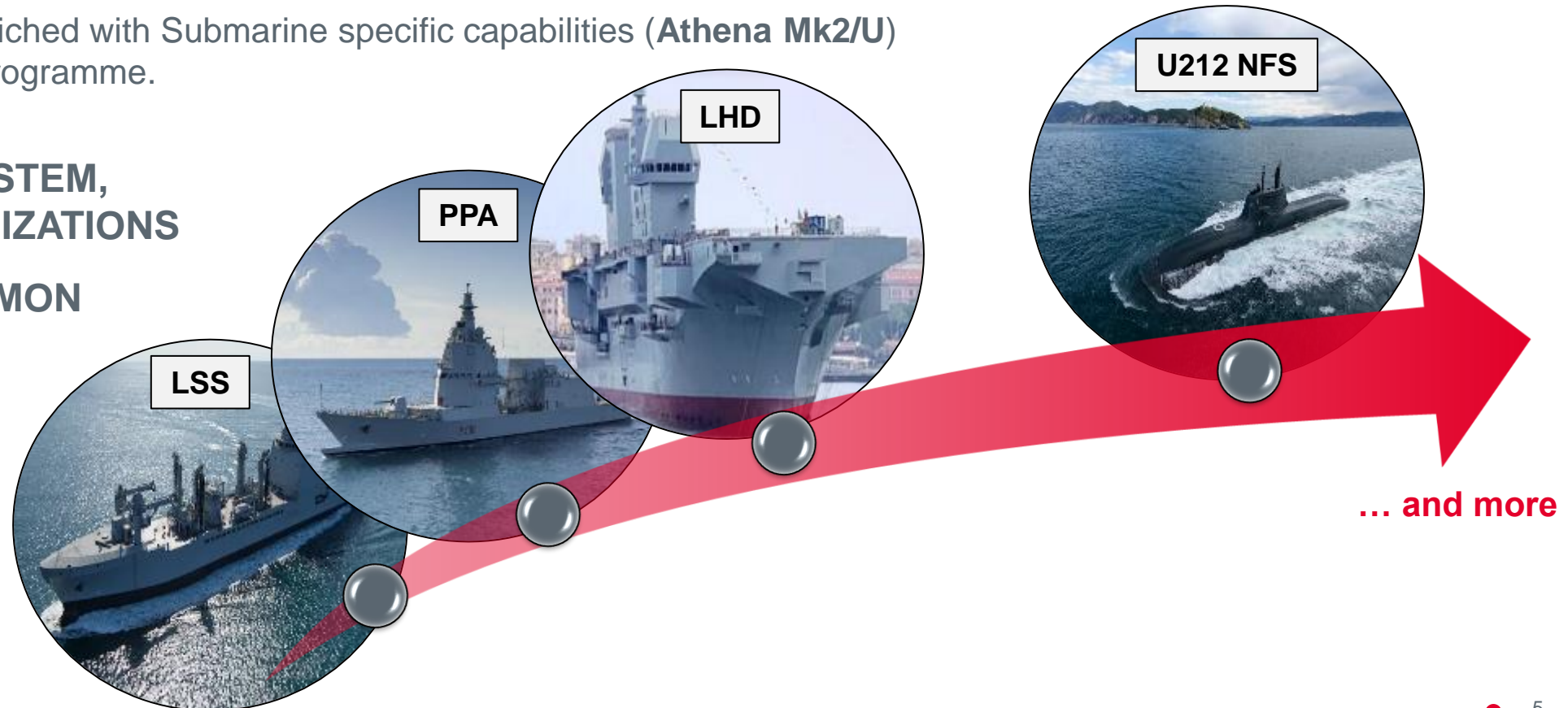
# U212 NFS Combat System Configuration



# CMS Athena Mk2/U for Submarines

- Athena Mk2 series is a new generation of Combat Management System, designed by Leonardo in collaboration with the Italian Navy. It joins the experience of previous Naval Programs with state-of-the-art technologies and updated operational requirements.
- Athena Mk2 series has been designed as a single product, able to interface with different Combat Systems and to implement both Common Requirements and Platform Specific Functionalities.
- Athena Mk2 has been enriched with Submarine specific capabilities (**Athena Mk2/U**) starting with U212 NFS Programme.

- **SAME MODULAR SYSTEM,  
DIFFERENT CUSTOMIZATIONS**
- **WELL PROVEN COMMON  
FUNCTIONALITIES**





# CMS Athena Mk2/U Capabilities

- Double screen Multi Functional Console with modern Multi-Touch interaction principles
- Enrichment of Local Area Picture Compilation with Target Motion Analysis (TMA)
- Identification (based on kinematic, special areas, sensors info) and Periscopes Video Classification based on Artificial Intelligence (AI)
- Periscopes Video Distribution and Processing (Computer Vision, Augmented Reality)
- Navigation Planning and Management
- Water Space Management and PMI
- Exchange of Surveillance Data and Management messages on Tactical Data Links networks
- Local Track/Remote Track correlation for a single Real World Object representation
- Command Support with the exchange of Formatted Messages, Plans, etc.
- Engagement Planning and Execution with integrated management of Heavy Weight Torpedo Launching System and Torpedo Countermeasures
- Data Recording and Analysis



# CMS Athena Mk2/U General Architecture



## CMS OPERATOR CONSOLES

TACTICAL FUNCTIONALITIES
Navigation Management
AWW/ASW Sensor Data Processing
AWW/ASW Tactical Picture Management
Identification & Classification
AWW/ASW Sensor Control
ASW Weapon Management
Interface with Multi Data Link Processing
MISSION-SPECIFIC FUNCTIONALITIES
Target Motion Analysis
Real Time Video Processing



COMBAT SYSTEM FUNCTIONALITIES
Network & Communication
Navigation System
Warship ECDIS

CMS SUPPORT FUNCTIONALITIES
Command Support System Interface
CSS Web Portal
Data Recording Analysis & Replay
Storage for CMS Data, Cartography and Recordings

TECHNICAL BASE APPLICATIONS		
Low Level Software	Software Configuration Manager	Middleware & Communication Services

LAN Network

OTHER CSE (NAVR, AIS, EWS...)



Optical Periscope  
Optronic Periscope



HWTS

SONAR SUITE



# CMS Athena Mk2/U Human Machine Interface (HMI)

- HMI design and development approach based on a **strong collaboration with OCCAR and Italian Navy**, in order to develop state-of-the-art technologies and solutions validated by Submarine Operators (Joint Prototyping process).
- Fully integrated Situational Awareness presentation and management, enriched with **specific layouts for Submarine Operators**, allowing management and coordination of all Combat System resources from the same CMS Operator Console.



# CMS Athena Mk2/U Human Machine Interface (HMI)

## Multi-Touch Interaction

- The usage of multi-touch paradigm for CMS Human-Machine Interface allows to have easy access to any tactical command and information directly on the selected object, by means of dedicated context menus and guided interaction
- The specific Role-Related CMS HMI is displayed as a set of interactive frames, overlapped on a full-map Tactical Picture representation



# CMS Athena Mk2/U Human Machine Interface (HMI)

## HMI Organization Example

The image shows a complex HMI interface for the CMS Athena Mk2/U. The interface is organized into several key areas:

- Synthetic display panels (GENERAL + ROLE INFORMATION):** Located at the top, this area contains various status and control panels. On the left, there's a 'PWO' panel with flight parameters. In the center, there are 'AIRCRAFT' and 'TASK FORCE ESCORT' panels with status indicators. On the right, there's a tactical map showing 'SCOOP LINE' and 'NAVY' assets.
- Tactical area (FULL MAP):** The central part of the interface is a large tactical map showing a coastal region with various assets and threat indicators.
- Hook Panel (MORE INFO):** A panel that provides detailed information about a selected asset on the map.
- Hook Panel (SYNT):** A panel that provides synthetic data or status for a selected asset.
- Context menu:** A menu that appears when an asset is selected, offering various actions.
- Display panel (OSF):** A large panel on the right side showing 'OSF' (Operational Status Function) parameters, including 'AAW Parameters' and 'ASW Parameters' with various gauges and sliders.
- Main menu:** A vertical menu on the right side of the OSF panel, containing options like 'AREAS', 'SETTINGS', 'IFF CODE MANAGEMENT', and 'IFF MANAGEMENT'.
- Input Frame (IF):** A panel at the bottom center for entering and applying data.
- Alert Frame (AF):** A panel at the bottom right for managing alerts, including 'NOTIFYING' and 'ALERTS'.



# CMS Athena Mk2/U Video Distribution and Processing

Periscopes

CSLAN

Video  
Decoding

Video Processing

HCI Presentation



## COMPUTER VISION & ARTIFICIAL INTELLIGENCE

Local Contrast Enhancement	Histogram Expansion
Fog Suppression	TV/IR Video Fusion (up to 3 videos)
Augmented Reality / Video Overlay	Air and Surface Target Detection
Digital Stadimeter	Super Resolution
Support for Manual Classification of Surface Targets	Semi Automatic Classification <b>(Artificial Intelligence)</b>
Panoramic Picture Reconstruction	Panoramic Video Reconstruction (Quick Look)
3D Mosaic Reconstruction	



# CMS Athena Mk2/U Tactical Overview



### Planning Facilities

- Navigation Planning / Management
- Water Space Management / PMI
- Implementation of Plans received from Headquarters

### Local Area Picture Compilation, Target Motion Analysis (TMA) (Association for additional CSE Information)

### Identification (based on kinematic, special area, sensors info) Visual Classification support based on AI

### Weapon Assignment

- Engagement Planning and Execution
- Integrated management of Torpedo Launching System and Torpedo Countermeasures
- Kill Assessment for decision making

### Interoperability

#### Tactical Data Link

- Exchange of Surveillance Data and Management messages on the available TDL Networks
- Local / Remote correlation for a single RWO representation

#### Command Support

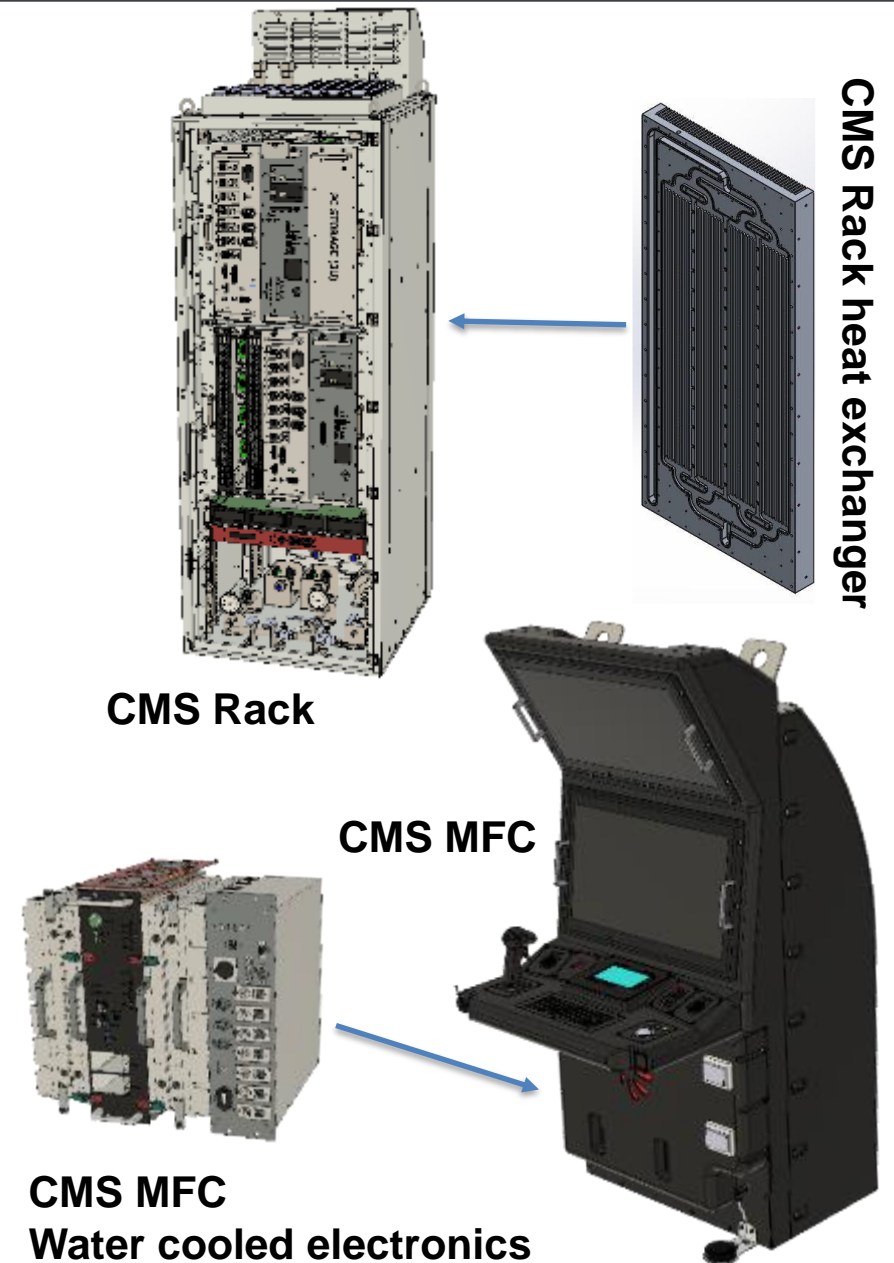
- Exchange of Formatted Messages, Plans, OPTASKs
- Joint Common Operational Picture sharing



# CMS Athena Mk2/U Hardware Technologies

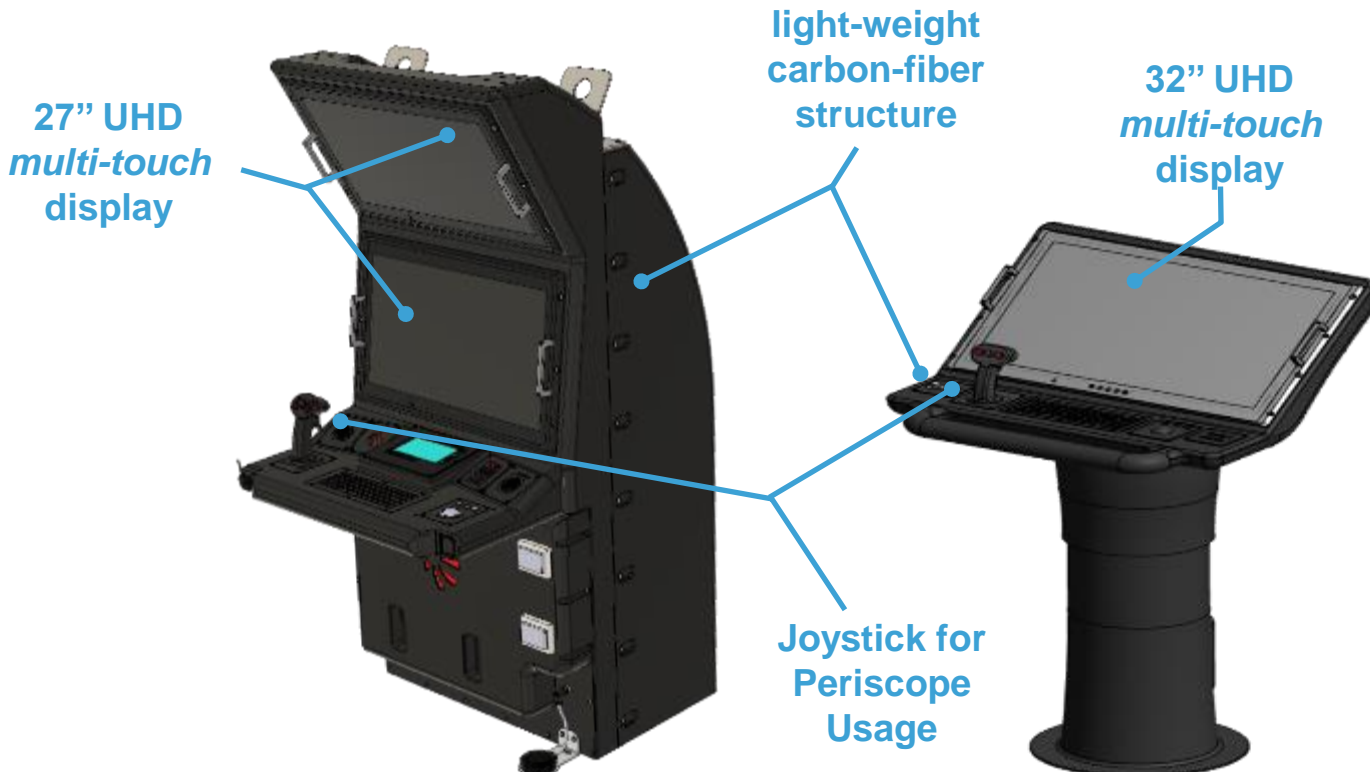
Innovative HW design and technologies in order to cope with specific critical requirements, typical of a submarine application:

- **Acoustic signature of the vessel:** High efficiency dissipation based on state-of-the-art water-cooling systems
- **Magnetic signature of the vessel:** Usage of amagnetic materials such as carbon fiber and aluminum
- **Resources Optimization:** New generation hardware components and boards guarantee high performances and limited power consumption
- **Limited spaces:** Optimization of dimensions and ergonomic aspects





# CMS Athena Mk2/U Operators Workstations



**Multi Functional Console (MFC) for Combat System Operator**

**Commander Console with Large Screen Display (LSD)**

- MFCs and LSD are equipped with High Performance Computers, in order to host both CMS HMI and Tactical CMS Applications
- Tactical CMS Applications are distributed among all the available Operator Workstations with Multiple Backup policy (to increase redundancy) and Load Balancing techniques (to optimize resources usage → heat, noise, power consumption)

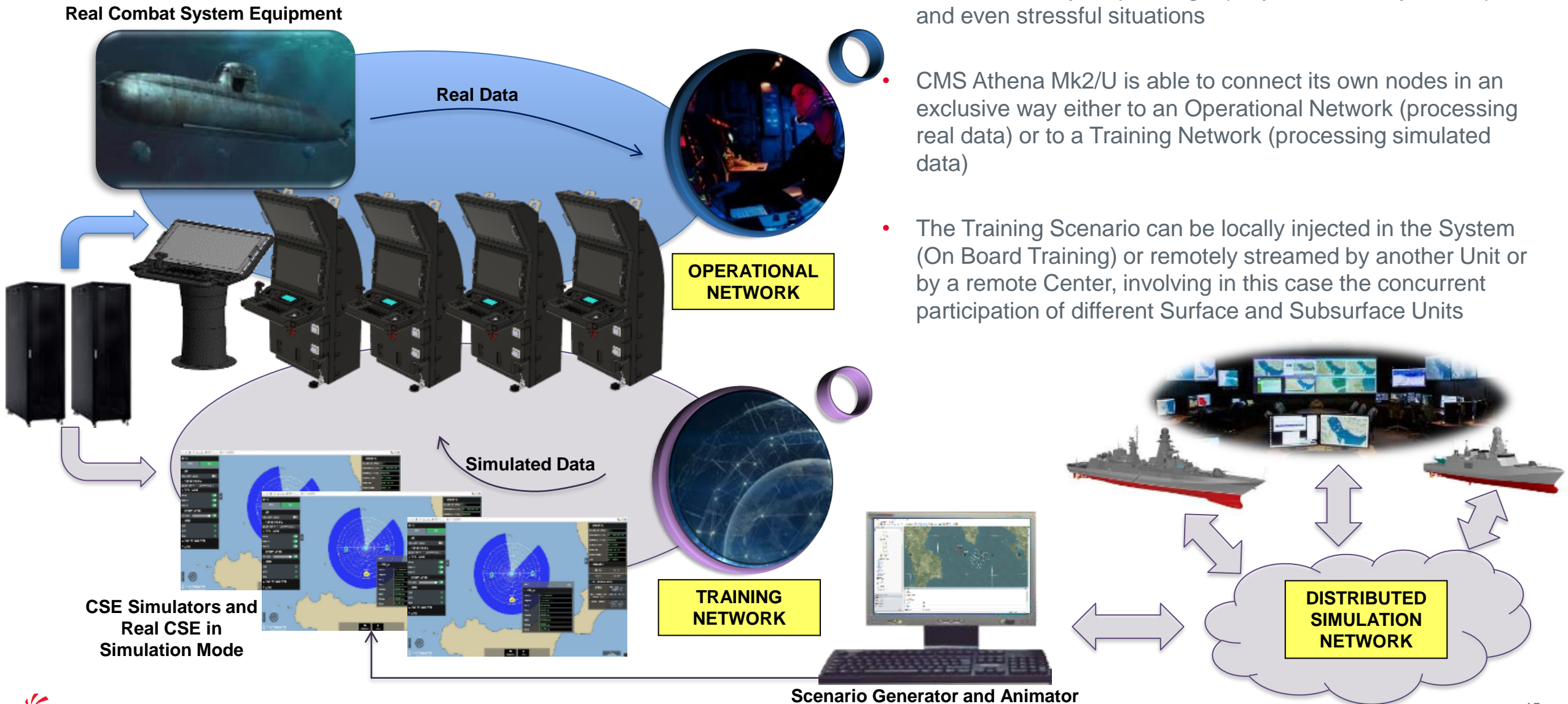


**Secondary Monitor:** for Support Operations, Data Entry, Data Supervision, External Applications

**Primary Monitor:** for Tactical Picture Supervision and Interaction, Complex Data Input / Editing, CMS settings and navigation menus



# CMS and Combat System Training



- The aim of Training function is to coach operators to know exactly how to react, in order to achieve the best operational effectiveness by responding rapidly and correctly in complex and even stressful situations
- CMS Athena Mk2/U is able to connect its own nodes in an exclusive way either to an Operational Network (processing real data) or to a Training Network (processing simulated data)
- The Training Scenario can be locally injected in the System (On Board Training) or remotely streamed by another Unit or by a remote Center, involving in this case the concurrent participation of different Surface and Subsurface Units





THANK YOU  
FOR YOUR ATTENTION

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# CONTACTS

## Leonardo Electronics

### Lorenzo COZZELLA

Product Marketing – Head of Naval Domain

T: +39 06 4150 5316

M: +39 360 1027343

[lorenzo.cozzella@leonardo.com](mailto:lorenzo.cozzella@leonardo.com)

