



for the

Shell
OCEAN DISCOVERY **XPRIZE®**

On behalf of the GEBCO-NF Alumni Team
Jaya Roperez

Modified presentation of Dr Rochelle Wigley



The inspiration to enter as a team for the challenge:



15 to 17 June 2016 in the Principality of Monaco

- Opening speech by Mr Sasakawa – Argued for ongoing alumni development & projects
- Jyotika Virmani, Senior Director in Prize Operations, at XPRIZE said at the Forum “*NF GEBCO training program is probably the most successful unknown capacity-building global initiative*”



June 2016



Mr Sasakawa, Chairman of the Nippon Foundation
Proposed ‘...to map 100% of the topography of the
World Ocean by 2030’



June 2017

Nippon Foundation - GEBCO
Seabed 2030 Project
announced



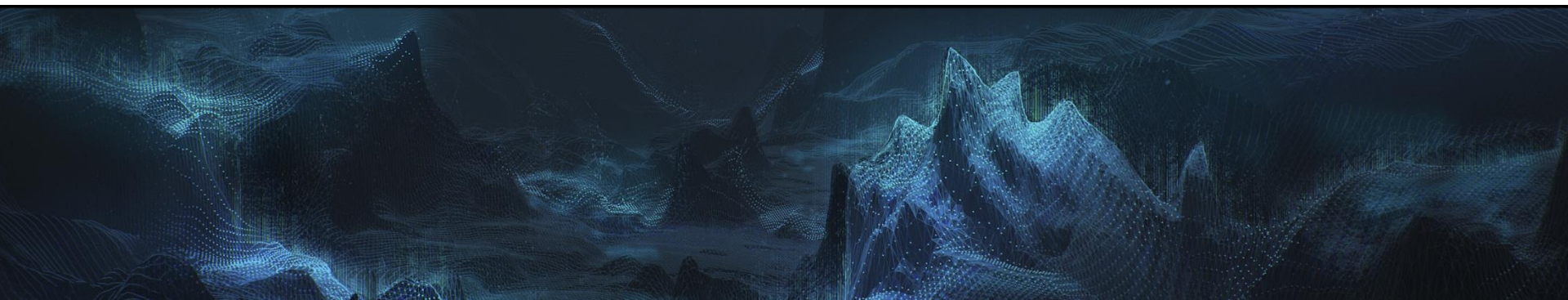
Mr Sasakawa – 1 of 8 IOC-UNESCO
“Champions of Global Ocean Science”



A \$7 million global competition challenging teams to advance deep-sea technologies for autonomous, fast and high-resolution ocean exploration.

Create solutions that advance the autonomy, scale, speed, depths and resolution of ocean exploration

<https://oceandiscovery.xprize.org>

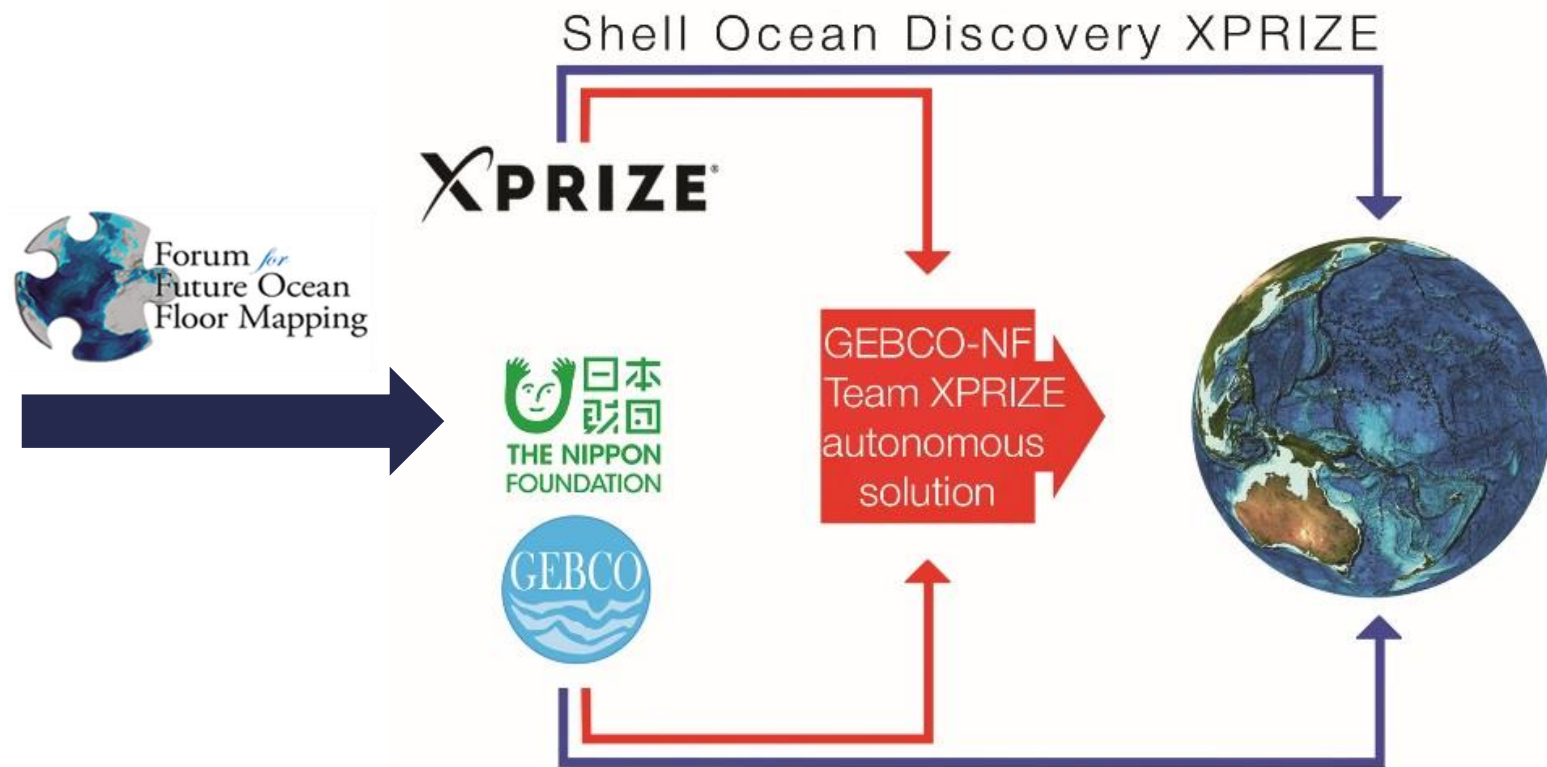


The key elements of the challenge

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 of 100 km²
(5 m horizontal and 0.5 m vertical resolution)
4. Produce images of a specified object
5. Identify and image five archeological, biological or geological features

**Data collection must be completed in 16 hours
with 48 hours for product generation**

Meeting global challenges



Nippon Foundation - GEBCO Seabed 2030

Produce: Bathymetric grids where no features of the accessible parts of the World Ocean floor larger than 100 m remains to be portrayed.

Challenges: Keeping up with technology



The Postgraduate Certificate in Ocean Bathymetry

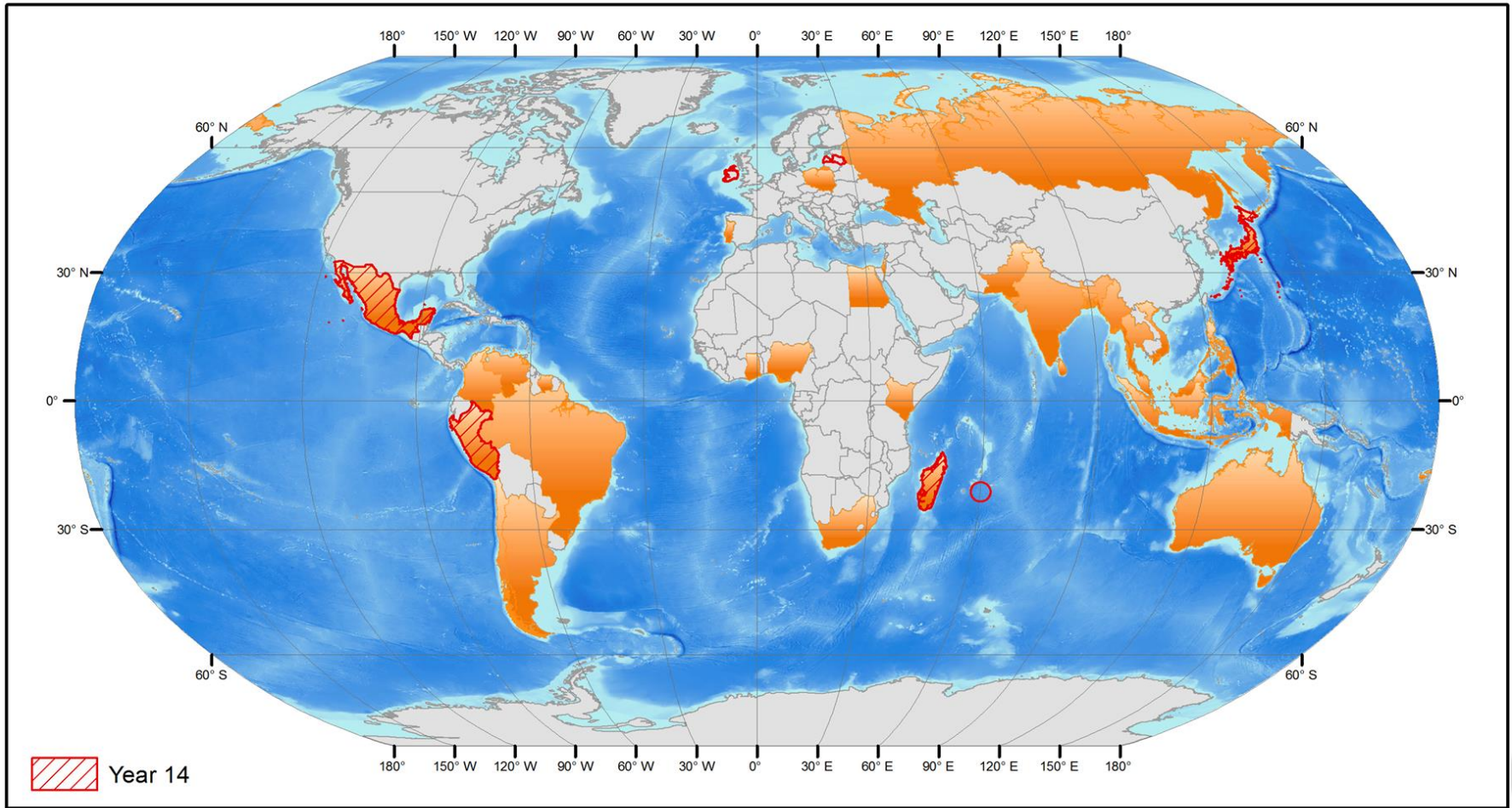
Designed to train a new generation of scientists and hydrographers in ocean bathymetry



The Center for Coastal and Ocean Mapping /Joint Hydrographic Center
University of New Hampshire, USA



84 scholars from 37 coastal states over last 14 years



GEBCO-NF Alumni Team: 12 active alumni

10 different coastal states & 8 years of training program

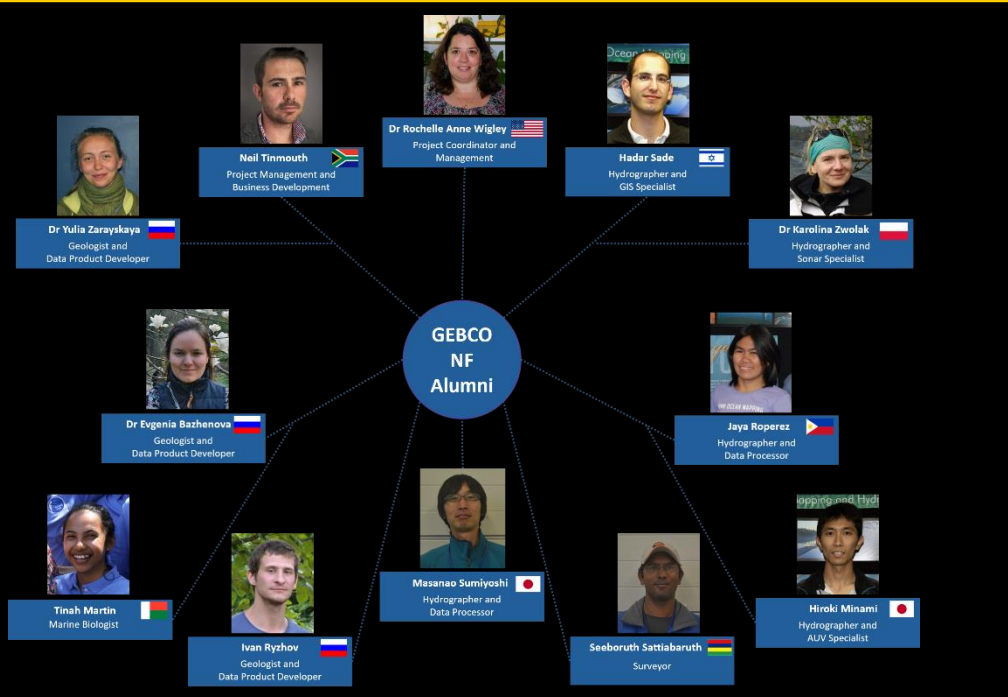
Industry Partners:

- Kongsberg Maritime
- Ocean Floor Geophysics
- Hushcraft Ltd
- University of New Hampshire
- OceanAero
- Teledyne CARIS

<http://gebco-nf.com>

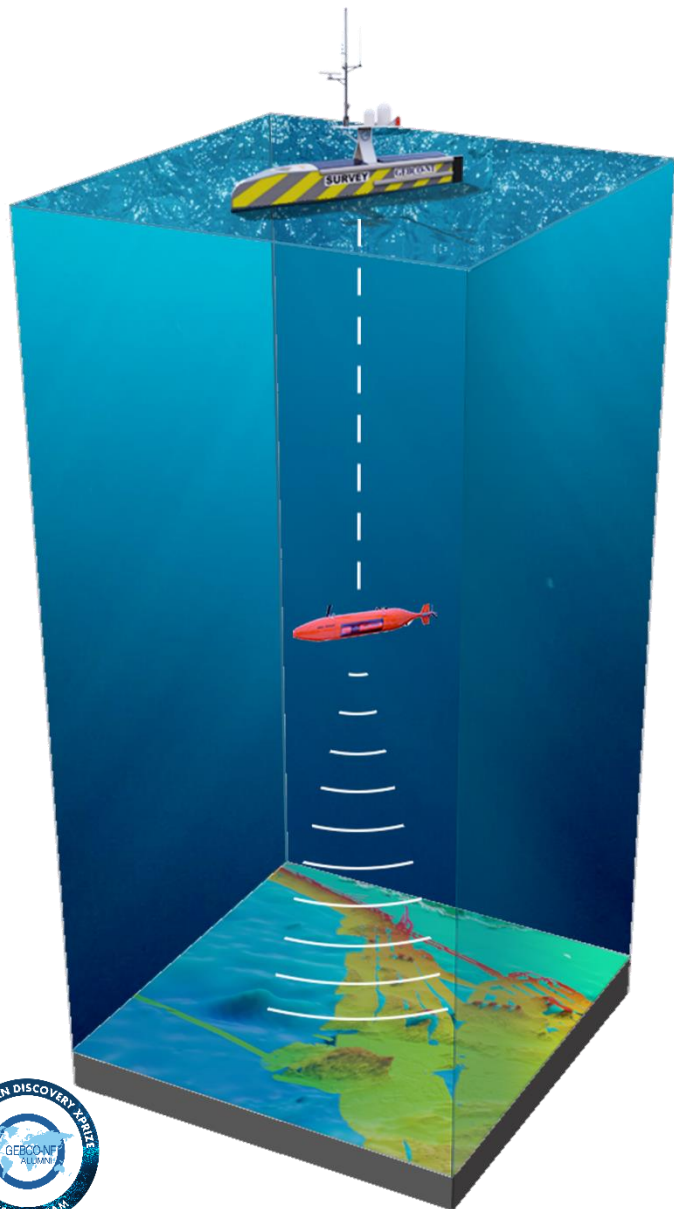


4 technical advisors from within GEBCO



The GEBCO-NF Alumni Team concept

Integrates existing technology with innovative new ideas



Hushcraft Limited USV



- Sea-Kit XP with KM HiPAP 351P-MGC
- Unmanned operations by KM



Kongsberg Maritime HUGIN 1000 AUV

- OFG Chercheur AUV (3,000 m)

OFG



TELEDYNE
CARIS



esri

High quality seafloor bathymetry and imagery

- Combination of EM2040 MBES, HISAS side-scan wide-area and HISAS bathymetry & spot-focused HiSAS imagery



Management Group



Unmanned
Surface Vessel



Autonomous
Underwater Vehicle



Data Group



AUV Sea Trials

System integration



Project Time Line

2016

June
↓
Sept
↓
5 Oct
↓
3 Nov
↓
11-14 Nov
↓
17 Dec
↓
7 Feb
↓
27 Feb
↓
16 March
↓
22 March
↓
6 April *
↓
11-14 April
↓
21 April
↓
22 April
↓
26 April
↓
15-16 May
↓

Decision to register a XPRIZE team
First discussion with boat designer
meeting
meeting
Shell Ocean Discovery XPRIZE summit
Submission of technical documents
Through to Round 1
Submission to Nippon Foundation
Round 1 funded by NF / SPF - \$3.25M
meeting
Metal cut for Boat Build
First installment of funds
meeting
K-MATE contract
SEA-KIT delivered
2nd installment of funds (\$2,741,500)
Data Group: 2 week visit
AUV arrives in Norway
AUV tests with chase boat Storm
AUV & Data Team sea-trials in Norway
OFG contract
SEA-KIT christened USV Maxlimer
USV Maxlimer's first wet test
USV Maxlimer in Norway
USV Maxlimer K-Mate development & trials
First USV – AUV trials: Testing HiPAP
First AUV retrieval
Start of final sea trials
Technology readiness test

2017

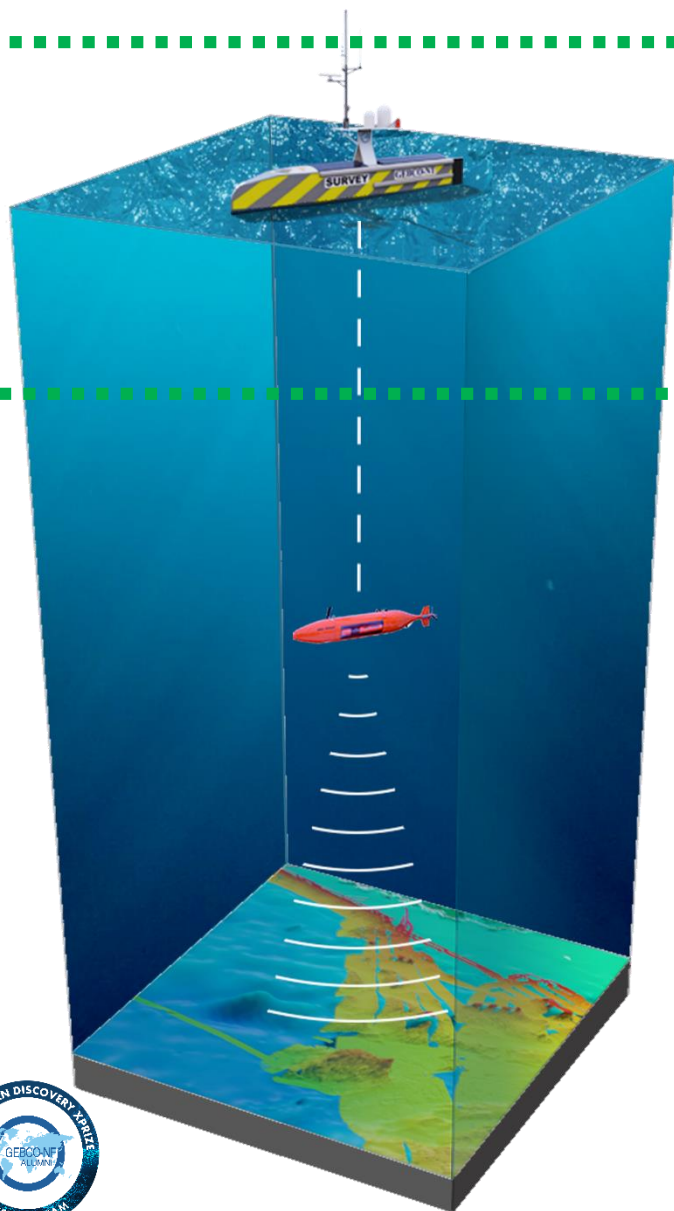
3 Oct
↓
3 Nov
↓
20 Nov
↓



Shell Ocean Discovery XPRIZE

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CARIS

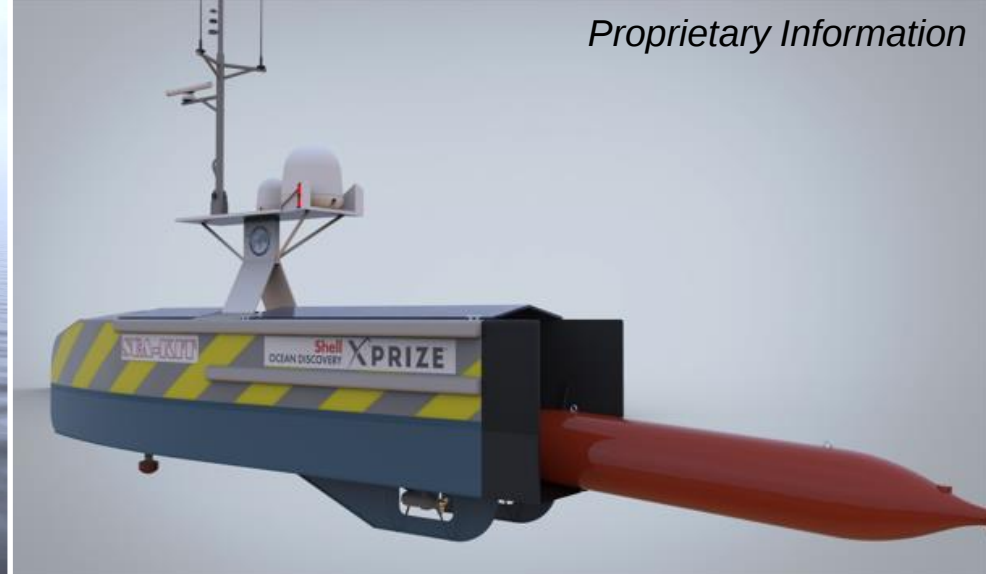
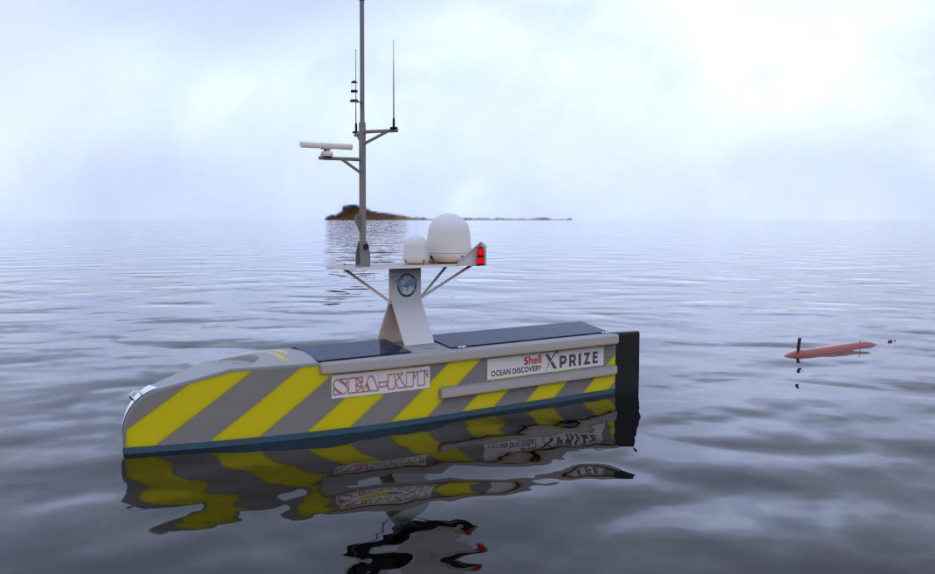


esri

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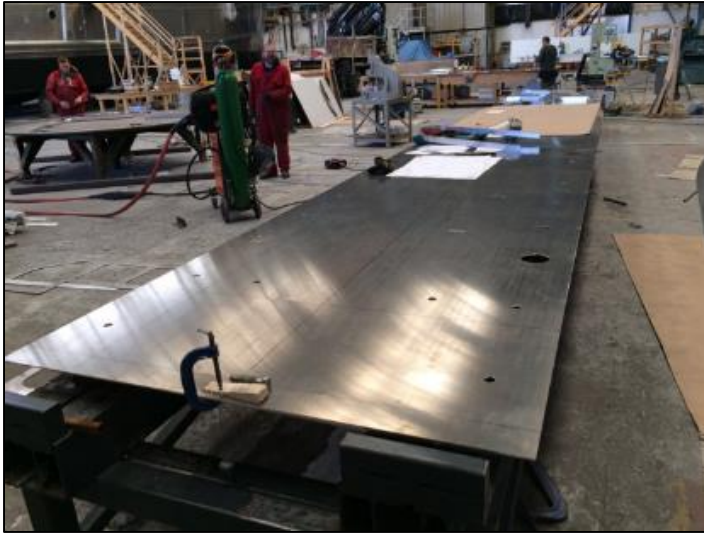
USV SEA-KIT: Unmanned surface utility craft



- Designed as mother vessel for AUV – fitting in 40 ft container
- Exclusion area safety vessel
- Border Safety / Patrol vessel
- Rapid survey deployment
- Passive Acoustic Monitoring
- Acoustic positioning USBL
- Ocean Data Collection Platform
- Communications Repeater Station



The start of construction with metal for the hull being cut (21 April 2017)



Delivery of completed hull (28 June 2017)



USV at work shop ready for wet test
(31 August 2017)



SEA-KIT 01 BUILD

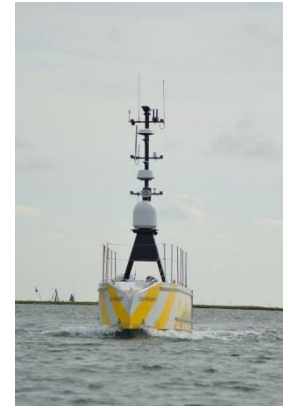
FIRST WET TESTS IN UK



Christened USV Maxlimer - 1 Sept 2017



SEA-KIT for Shell Ocean Discovery XPRIZE



SEA-Kit Dimensions:	• Length: 11.75 m (38.55 ft) • Beam: 2.2 m (7.22 ft) • Transport Height: 2.0 m (6.56 ft) - Operational Height: 7 m (22.97 ft) • Weight: 11,200 kg (estimated)
Fully redundant propulsion and communication systems	• Propulsion: 2 X 10 kW / 1200 rpm electric directional thrust motors • Communication: Wi-Fi, Radio, Satellite (Iridium and Inmarsat) and Kongsberg Maritime Broadband Radio (<45 km offshore) • CCTV: 2 interior and 6 fore and aft cameras, 1 night-vision camera
Two independent power supplies and power charge	• Generator 2 X 18 kW 48 V DC • Fuel 2,000 L • 56 Gel and Absorbent Glass Mat (AGM) types of valve-regulated lead-acid battery (VRLA) Marine Batteries, 12 V – 214 Ah capacity • 4 dry cell Absorbed Glass Matt (AGM) VRLA 12 V 100 Ah Marine Dual Purpose Batteries for the engine and propulsion

SEA-KIT Communication & Navigation



Remote control antennae

Kongsberg Seapath 130 GPS antenna

Wind Sensor & AIS antenna

Kongsberg MBR

Wifi and Radio antennae for AUV (OFG) & Iridium antenna

HS70 GPS compass

Simrad 4G radar & GPS for Iridium

Loud hailer: anti-hijack!

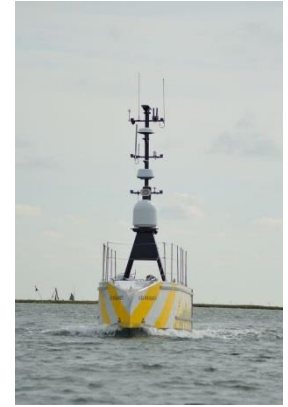
Inmarsat SAILOR 500

FleetBroadband

HIPAP 351P-MGC
Transducer



SEA-KIT for Shell Ocean Discovery XPRIZE



Modes of Operation

1. Unmanned, partly autonomous
(Kongsberg Maritime AS K-MATE)
2. Remote control (joystick)
3. Manned



USV Maxlimer on her way to Norway



8 Sept 2017

Unpacking SEA-KIT container in Horten, Norway

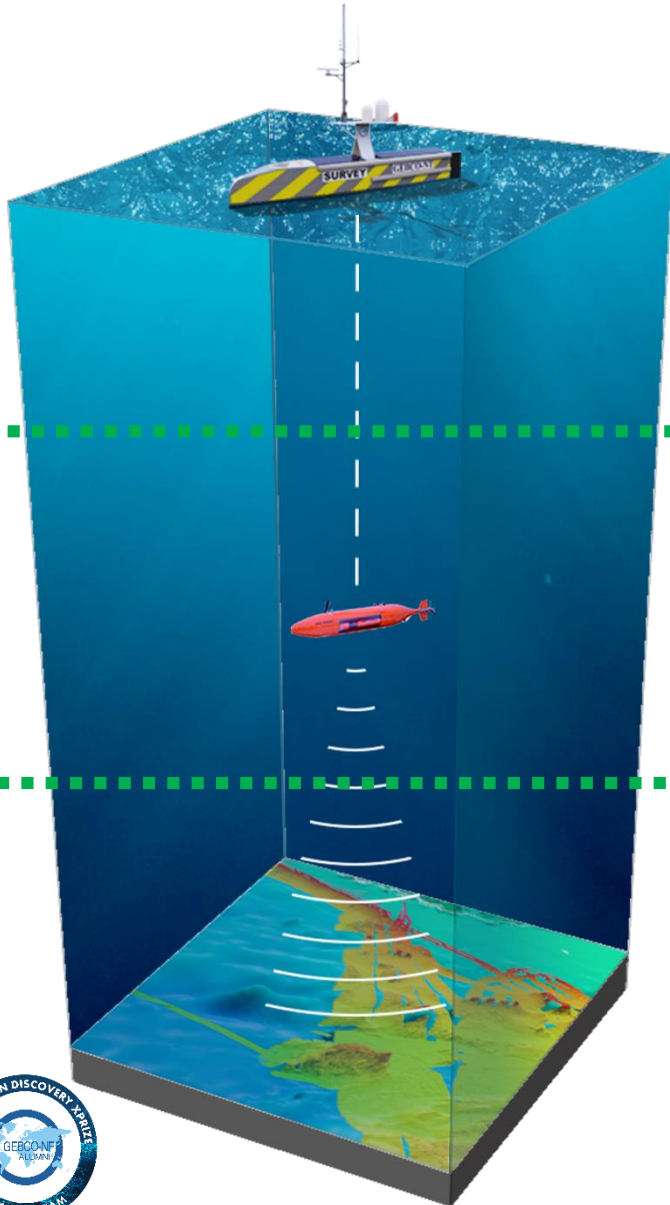


14 Sept 2017



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esri

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Ocean Floor Geophysics

Capabilities:

- Deep water **AUV** operations and data acquisition for **infrastructure inspection** and **survey**
 - * *Route and Site Surveys* * *Pipeline Inspection* * *Mineral Exploration*
 - * *Decommissioning Survey* * *Archeology and Salvage*
 - * *Seafloor Search* * *Environmental Baseline Studies*
 - * *Seafloor Classification* * *Unexploded Ordinance* * *Physical Oceanography*
- Electromagnetic mapping and Magnetic 2D & 3D surveys
- Geo-chemical prospecting and mapping surveys
- Gravity and inversion post processing (ROV/AUV borne)
- Sensor Development - Self Compensating Magnetometer (SCM) System for **real-time** compensated magnetic data.

WHY OFG:

- OFG Personnel have diverse AUV Experience - Operations, System Integration and Design
- Mission Planning
- Selection, Design, and Integration of Sensors
- R&D background
- Similar philosophical approach



“Chercheur” HUGIN 1000 AUV Specs

General	• Rating: 5 - 3,000 m • Length: 5.5 m • Weight in Air: 1,200 kg • Neutrally buoyant 
Sensors	• SAS: Kongsberg Maritime HISAS 1032 • MBES: EM2040 200-400 kHz (0.7° x 0.7° beam width) • Sub-Bottom Profiler: EdgeTech DW 106 SBP
Navigation Sensors	• IMU: Honeywell HG9900 • Compass: Leica DMC • DVL: Teledyne RDI Workhorse Navigator 300 kHz • Altimeter: Kongsberg Mesotech 675 kHz down looking • Forward Looking Sonar: Imagenex MBES sonar • CTD: SAIV CTD • USBL: HiPAP Transponder • Depth Sensor: DigiQuartz 8CB4000 • GPS Receiver: Novatel
Power	• 3 batteries (24 kWh) • Endurance estimates: 37 hrs @ 3 kts & 27 hrs @ 4kts



KONGSBERG

THANK YOU
to
Kongsberg Maritime
in Horten, Norway
for supporting us
through 2 months of
sea-trials



AUV Sea-trials:

To maximize coverage and resolution

Data group and OFG operators acquired bathymetric and side-scan data, as well as sub-bottom profiles. The data was collected during 12 dives in 4 weeks.

Included:

- DVL calibrations
- Patch tests separately for EM2040 and HISAS 1032
- Various operational modes: getting wide-area side scan bathymetry operational (KM input), testing standard HISAS bathymetry and HISAS imagery
- Data collection different altitudes and speeds





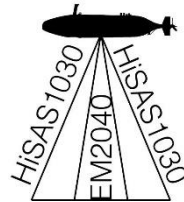
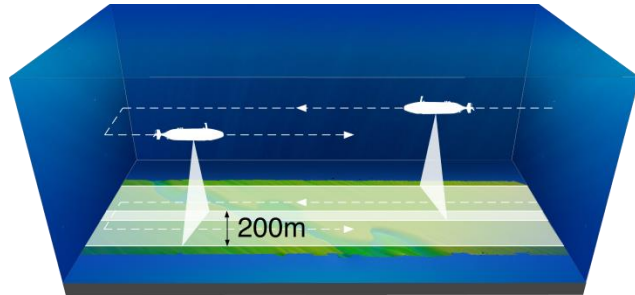


Data Group

Focus on Automated Data Flow

- Masa worked with Teledyne CARIS to understand:
 1. AUV work flow in processing HISAS data & EM2040 data (Ms. Fernanda Viana Da Conceicao)
 2. Developed automated work flow based on CARIS processing tools
- Fine-tuned and further developed during sea trials at Kongsberg Maritime
- CARIS output will be imported into ArcGIS
 1. Analysis of bathymetric data (contours, slope etc.)
 2. Publishing of image services in ArcGIS Online
 3. Collection of bathymetric data available from internet sources

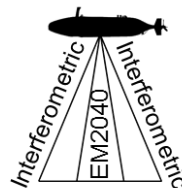
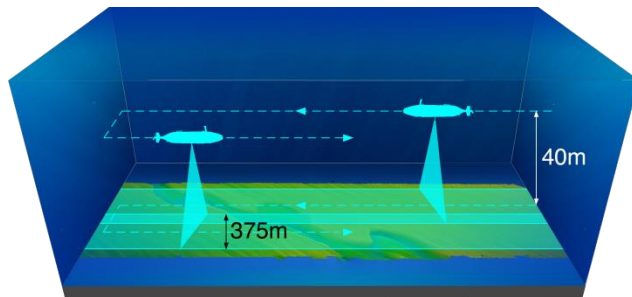
HUGIN 1000 with HISAS 1032 Data Collection



STANDARD HISAS MODE:

Distance-triggered

- Swath width: ± 200 m (400 m)
- Side scan image: ≈ 4 cm
- HISAS Bathymetry Resolution: $= 1$ m
- HISAS Spot Bathymetry Resolution: $= 10$ cm
- Speed: $= 3.9$ knots (2.0 m/s)



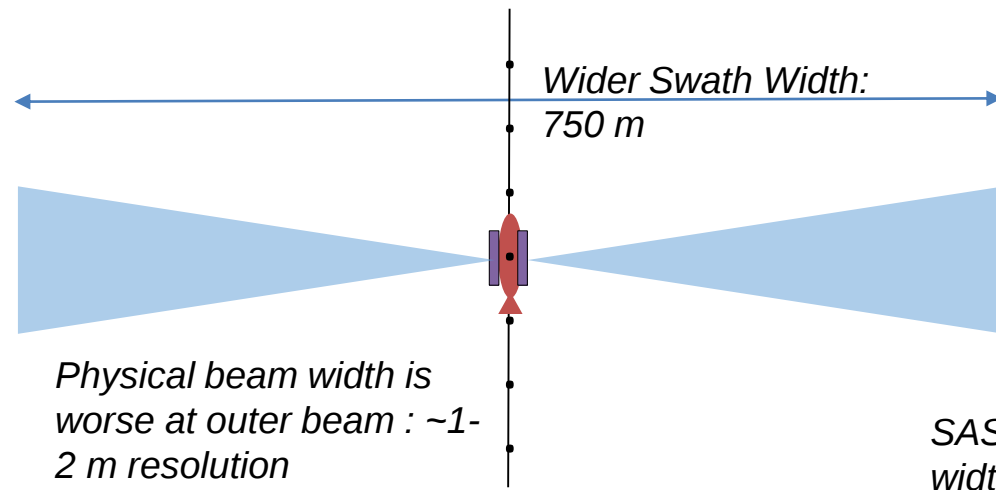
WIDE-AREA (SIDE-SCAN) MODE:

Time-triggered

- Swath width: ± 375 m (750 m)
- Side scan image: $\approx 1 - 2$ m
- Bathymetry Resolution: ≈ 2 m
- Speed: $= 4.3$ knots (2.2 m/s)

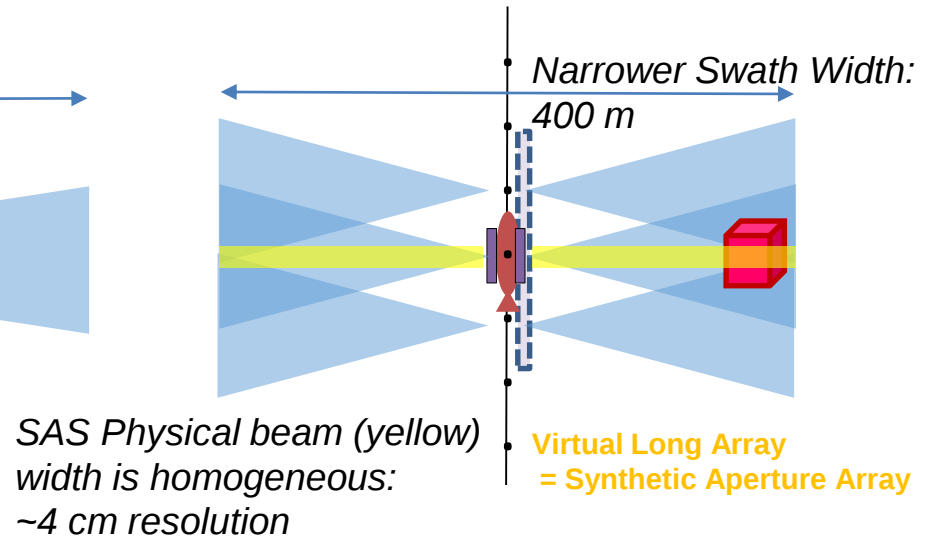
WIDE AREA MODE

Bathymetric Side-Scan Method

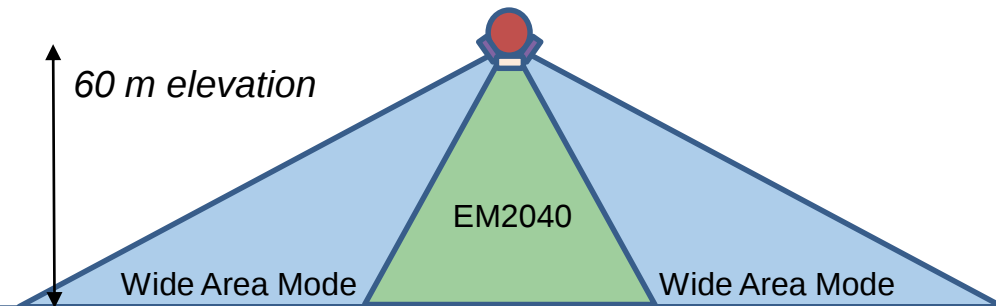


Standard HISAS MODE

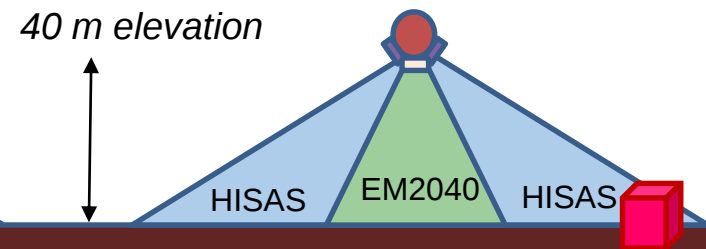
Synthetic Aperture Sonar (SAS) Method



For wide area bathymetry



For seafloor feature detection



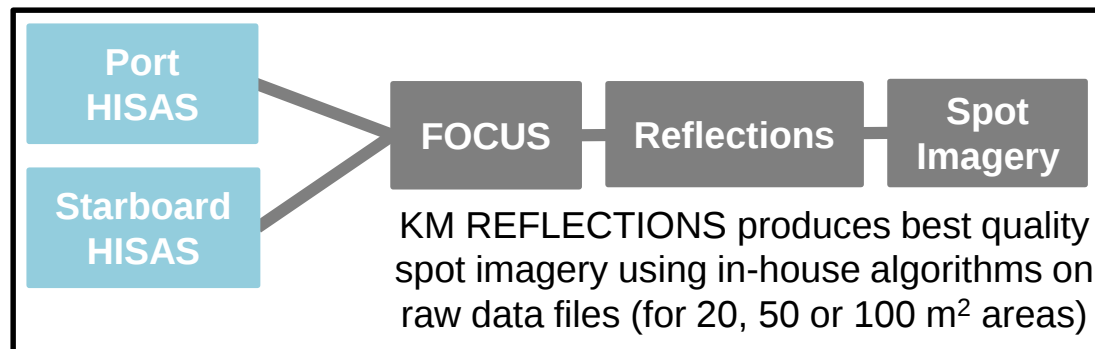
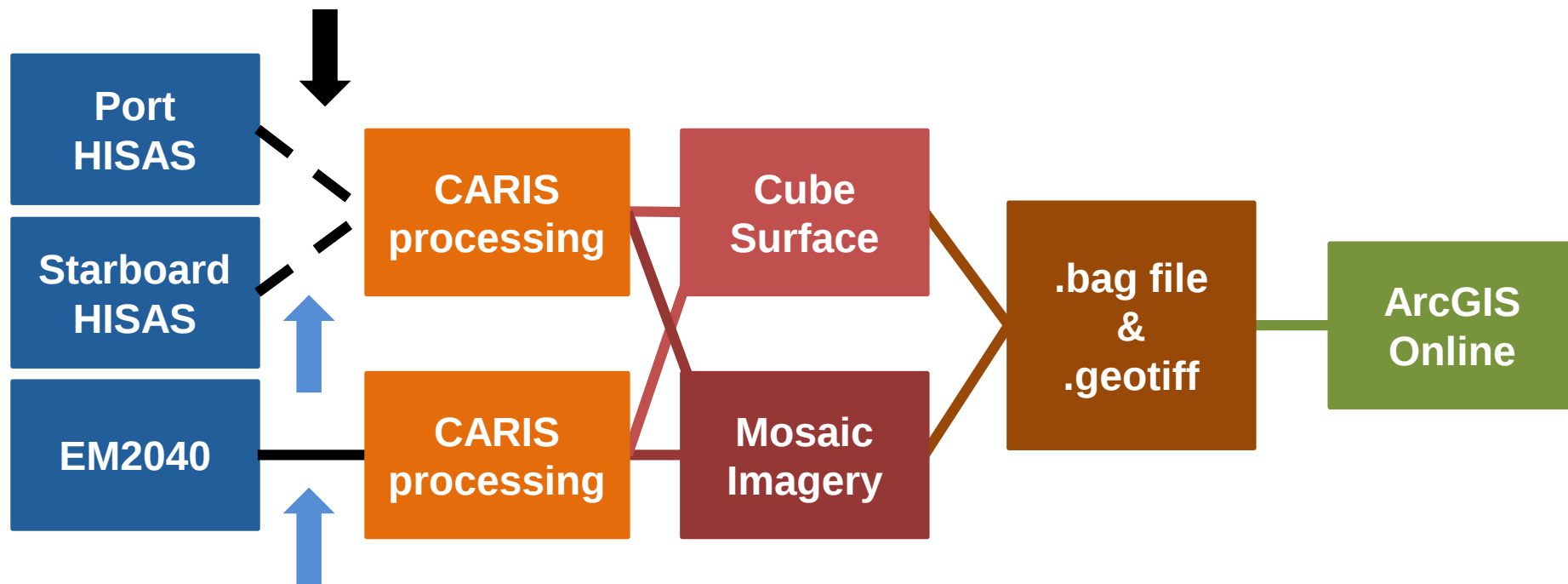
AUV “Chercheur” Data types

Sonar	File type	Data	Resolution
EM2040	*.all	Bathymetry & Imagery	<1 m
HISAS (Standard)	*.all	Port and Starboard Bathymetry	1 m
HISAS (Standard)	*.xtf	Imagery	4 cm
HISAS (Standard)	*.all	Port and Starboard Spot Bathymetry	10 cm
HISAS (Standard)	raw data	Port and Starboard Spot Imagery	~2-4 cm
HISAS (Wide-area)	*.all	Port and Starboard Bathymetry	2 m
HISAS (Wide-area)	*.xtf	Imagery	1-2 m

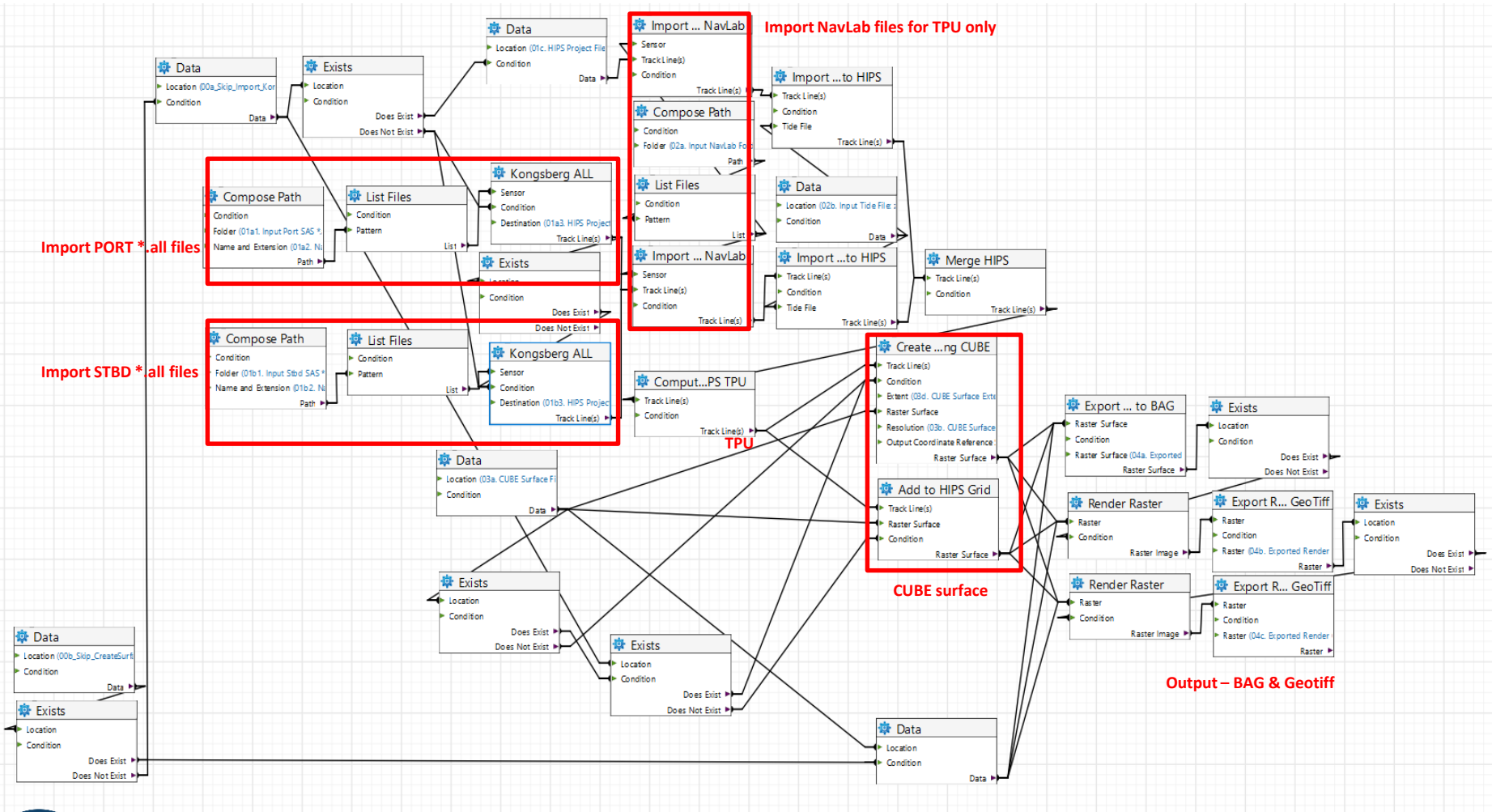


Kongsberg Proprietary software
FOCUS & REFLECTIONS takes
raw HISAS data and produces
.all & .xtf for input into CARIS

Simplified data work flow



DETAILED EXAMPLE: HISAS wide-area mode work flow

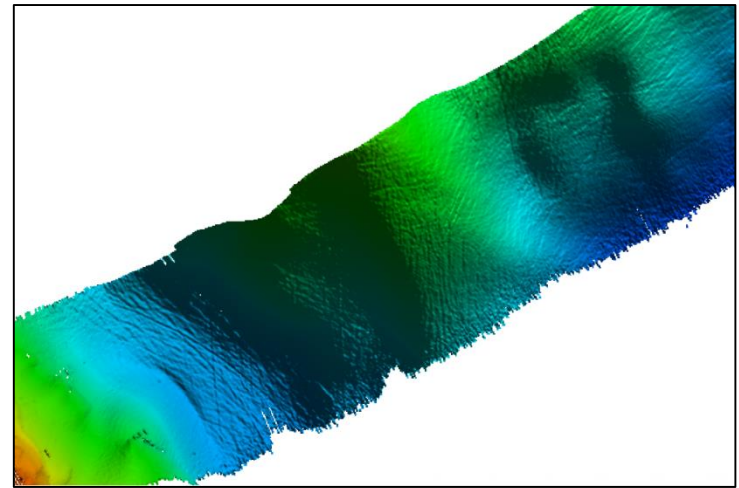
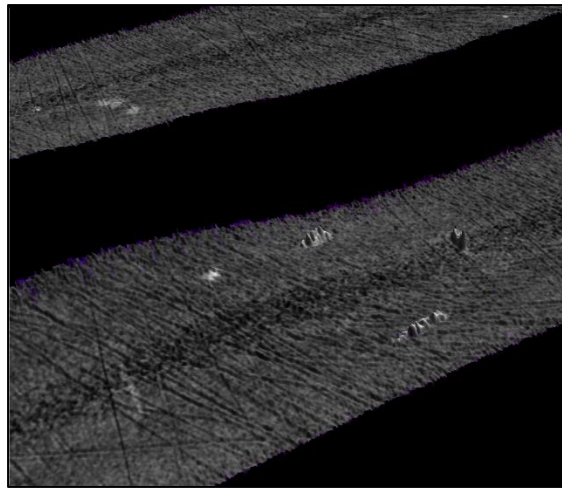
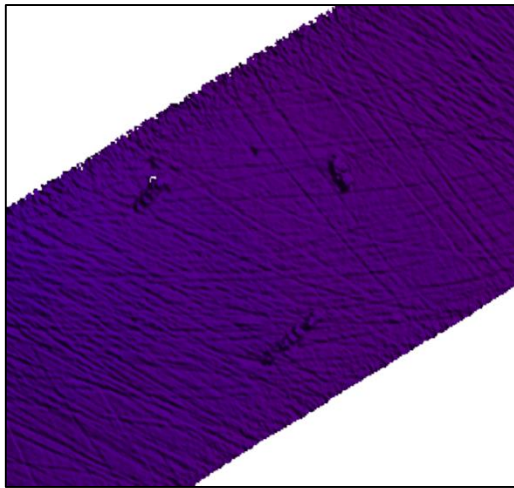


Want to know more... speak to Masanao Sumiyoshi



EM2040 data

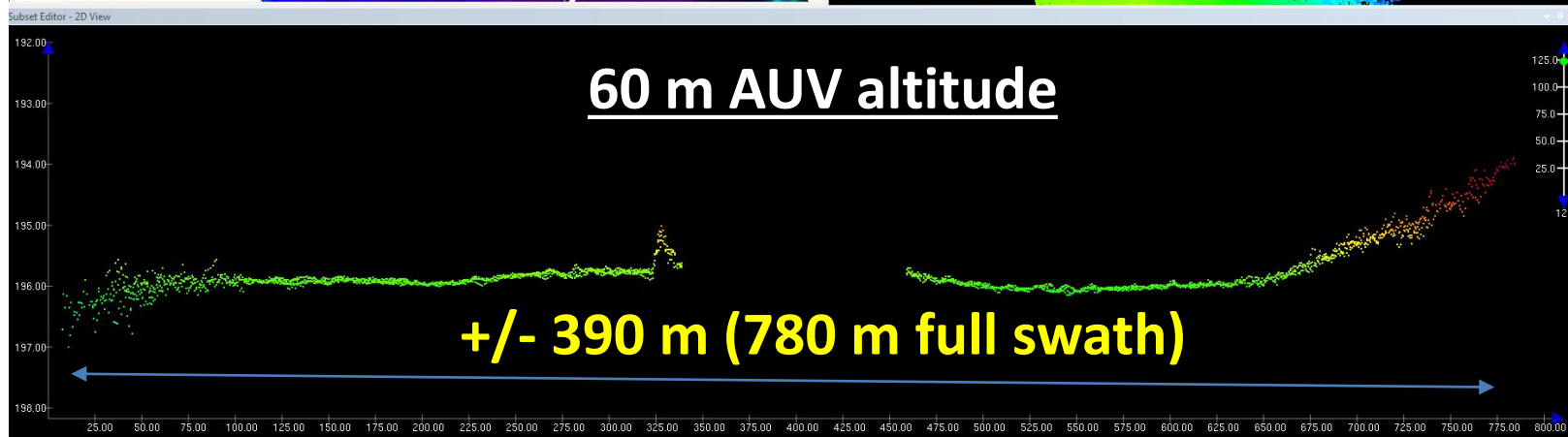
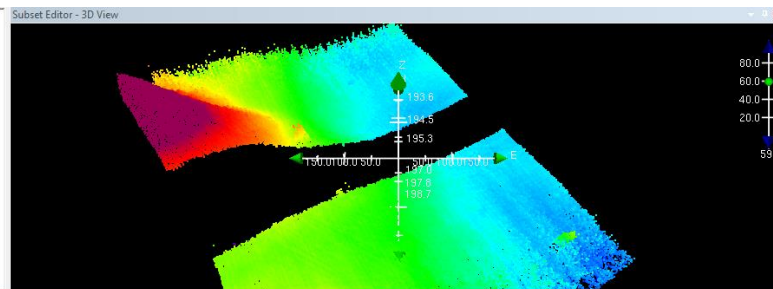
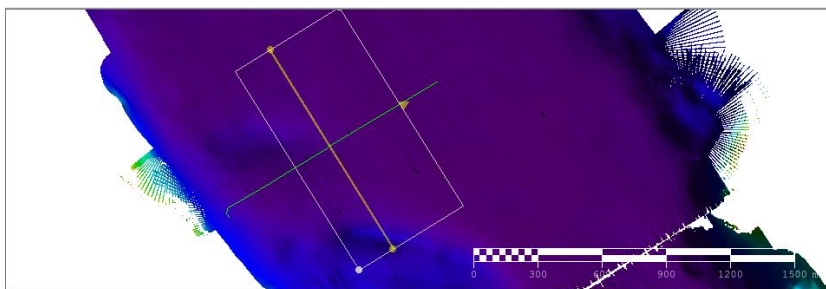
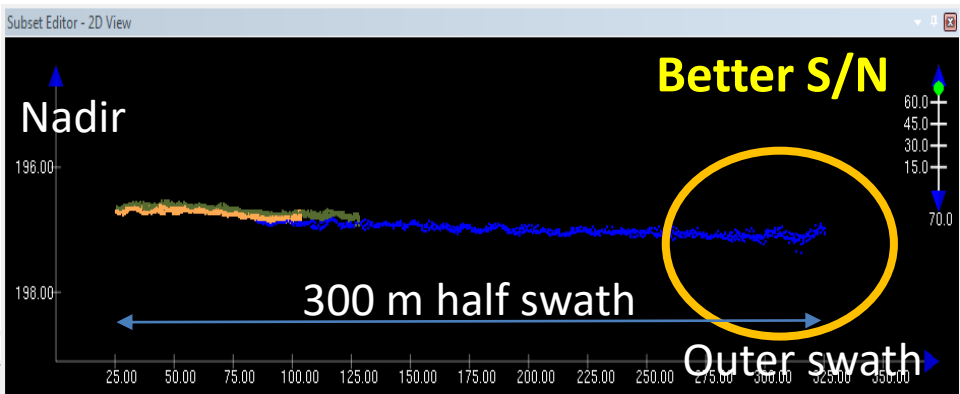
- Nadir fill
- Approximate total swath width = 200 m
(120° swath & 400 beams at 60 m altitude)
- Data resolution ≤ 1 m



HISAS Wide-Area Test

30 m AUV altitude

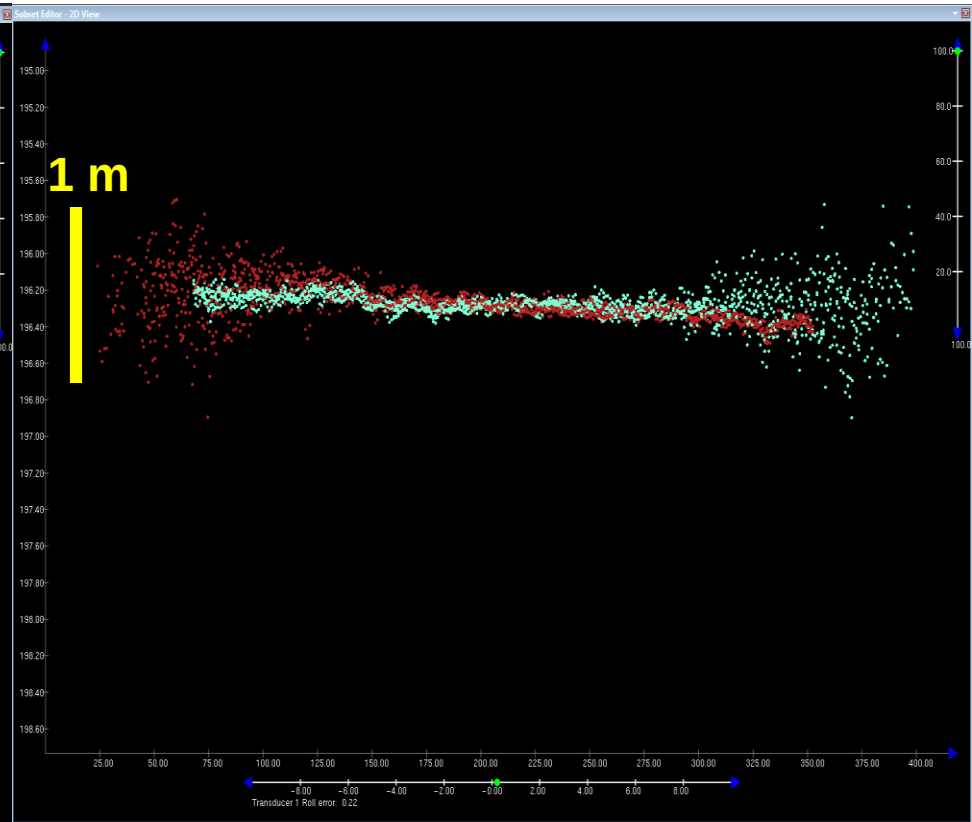
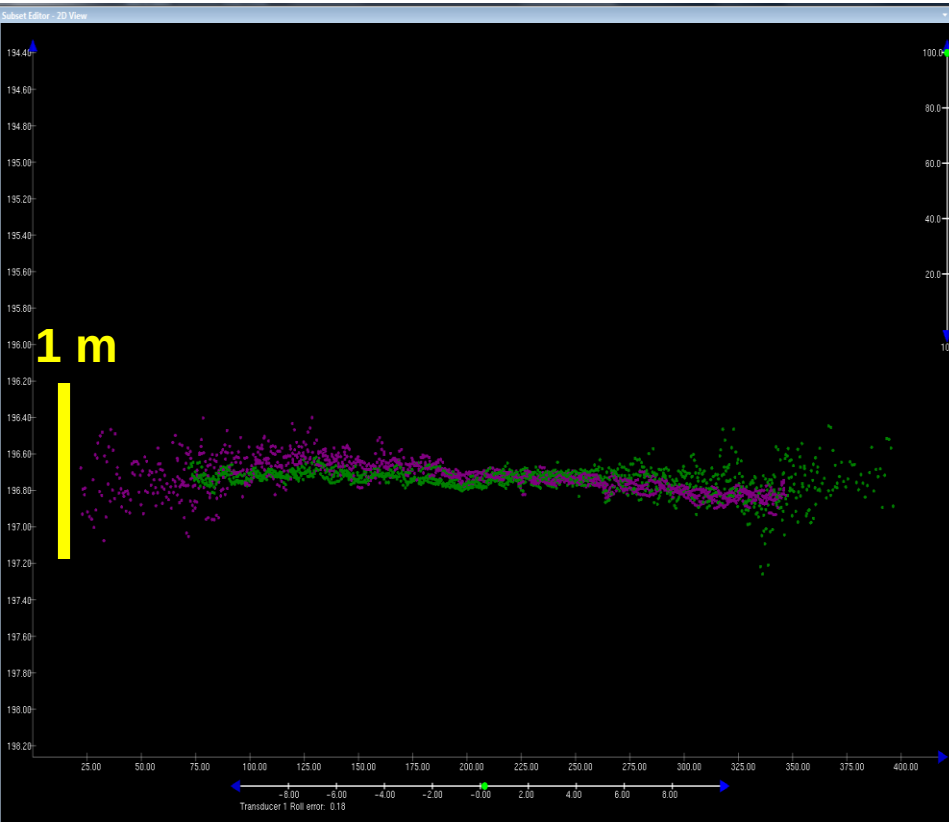
60 m AUV altitude



Patch Test for HISAS Wide-Area

[PORT] Roll: +0.225 degree

[STBD] Roll: +0.185 degree



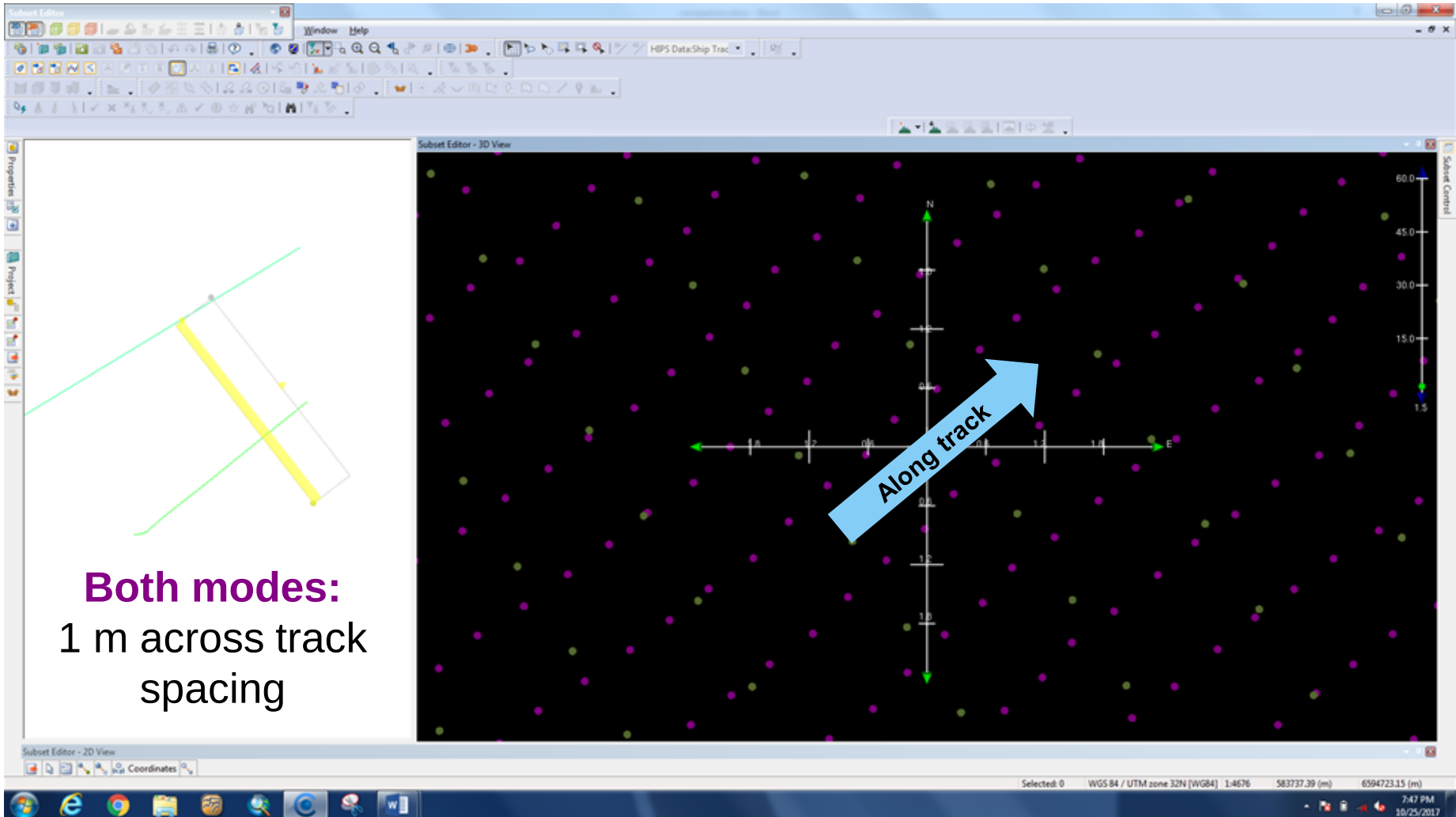
Data density: Different HISAS modes

Standard HISAS

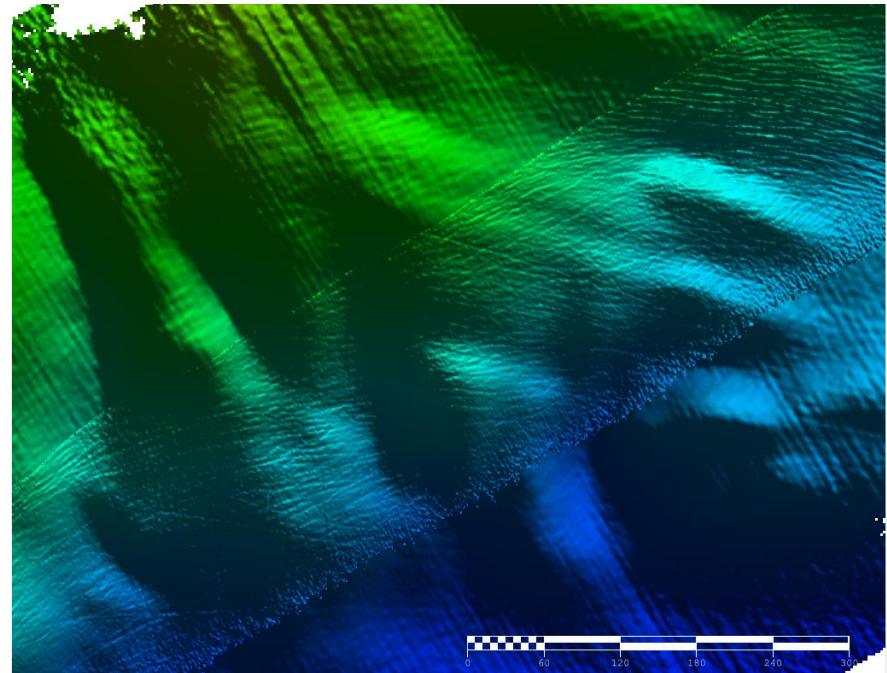
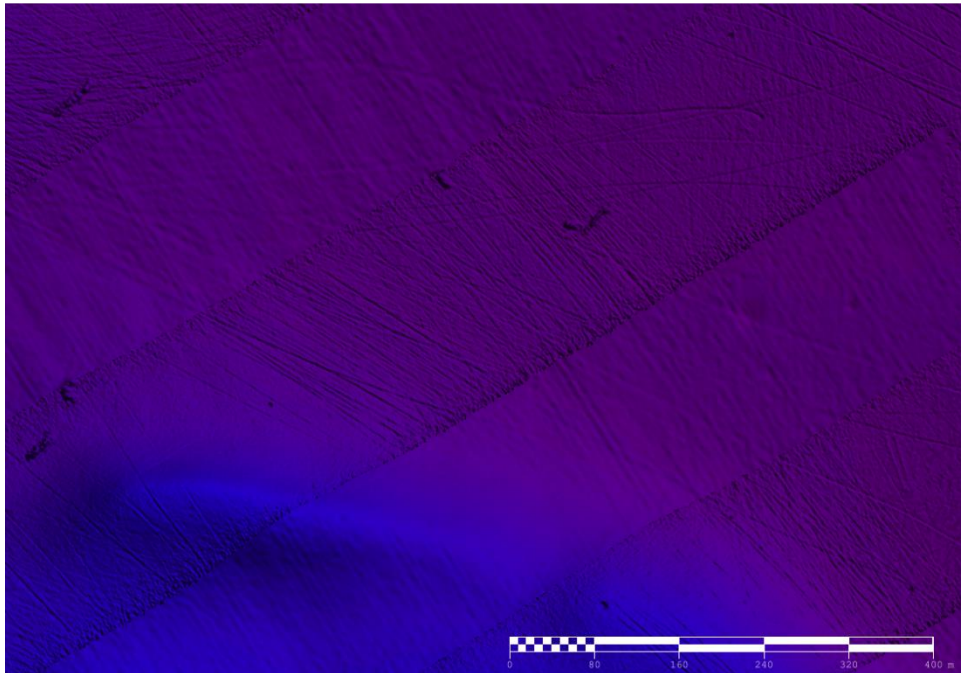
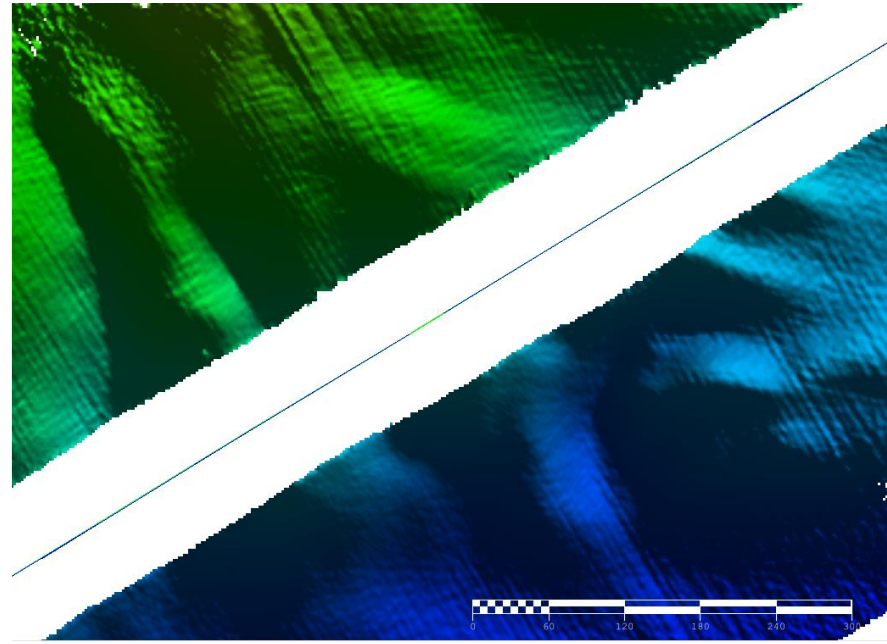
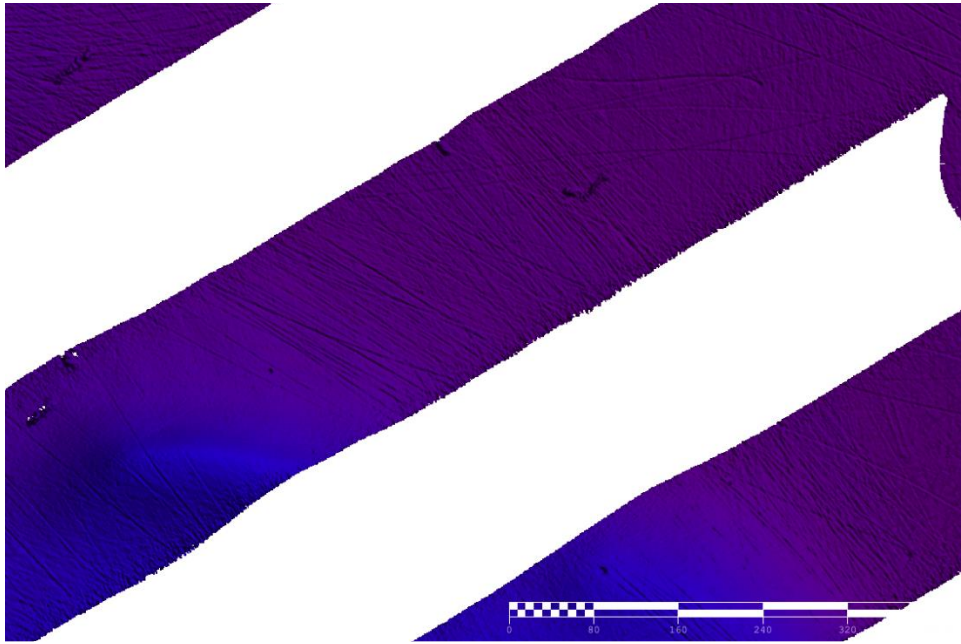
0.5 m along track spacing

Wide-area mode

~1.5 m along track spacing



HISAS wide-area mode with EM2040 nadir gap filling



Coverage Estimates

- Standard HISAS: 2.7 km²/hour
- HISAS wide-area side-scan: 6.2 km²/hour

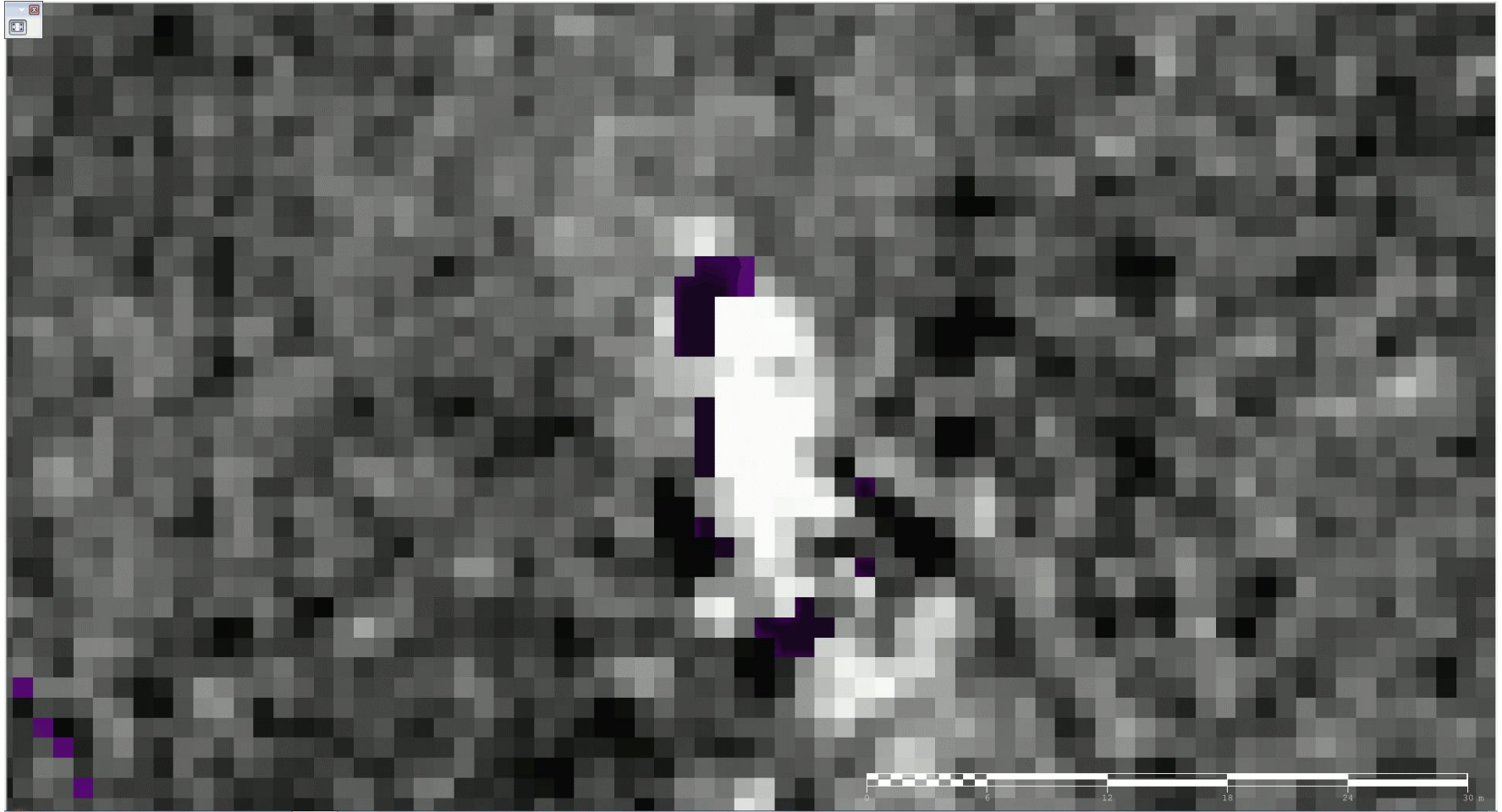
This includes EM2040 nadir gap data

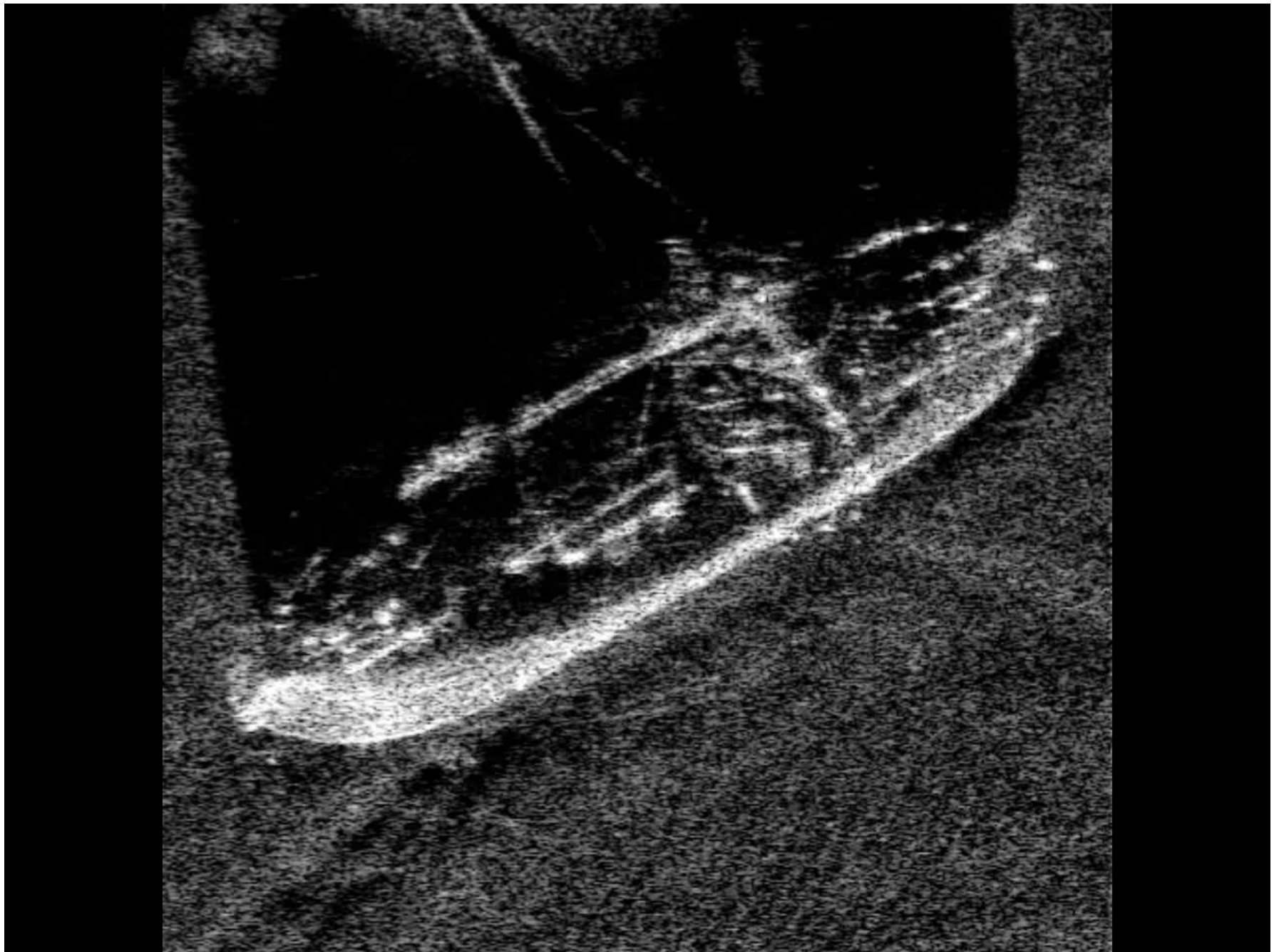
The Team plan for XPRIZE was to run various AUV modes:

- 13 hours of HISAS wide-area mode (80.3 km²)
 - 2 hours of standard HISAS mode (5.4 km²)
- = ~86% of required coverage

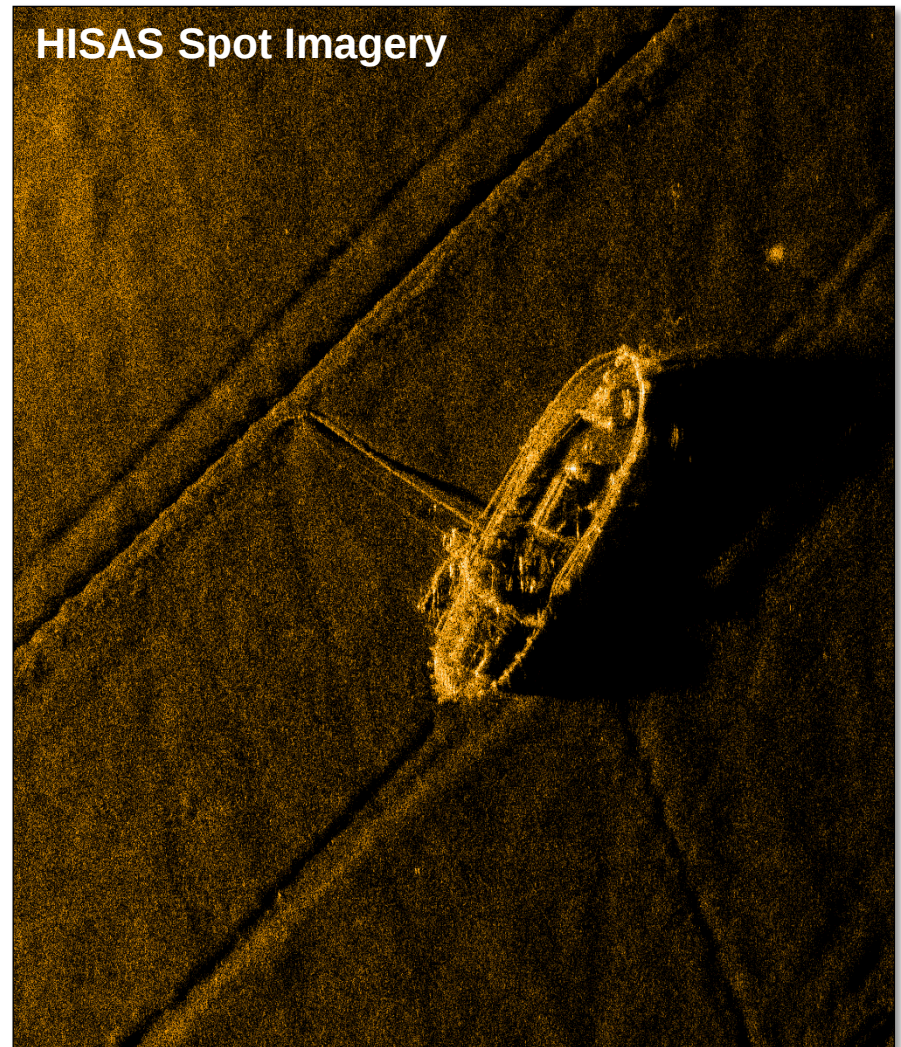
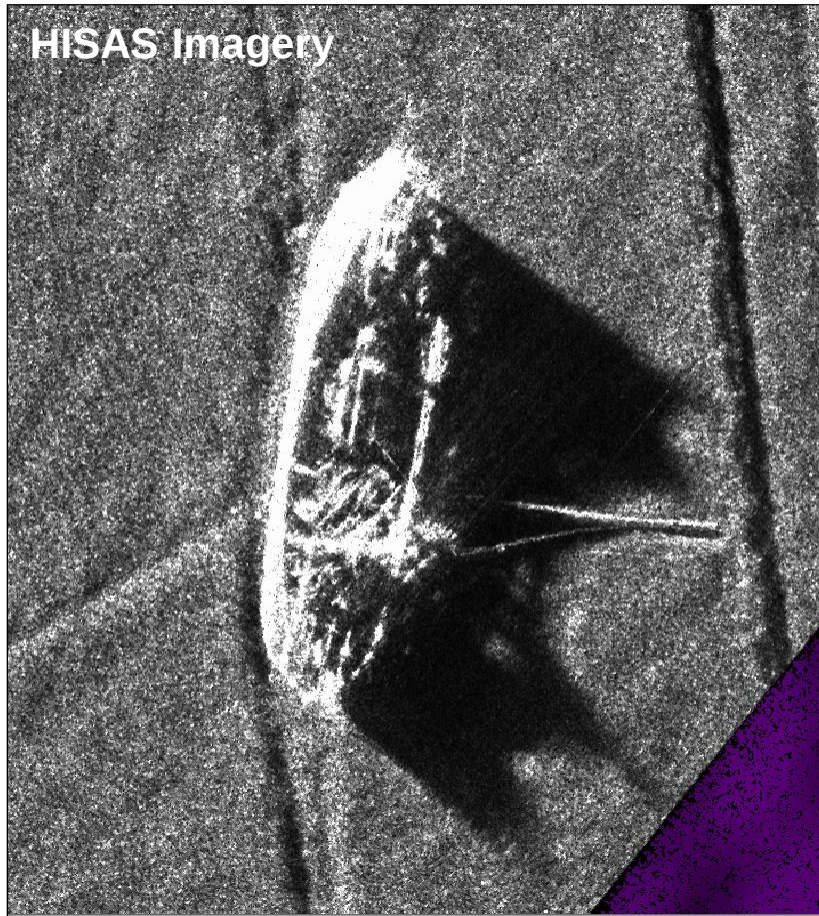


EM2040 backscatter vs. HISAS imagery



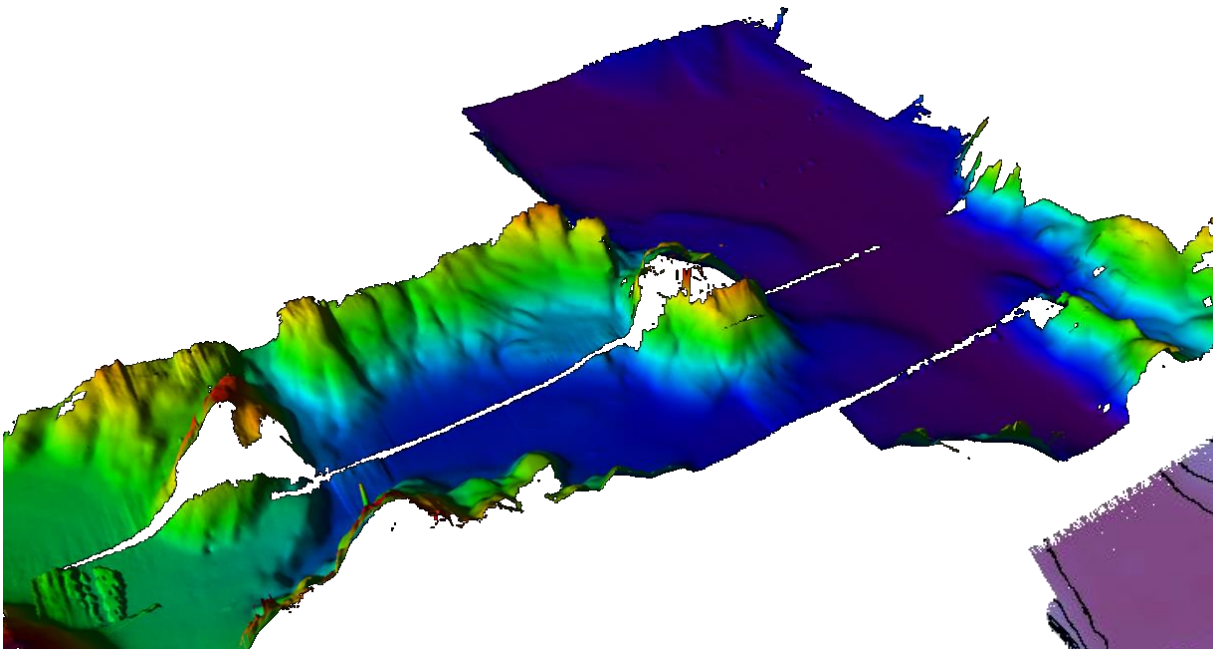


Only wreck covered using HISAS mode – more to come.....

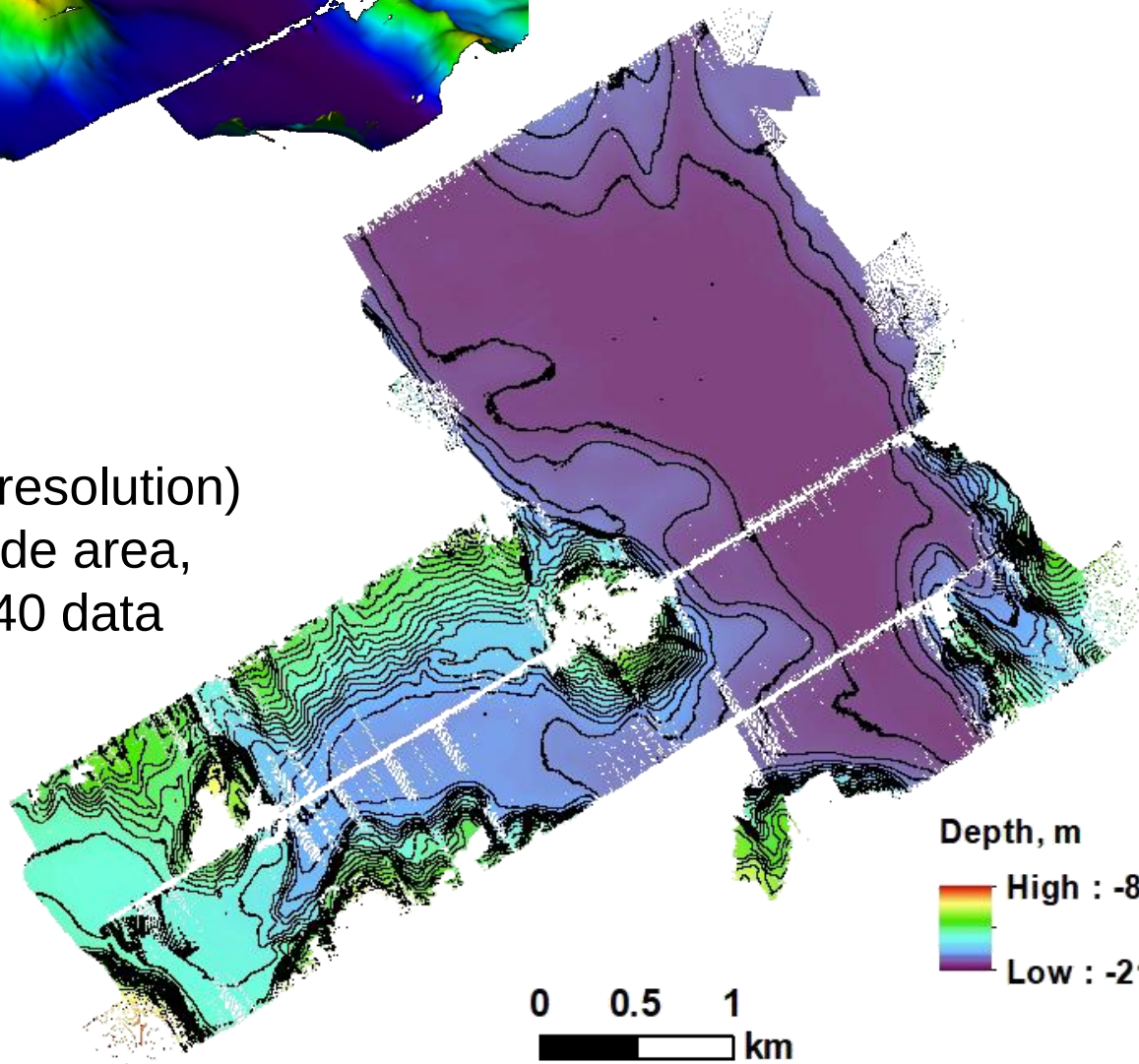


Shipwreck 20 m Length; 5 m Beam
in ~200 m water depths





Dive 12 surface (1 m resolution)
based on HISAS wide area,
HISAS and EM2040 data

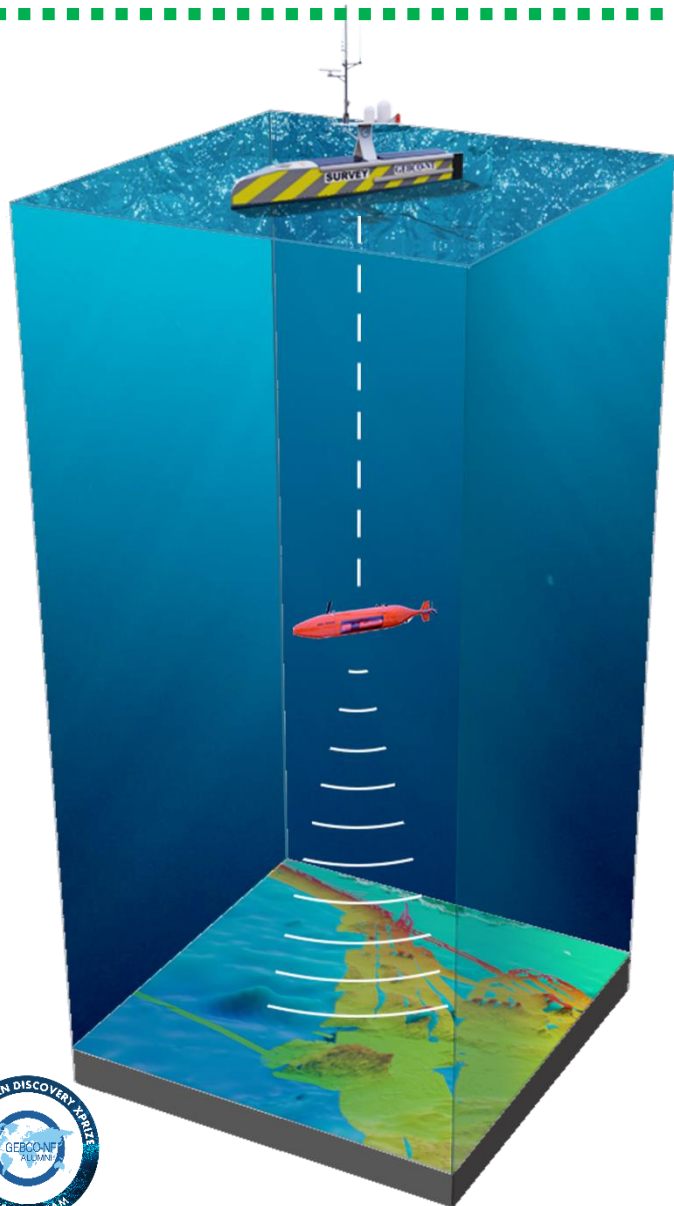


Depth, m
High : -80
Low : -210



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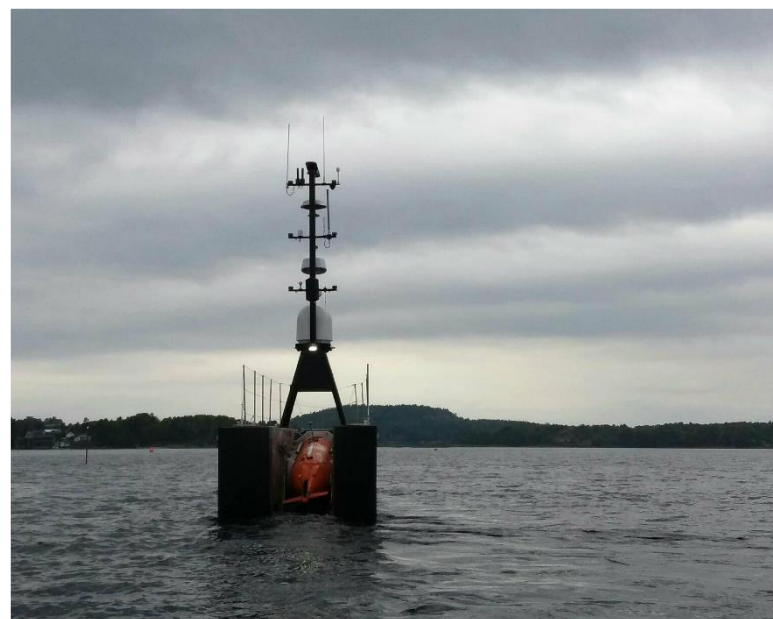
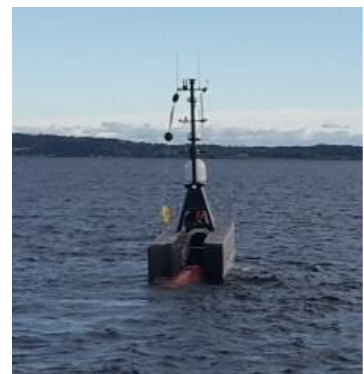
OFG



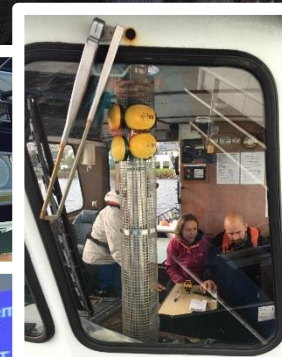
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THANK YOU



