



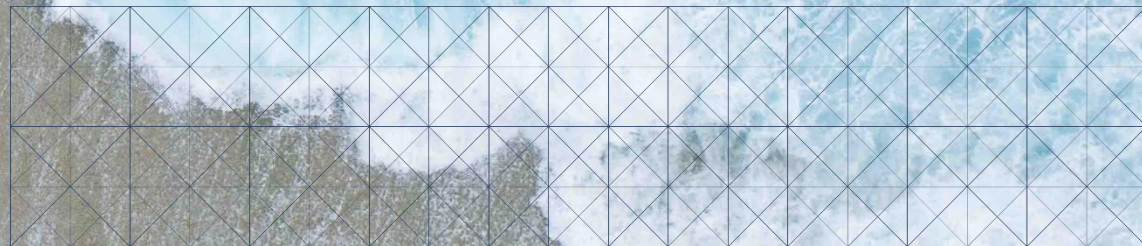
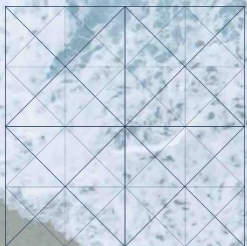
KONGSBERG

KONGSBERG MARITIME

TECHNOLOGY FOR RESEARCH VESSELS

25/10/2019

Dr Martin Gutowski  
Regional Sales Director, Subsea



# KONGSBERG has a long and unique history

Our history spans over  
two centuries

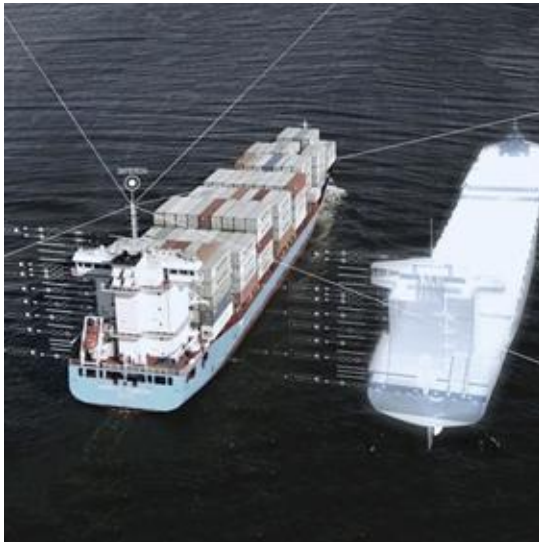


Est.  
**1814**



# Business Areas

Technology is our common core



## KONGSBERG DIGITAL

Maritime simulation  
Industrial digitalization



## KONGSBERG MARITIME

Seaborne transportation  
Robotics and Sensors  
Offshore, Oil & Gas



## KONGSBERG DEFENCE & AEROSPACE

Defence  
Space and Surveillance

# The latest news

Kongsberg acquires Rolls Royce  
Commercial Marine April 2019



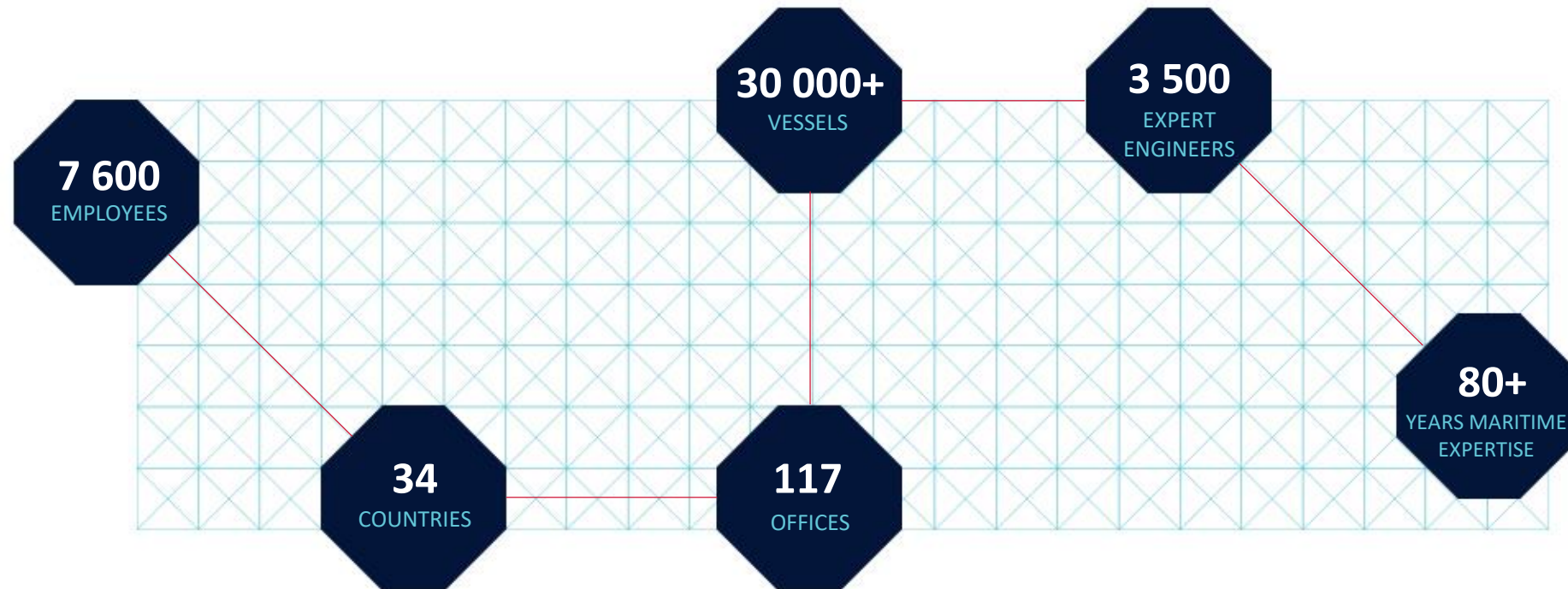
# The Broadest Portfolio of Products

Throughout the entire maritime industry



# Kongsberg Maritime

## Company Highlights



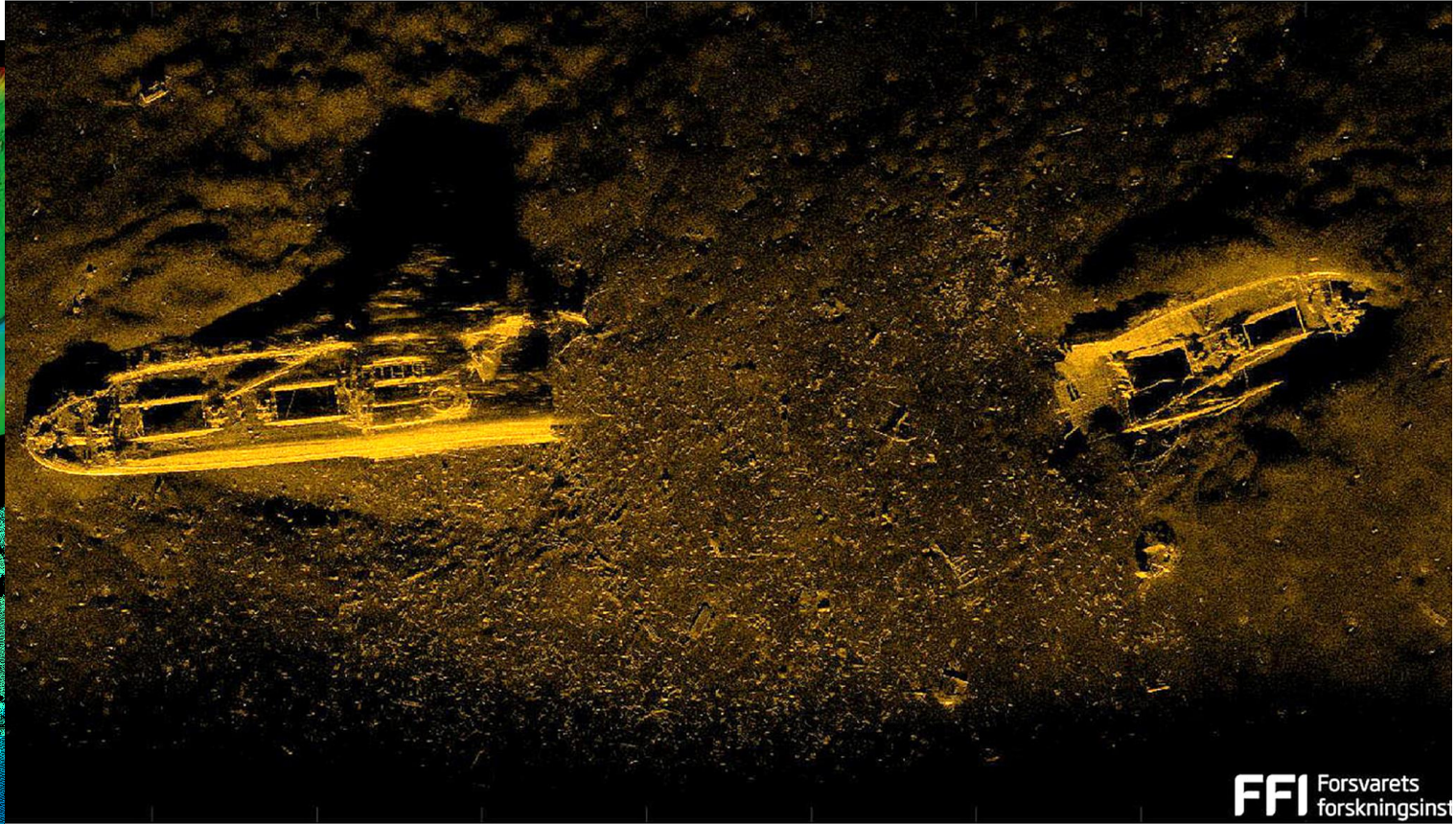
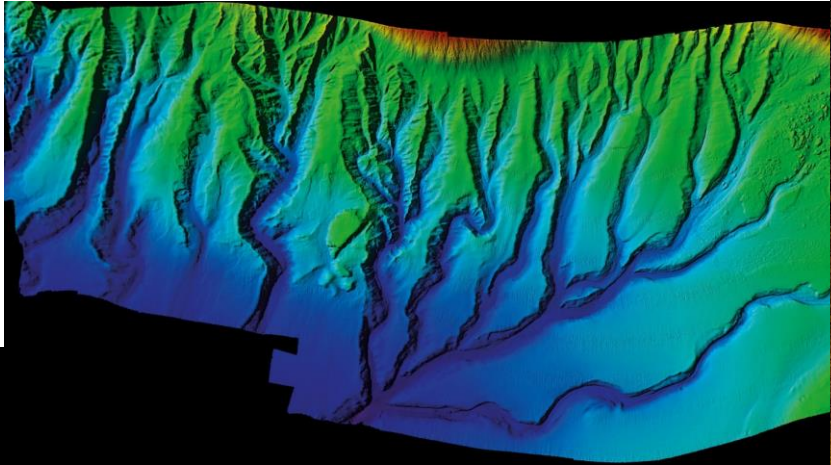
# Our Global Reach



# What are the game changing technologies today?



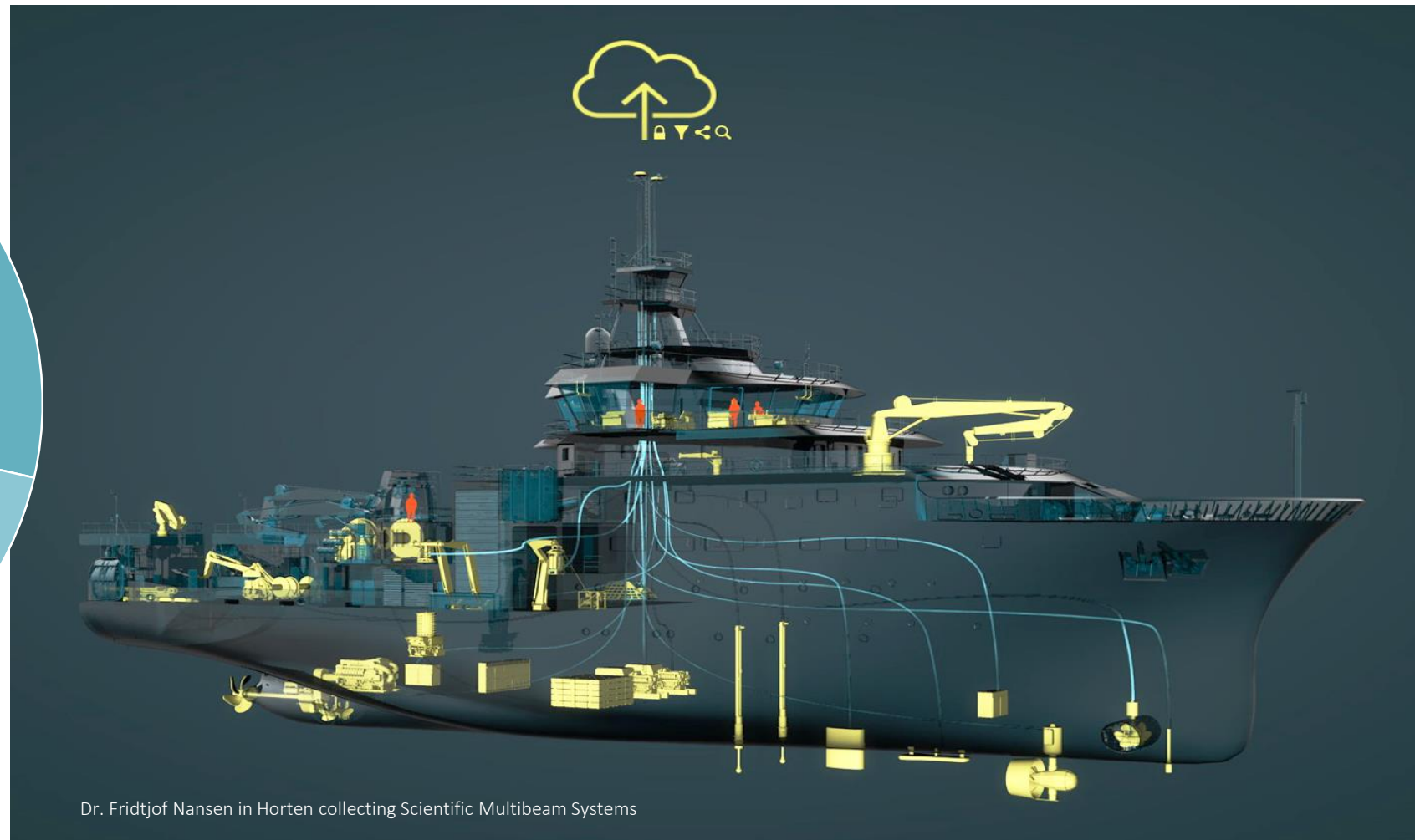
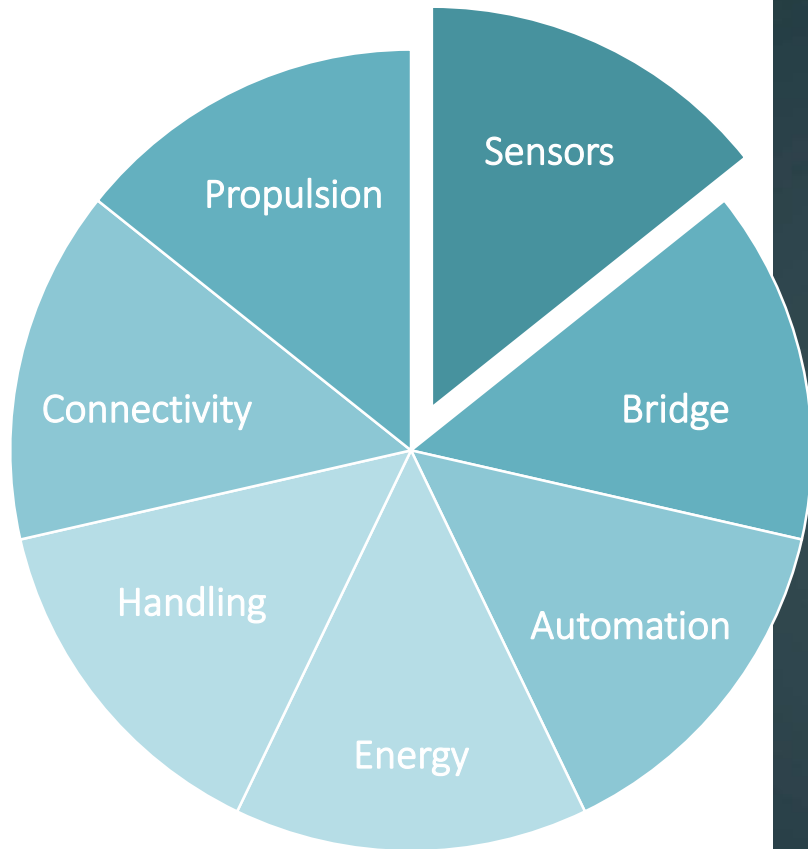
# Better sensors



**FFI** Forsvarets  
forskningsinst

# Integration = Efficiency

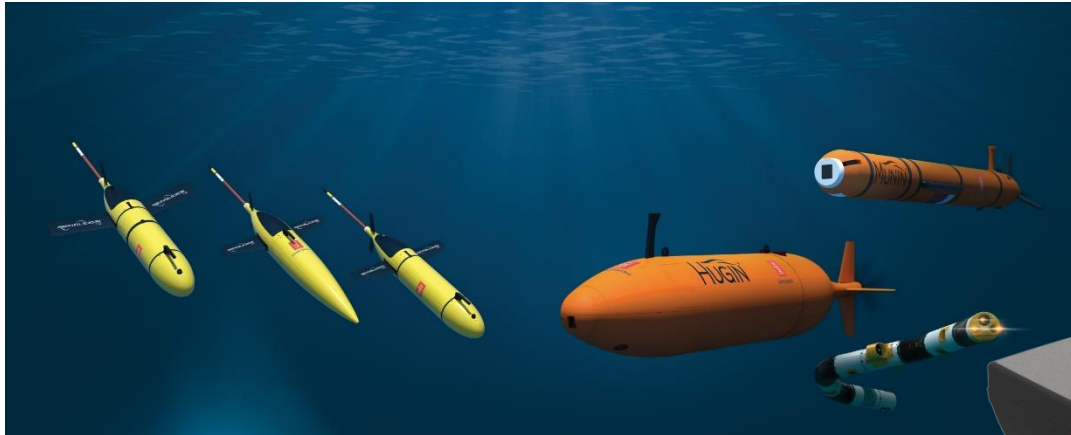
## Safe and Efficient Marine Operations



Dr. Fridtjof Nansen in Horten collecting Scientific Multibeam Systems

# Autonomy - Marine Robotics

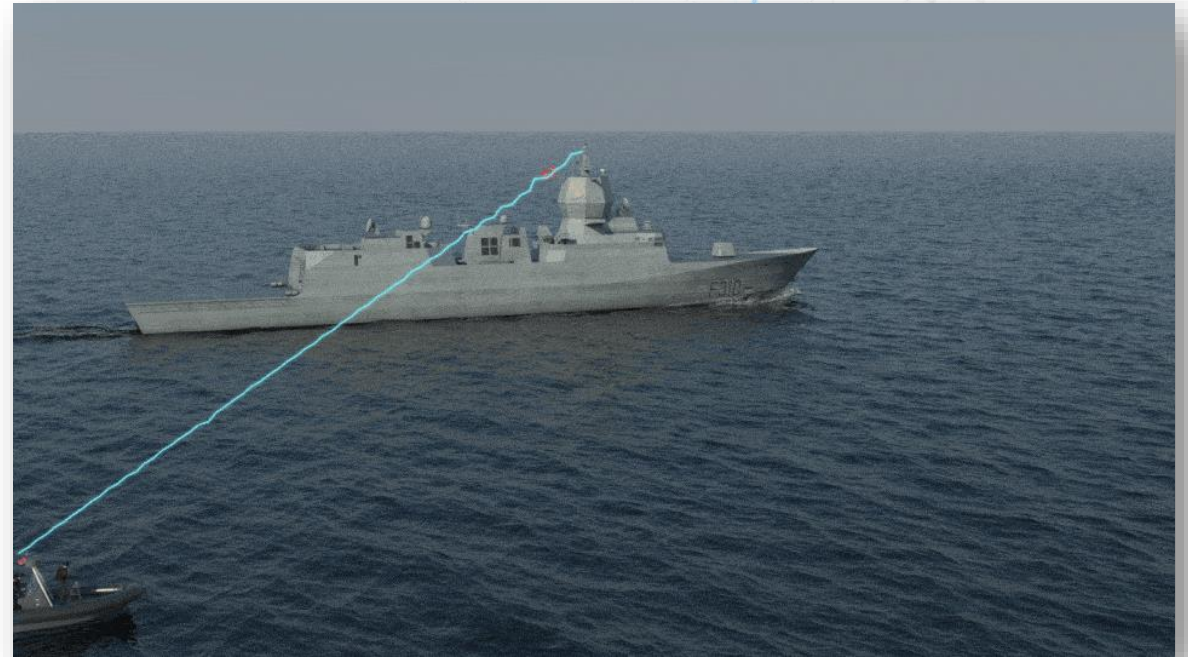
## enhancing the data quality - force multipliers



# Interconnectivity data transmission – remote operations



Conventional radio systems

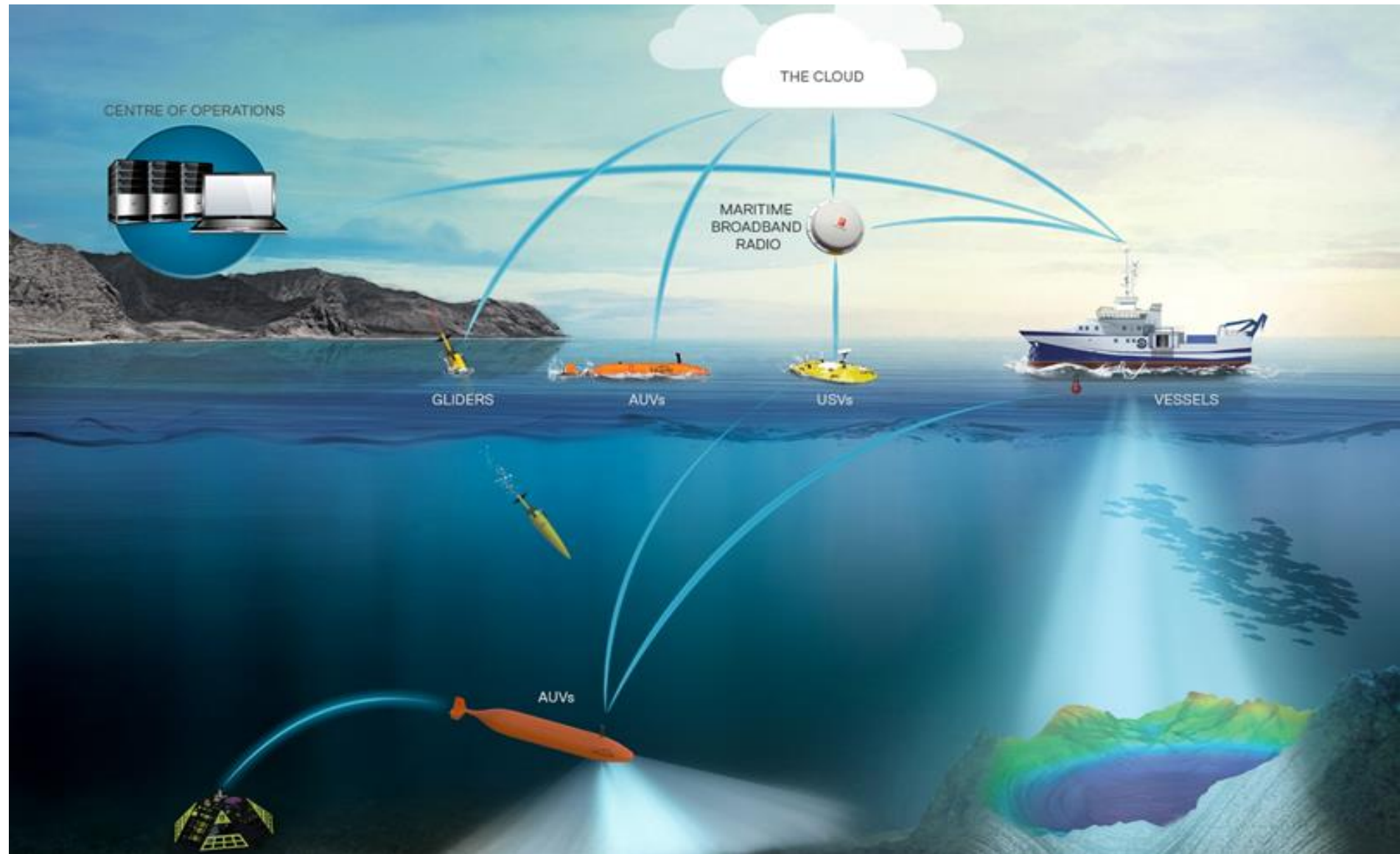


Marine Broadband Radio - MBR



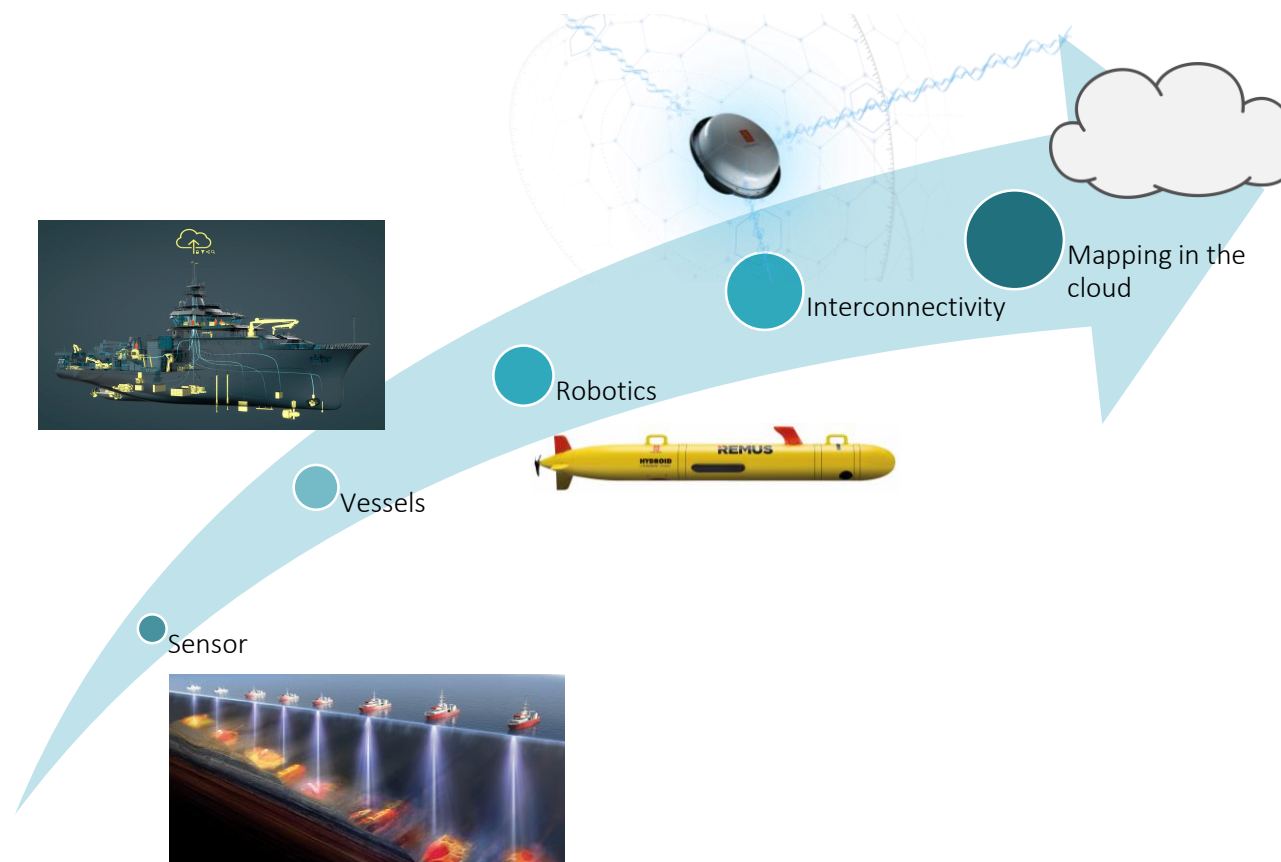
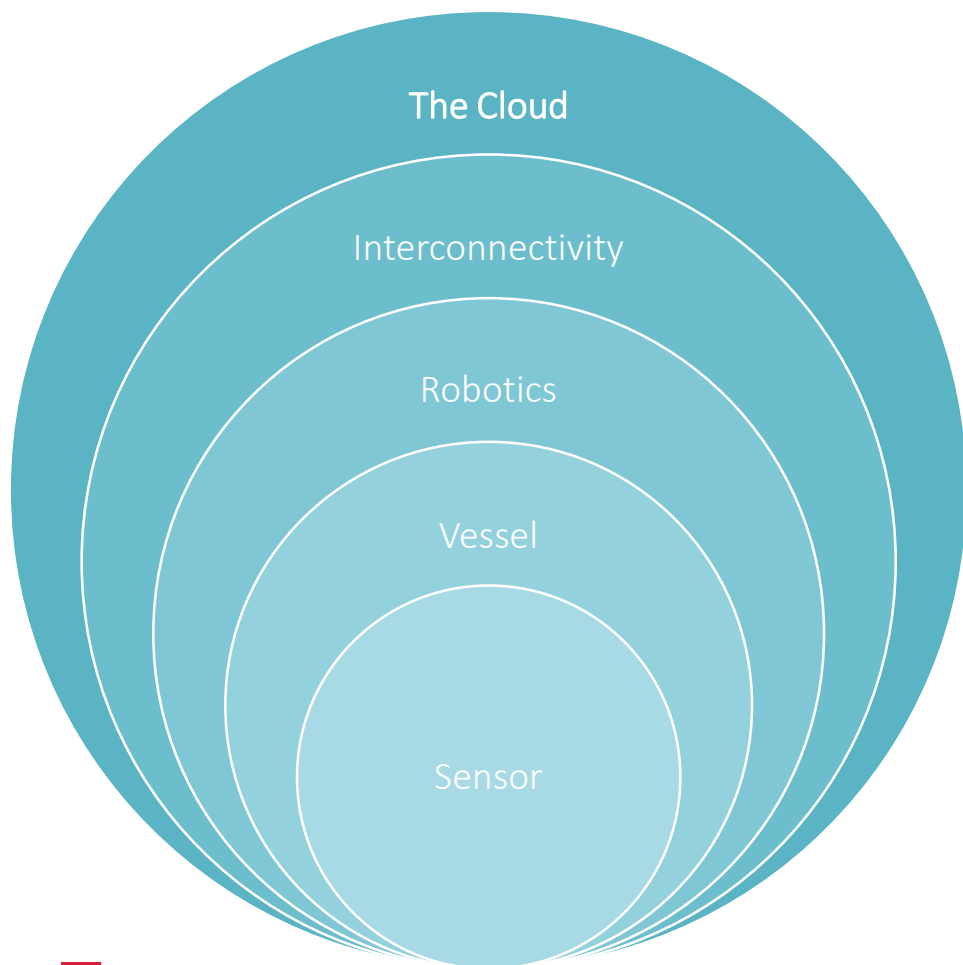
# Digitalization Bringing it into the cloud

Collect the best  
quality data in the  
most effective  
manner



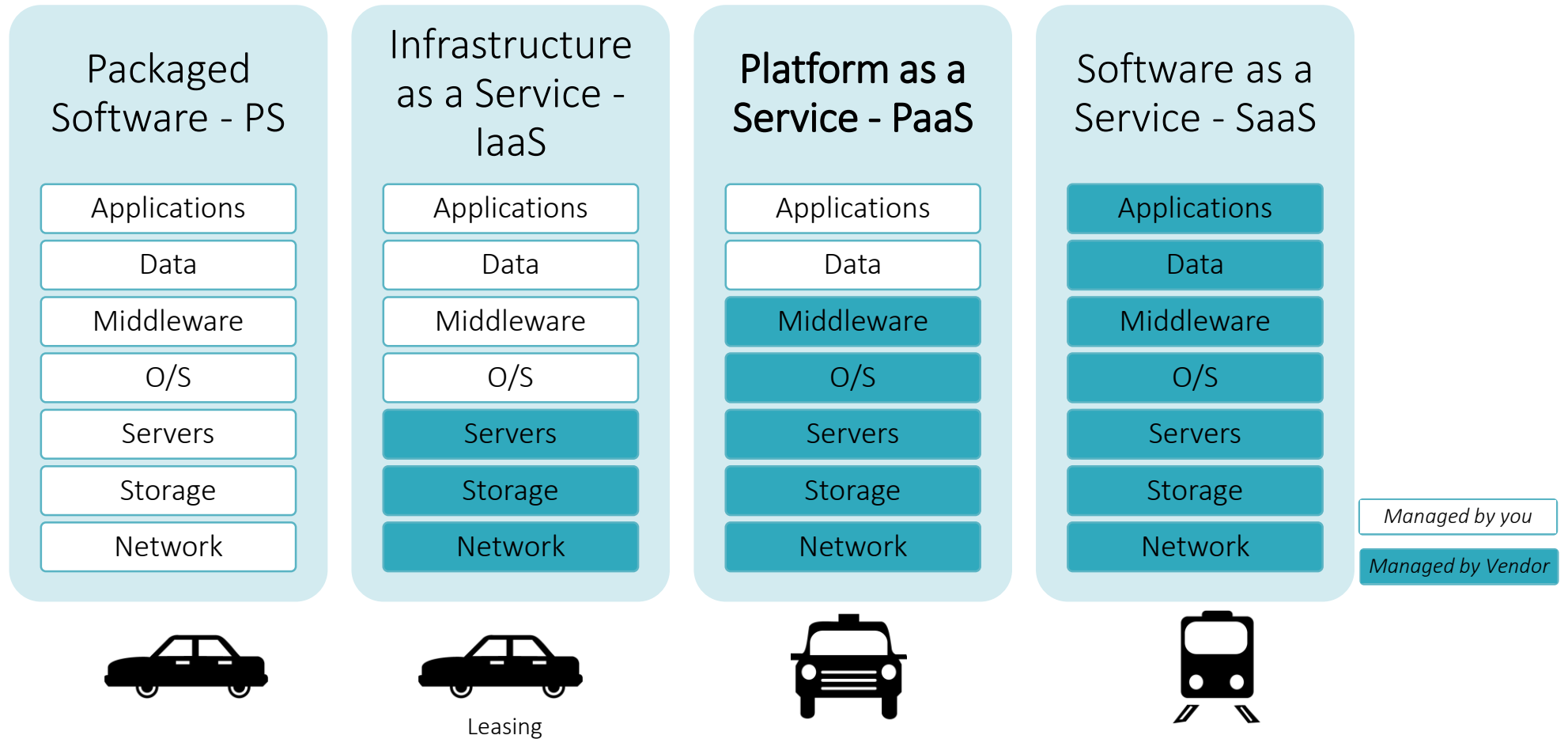
# Bringing it together

## Effective operations



# Business Model

## How do we work together?

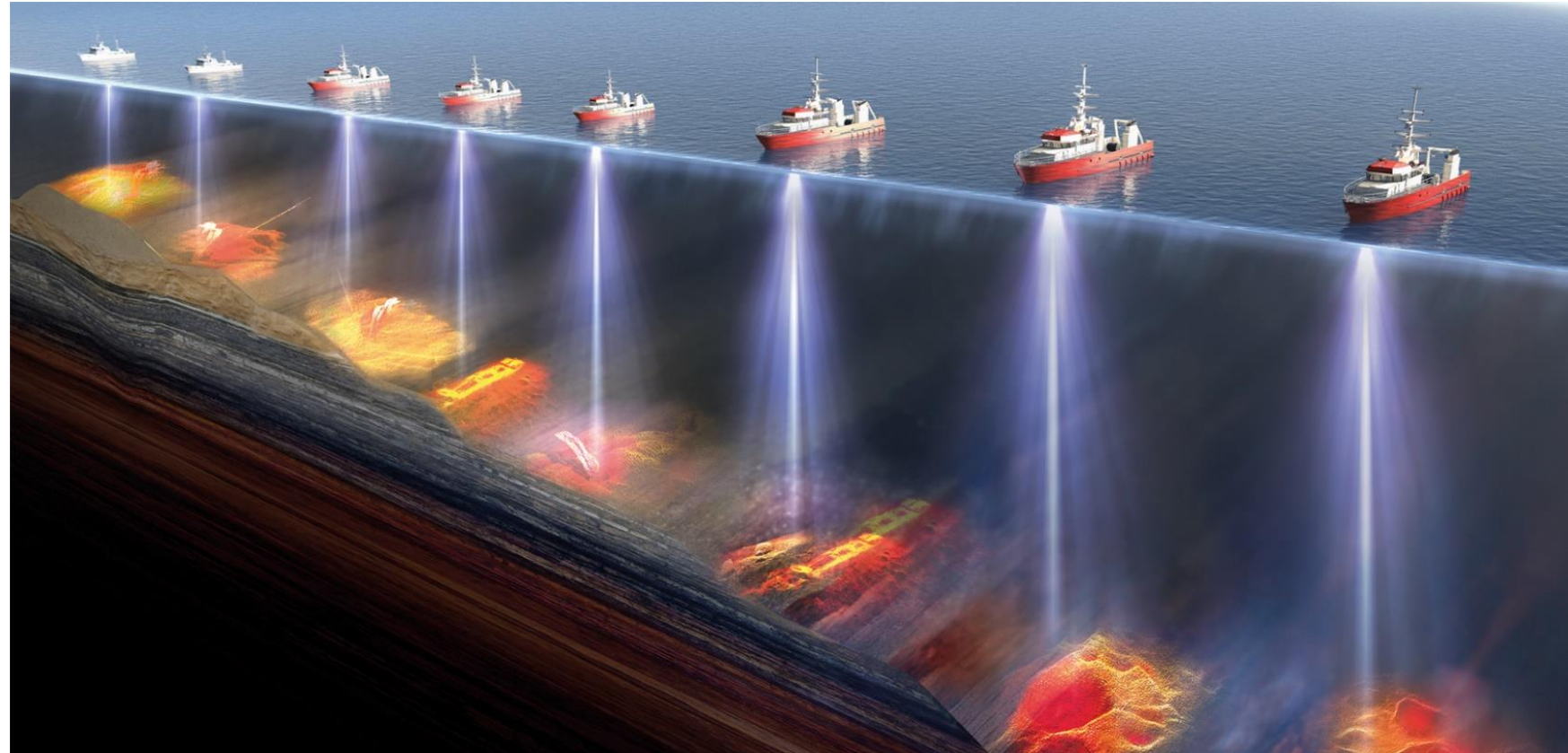


# Better sensors

## Multibeam echosounder

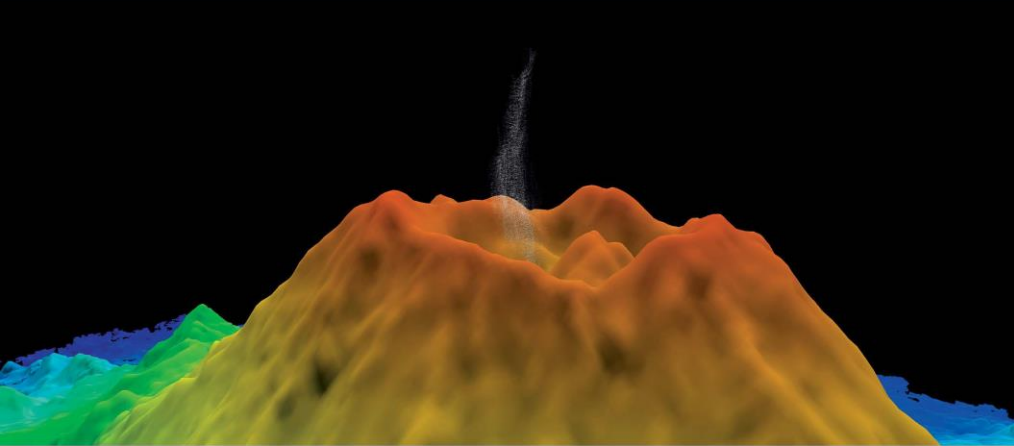
### New releases:

- GS4
- EM 2040 MK II
- EM 2040C MK II
- EM 712
- EM 304
- EM 124





# EM<sup>®</sup> 304



## 30 KHZ MULTIBEAM ECHO SOUNDER

The modular, state-of-the-art EM 304 performs accurate, high resolution seabed mapping in shallow to deep waters at depths of more than 8000 m. The successor to the EM 302, the EM 304's broad range of functionality supports simultaneous collection of multiple data types, saving time in the planning, execution and analysis phase. A low noise echo sounder, EM 304 delivers superior data requiring minimal post-processing.

### Modular and flexible design

The EM 304 consist of new state-of-the-art electronics and separate transmit and receive transducers in a Mills Cross configuration. It utilizes the same field-proven transducers as the EM 302, making it easy to upgrade. Care has been taken to design a highly, modular and flexible solution with compact electronics for easier and faster installation. Due to a flexible transducer design, the system can be tailored to almost any required size. The largest standard size, 0.5 x 0.5 degrees, gives the ultimate system performance in terms of resolution and range, while a smaller 4 x 4 degrees solution can be installed on any vessel of opportunity.

### Full seabed coverage

The transmit fan is divided into up to 16 individual sectors in dual swath mode. This allows for unique control of the transmit fan, enabling active stabilization in real time to correct for any yaw and pitch movement of the vessel, while roll stabilization is applied on the receiving beams. The result is a stabilized system for full ensonification of the seabed with equally distributed footprints, even in bad weather conditions, leaving no gaps or holes in the mapped area. All beams are maintained and automatically adjusted according to achievable coverage or operator defined limits. Up to 1600 individual beams are available in dual swath mode. Two individual transmitting fans are generated with a small difference in tilt giving a constant sounding separation alongtrack, resulting in a dense sounding pattern on the seafloor.

### Clean and high resolution data

Due to the sector transmission technique, the system produces a strong dampening of multi-bounce interference from false echo, resulting in significantly cleaner data. Near field beam focus is applied in real time, both during transmission and reception. Due to sector transmission the focal point will be individual for each sector, resulting in a much sharper transmit beam over the entire swath. On reception, the focus is done dynamically for each beam. The result is a much higher resolution representation of the seabed.

### The Kongsberg EM systems

The EM 304 is part of the new EM platform designed for future challenges. The new datagram format supports several new features, such as extended backscatter calibration and more features will be available going forward. The new format is supported by the Kongsberg Kognifai digital open ecosystem.

All Kongsberg EM multibeam echo sounders ensure the best operating environment to safeguard mammals inhabiting the survey area.

## TECHNICAL SPECIFICATIONS AND FEATURES

Feature	
Depth range	10 to more than 8000 metres The depth range depends on water temperature, noise level and bottom type. **
Nominal frequency	30 kHz
Operating frequency	26 - 34 kHz
Swath width	Typically 5.5 times the depth or more than 9 km
Number of swath	2 swaths per ping
Pulse length	0.4 ms CW to 200 ms FM effective pulse length
Number of transmit sectors	16 frequency coded transmit sectors per ping / 8 per swath
Available models (receiver and transmitter)	0.5 degree, 1 degree, 2 degrees and 4 degrees
Number of receiver beams (per ping)	1600 beams, 0.5 degree RX and 1 degree RX 1024 beams, 2 degree RX 512 beams, 4 degree RX
Multi-bounce suppression	Better than 50 dB
Beam focusing	On transmit and receive
Deliverables	Bathymetric data Seabed imagery data Water column data Extra depth detections
Realtime motion stabilization	Roll: ± 15 degrees Pitch: ± 10 degrees Yaw: ± 10 degrees
Sounding pattern	Equidistant and equiangular
Gain control	Automatic
Mammal protection	Gradual start up transmit ramp
New datagram format * KMall replaces * all format	
Sub Bottom Profiler integration available	
Compliant to IHO S-44 order 1A	

\* *Vailulu'u Plume. Image courtesy of Amanda Bittinger, Sunset Hydrographic, LLC. Kongsberg product: EM 302 bathymetry and water column data. Location: American Samoa. Depth: (Plume) 100.2 - 800.7 m (Bathymetry) > 547.1 m.*

\*\* 9700 m was achieved by RV Falkor with an EM 302 1 x 1 degree system.

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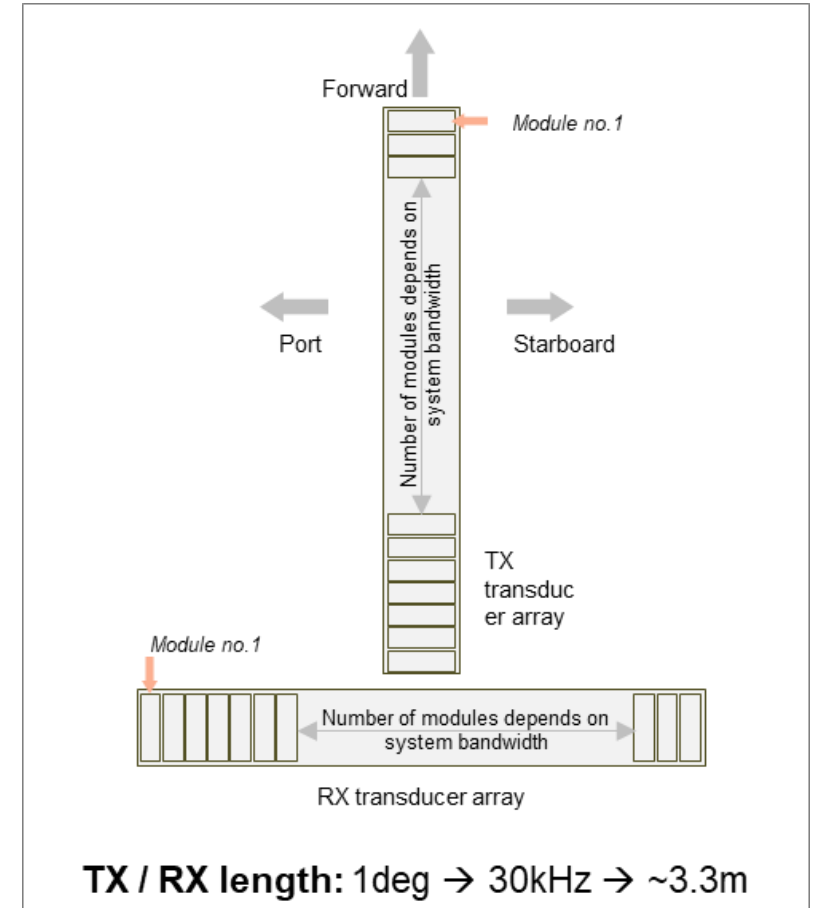
# EM 304

## EM 304 – Benefits

- Modular design
  - 0,5x0,5
  - 0.5x1
  - 1x1
  - 1x2
  - 2x2
  - 2x4
  - 4x4
  - RXU
  - TXU
  - PU
  - Topside

Transducer size	No of transmitter modules	No of receiver modules
0.5 degree	16	16
1 degree	8	8
2 degree	4	4
4 degree	2	2

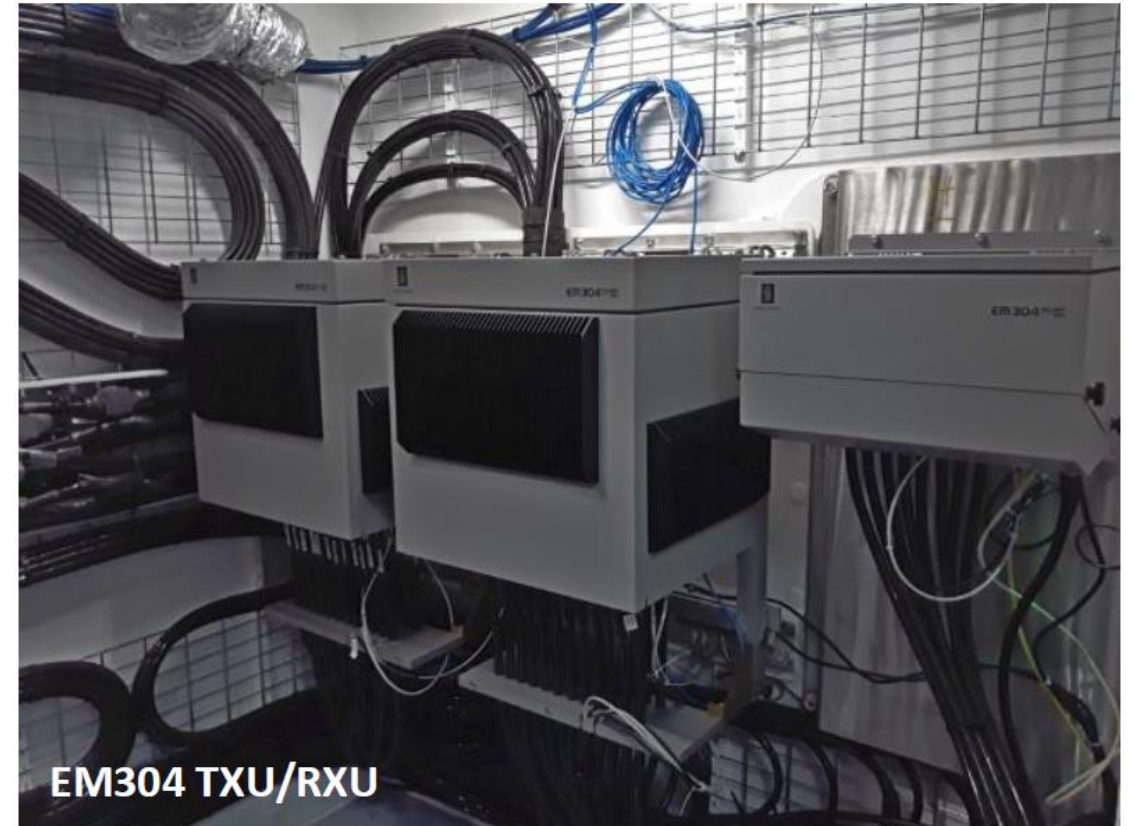
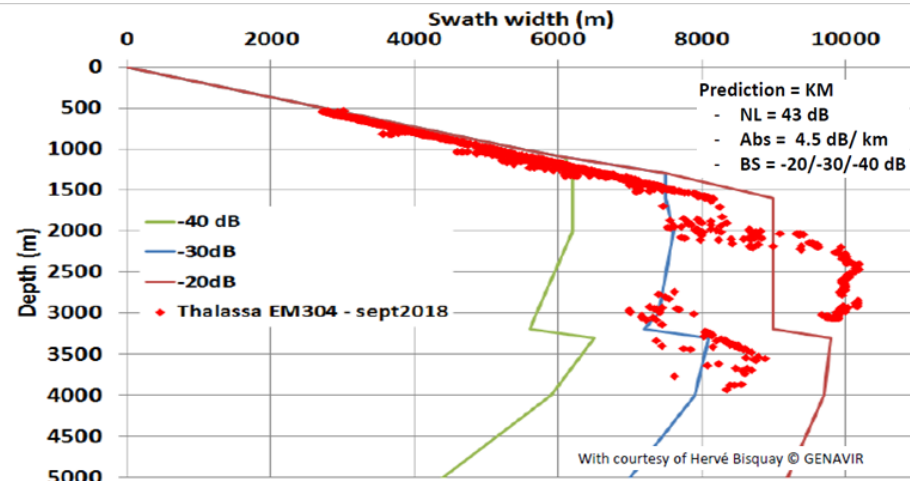
To optimize the system performance in accordance with the vessel hull shape and size, a system can be delivered with non-standard number of modules (longer lead time)



# EM 304

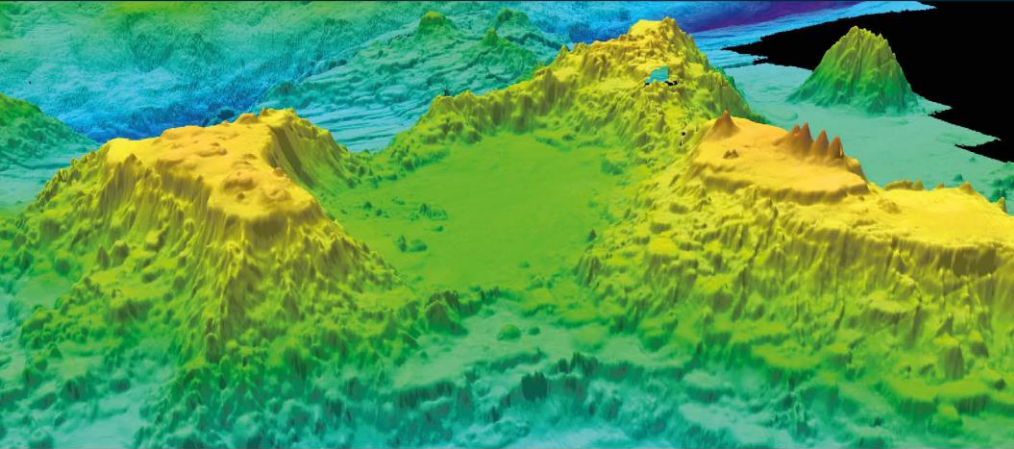
## EM 304 – Benefits

- Wider swath coverage
  - New electronics with very low self noise, ~ 5-10dB lower than EM 302
  - Range is mainly limited by vessel noise, potentially 1000m wider swath coverage



EM304 TXU/RXU

# EM<sup>®</sup> 124



## 12 KHZ MULTIBEAM ECHO SOUNDER

The modular, state-of-the-art EM 124 performs accurate, high resolution seabed mapping in shallow to full ocean depth. The successor to the EM 122, the EM 124's broad range of functionality supports simultaneous collection of multiple data types, saving time in the planning, execution and analysis phase. A low noise echo sounder, EM 124 delivers superior data that requires minimal post-processing.

### Modular and flexible design

The EM 124 consist of new state-of-the-art electronics and separate transmit and receive transducers in a Mills Cross configuration. It utilizes the same field-proven transducers as the EM 122, making it easy to upgrade. Care has been taken to design a highly, modular and flexible solution with compact electronics for easier and faster installation. Due to a flexible transducer design, the system can be tailored to almost any required size. The largest standard size, 0.5 x 1 degrees, gives the ultimate system performance in terms of resolution and range, while a smaller 4 x 4 degrees solution allowing full ocean depth surveys even on smaller vessels.

### Full seabed coverage

The transmit fan is divided into up to 16 individual sectors in dual swath mode. This allows for unique control of the transmit fan, enabling active stabilization in real time to correct for any yaw and pitch movement of the vessel, while roll stabilization is applied on the receiving beams. The result is a stabilized system for full ensonification of the seabed with equally distributed footprints, even in bad weather conditions, leaving no gaps or holes in the mapped area. All beams are maintained and automatically adjusted according to achievable coverage or operator defined limits. Up to 1600 individual beams are available in dual swath mode. Two individual transmitting fans are generated with a small difference in tilt giving a constant

sounding separation alongtrack, resulting in a dense sounding pattern on the seafloor.

### Clean and high resolution data

Due to the sector transmission technique, the system produces a strong dampening of multi-bounce interference from false echo, resulting in significantly cleaner data. Near field beam focus is applied in real time, both during transmission and reception. Due to sector transmission the focal point will be individual for each sector, resulting in a much sharper transmit beam over the entire swath. On reception, the focus is done dynamically for each beam. The result is a much higher resolution representation of the seabed.

### The Kongsberg EM systems

The EM 124 is part of the new EM platform designed for future challenges. The new datagram format supports several new features, such as extended backscatter calibration and more features will be available going forward. The new format is supported by the Kongsberg Kognifai digital open ecosystem.

All Kongsberg EM multibeam echo sounders ensure the best operating environment to safeguard mammals inhabiting the survey area.

## TECHNICAL SPECIFICATIONS AND FEATURES

Feature	
Depth range	20 to 11000 metres, or full ocean depth The depth range depends on water temperature, noise level and bottom type.
Nominal frequency	12 kHz
Operating frequency	10.5 - 13.5 kHz
Swath width	Typically 6 times the depth or more than 40 km
Number of swath	2 swaths per ping
Pulse length	1 ms CW to 100 ms FM effective pulse length
Number of transmit sectors	16 frequency coded transmit sectors per ping / 8 per swath
Available transmitter models	0.5 degree, 1 degree, 2 degrees and 4 degrees
Available receiver models	1 degree, 2 degrees and 4 degrees
Number of receiver beams (per ping)	1600 beams, 1 degree RX 1024 beams, 2 degree RX 512 beams, 4 degree RX
Multi-bounce suppression	Better than 50 dB
Beam focusing	On transmit and receive
Deliverables	Bathymetric data Seabed imagery data Water column data Extra depth detections
Realtime motion stabilization	Roll: ± 15 degrees Pitch: ± 10 degrees Yaw: ± 10 degrees
Sounding pattern	Equidistant and equiangular
Gain control	Automatic
Mammal protection	Gradual start up transmit ramp
New datagram format * KMall replaces *.all format	
Sub Bottom Profiler integration available	
Compliant to IHO S-44 order 1A	

Image: Bathymetry of the Northern Portion of the Mariana Trench. Courtesy of Dr James V. Gardener, University of New Hampshire.

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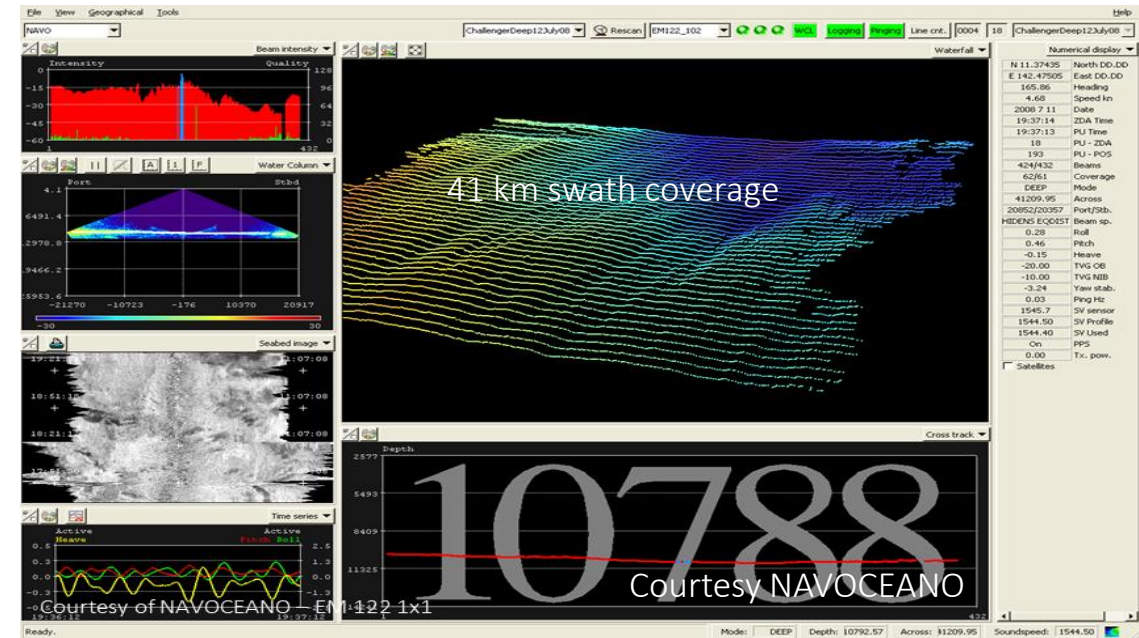
Slide

4277/86(C) January 2018

# EM 124

## EM 124 – Benefits

- Unmatched performance in range and resolution, De facto standard in Deep waters
- Well proven
  - Based on EM 122
  - Same transducers as EM 122
  - Same electronics as EM 712, EM 304 and EM 2040



# EM 124

## EM 124 – Benefits

- Wider swath coverage
  - New electronics with very low self noise, ~ 5-10dB lower than EM 122
  - Range is mainly limited by vessel noise

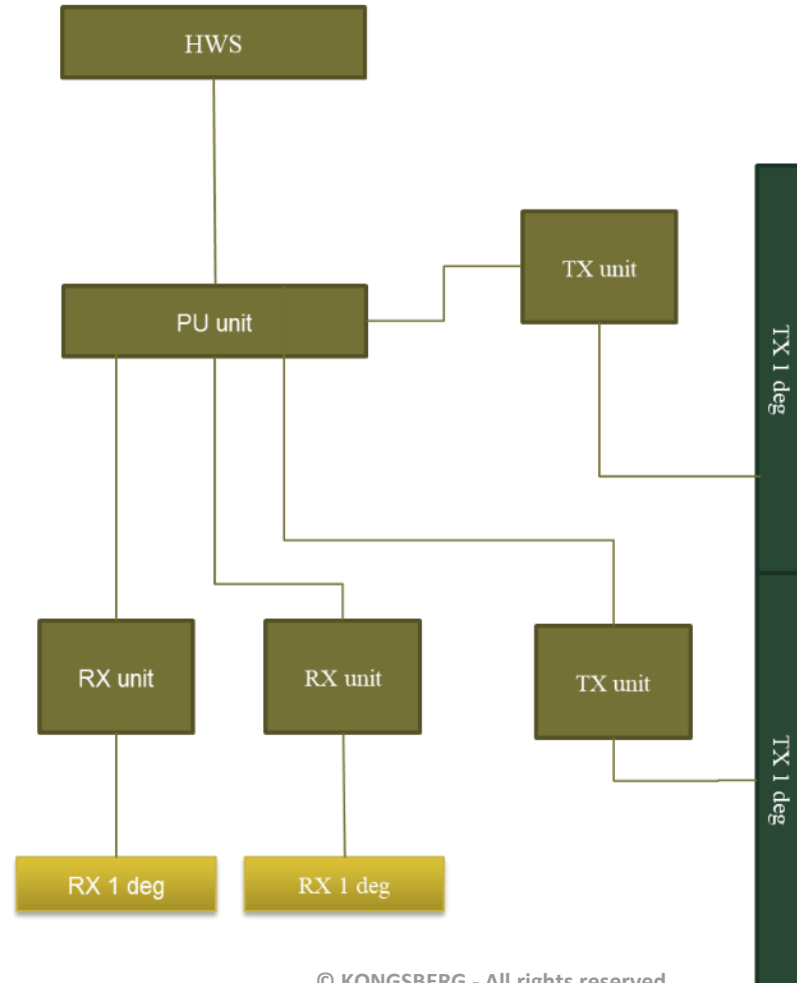


Same electronics as for EM 304  
EM304 TXU/RXU

# EM 124

## EM 124 – Benefits

- Modular design
  - 0.5x1
  - 1x1
  - 1x2
  - 2x2
  - 2x4
  - RXU
  - TXU
  - PU
  - Topside



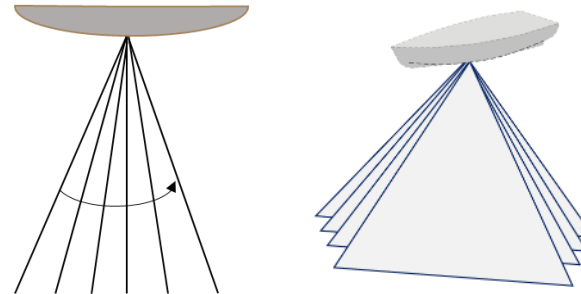
# EM 124

## EM 124 – Options

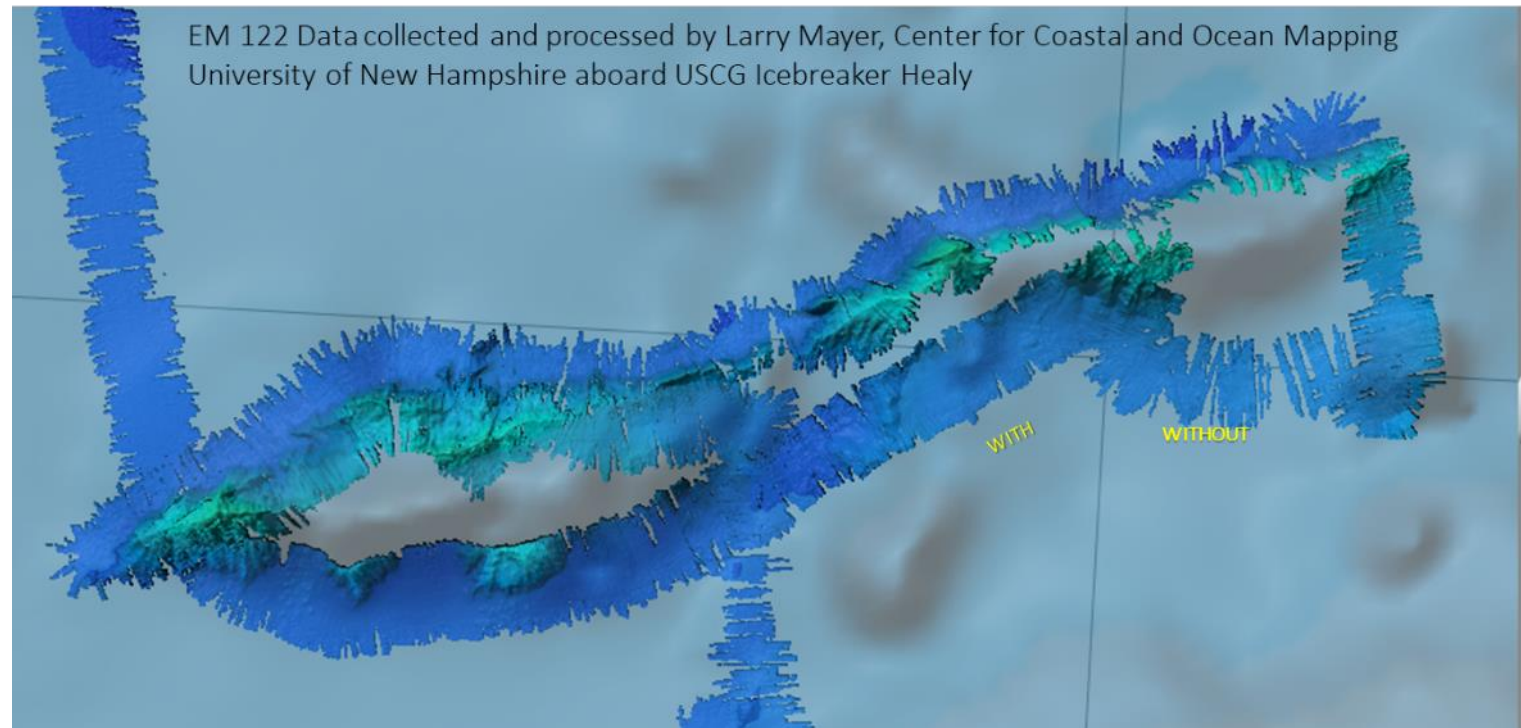
Scanning mode

Specialized mode for ice breaking vessels.

Ships not moving while the echosounder electronically steers the transmit and receiver fans.



USGS Healy  
EM 122







# FIVE DEEP DIVES

## THE LIMITING FACTOR

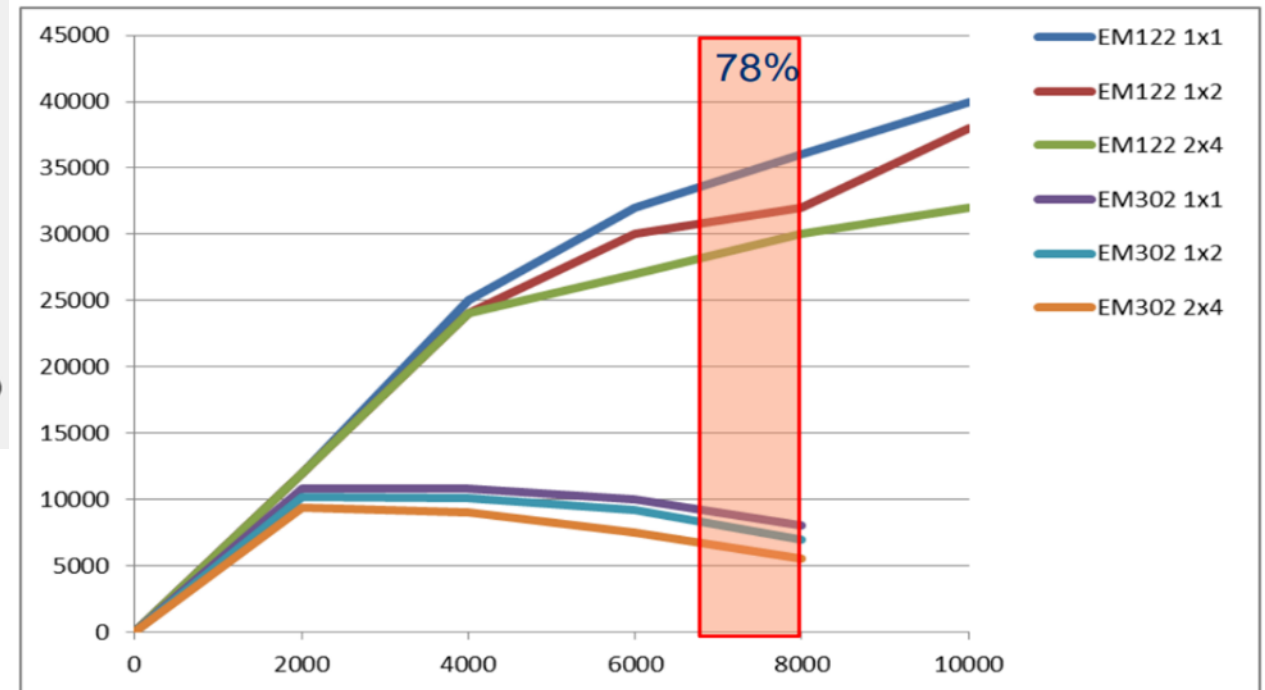
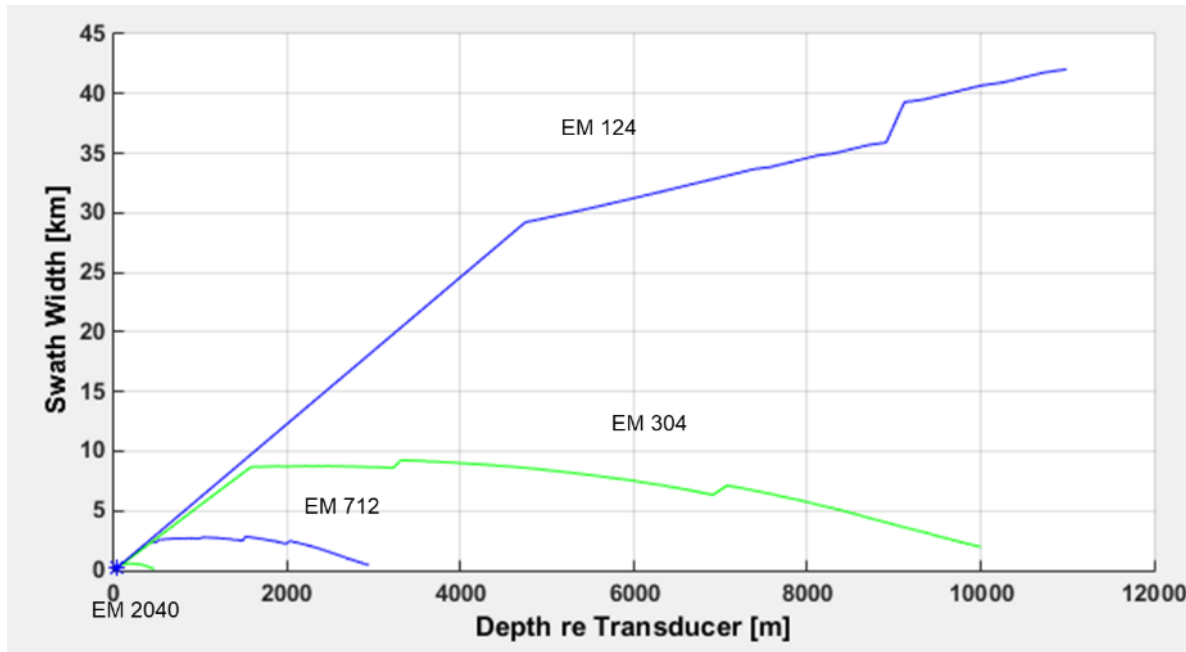
- Two-man submersible
- Dive depth 11,000m
- Pressure test 14,000m
- Hull 90mm titanium alloy
- In-air weight 12,500kg
- Endurance 16 hours + 96hrs emergency life support



**VICTOR VESCOVO**  
Has climbed the highest peaks on all seven continents including Mt Everest and could become the first person to have been to the top of all the continents as well as the bottom of all the oceans

<https://fivedeeps.com/>

# EM 124 vs EM 304 vs EM 712



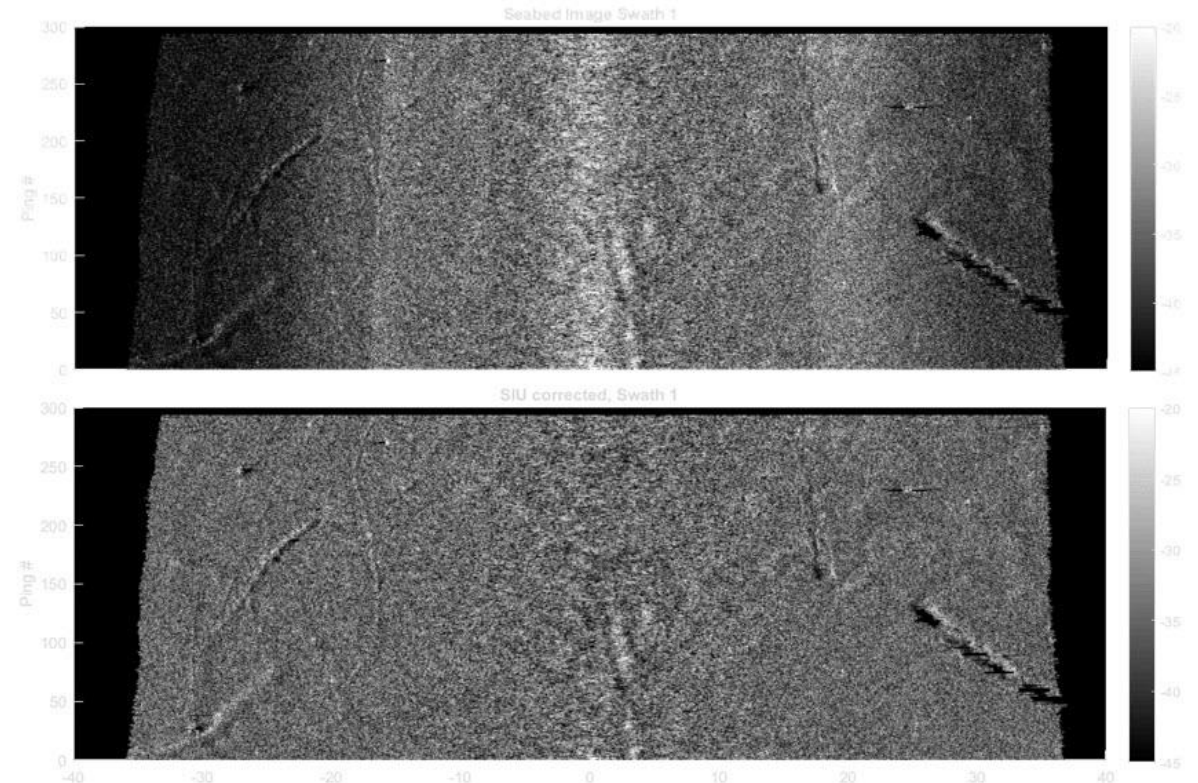
# Calibrated backscatter

## EM - Options

### Backscatter Calibration

- KONGSBERG provides backscatter calibration as a service
- Backscatter calibration is sonar and installation specific
  1. Customer submits data collected using a data collection procedure
  2. Kongsberg creates a new backscatter offset values
  3. Deliverables are is a new BS corr file and an application capable of post processing old data from that specific sonar.
  4. User updates sonar with new BS corr file and all new data is collected with calibrated backscatter

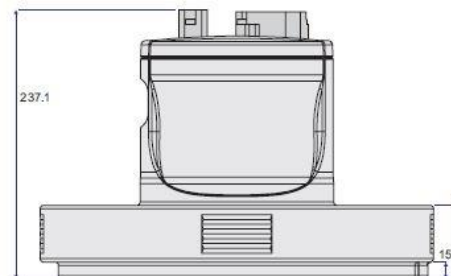
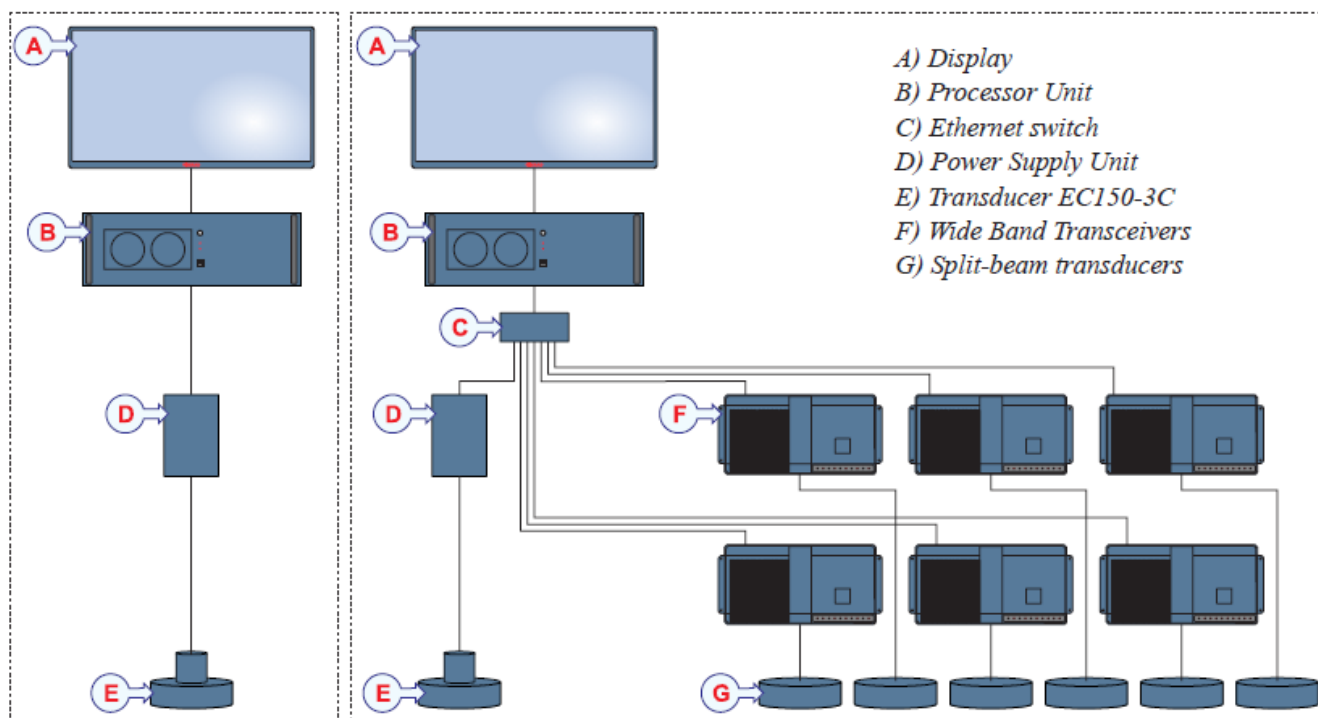
To get optimum backscatter (BS) values, all EM's should be calibrated for the actual installation



- Old data can be re-processed using an executable file

# Scientific echsounders

## ■ EK80 – ADCP option - EC150-3C



Transducer  
Largest diameter is 346 mm  
Weight in air: 12 kg

# EK80 Echo sounder & ADCP

## ■ General

- Technology: Phased array
- Nominal frequency: 150 kHz
- Frequency range: 130 to 170 kHz
- Dynamic range: 135 dB

## ■ Echo sounder

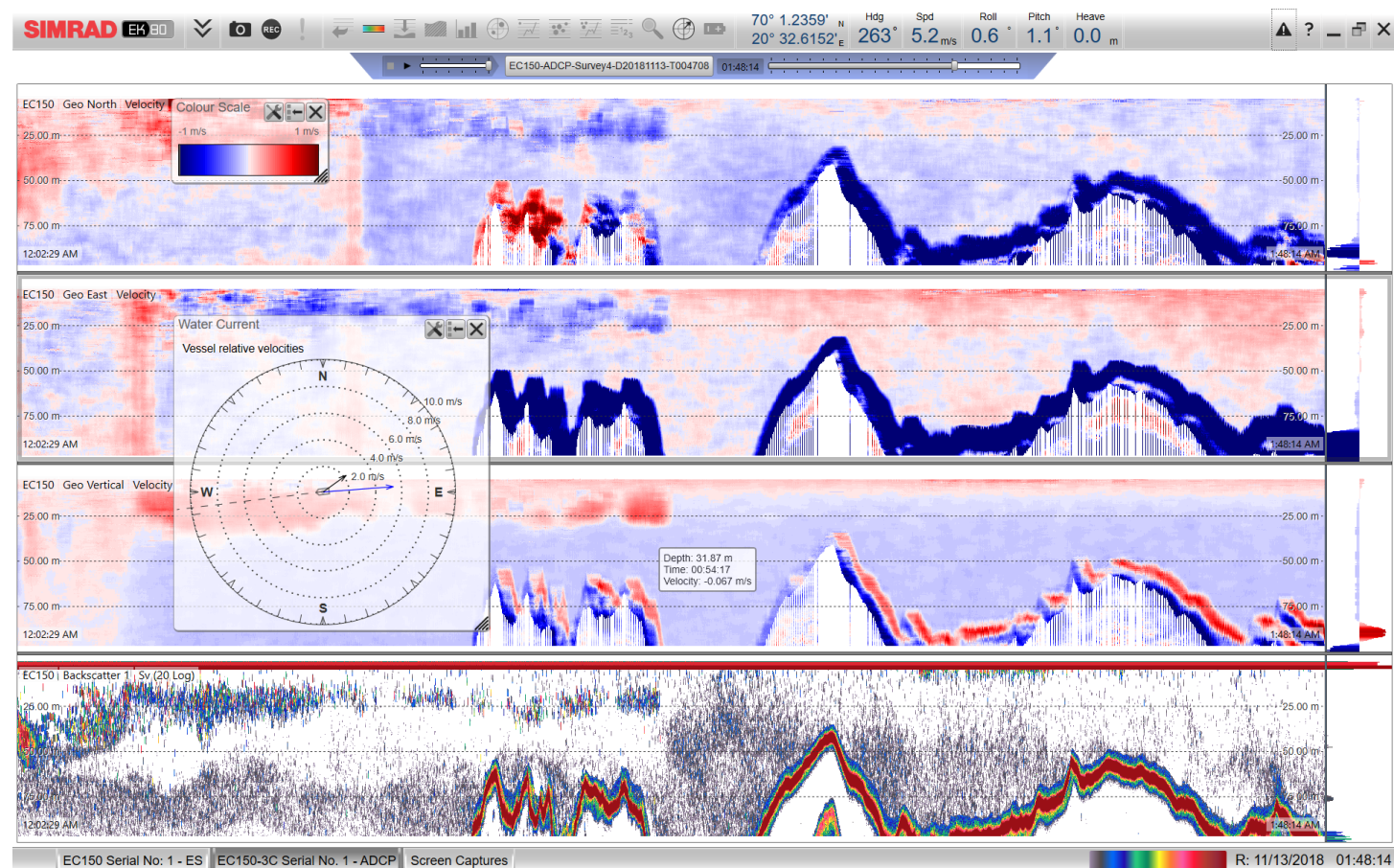
- Number of beams: 1 split beam
- Beam width: 2.5 degrees @ 150 kHz
- Pulse type: CW or FM

## ■ ADCP

- Number of beams: 4
- Beam vertical tilt: 30 degrees
- Beam width: 3 degrees @ 150 kHz
- Pulse type: CW or FM
- Cell size: 2 to 16 m
- Max output sample interval: 40  $\mu$ s
- Max number of depth cells: Unlimited
- Max range: > 400 m @ CW, 8 m cell size

# EK80 Echo sounder & ADCP

- EK80 Software



# Integration – Vessel system

From sensors to ship design



- Acoustic Systems for Marine Ecosystem Surveys and bottom mapping
- Operation environment (Bridge equipment, Consoles and Multi-monitor solution)
- Navigation system (Radar and ECDIS)
- Telecom
- Dynamic positioning
- Propulsion & Engines
- Rudder and steering gear
- Deck machinery

- Integrated Automation System (IAS)
- Electrical Power Solution
  - Switchboards
  - Hybrid solution with batteries
  - Drives
  - EI-motors
  - Power Management System (PMS)
- Vessel Management
- Remote Support

# A comprehensive range of products

Ship Design



- Supply and service vessels
- Exploration and production vessels
- Cargo, container and passenger vessels
- Fishing vessels
- Naval vessels

Deck Machinery & Motion Control



- Anchor handling and mooring winches
- Safer deck operations
- Handling systems for subsea, seismic and oceanography
- Positioning mooring
- Fishing winches
- Steering gear & Rudders
- Stabilizations

Automation & Control



- Unified Bridge
- Propulsion control
- Dynamic Positioning
- Automation systems
- Electrical power systems

Engines & Gas Turbines



- Diesel and gas propulsion engines and generator sets
- Gas turbines

Propulsion









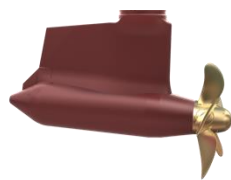




- Propellers and thrusters



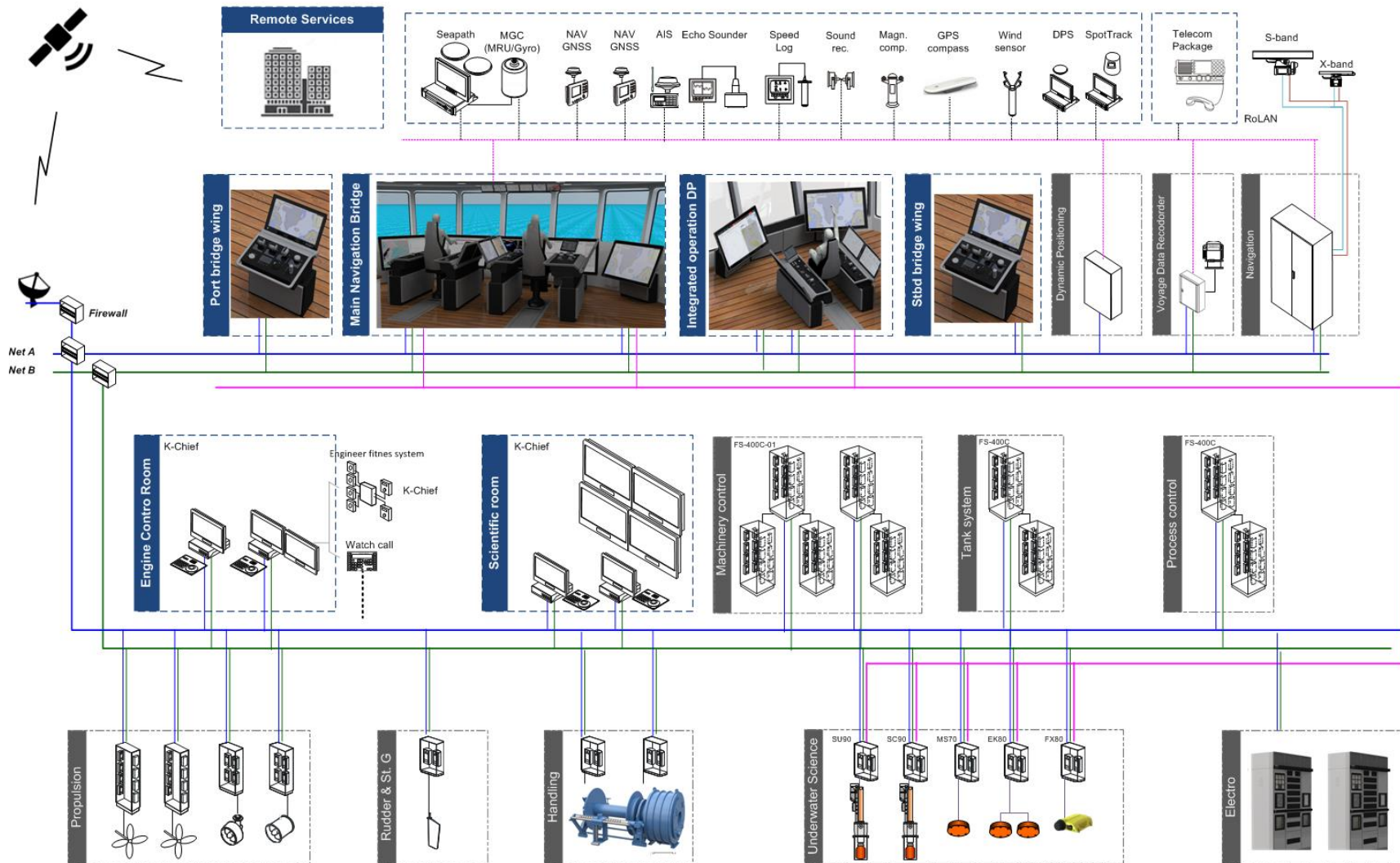
# Propulsion Product Range

Full range of environmental friendly solutions

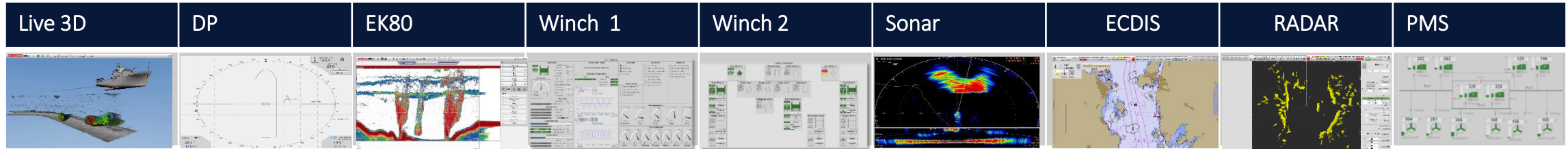
<p>Propellers and reduction gears</p> 	<p>Rudders</p> 	<p>Diesel and gas engines</p> 	<p>Steering gear</p> 
<p>Azimuth thrusters</p> 	<p>Contra rotating thrusters</p> 	<p>Azimuth pulling thrusters</p> 	<p>Azimuth underwater mountable thrusters</p> 
<p>Swing-up and vertical retractable thrusters</p> 	<p>Electrical podded propulsors</p> 	<p>Tunnel thrusters</p> 	<p>Automation and control</p> 

- 99 years experience in propeller production.
- Own dedicated hydrodynamic research center.
- Advanced CDF, Design and Analysis in all areas.
- Extensive testing and verification to ensure maximum efficiency and reduce cavitation.
- Close cooperation with customers, external research centers and universities.
- Trusted partner with all relevant experience inhouse

# «Full picture» to research vessels

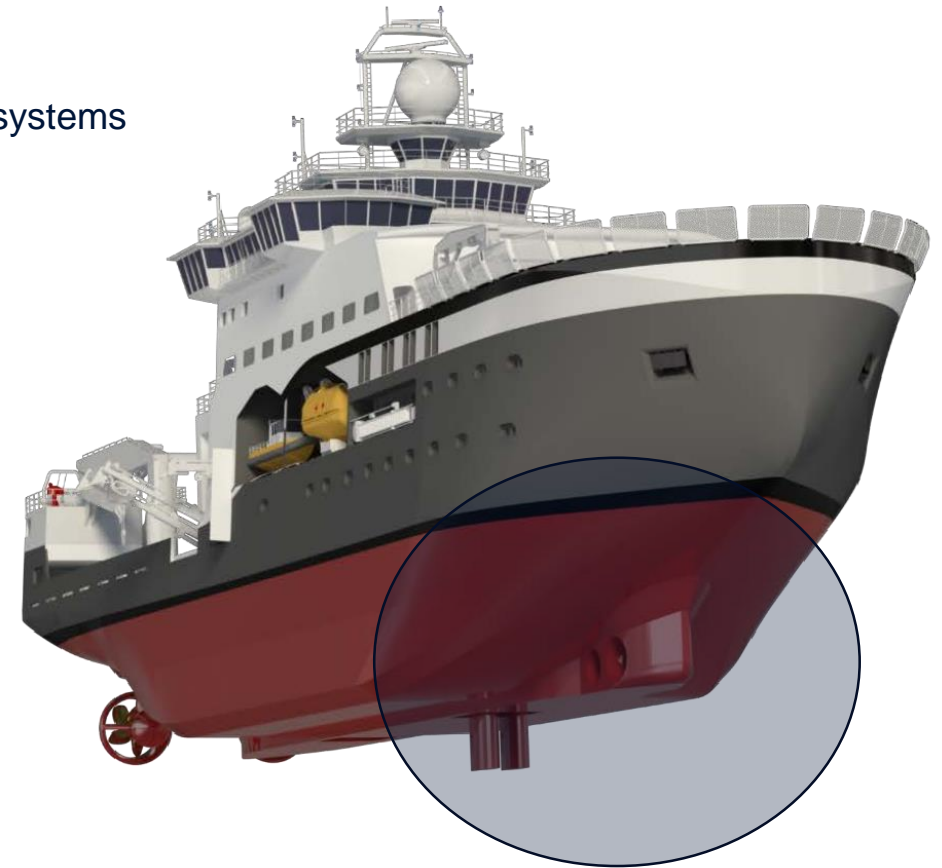


# Integrated bridge operation



# Kronprins Haakon Scientific Icebreaker

- Main challenges:
  - The bow shape is far from optimal to avoid bubble sweep down
  - Heavy machinery might create vibrations adversely influencing the acoustic systems
  - Blister or Gondola can not be used
- Kronprins Haakon design tries to minimize challenges:
  - The knife will push aerated water to the sides of the box keel
  - The box keel gives additional draft to the vessel. Deeper is better!
  - The box keel houses a number of acoustic systems that can be used in ice
  - Two dedicated drop keels house the most sensitive instruments



# Kronprins Haakon Scientific Icebreaker

- Quantitative scientific echosounders, covering from bottom to surface
  - EK80 6 transducer system in Drop keel (non ice conditions)
  - EK80 6 transducers in hull with ice protection
  - ME70 in drop keel
  - MS70 in drop keel
  - SU90 on retractable hull unit
  - SH90 on retractable hull unit
  - PX & FX80 trawl monitoring systems
- High resolution mapping and sub-bottom mapping systems
  - EM304 & EM712
  - SBP 300 & TOPAS PS18
- High Precision Acoustic Positioning & Sensor system
  - HIPAP 502
  - Seapath



# Kronprins Haakon Scientific Icebreaker

- Generating set
  - 2 x Kongsberg B32:40L9ACD
  - 2 x B32:40L6ACD
- Vessel operation systems
  - K-bridge



# Sir David Attenborough Scientific Icebreaker

- Quantitative scientific echosounders, covering from bottom to surface
  - EK80 4 transducer system on retractable hull unit (non ice conditions)
  - EK80 6 transducers in hull with ice protection
  - ME70 on retractable hull unit
  - MS70 on retractable hull unit
  - SX90 on retractable hull unit
  - SH90 on retractable hull unit
- High resolution mapping and sub-bottom mapping systems
  - EM122 & EM712
  - TOPAS PS18
  - EA640
  - K-Sync
- Motion correction and positioning



# Kronprins Haakon Scientific Icebreaker

- Generating set
  - 2 x Kongsberg B33:45L9A
  - 2 x B33:45L6A
- Vessel operation systems





# Autonomy - Marine Robotics

## enhancing data quality - force multipliers

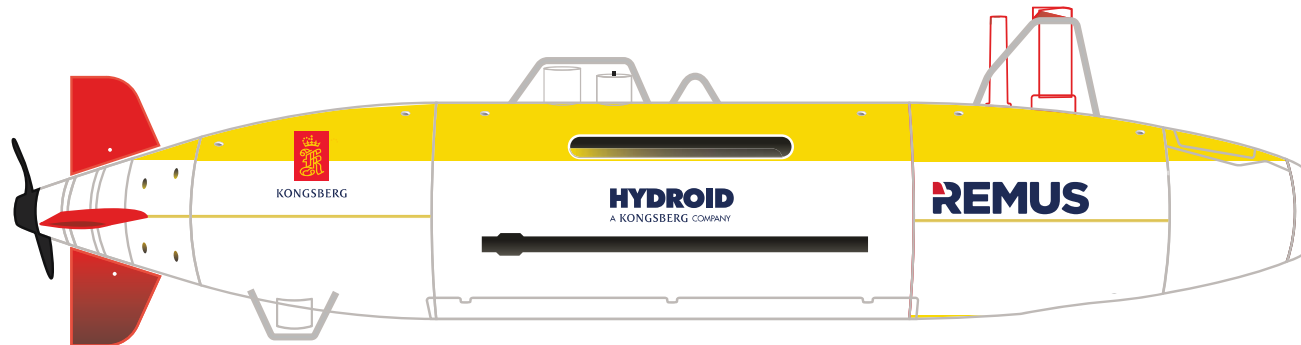
# REMUS AUV Family



REMUS 100 – Industry Standard, Compact Two-Man Portable



REMUS 600 – Highly Modular, Mid-Range, Rapid Deployment Vehicle

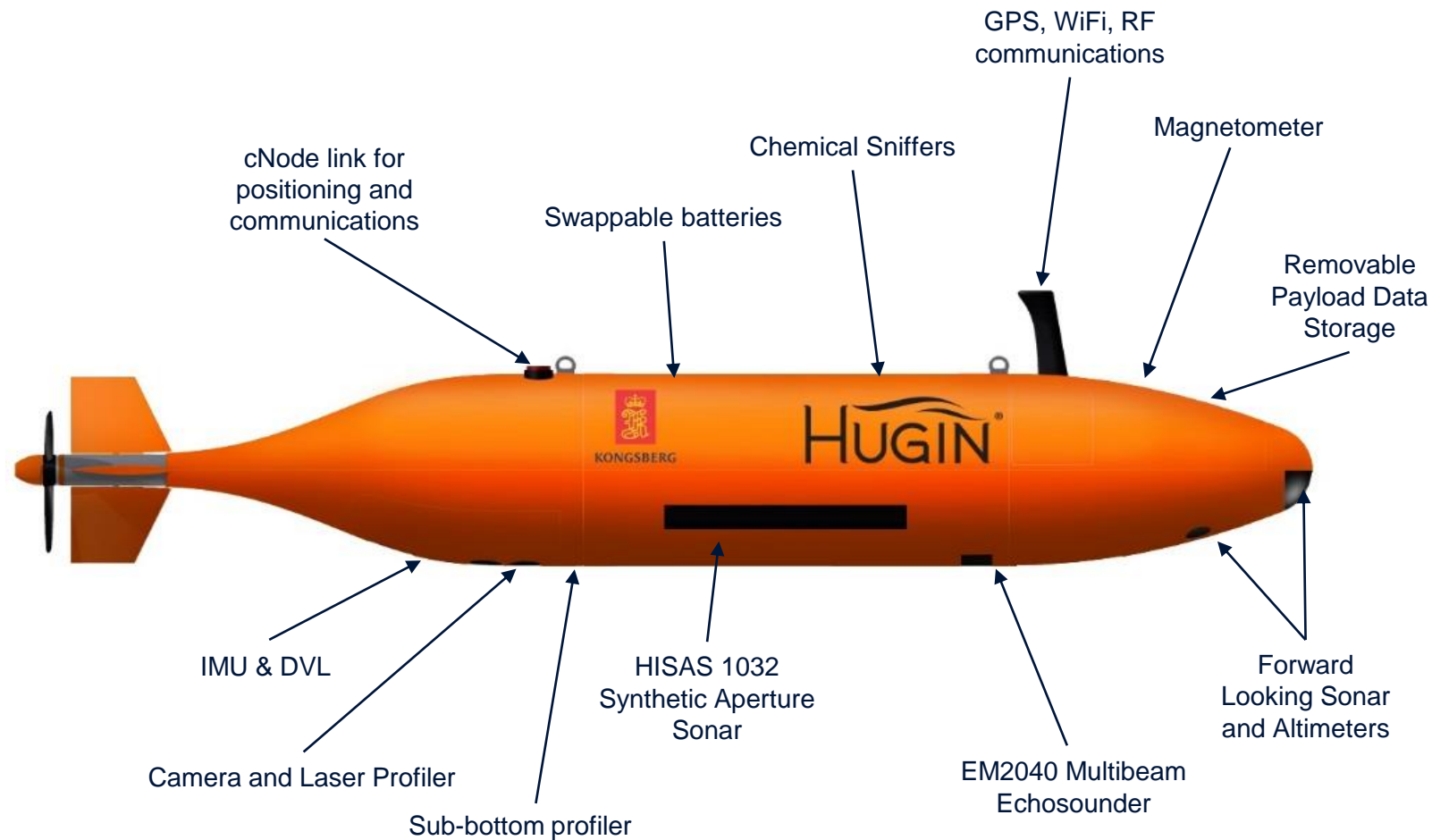


REMUS 6000 – Deep Water Work Horse

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# HUGIN AUV SYSTEM

General arrangement





KONGSBERG

# SOUNDER

USV SYSTEM



# Autonomous cargo vessel



# HUGIN<sup>®</sup>

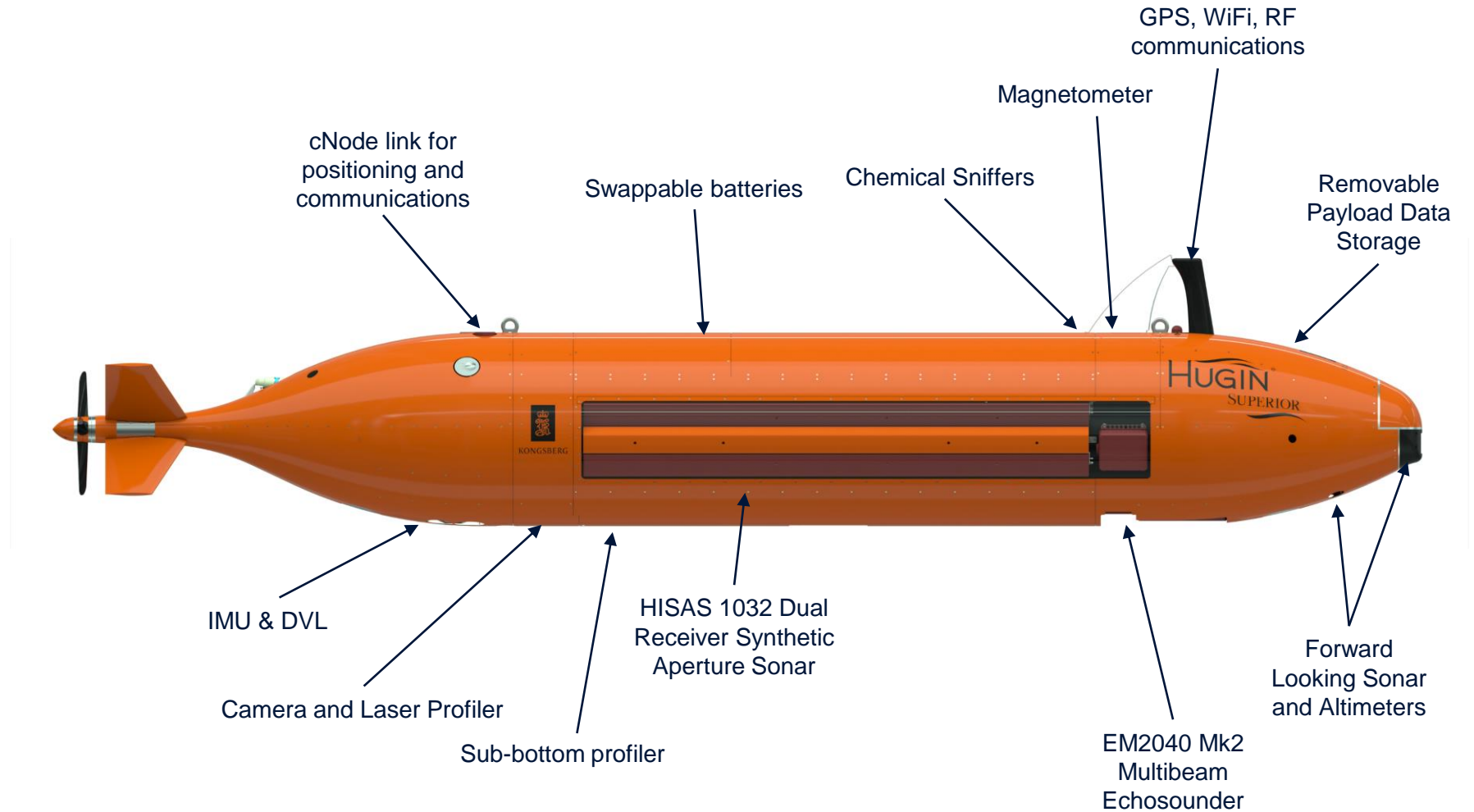
SUPERIOR

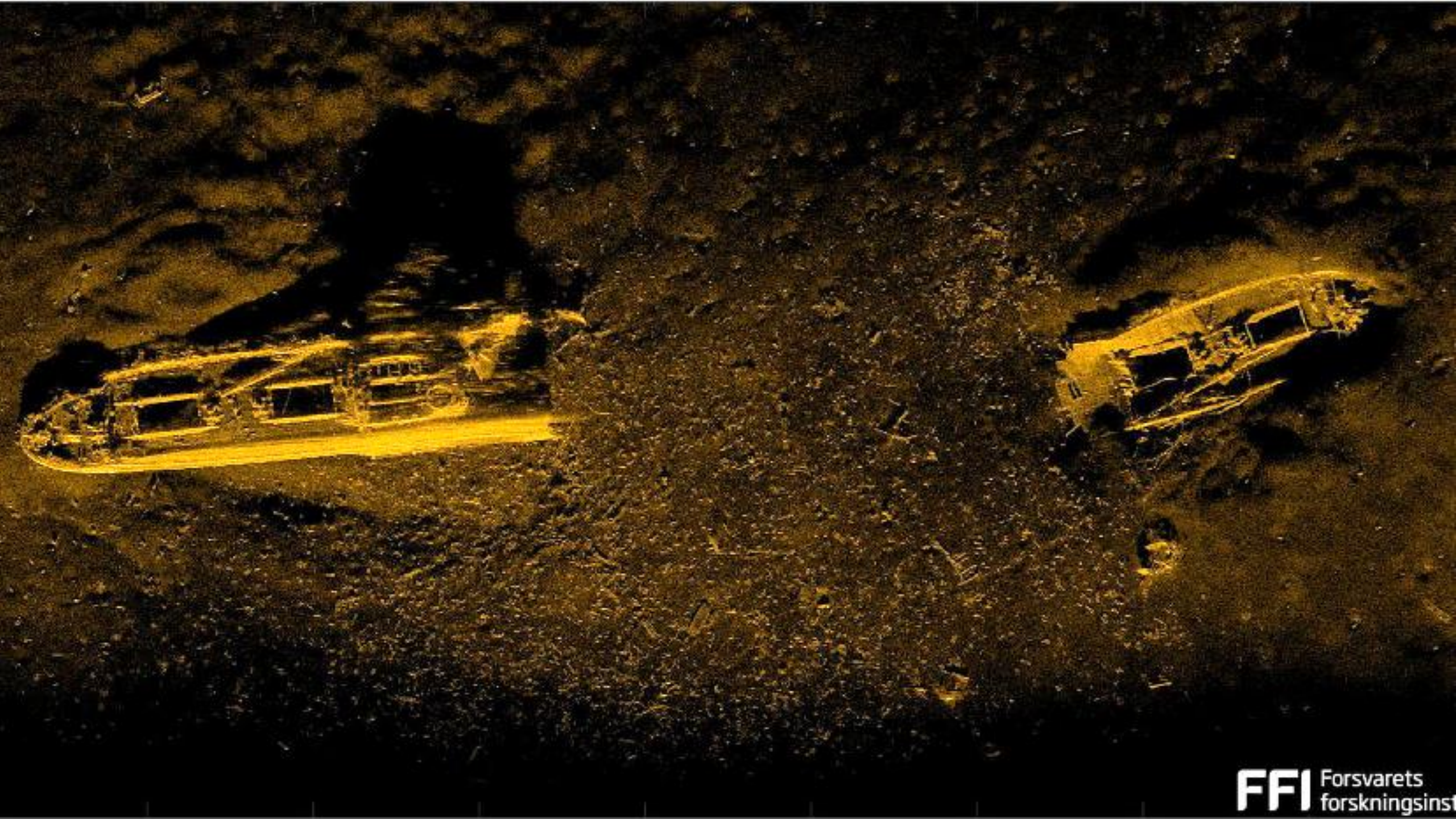
Introducing Superior data, navigation and endurance in the best AUV you can get.



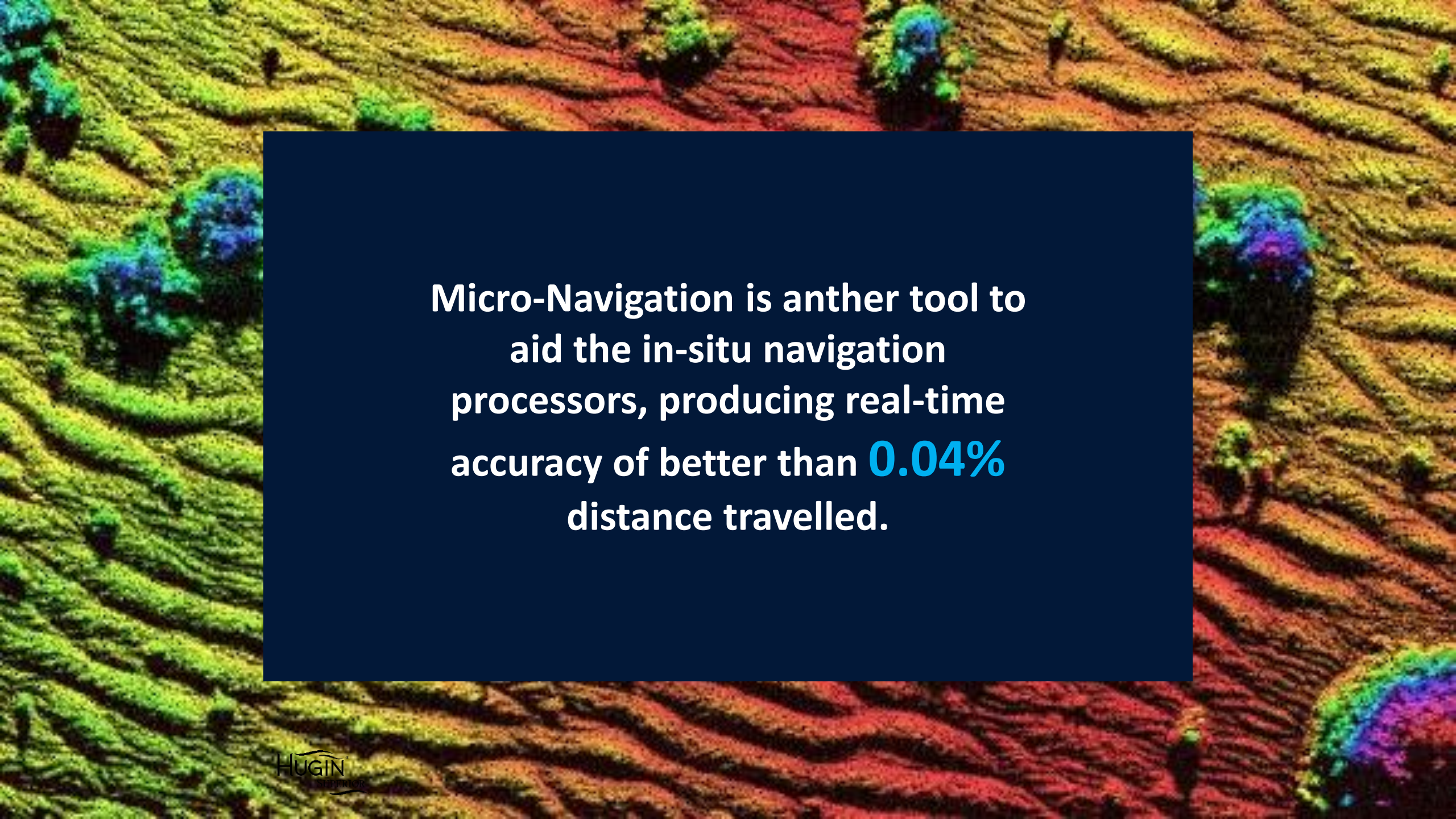
# HUGIN SUPERIOR AUV SYSTEM

- Superior data
- Superior navigation
- Superior productivity
- Superior data handling









**Micro-Navigation is another tool to aid the in-situ navigation processors, producing real-time accuracy of better than **0.04%** distance travelled.**

# Customer case study – Ocean Infinity



# Customer case study – Ocean Infinity

7 year vessel charter agreement signed between Ocean Infinity and Island Offshore



3<sup>rd</sup> vessel signed **Frontier** comes online Q3-2019, firm



25% Stock purchase in Survey company (Guardian Geomatics)



With Brazilian partners CP+ appointed to 3 yr contract for Petrobras



November 2018

December 2018

January 2019

March 2019



Located missing Argentinian submarine ARA San Juan



# 15 Hugin



Our under ice AUV is sent to the Antarctic with the Weddell Sea Expedition



First Multi-USV Commercial Project

# Customer case study – Ocean Infinity



- Fleet of 15 HUGIN Autonomous Underwater Vehicles
  - ~30,000+ Survey Hours
  - 150,000 LKm
  - 200,000 Sq Km
  - ~700 Missions
  
- “Off the Shelf” Technology – built to OI Specifications

# Ocean Infinity MH370 Search



## Ocean Infinity Search Area

4.5 months of operations

1 Vessel - 8 AUVs

- ✓ 125,134km<sup>2</sup> (36,483nm<sup>2</sup>)
- ✓ Up to 1500sq Km/ Day
- ✓ Man Hours 225,000
- ✓ Fuel 2,500 tonnes
- ✓ Emissions
- ✓ 11 tonnes CO<sub>2</sub>

## ATSB Search Area

27 months of operations

3 Deep-tow Vessels and 1 AUV Vessel

- ✓ 121,502km<sup>2</sup> (35,425nm<sup>2</sup>)
- ✓ Man Hours 550,000 (Est)
- ✓ Fuel 12,250 Tonnes
- ✓ Emissions – 39 Tonnes CO<sub>2</sub>



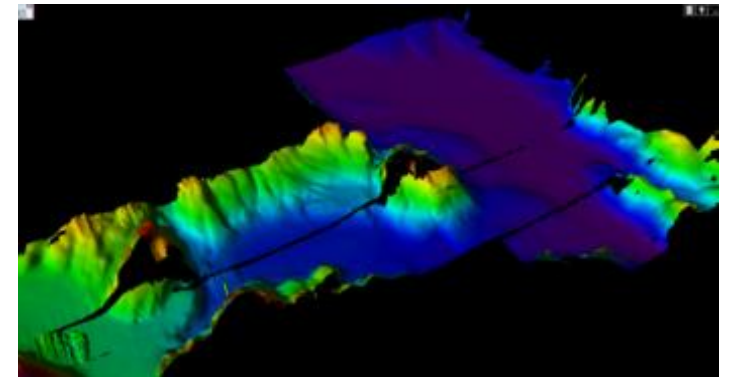
## The key elements of the Round 1 / 2 challenge

1. Create an autonomous solution to collect data
2. All components used for data gathering must fit within a standard 40 ft shipping container
3. Produce a high-resolution bathymetric map of an area - **250 km<sup>2</sup>** / **500 km<sup>2</sup>**; minimum 250km<sup>2</sup> in round 1 (5 m horizontal and 0.5 m vertical resolution) minimum 250km<sup>2</sup> in round 2
4. Produce images of a specified object
5. Identify and image **five** / **ten** archeological, biological or geological features

Preliminary phase: written description of the proposed solution

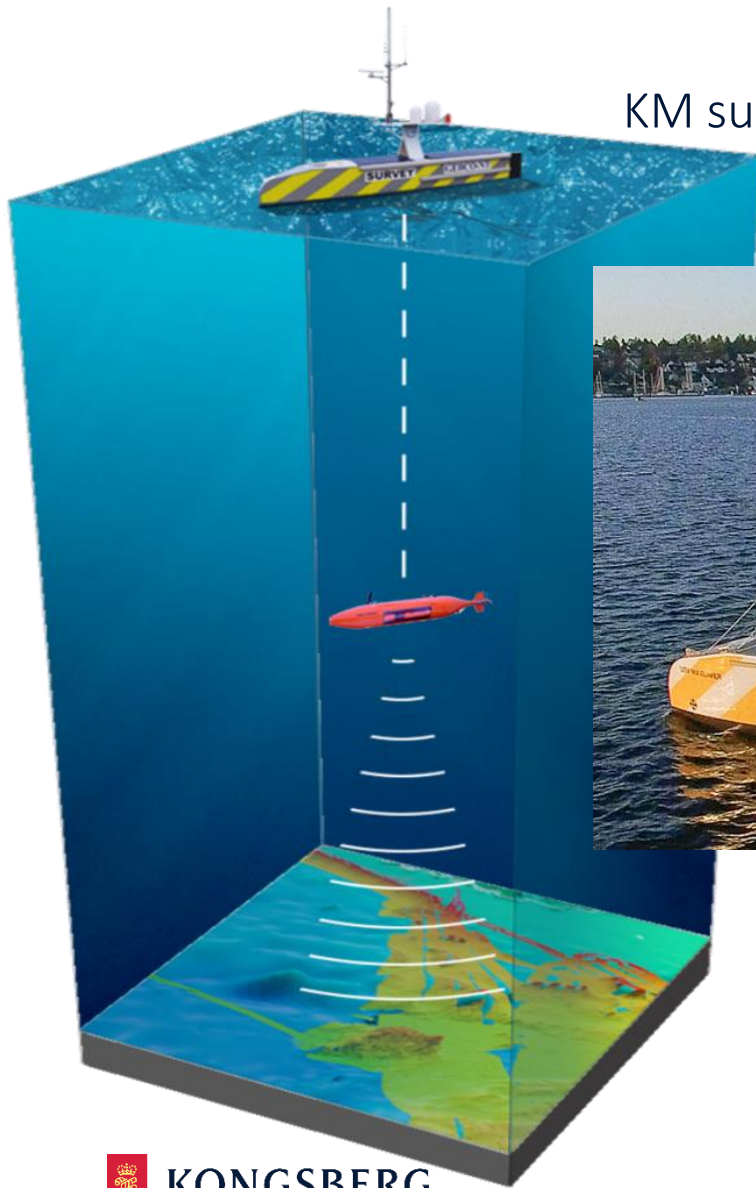
**Round 1**  
Min. **100 km<sup>2</sup>** in **16 hours**  
**48 h** of data processing  
Max. Depth - **2000 m**

**Round 2**  
Min. **250 km<sup>2</sup>** in **24 hours**.  
**48 h** of data processing  
Max. Depth - **4000 m**



# Shell XPrize

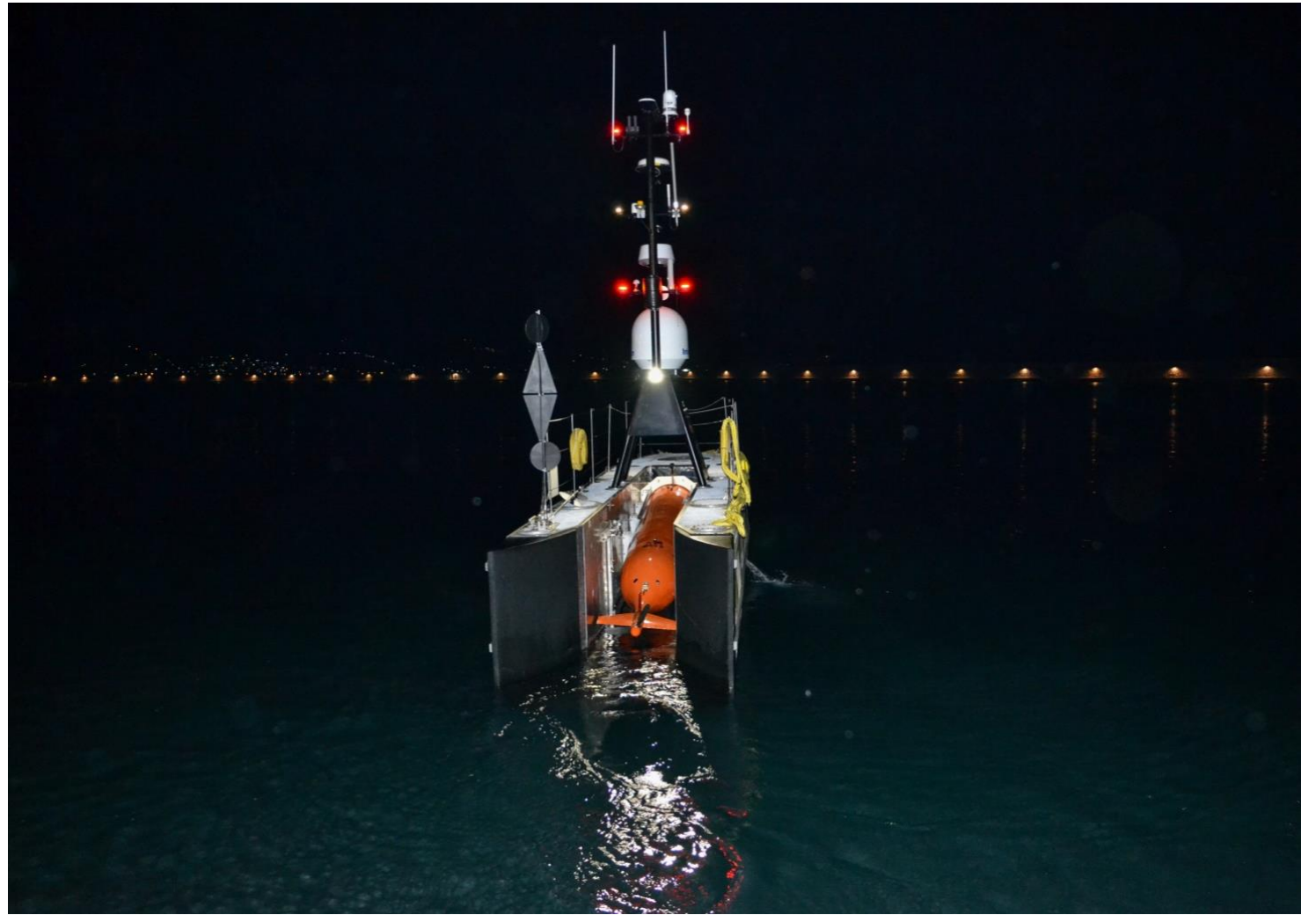
KM supported the Nippon Foundation-GEBCO Alumni team



- SEA-KIT USV controlled by K-MATE autonomy engine
- Positioning provided by Seapath and HiPAP 502
- Deepwater multibeam EM304 on USV gondola
- HUGIN AUV with modified HISAS 1032 configured for long range bathymetry
- Communications via MBR and Mapping Cloud for data transfer

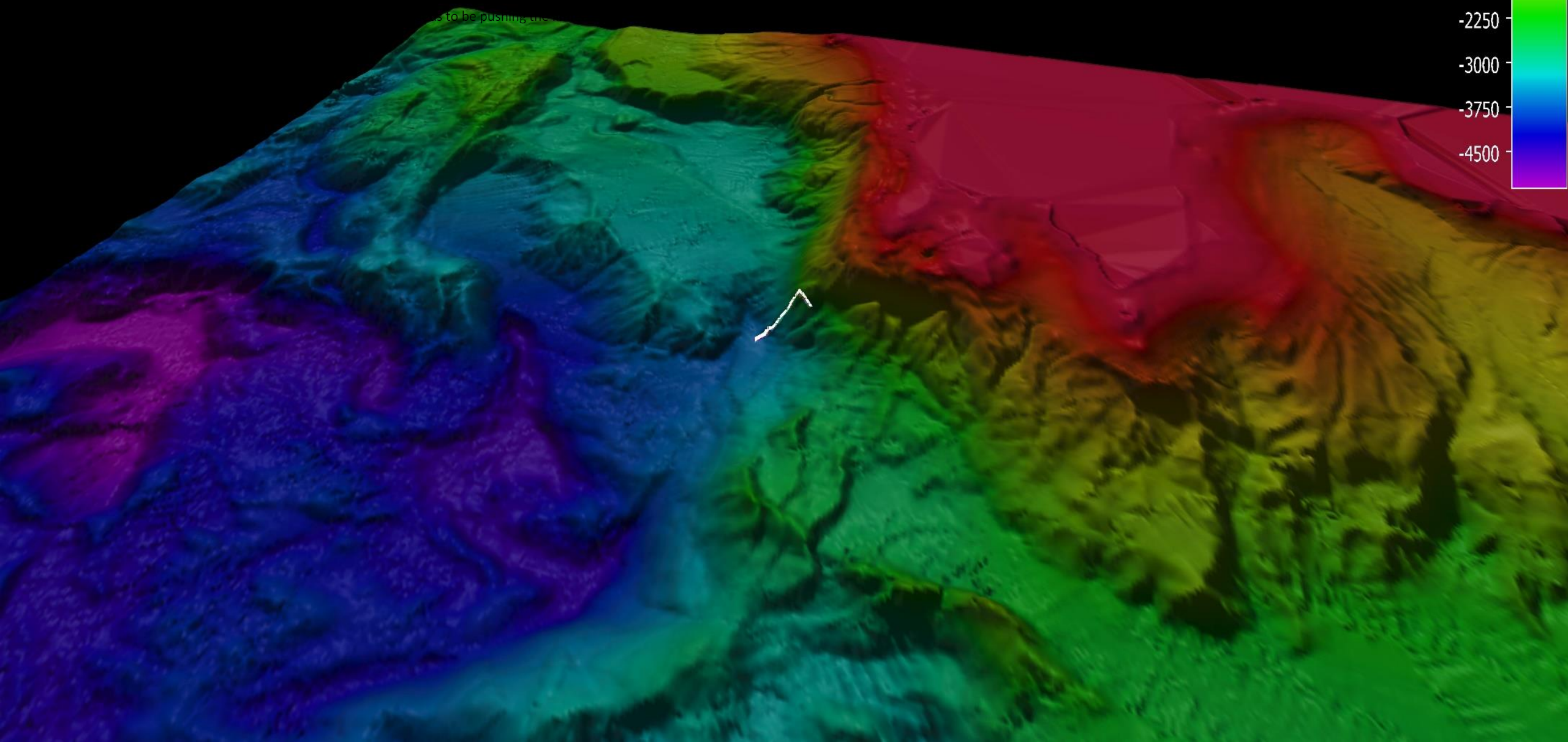


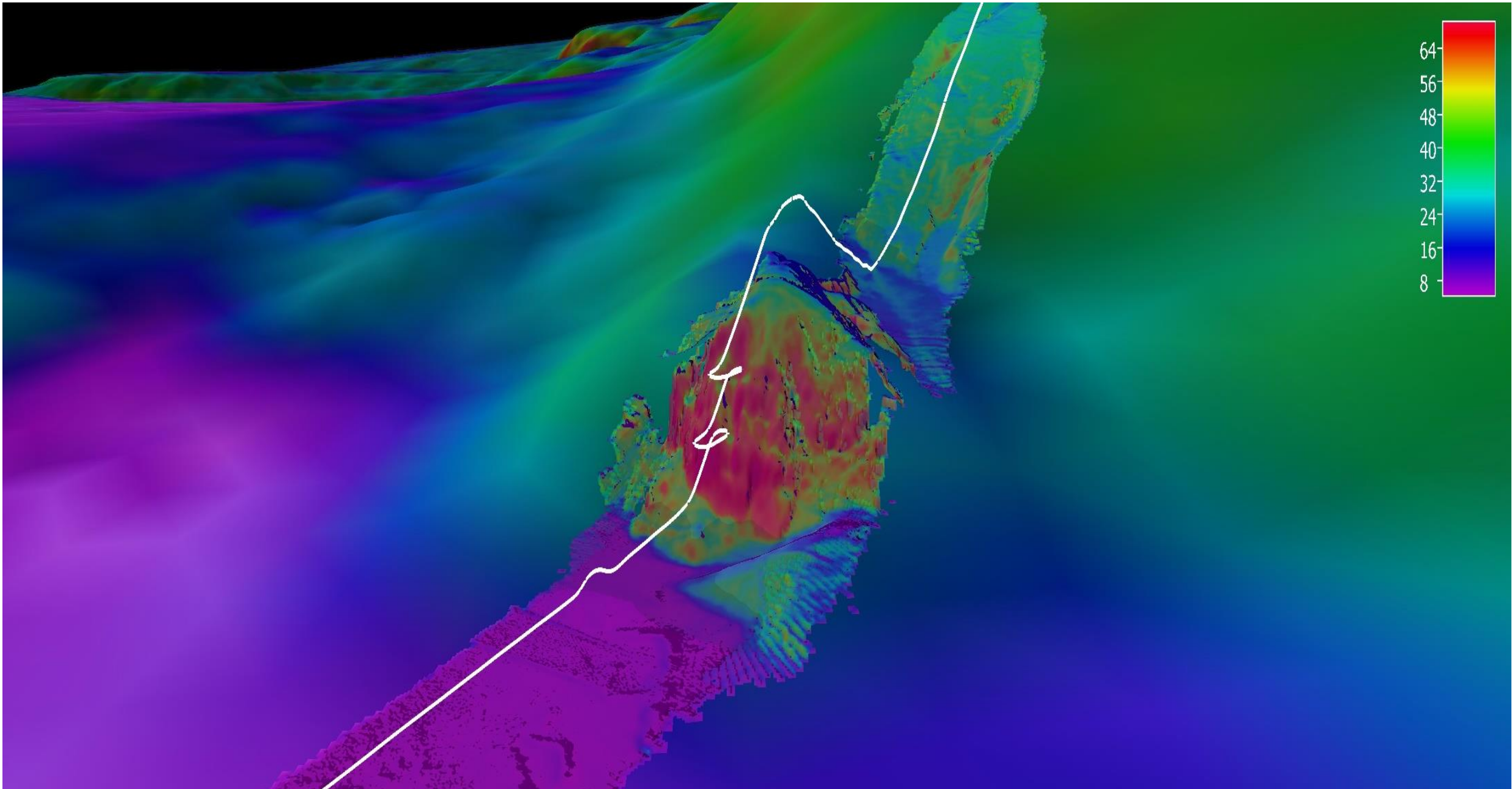
## Start key!





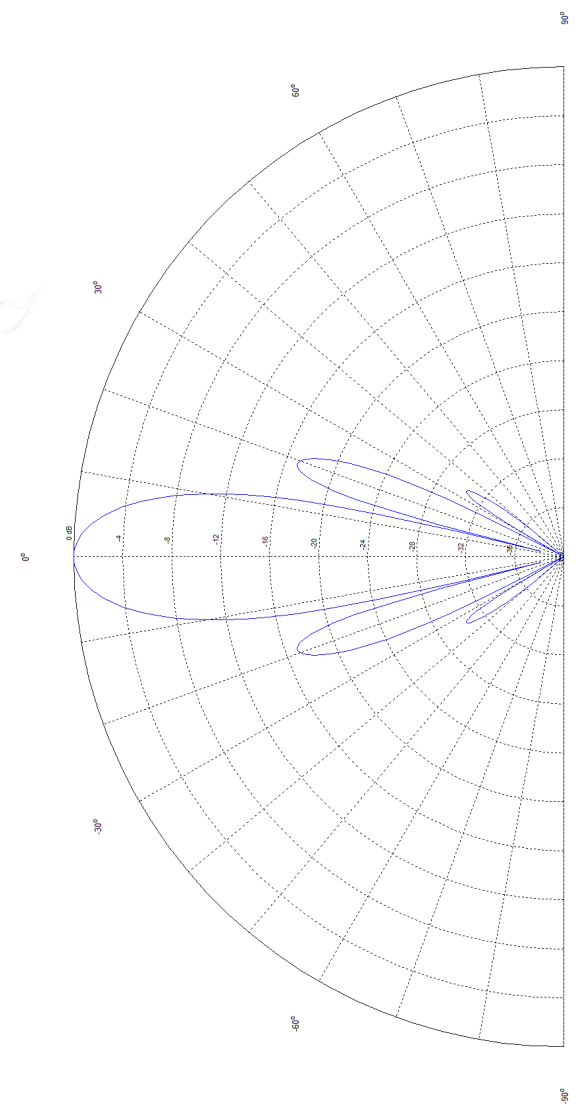
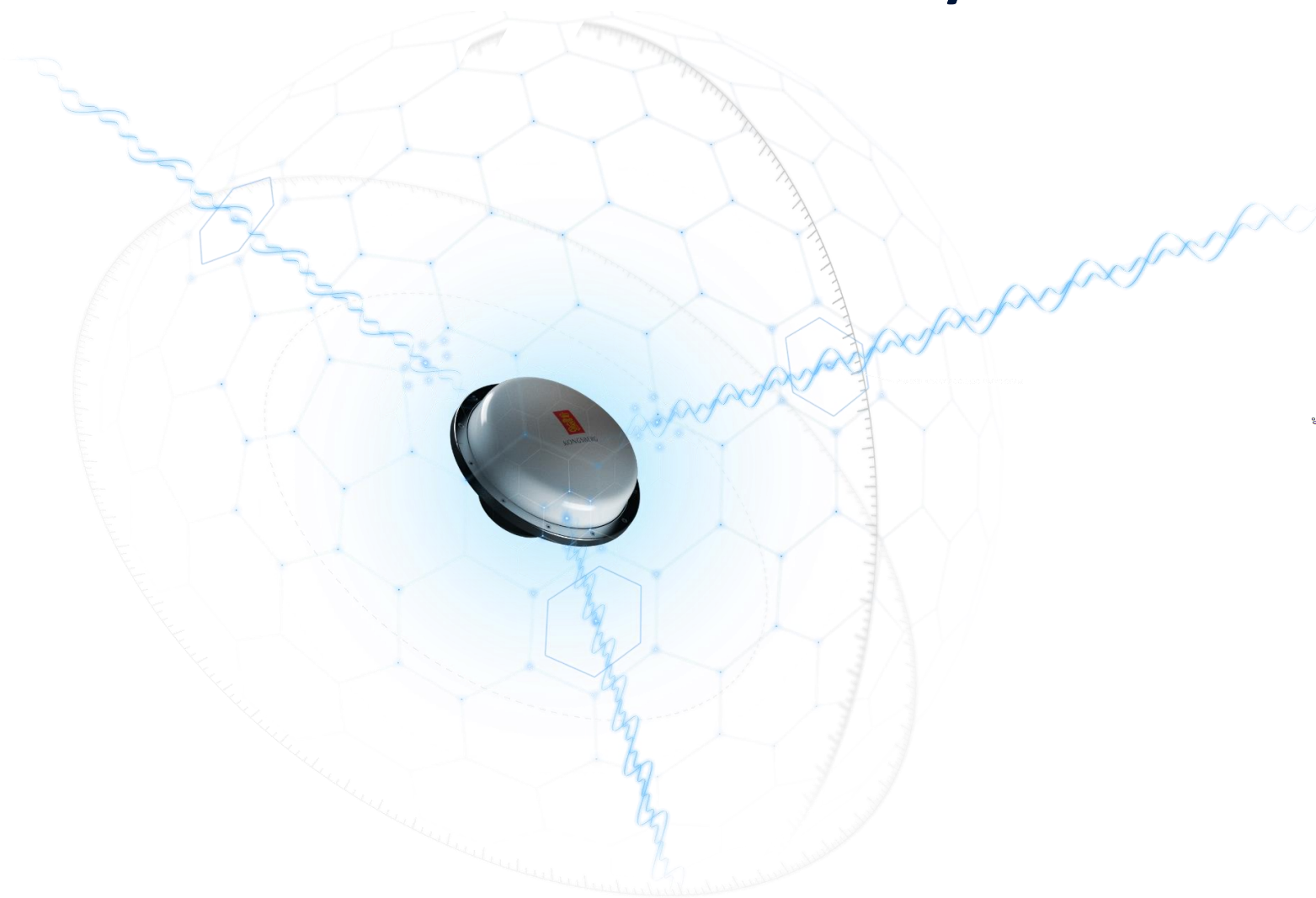
# Reflective Avoidance







# Interconnectivity



# MBR – Marine Broadband Radio



IP- based data networking



Point to point and point to multipoint

15 Mbps Payload

Beyond Line-Of-Sight

Deterministic Latency(video)

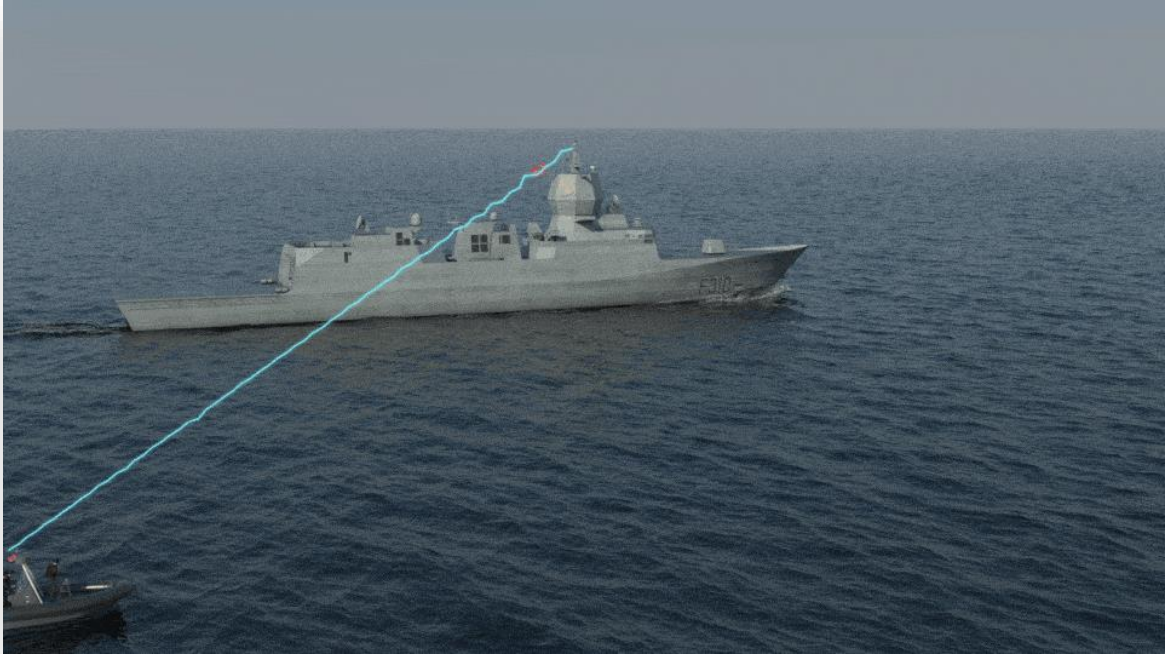


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# Phased array advantage

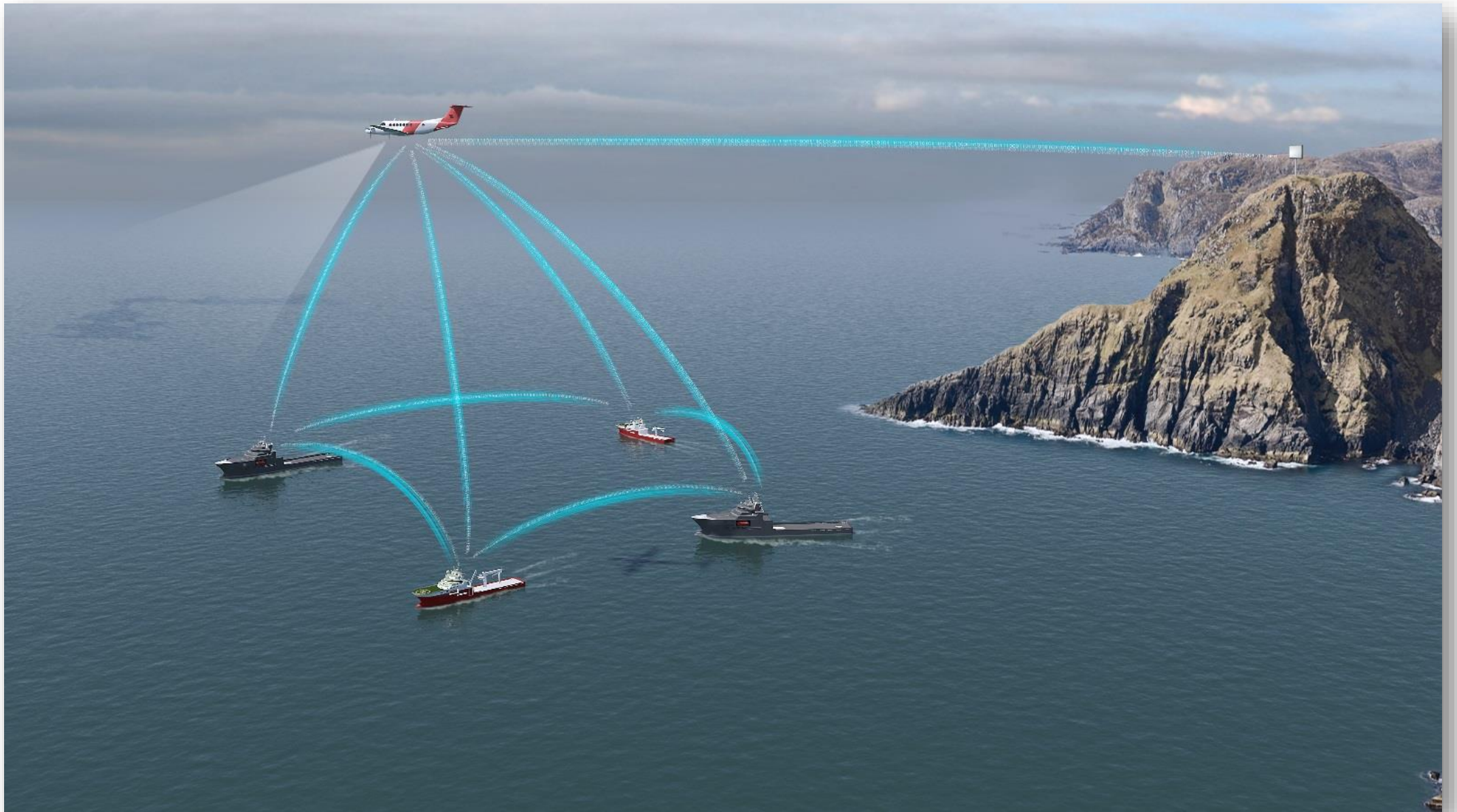


Conventional radio systems. Radiates in all directions. Limited range, limited bandwidth and easy to monitor and jam.



Phased array radio system. Fast moving directed beam without any moving parts. Long range, high bandwidth, difficult to monitor and jam.





## Ranges and data rates

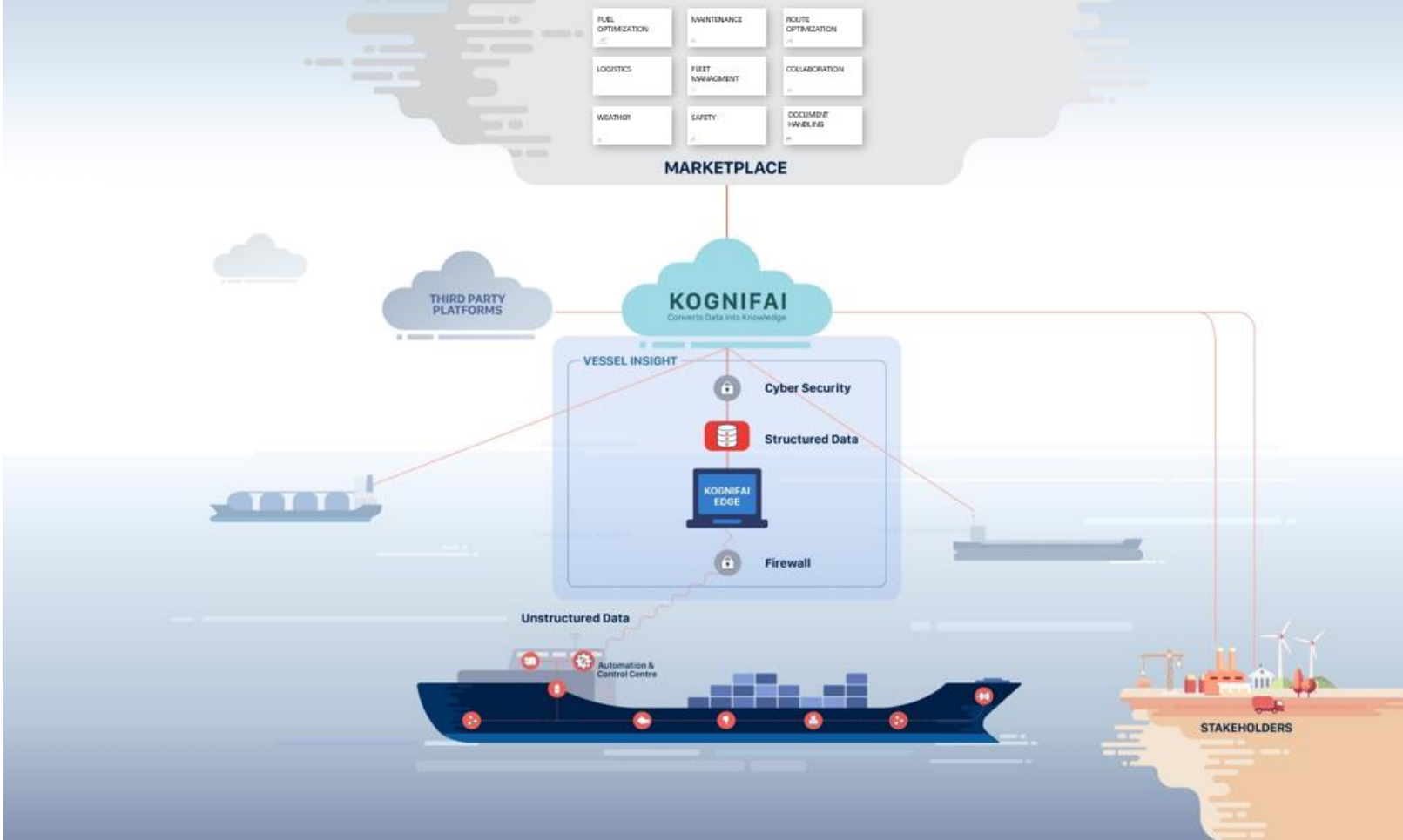
### MBR rekkeviddekalkulator

Montasjehøyde på antenne A	3	m			
Montasjehøyde på antenne B	1	m			
Avstand til visuell horisont	9	km			
<b>Maksimale operative avstander (km)</b>	<b>500 kbps</b>	<b>1,2 Mbps</b>	<b>2,3 Mbps</b>	<b>7 Mbps</b>	<b>15 Mbps</b>
Mellom MBR-189 og MBR-189	37	35	34	31	28
Mellom MBR-189 og MBR-179	31	29	28	25	23
Mellom MBR-189 og MBR-144	22	20	19	16	13
Mellom MBR-179 og MBR-179	29	28	26	23	21
Mellom MBR-179 og MBR-144	19	18	16	13	11
Mellom MBR-144 og MBR-144	13	11	10	5	3



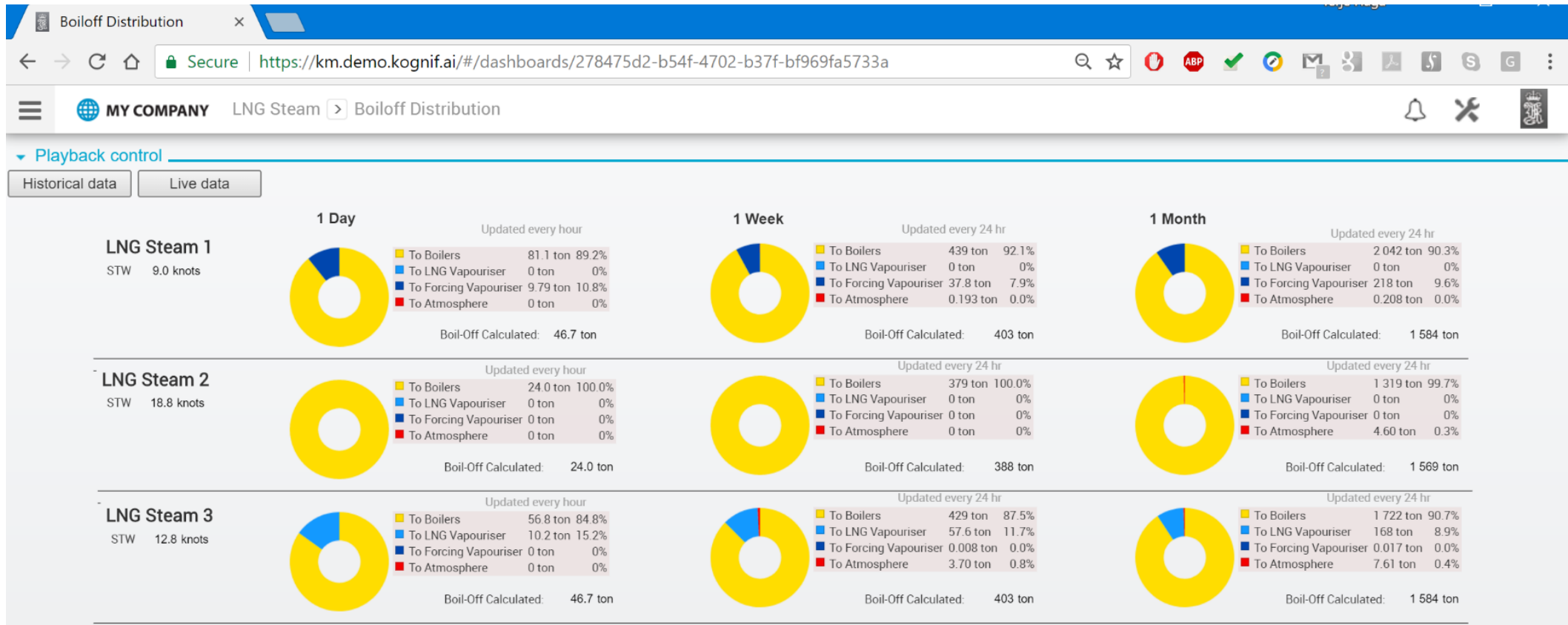
# Digitalization - Vessel Insight

Kongsberg's Open Digital Environment



# Vessel Insight

## Vessel & Fleet Management



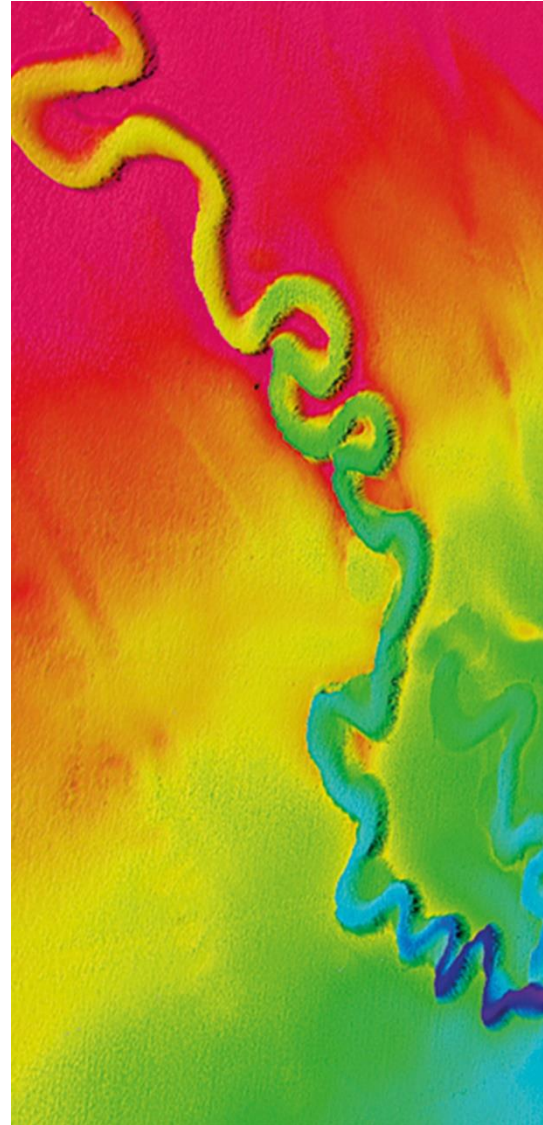
# Mapping Cloud

Visualize, analyze and share multibeam data in real time



## Deliverables

- Storage
- Virtual Machine
- Connection to Partners



### Processing VM

- Choose preconfigured VMs
- VM is connected to Storage, ready to process data
- Install your own processing software on VM just as a regular PC

### Storage

- Download Windows Desktop Application to help copy files from Local Storage to Mapping Cloud
- Storage App to manage Hot/Cold storage
- File management

### Partners

- ESRI
- Earth Analytic
- Geocap





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