GeoAcoustics
A KONGSBERG COMPANY

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Swath Bathymetry II: GeoSwath Plus ROV/AUV – technology and data examples

Why GeoSwath works well on AUVs and ROVs

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- Intrinsic advantages of interferometric technology
  - Wide coverage even in low fly heights
  - Swath width insensitive to vehicle motion
  - Simultaneous bathymetry and Side Scan
- Dimensions
  - Small, light and rugged transducers
  - Compact electronics
- Communications
  - PC based - Windows XP
    - Ethernet and serial interfaces
    - Proprietary acquisition and processing software package

Comparison with beamformer

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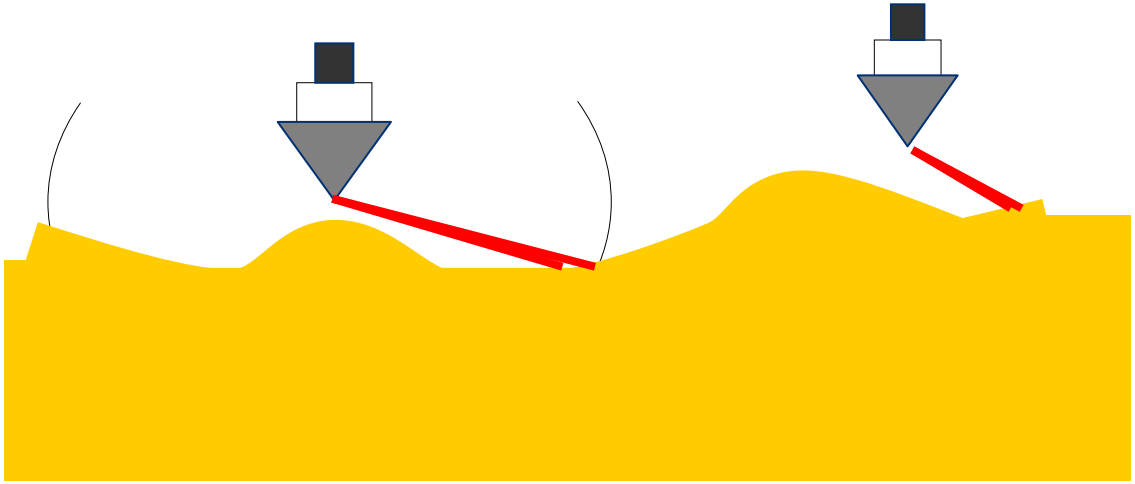
- Wide view angle, over 240 degrees.
  - Very wide swath bathymetry, even in shallow depth beneath transducers.
  - Coverage limited by S/N not number of beams
    - Swath width insensitive to roll.
- Raw data is a time series of angles (not angle series of times)
- Simultaneous co-registered true digital side scan
- Low power consumption
- Compact and robust transducers and electronics



GeoSwath specifications

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Sonar Frequency	**125 kHz**	**250 kHz**	**500 kHz**
Maximum Water Depth below transducers	200 metres	100 metres	50m
Maximum Swath Width	780 metres	390 metres	190m
Range	Up to 12 x depth	Up to 12 x depth	Up to 12 x depth
Resolution Across Track	1.5 cm	1.5 cm	1.5 cm
Two Way Beam Width	0.9º Azimuth	0.5º Azimuth	0.5º Azimuth
Depth Resolution	6 mm	3 mm	1.5 mm
Swath Update Rate (max)	Up to 30per second (range dependent)		
Transducer dimensions	540 x 260 x 80 mm	375 x 170 x 60 mm	255 x 110 x 60 mm
Transducer Weight	11.6 kg (in air) 3.3 kg (in water)	3.8 kg (in air) 1.8 kg (in water)	1.5 kg (in air) 0.5 kg (in water)

Power requirements: 150 W at max ping rate 20 W standby

500 kHz transducer and electronics for ROV and AUV

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GeoSwath AUV/ROV Specs

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Hardware	EBX format, with PC104 processor stack. 1.6GHz Pentium-M Processor with 2GB RAM.
Data Storage/ retrieval	120 GB hard drive, 10/100/1000 BaseT Ethernet link.
Mission Endurance	12 hour data collection (upgradeable with larger hard drive capacity)
Interface to AUV	Ethernet (2 x 1Gbit Ethernet ports available), RS232 for ancillaries (optional)
Power requirements	24VDC, 50W (at max ping rate), 20W (standby)
Max depth rating	2000m (optional 4000m)
Electronics bottle size	200 mm OD x 400mm long
Electronics bottle weight	5 kg (in air), 3 kg (in water)

GeoSwath Plus ROV

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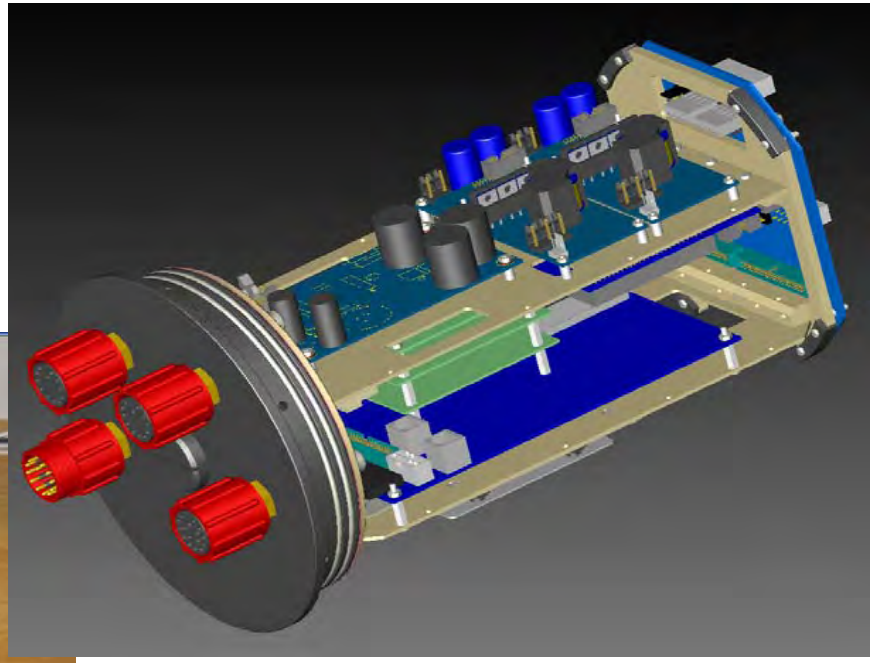

GeoSwath ROV

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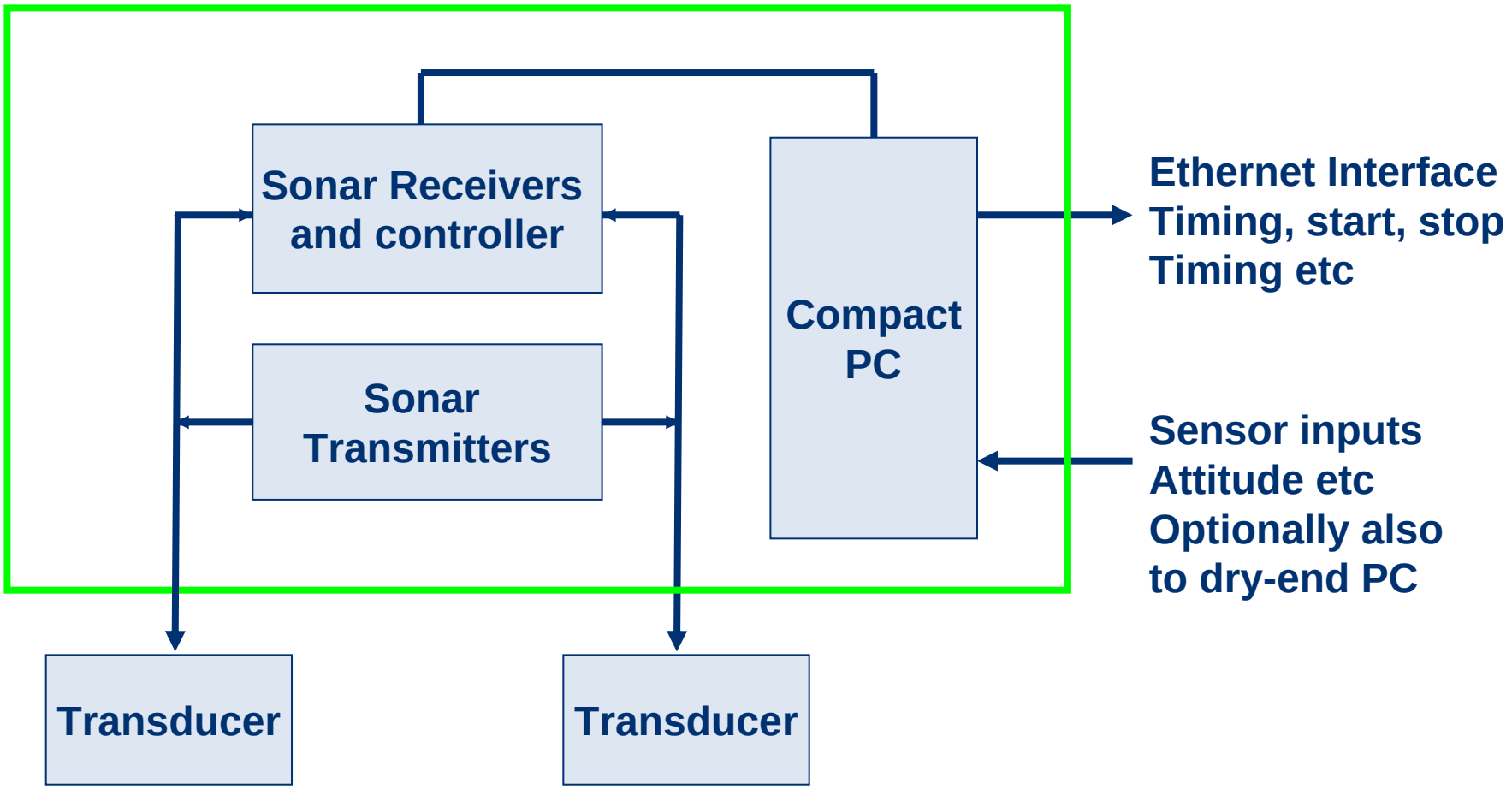

GeoSwath Plus AUV

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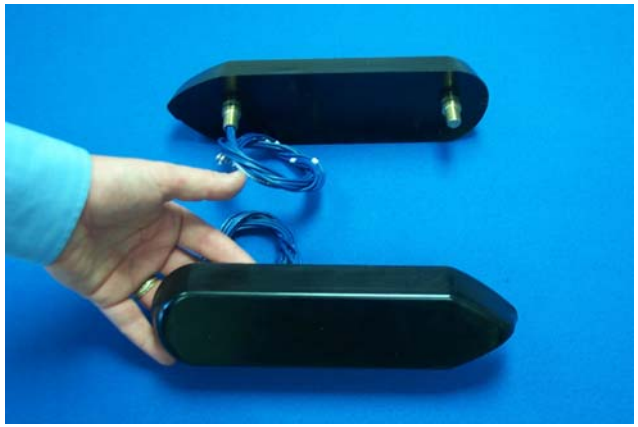

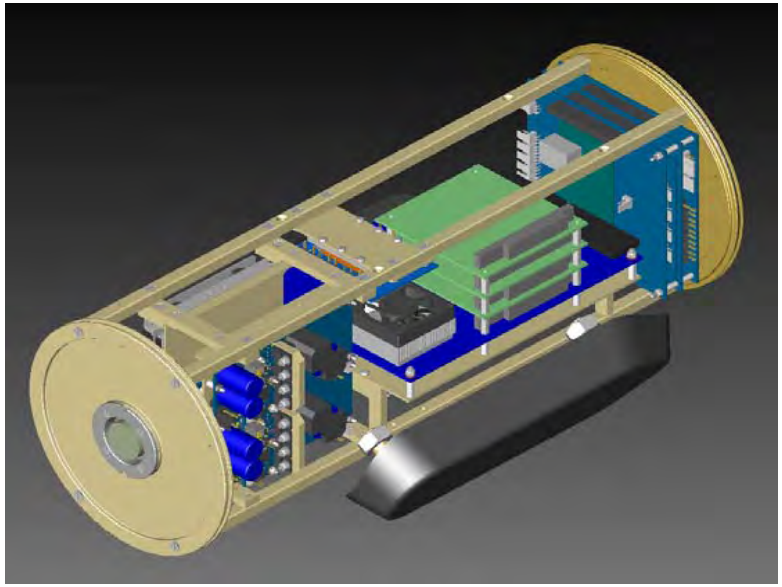

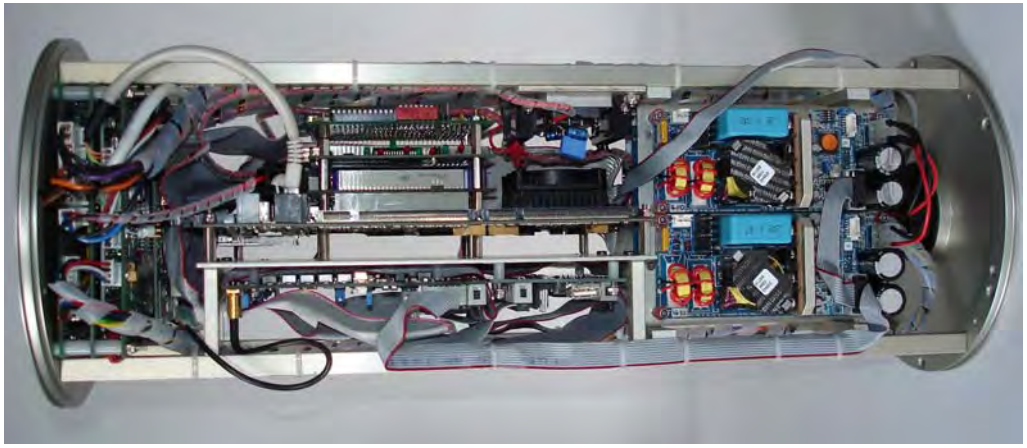

GeoSwath AUV

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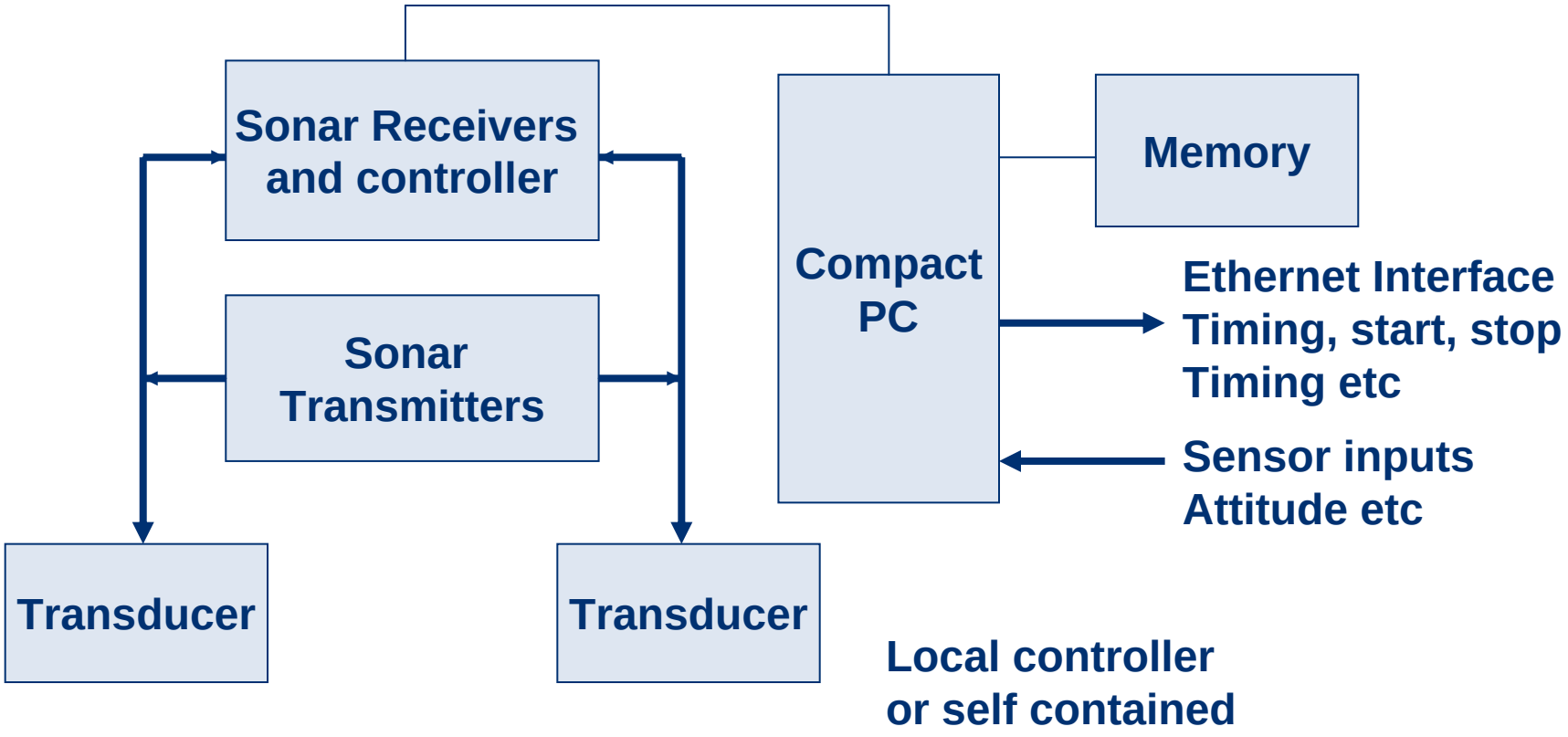
Generic AUV application using
Standard GeoSwath Electronics Modules



Ancillary sensors

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For high quality bathymetry data the ancillary sensors must be of a high specification.

- Position
  - x, y
  - Generally processed from ROV/AUV navigation system
- Attitude
  - Pitch, roll
  - Heave generally not useable – use pressure depth instead
  - heading
- Altimeter
- Sound velocity
  - e.g. Valport MiniSVS
- Pressure depth
  - e.g. Parascientific Digiquartz 8CB4000-I
  - A Valport combined pressure and MiniSVS available
- Timing
  - 1pps
  - Hard Ethernet sync – no NTP

Keys to Performing a High Accuracy Survey

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- Stability of mount (transducers to motion sensors)
- 1PPS time synchronisation
- Position accuracy
- Accurate attitude sensing (Roll measurement, and attitude timing)
- Good calibration

Timing – 1PPS

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- PPS updating every second
- PPS hardware interface, rising or falling edge selectable
- Corrects PC “internal” time to UTC time
- Tests show errors below 300us absolute, less than 20us ping to ping
- Allows processing with GPS time - zero nav latency
- Makes calibration easier
- Requires PPS availability on the AUV while submerged
- Various options for PPS on ROV

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GeoSwath Plus ROV

Technology

GeoSwath ROV

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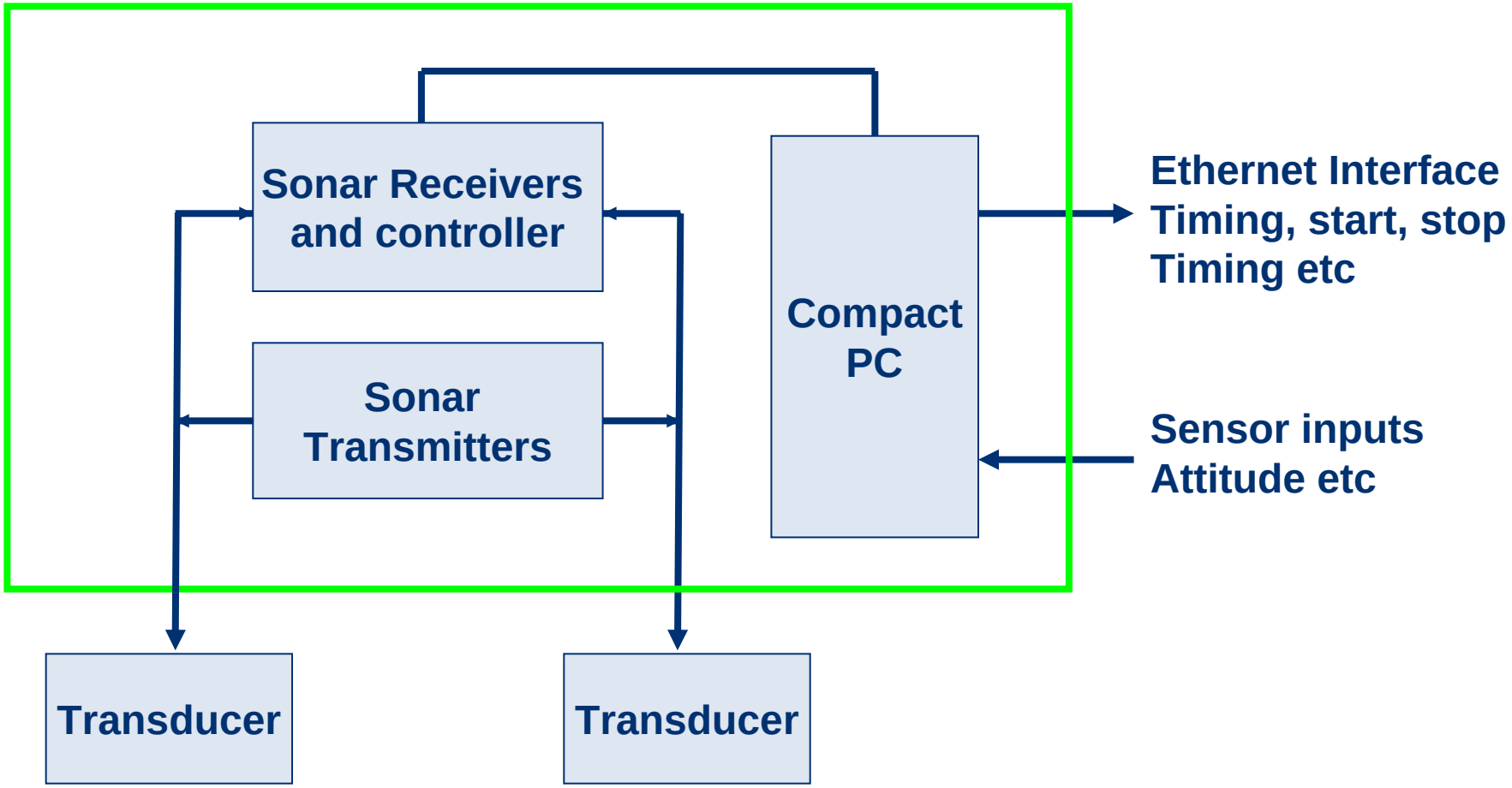

Integration Considerations

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- How to mount it on your ROV?
- Communications and power?
- Positioning: No fixed relationship to vessel, so lose absolute GPS fixes. Thus accurate relative positioning is essential for accurate dtm (grids), but not for single swaths (pipelines?). USBL or Inertial Nav etc are needed.
- Height and absolute tide corrected depth are required for accurate “z” or vertical accuracy
- Calibration requirements

GeoSwath ROV Communications

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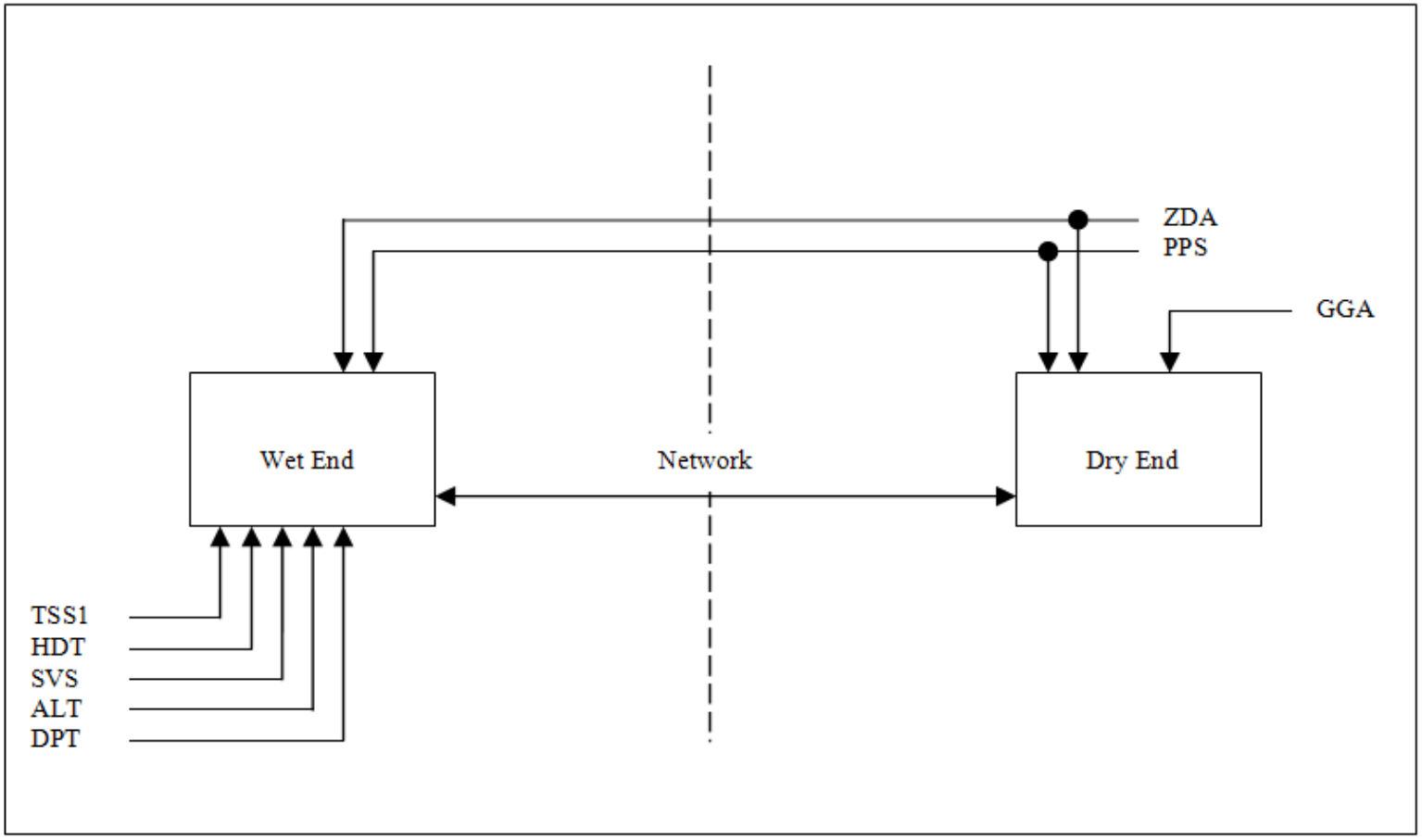
- Standard Ethernet Link, Copper or Fibre
- Copper Ethernet Link allows long cable operation (tested on 3 km of 8 mm coax so far)
- Standard serial interfaces to sensors
- 24V/48V DC power supply requirements

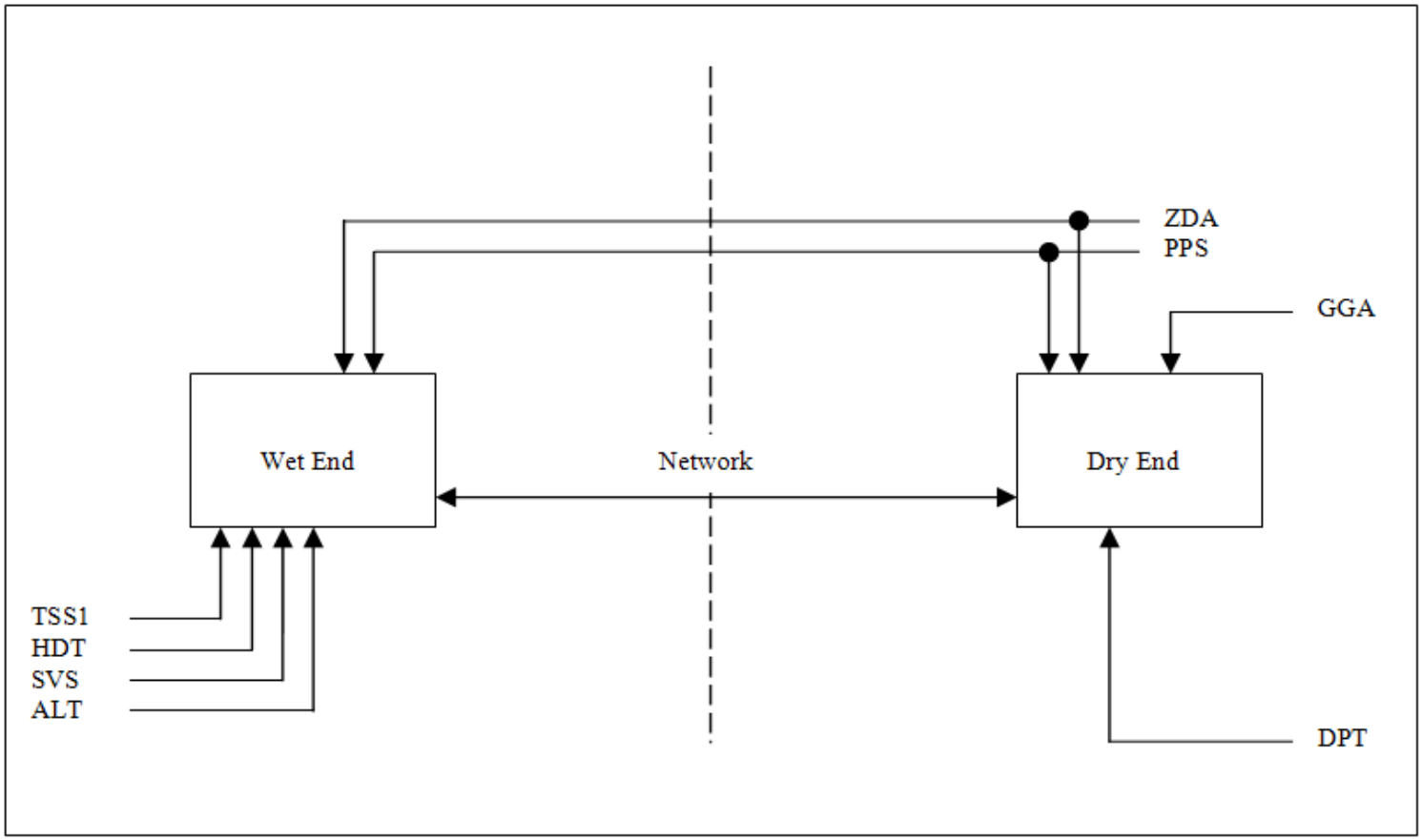
ROV data connection options

1. Standard GeoSwath peripherals connected at wet-end with addition of pressure sensor, navigation connected at top end, wet and dry ends time synchronized using PPS/ZDA.



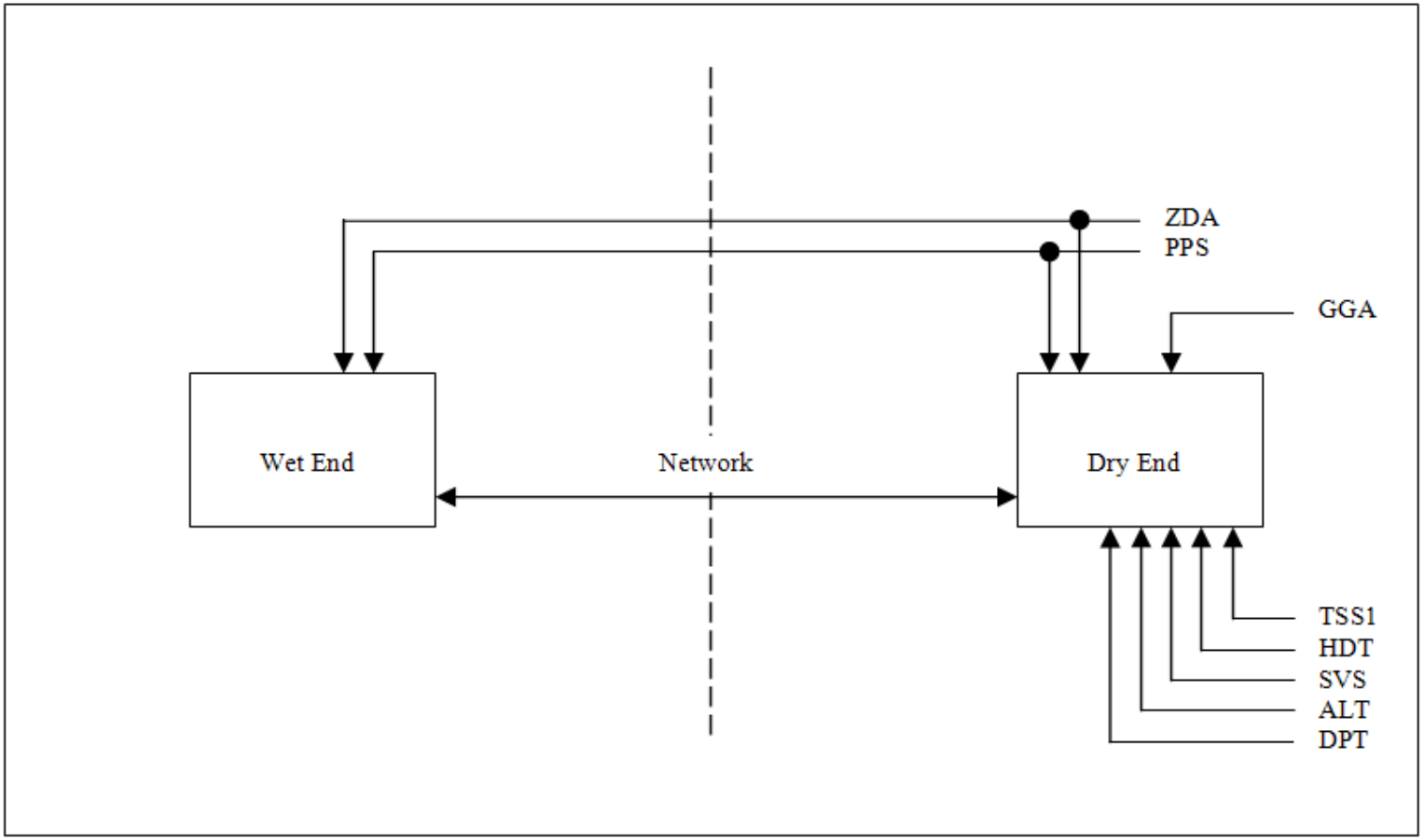
ROV data connection options

2. Standard GeoSwath peripherals connected at wet end, pressure depth supplied at top end with navigation, wet and dry ends time synchronized using PPS/ZDA.



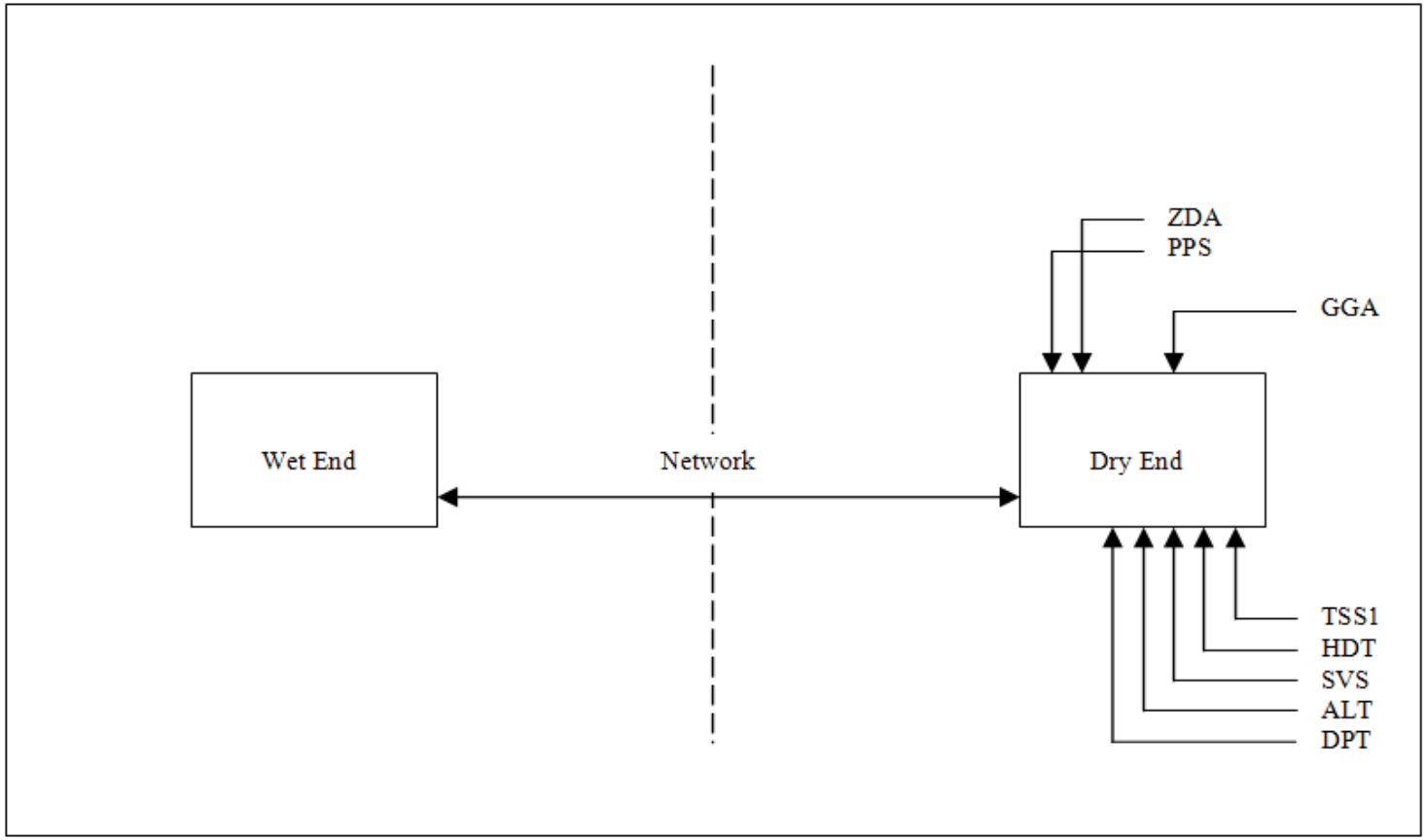
ROV data connection options

3. All peripheral data connected at dry end, wet and dry ends time synchronized using PPS/ZDA.



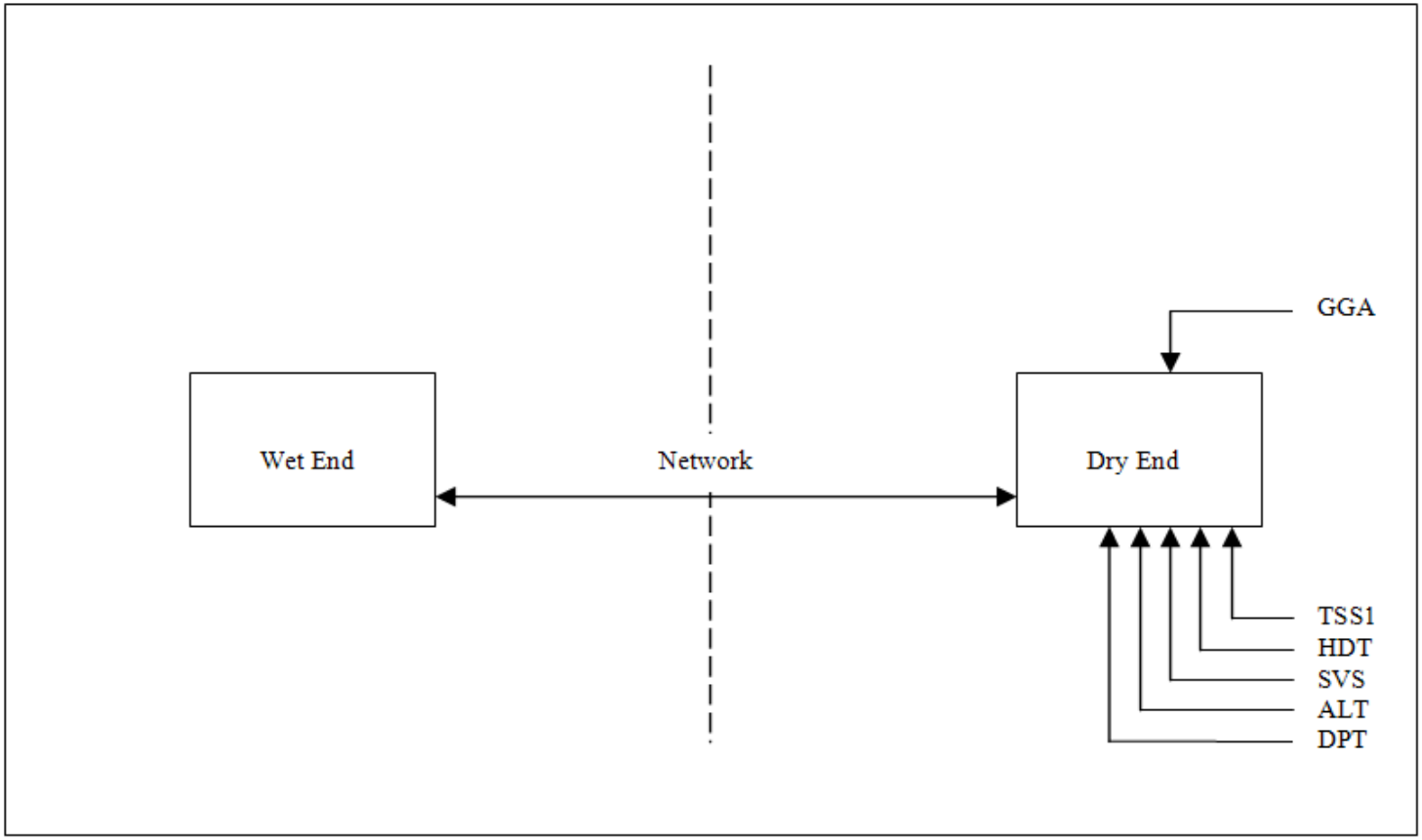
ROV data connection options

4. All peripheral data connected at dry end, dry end time synchronized using PPS/ZDA, interal dry to wet end synchronization.



ROV data connection options

5. All peripheral data connected at dry end, internal dry to wet end time synchronization only.



GeoSwath Plus on Minerva ROV

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GeoSwath Plus on Minerva ROV
Data flows

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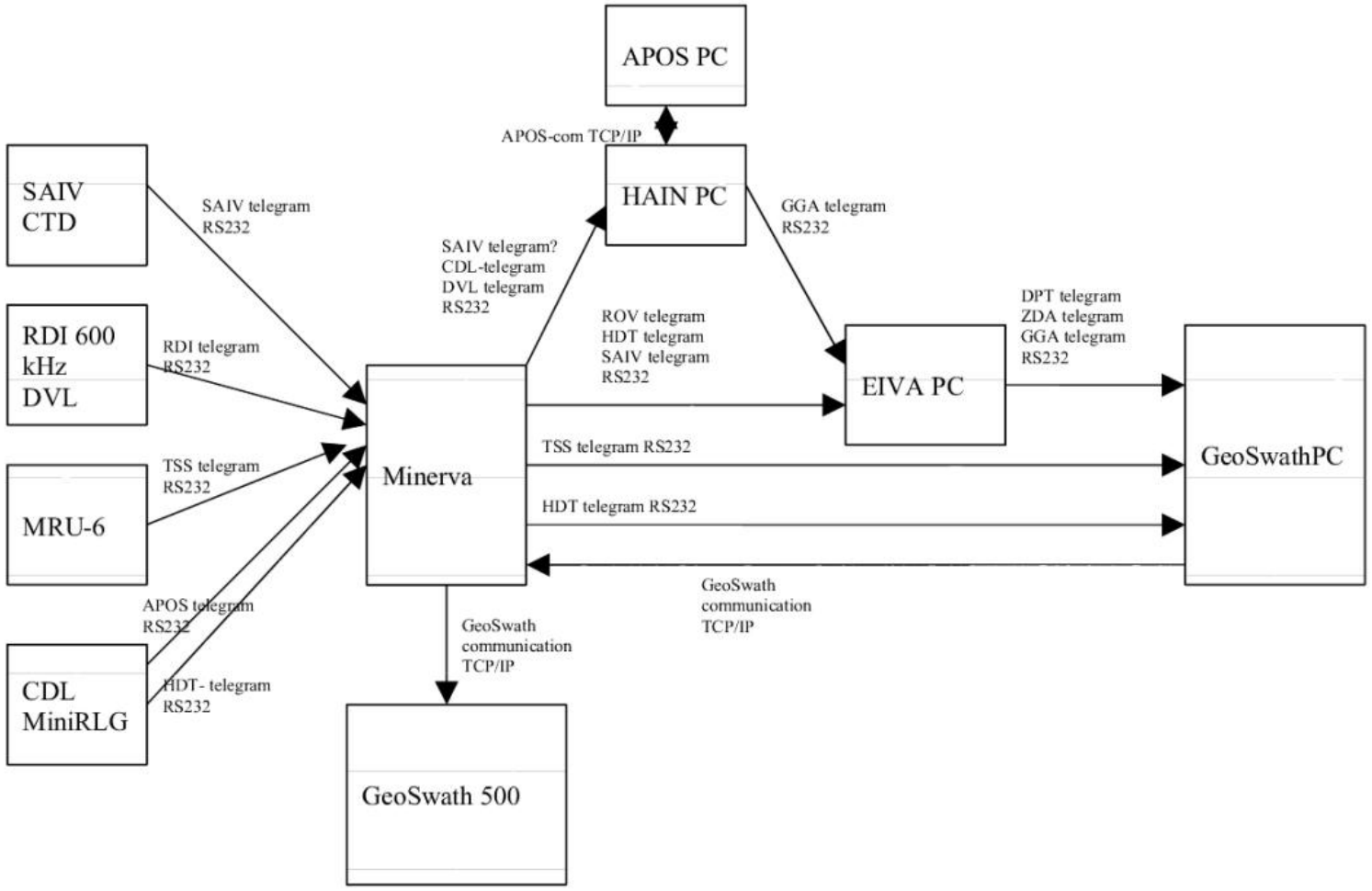

GeoSwath ROV/AUV software

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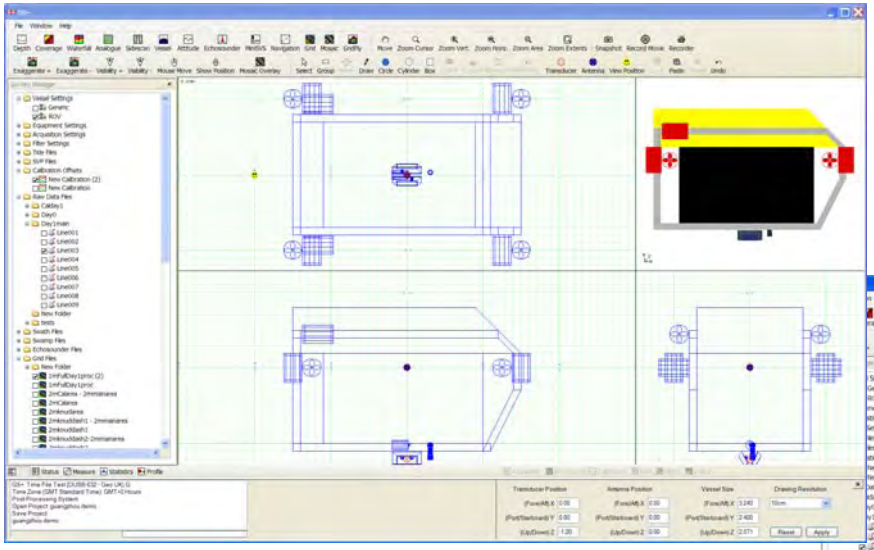

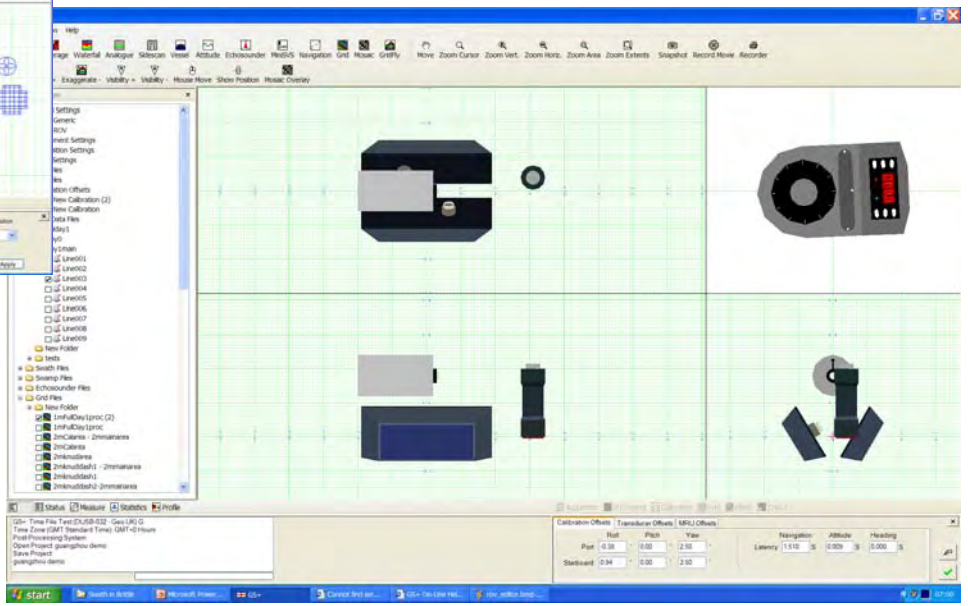

GeoSwath Plus on ROV

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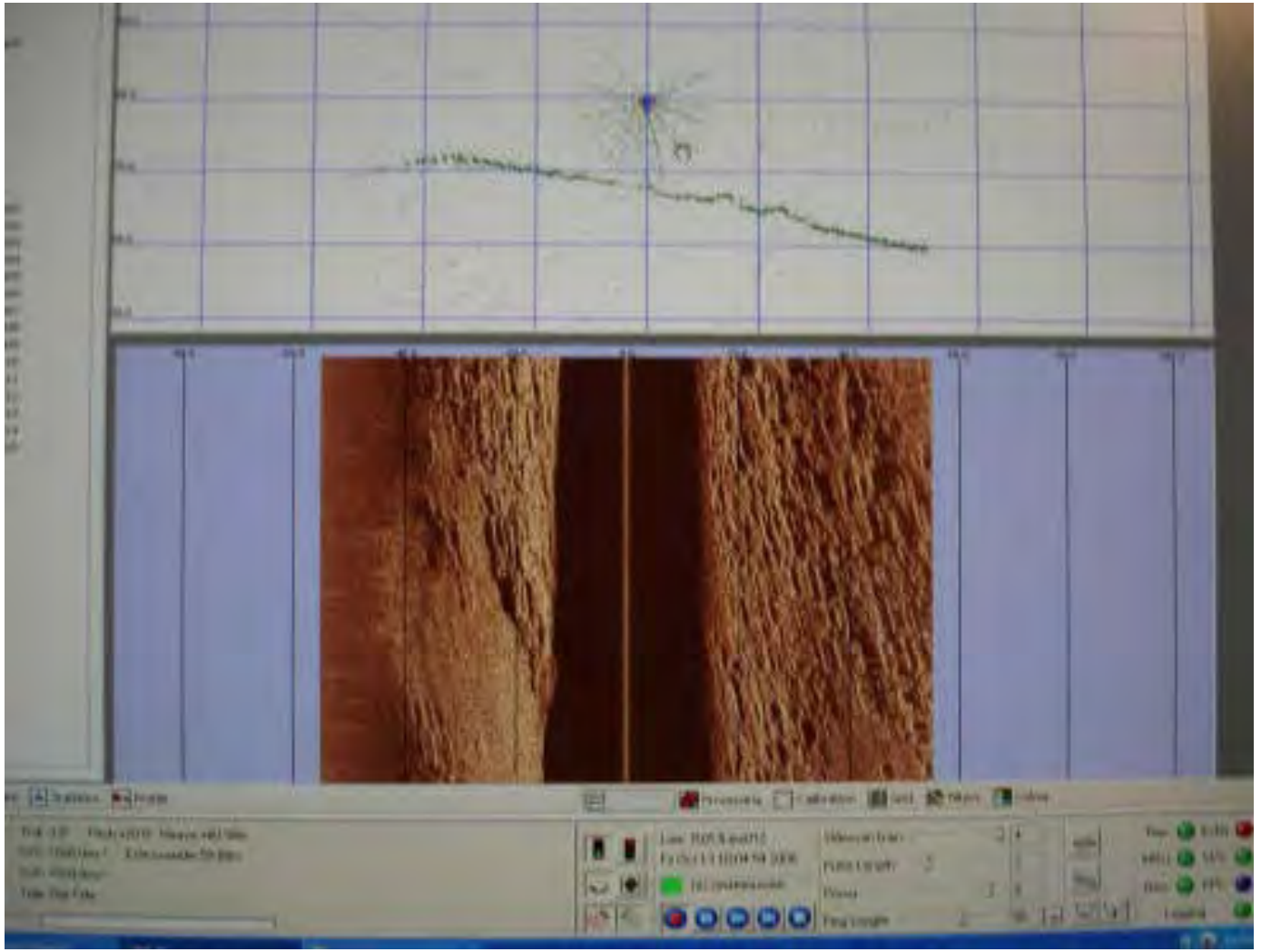

Operator's Screen

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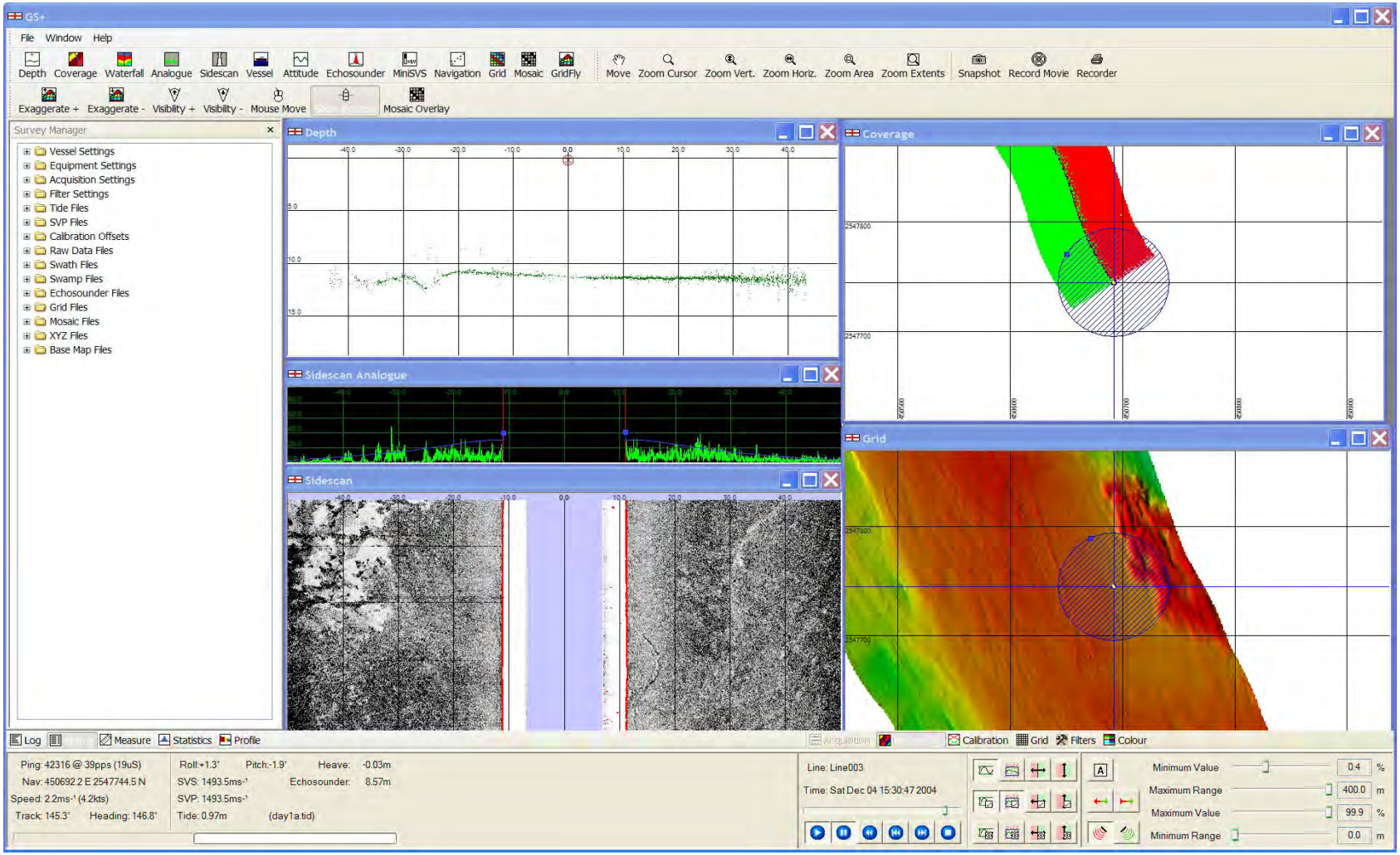

Customisable Layout and Views

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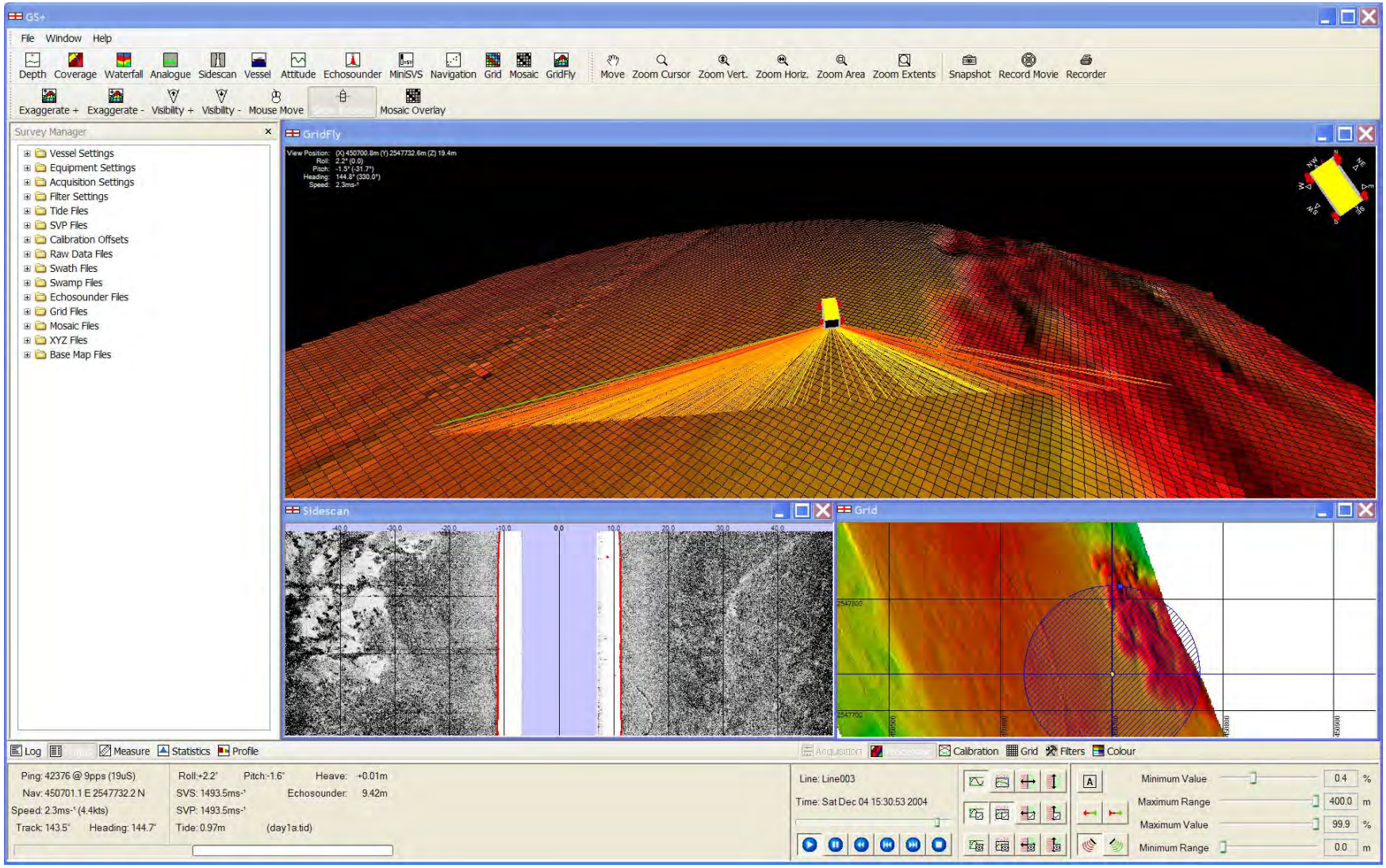

ROV: Ability to Flag and Store Targets in Vehicle Context in Real Time

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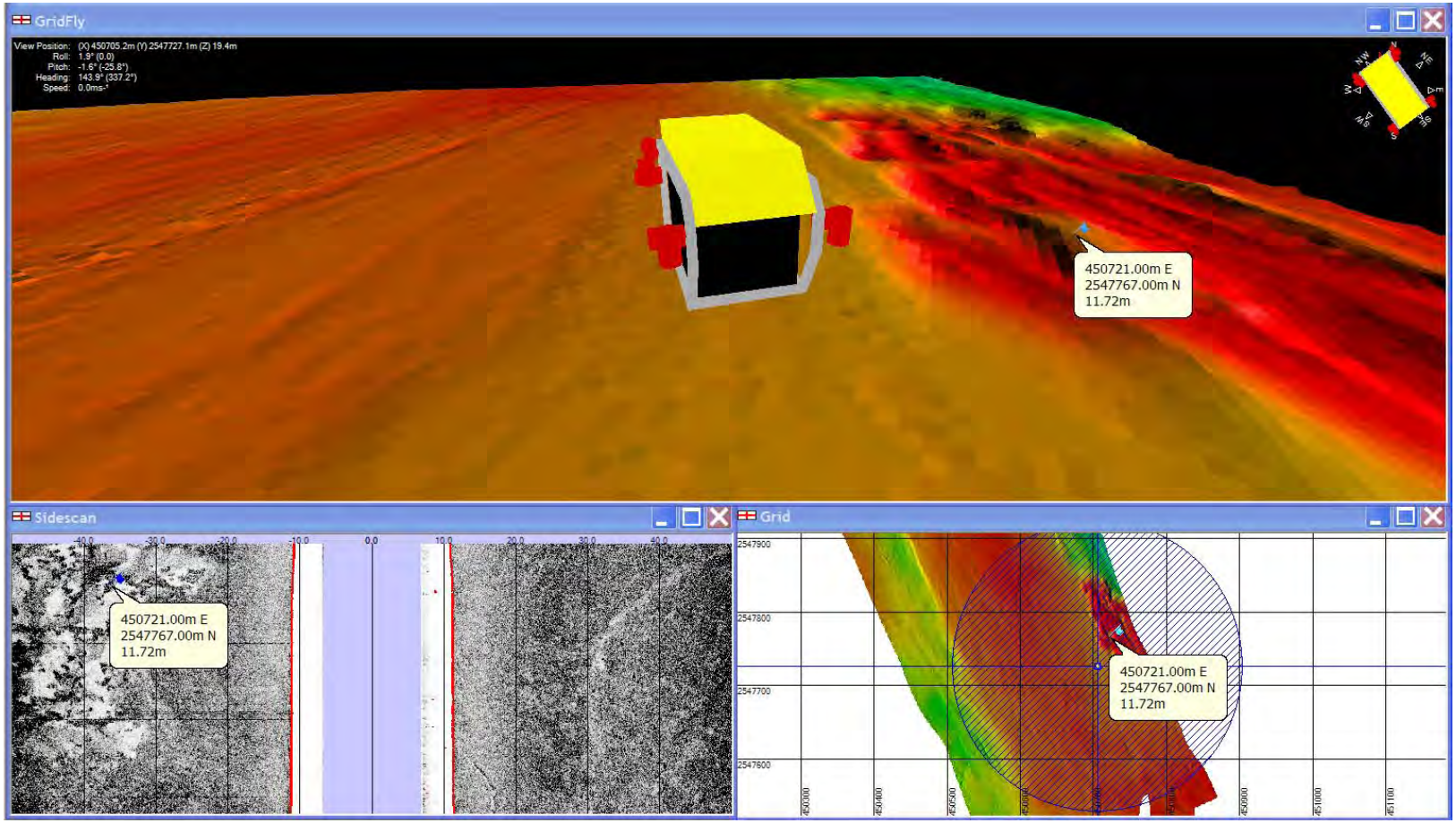

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GeoSwath Plus ROV

data examples

- Minerva ROV operated by NGU
- Oslo Fjord
- Cold water coral reef of Norway

Side scan Data Examples

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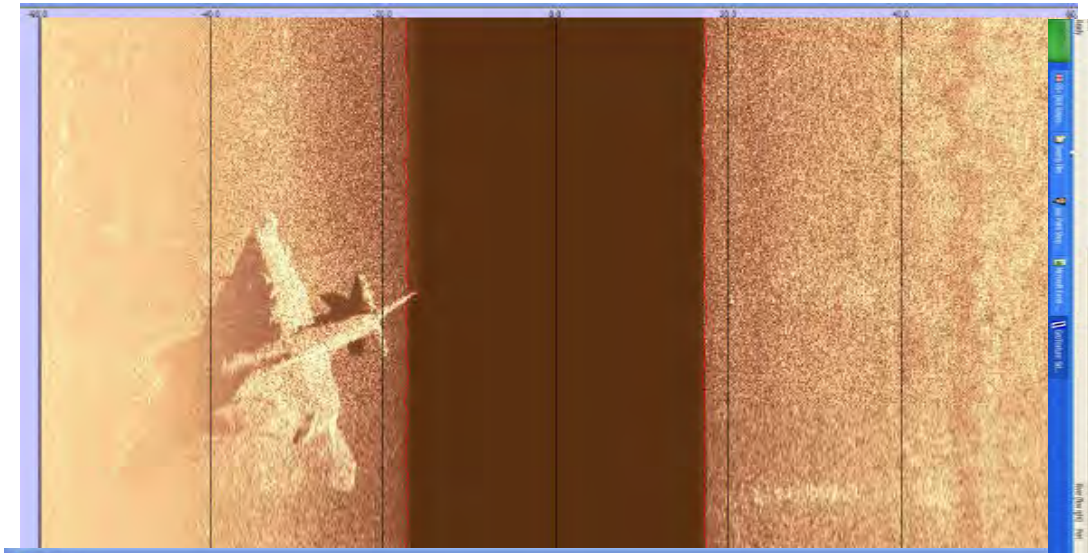

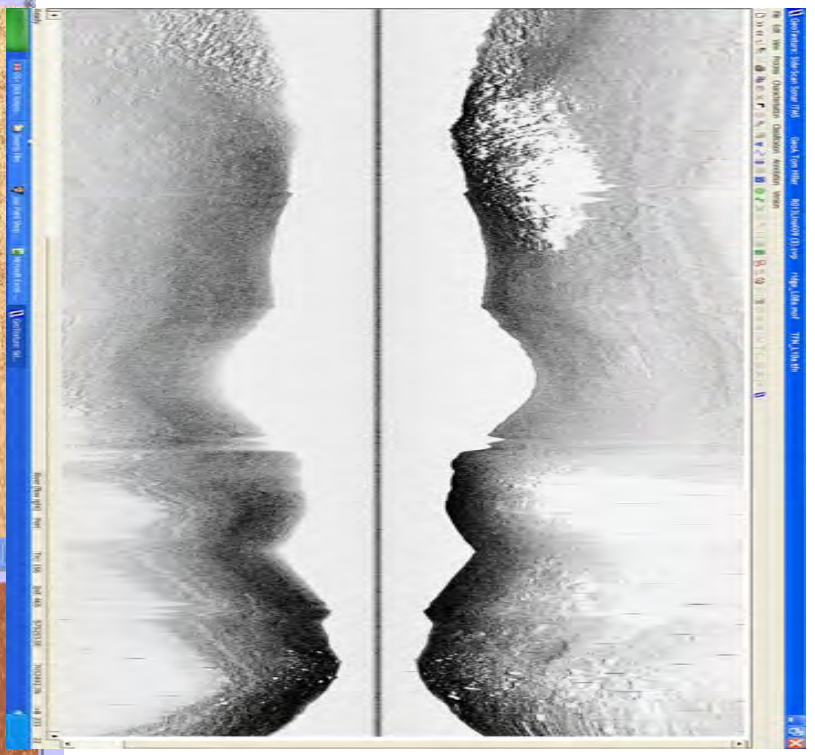

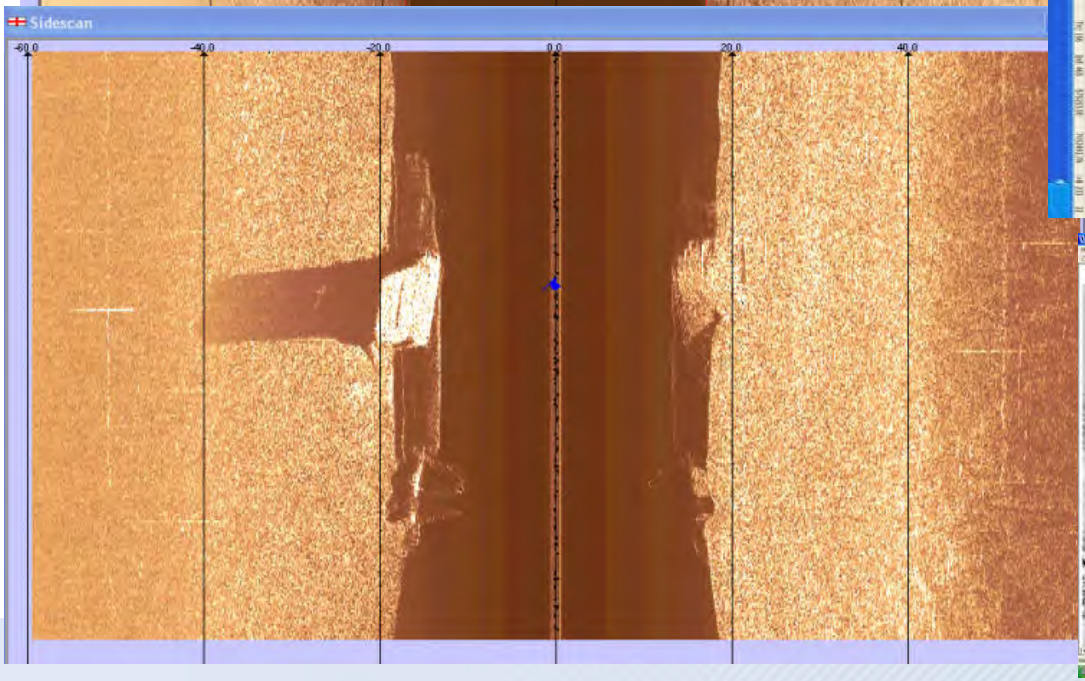

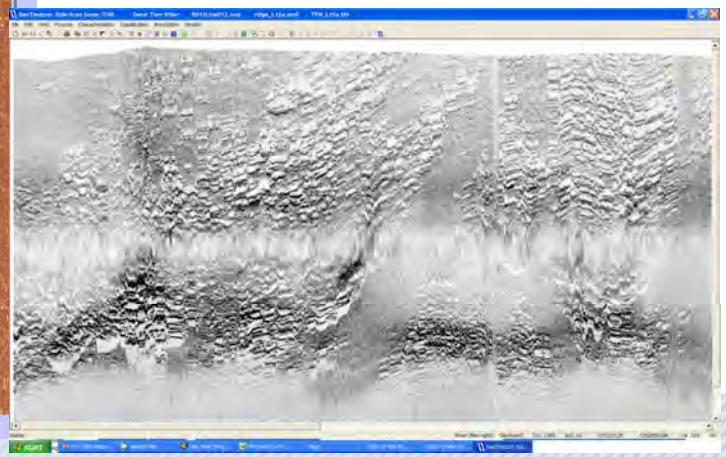

ROV Survey Data Bathymetry: Subsea ridge

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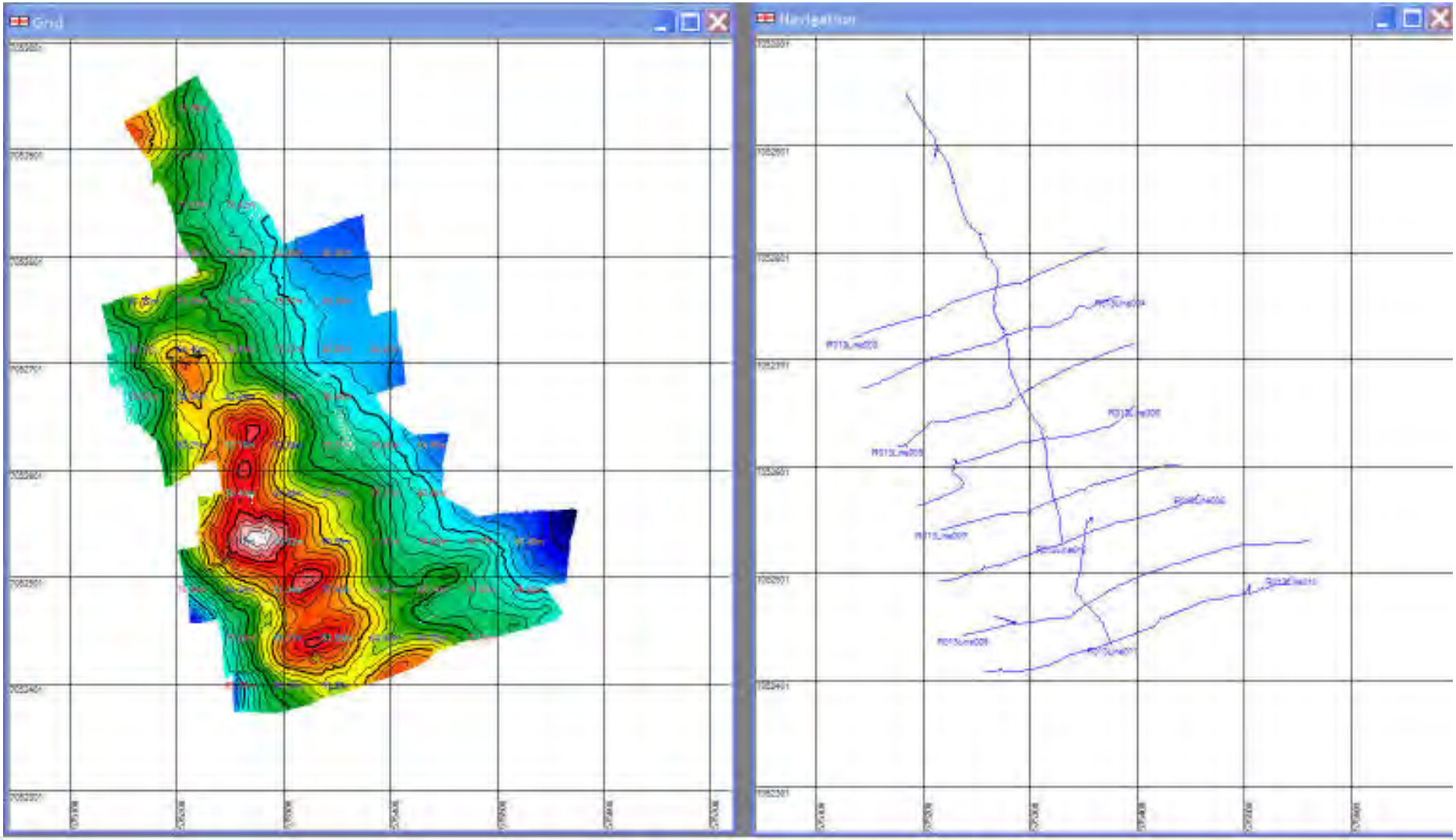

Sidescan and bathymetry for on-line object investigation

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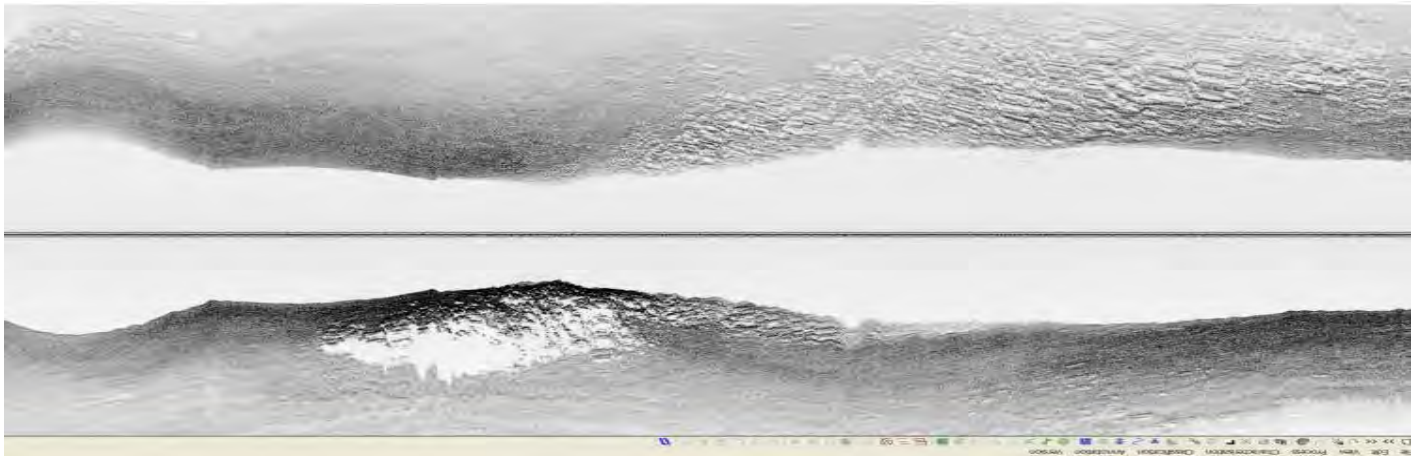

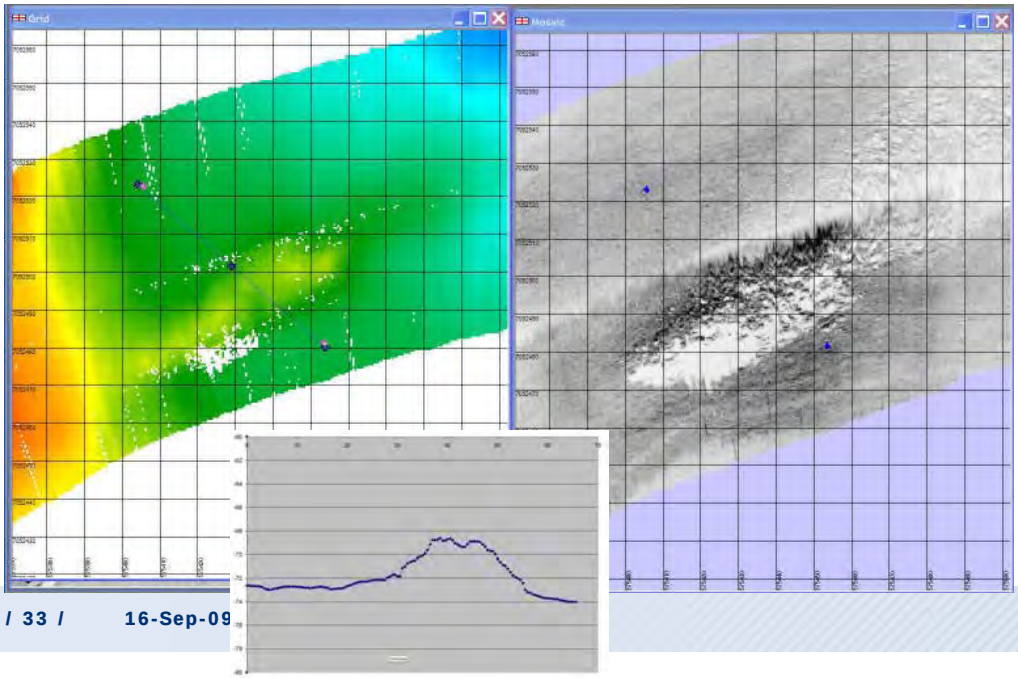

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GeoSwath Plus AUV

Technology

GeoSwath AUV

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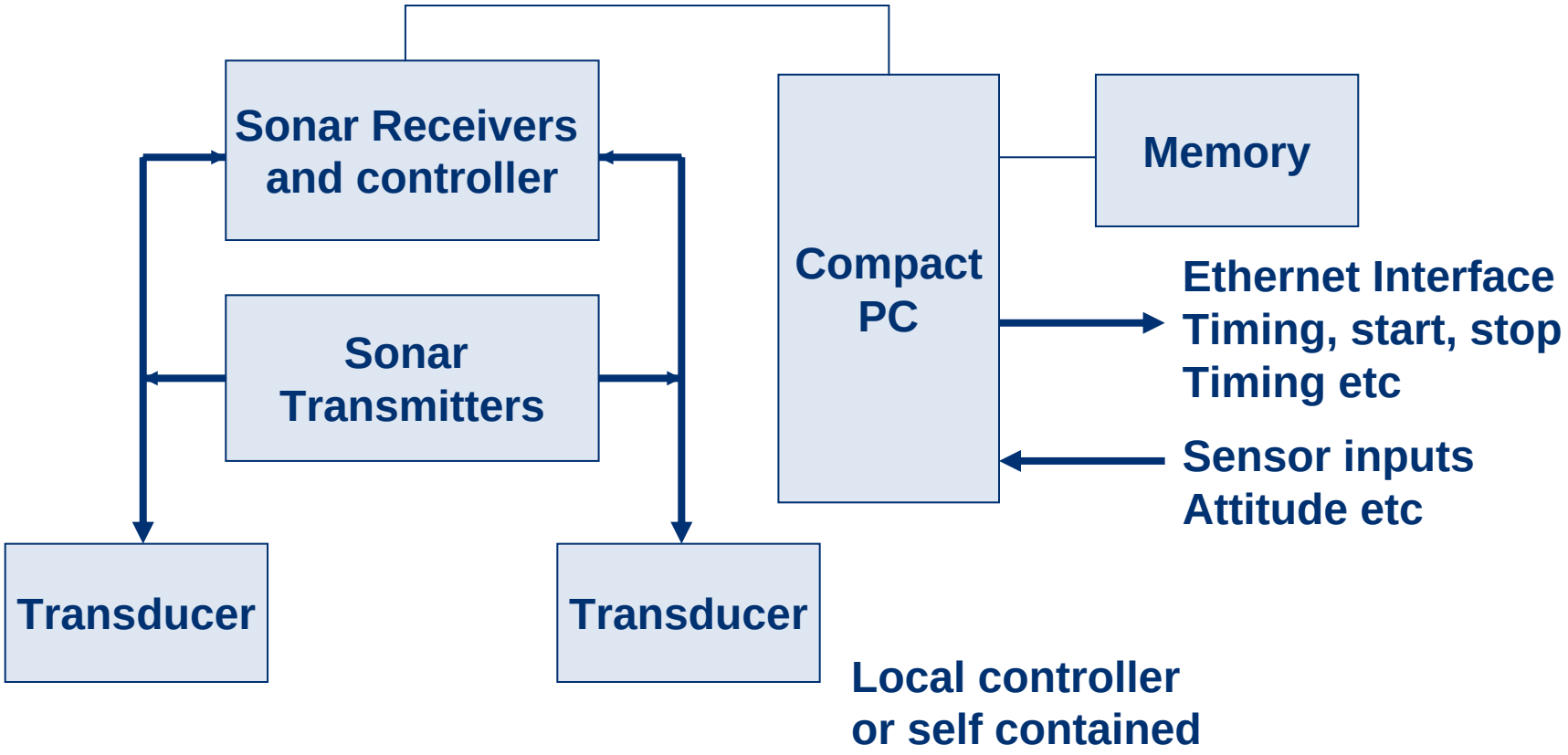
Generic AUV application using
Standard GeoSwath Electronics Modules



GeoSwath Plus AUV Communications

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- Standard Ethernet
- Controlled by pre-set parameters or by broadcast command messages on Ethernet from the AUV control system.
- During operation can provide QA/QC messages to the AUV control software, enabling monitoring of sonar operation.
- All sonar and available ancillary data is logged on hard disk and stored in GeoSwath raw data format (.rdf) files.
- can be powered down by network remote command allowing the tools kid to be turned off to conserve power during transit.

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GeoSwath Plus on the Gavia AUV

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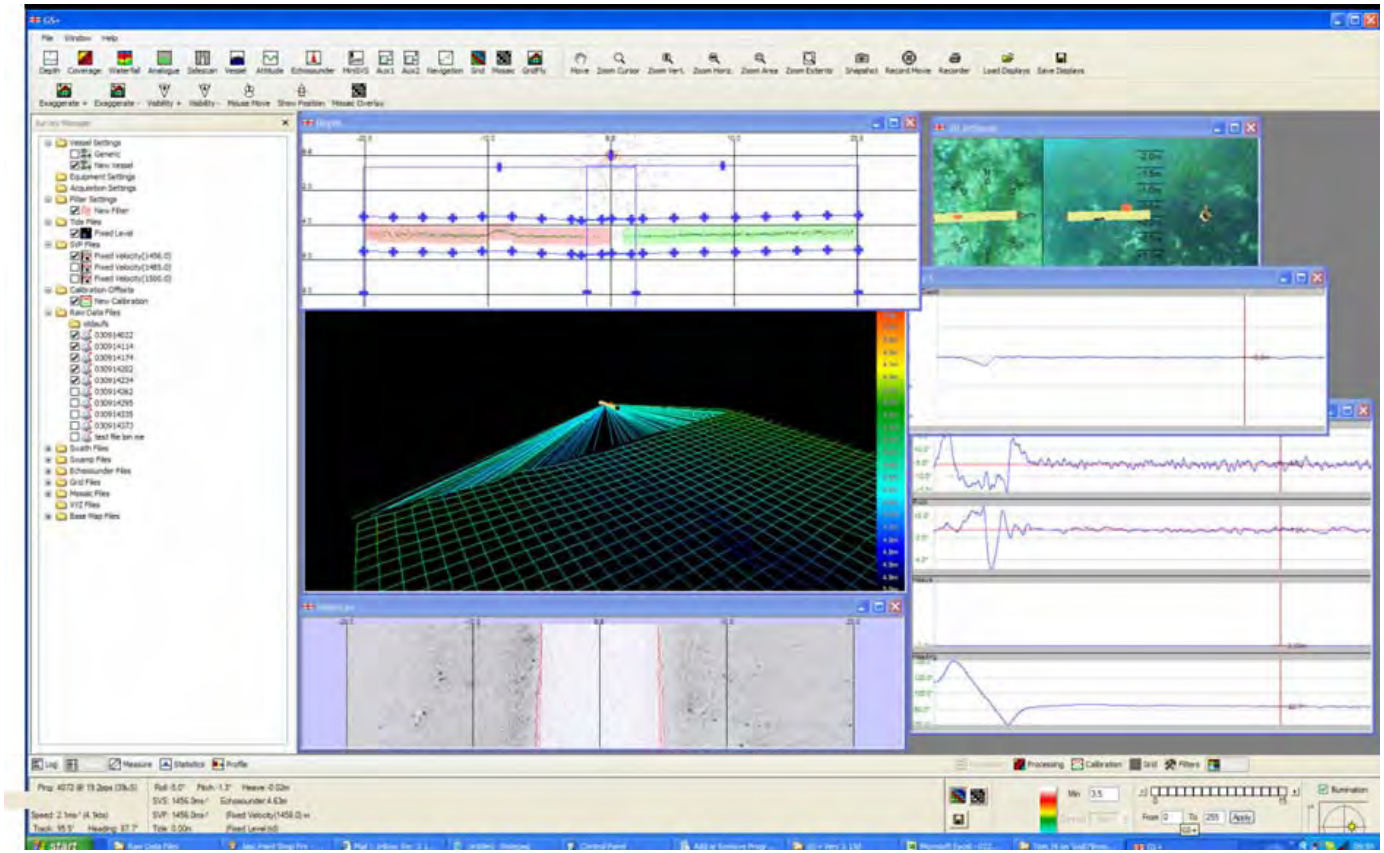
GeoSwath Plus AUV

data examples

GeoSwath Plus on Gavia AUV Iceland



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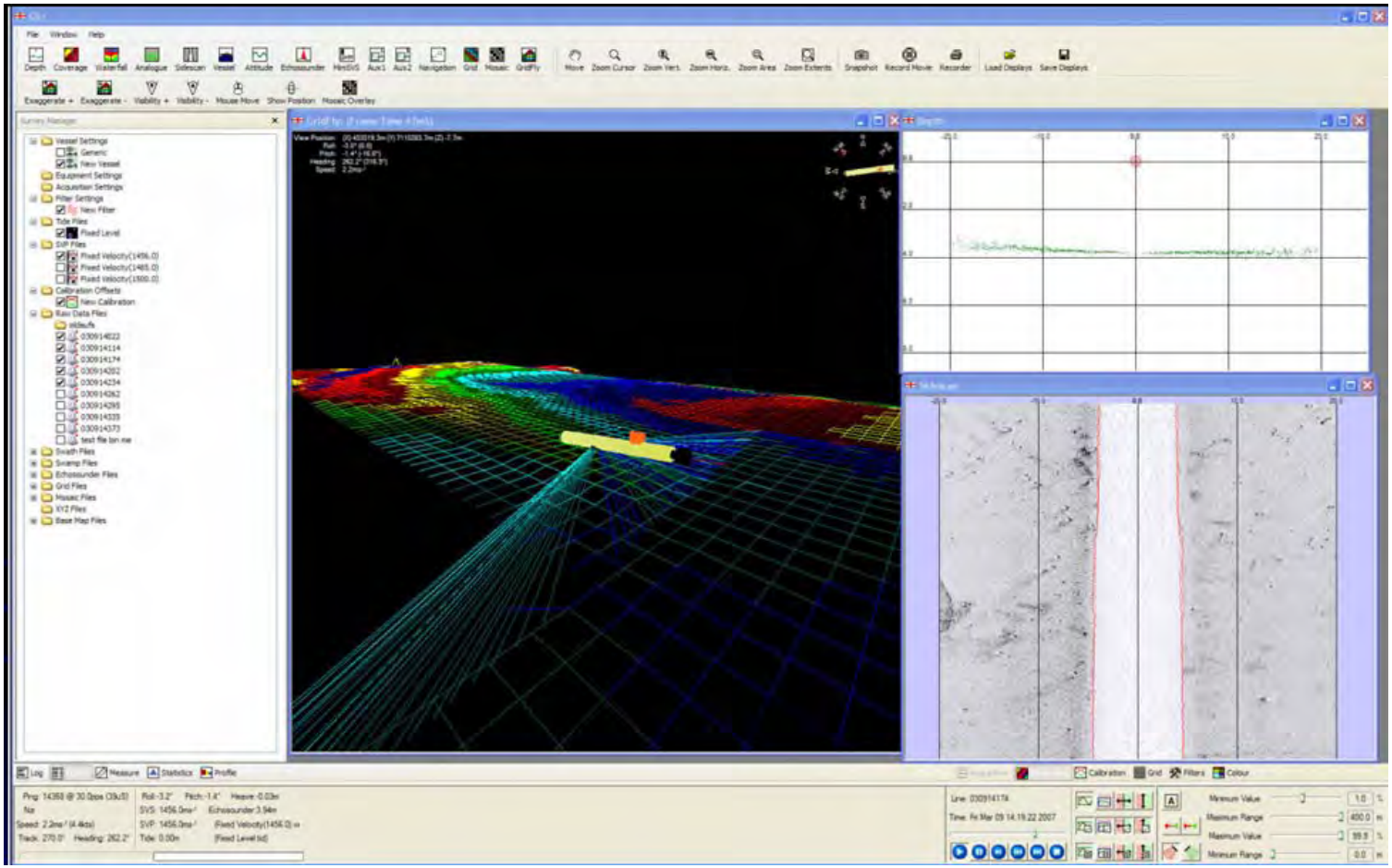
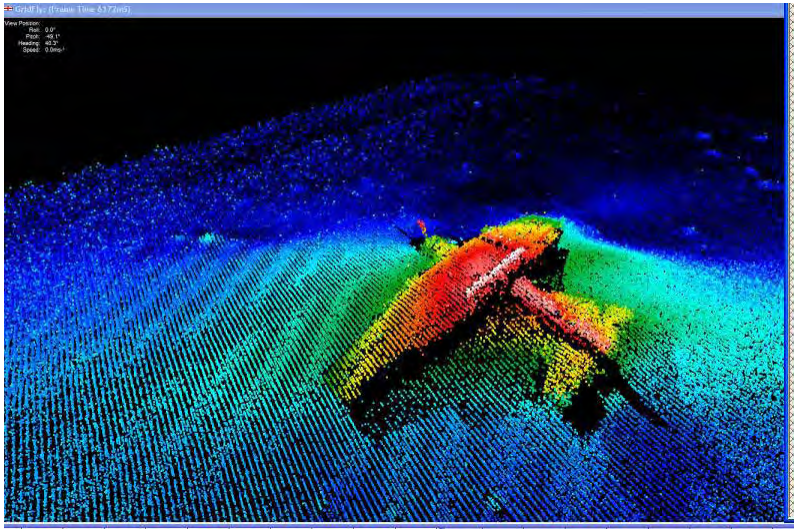
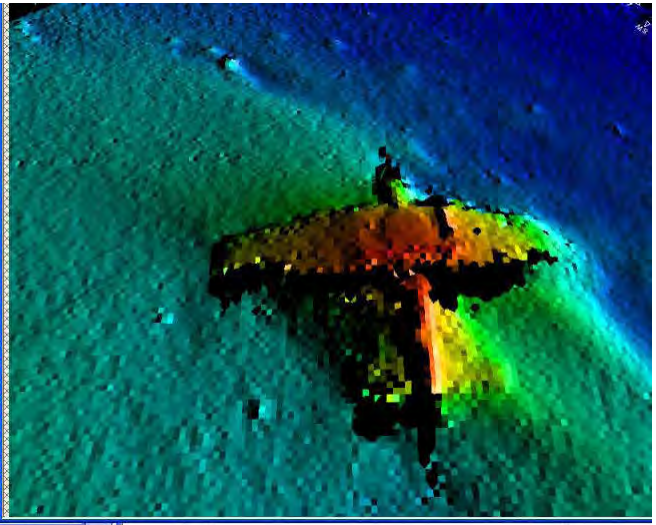
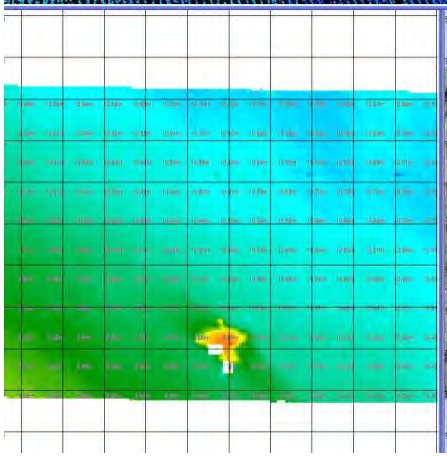
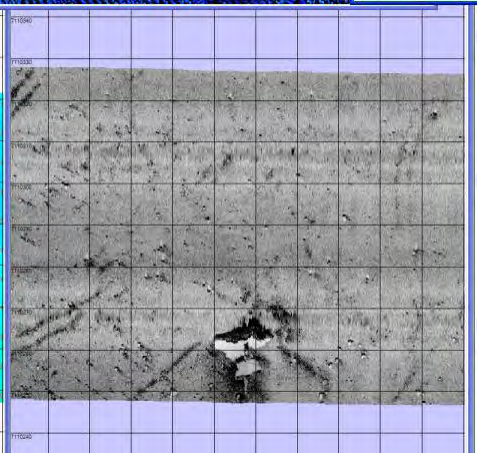




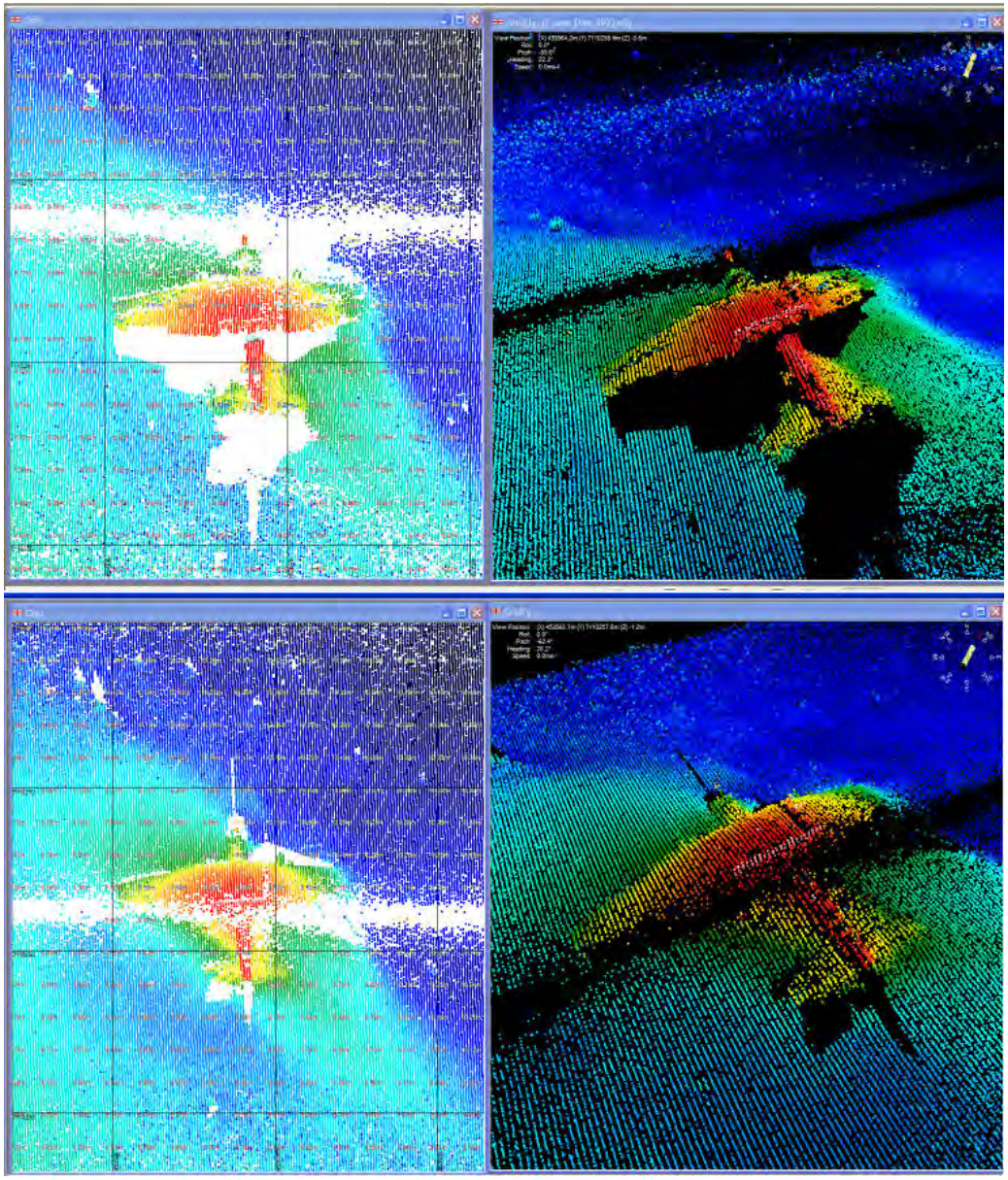






Northrop N-3PB
In flight over Lake Elsinore, CA during flight test program
(WMoF Archive / Northrop Photo)

Northrop N-3PB Specifications	
Manufacturer	Northrop Aircraft, Inc., Hawthorne, California
Number Built	24
Wing Span	48 feet, 11 inches
Overall Length	38 feet
Overall Height	12 feet



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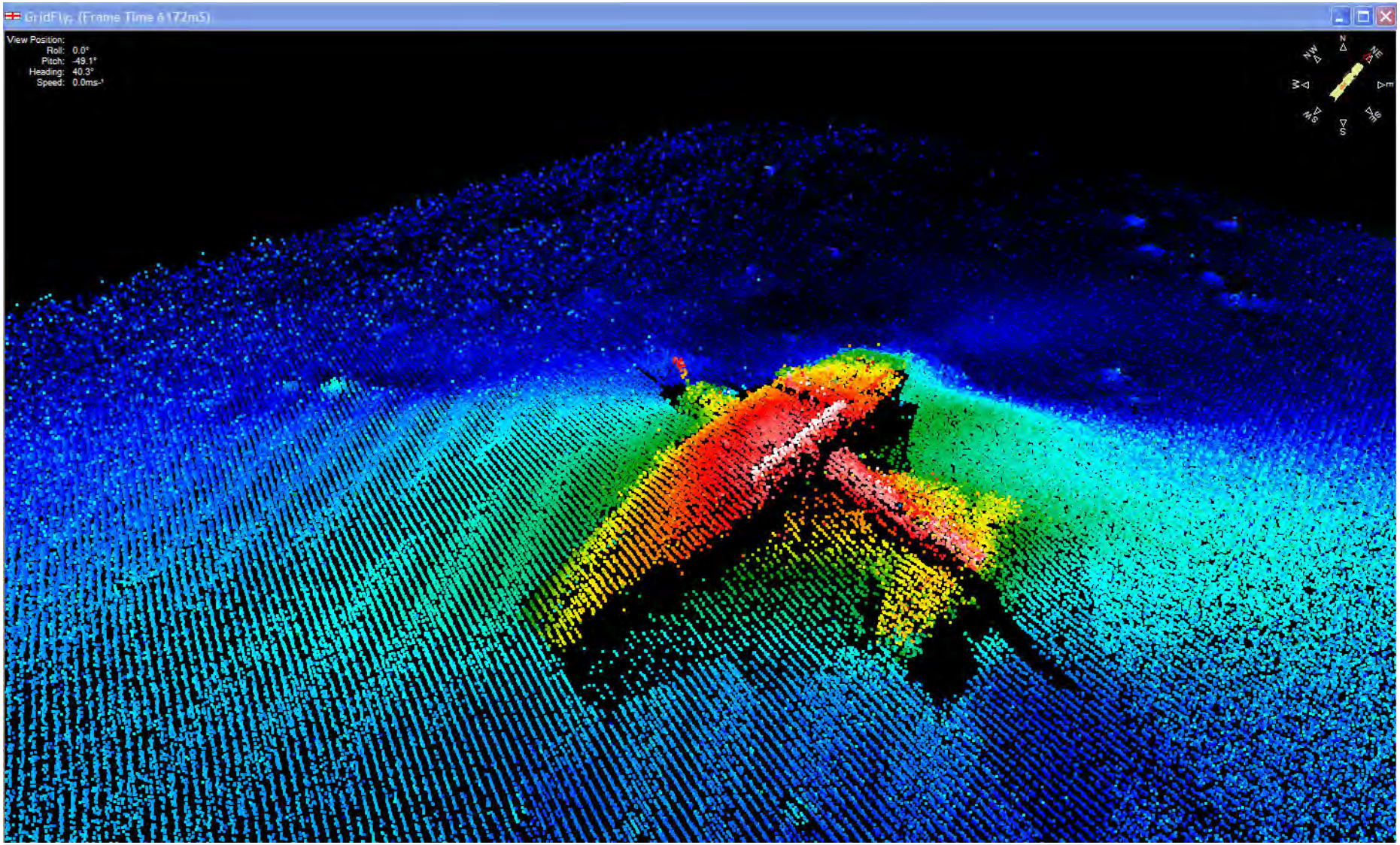
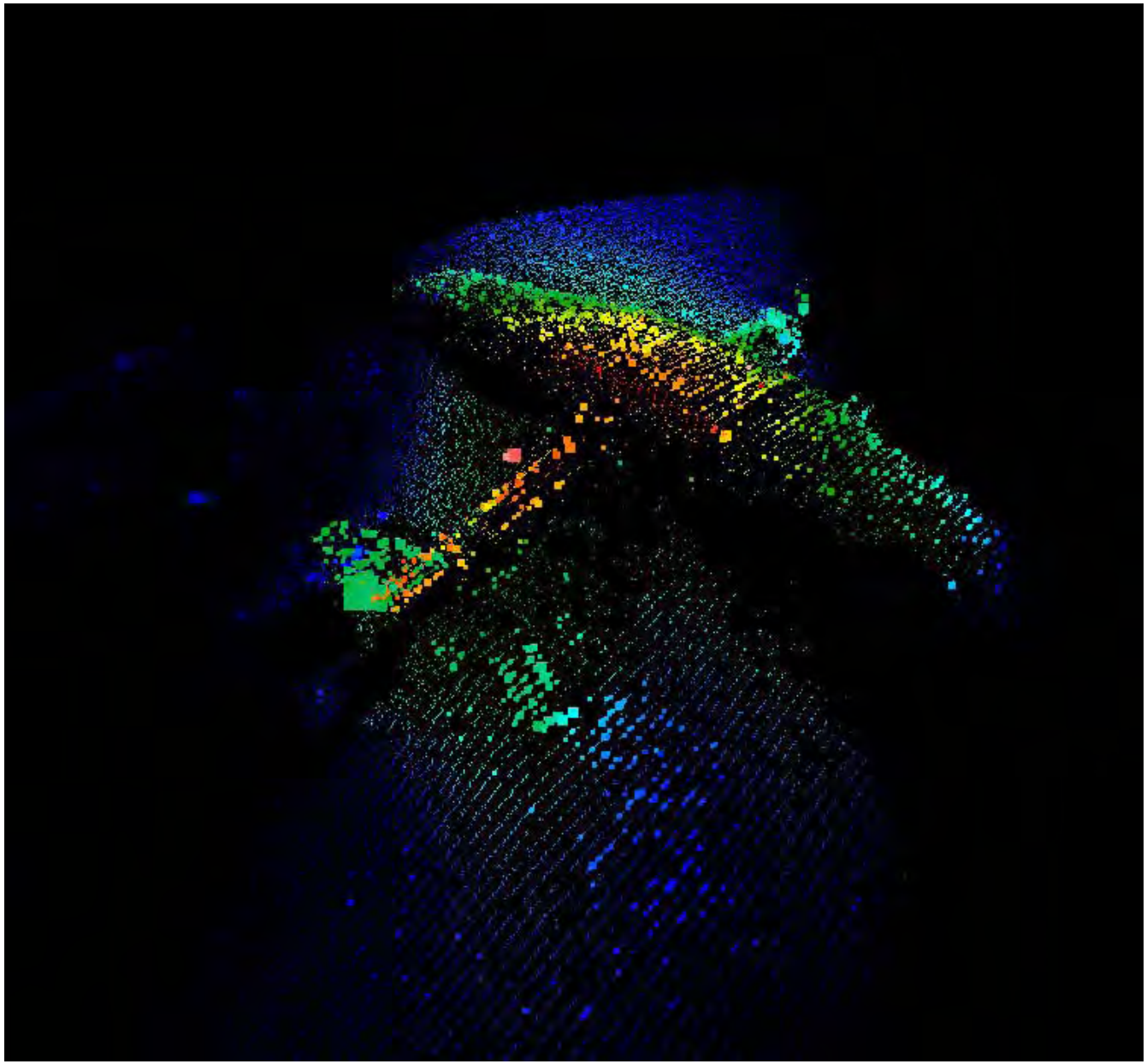

GridFly. (Frame Time 0.172mS)
View Position:
Roll: 0.0°
Pitch: -49.1°
Heading: 40.3°
Speed: 0.0ms-1



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GeoSwath Plus on Gavia AUV
A commercial deployment in the Caspian Sea

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Pre-lay pipe trench survey using AUV mounted GeoSwath

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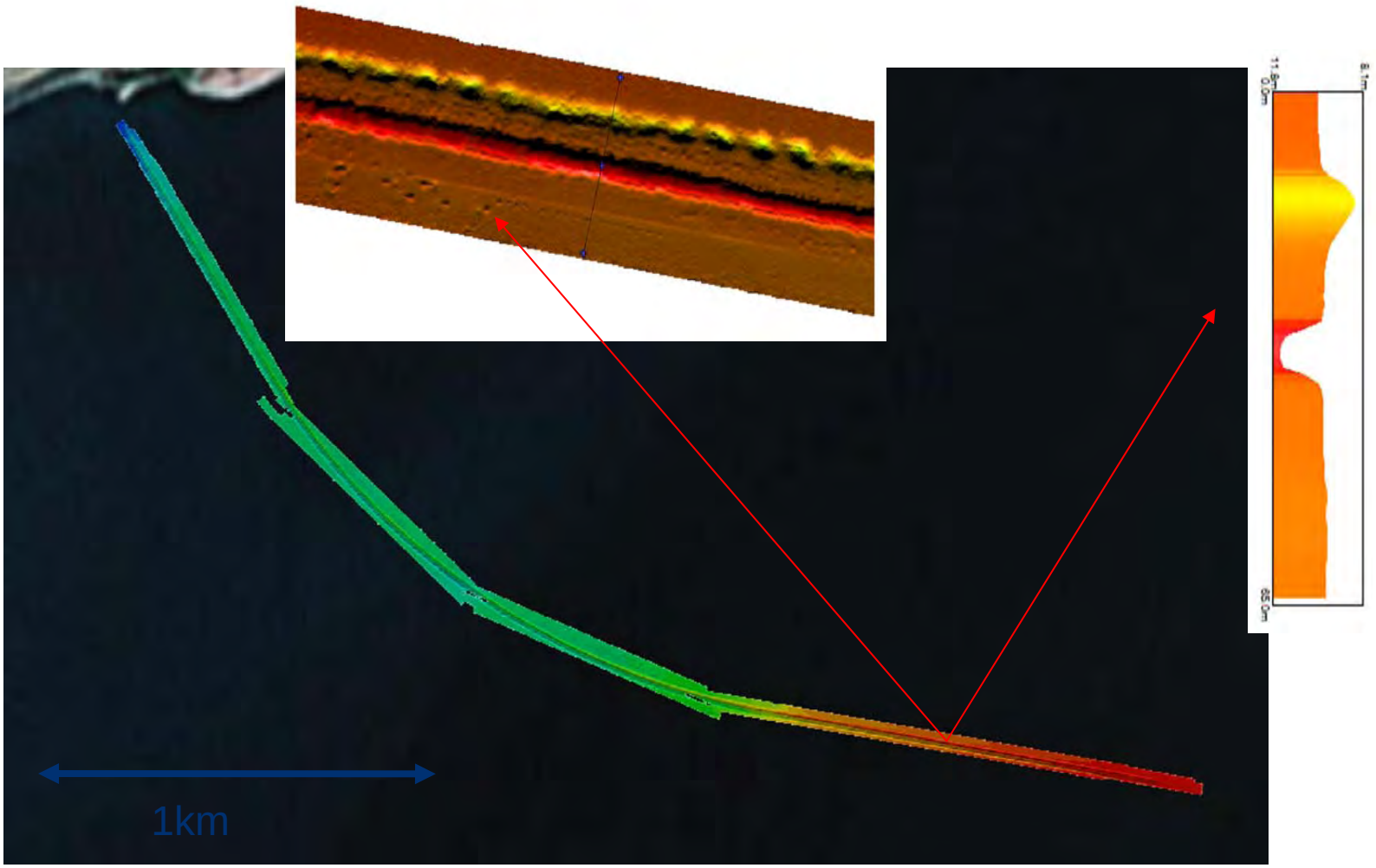

Harbour post-dredge survey

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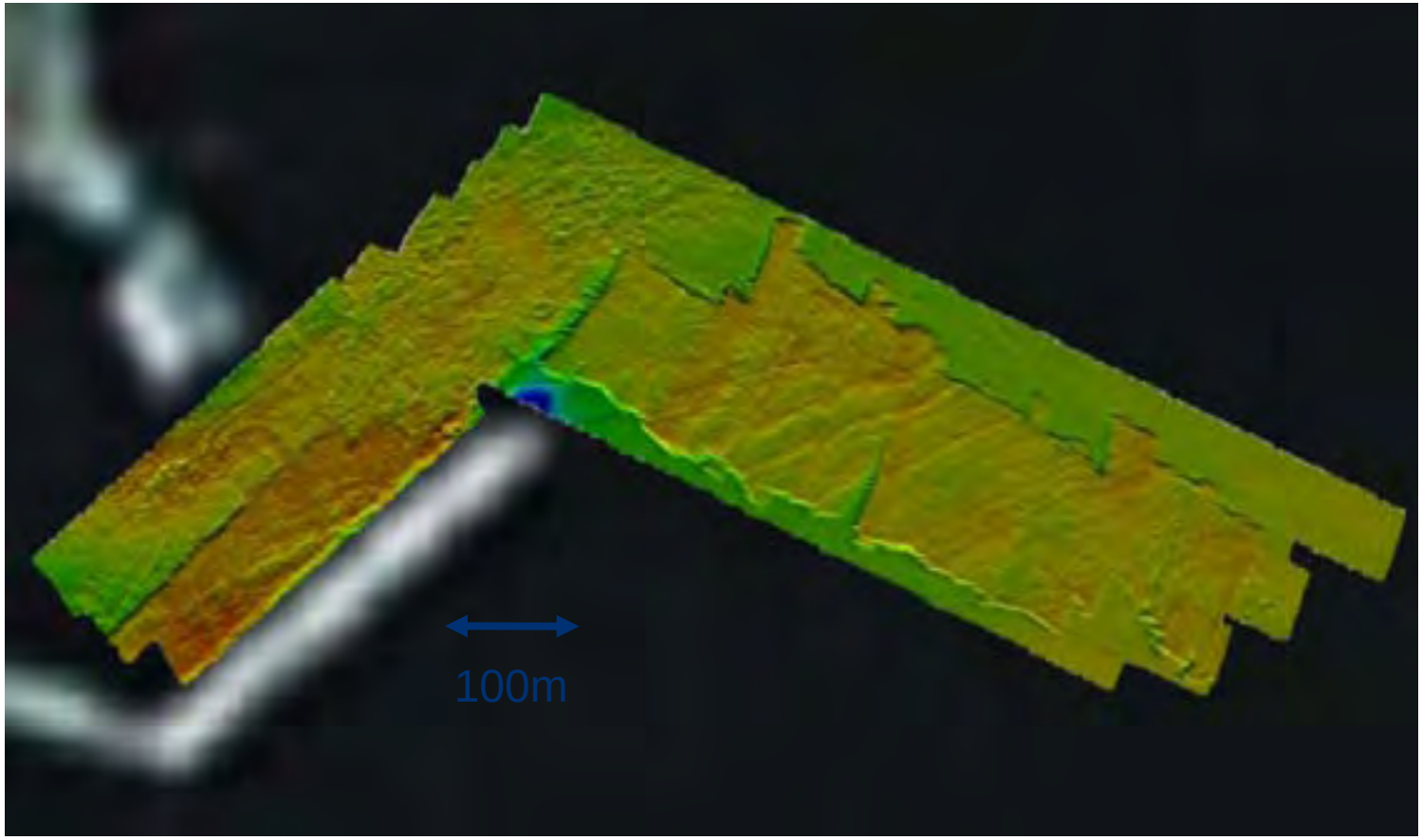

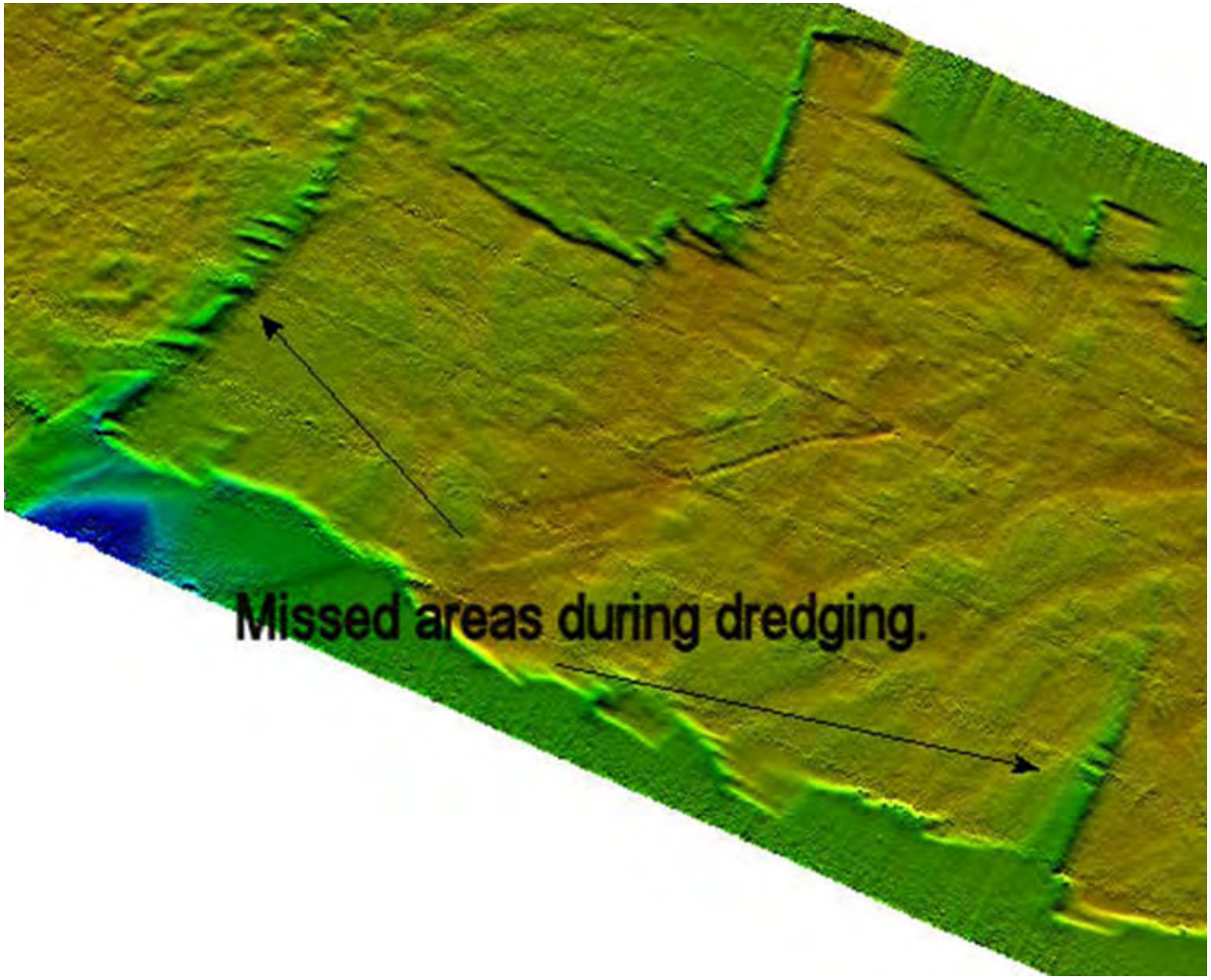
Missed areas during dredging.

GeoSwath Plus on Gavia AUV
Under the Artic Ice

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Location of Aplis ice camp: 73° N, 146° W

The Survey Area

The Environmental Protection Officer

Launch Hole

Views from the AUV: Mission Start

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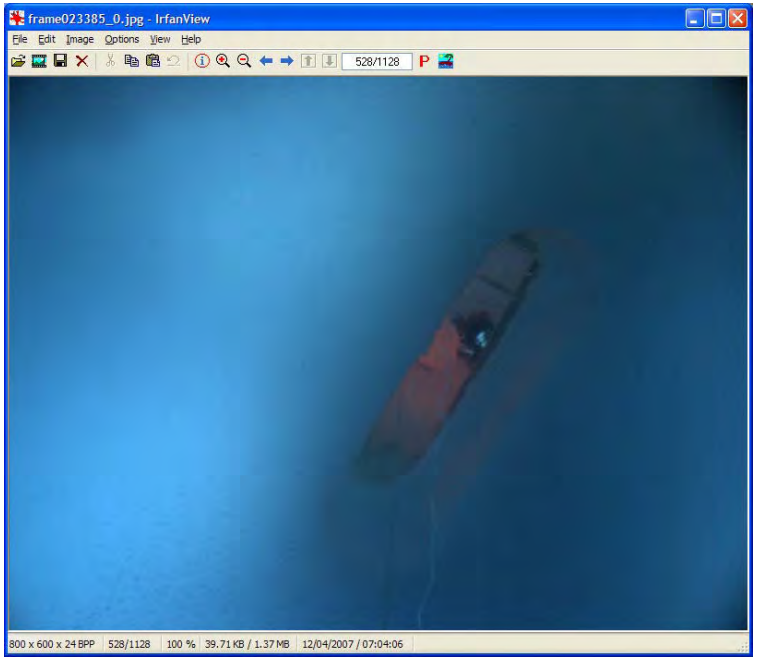

Views from the AUV: Under the Ice

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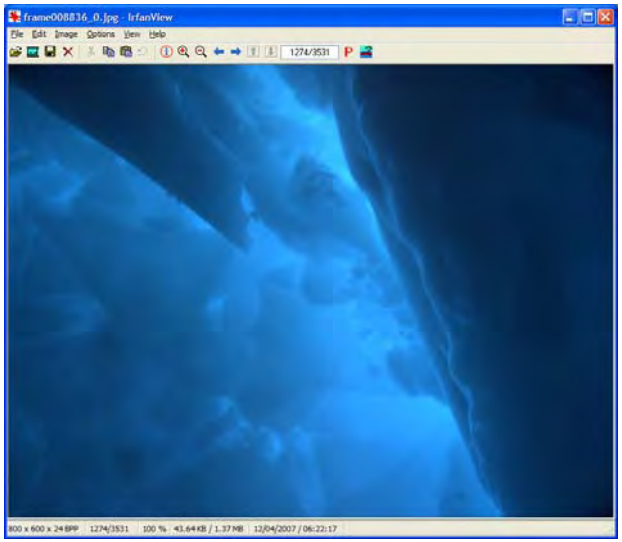
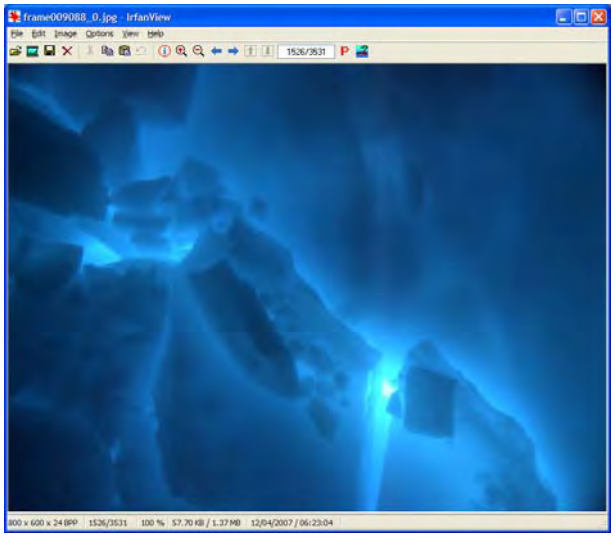
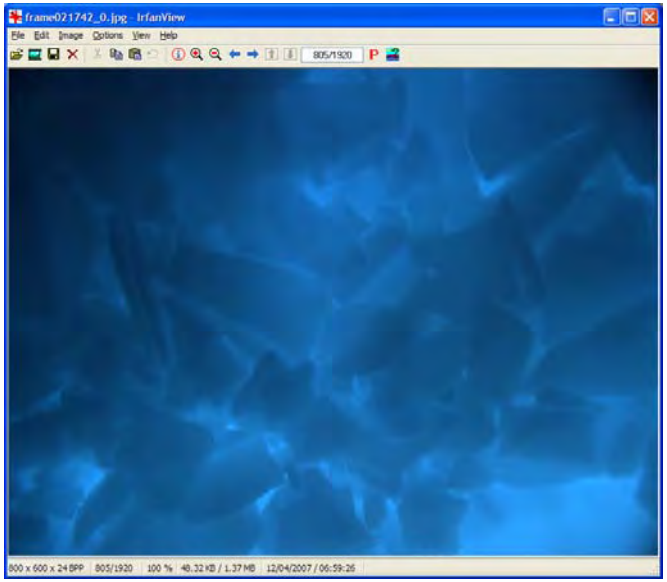
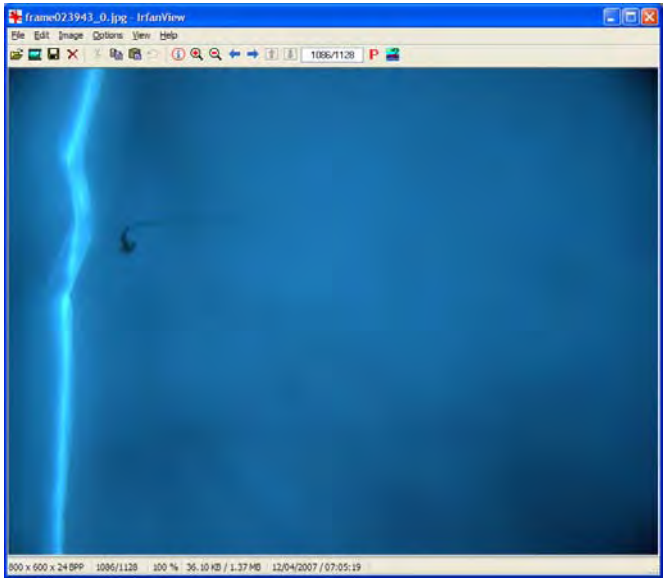
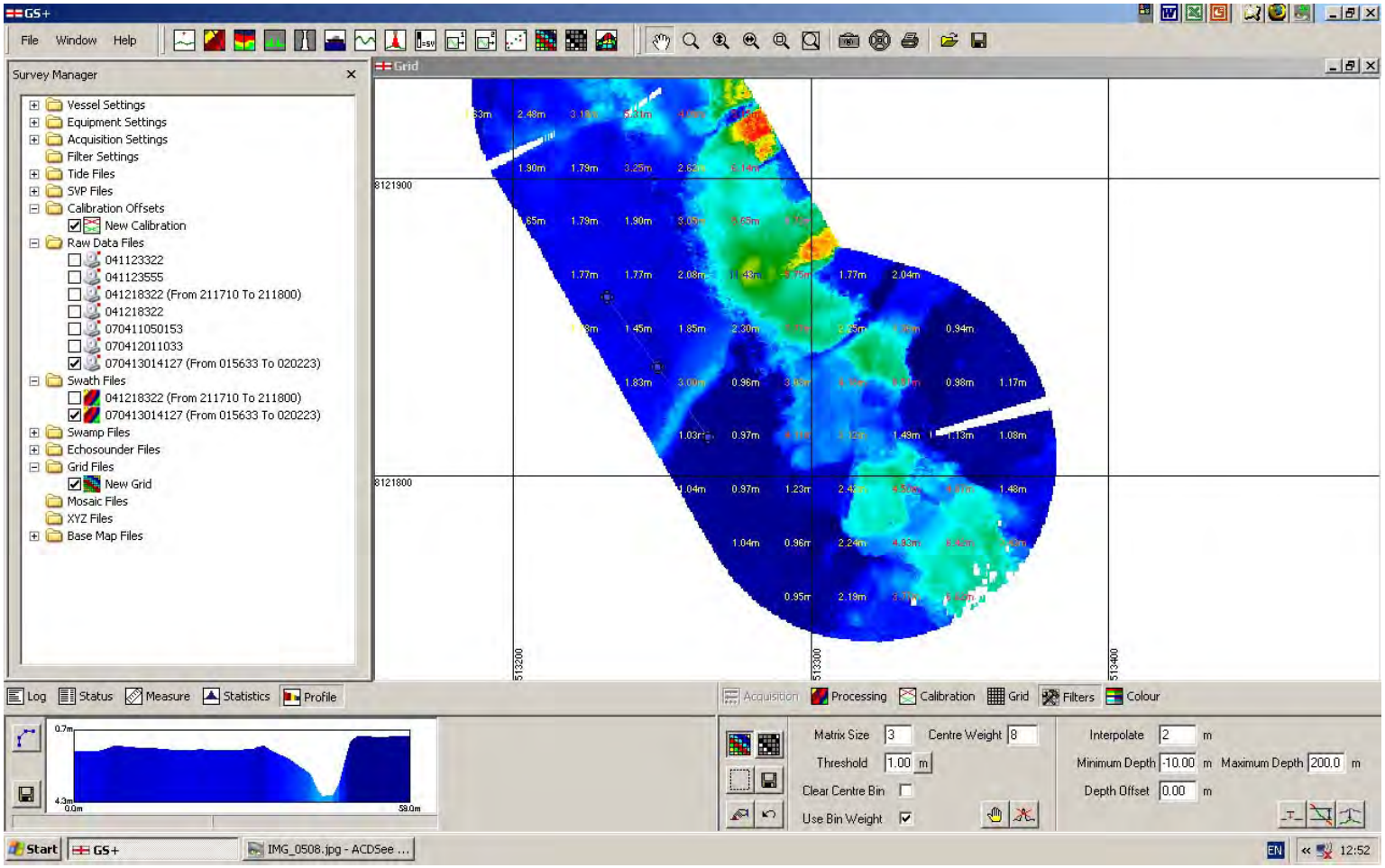








Mission data



Maps of the underside of the Arctic ice
(from M. Doble and P. Wadhams, University of Cambridge, UK)

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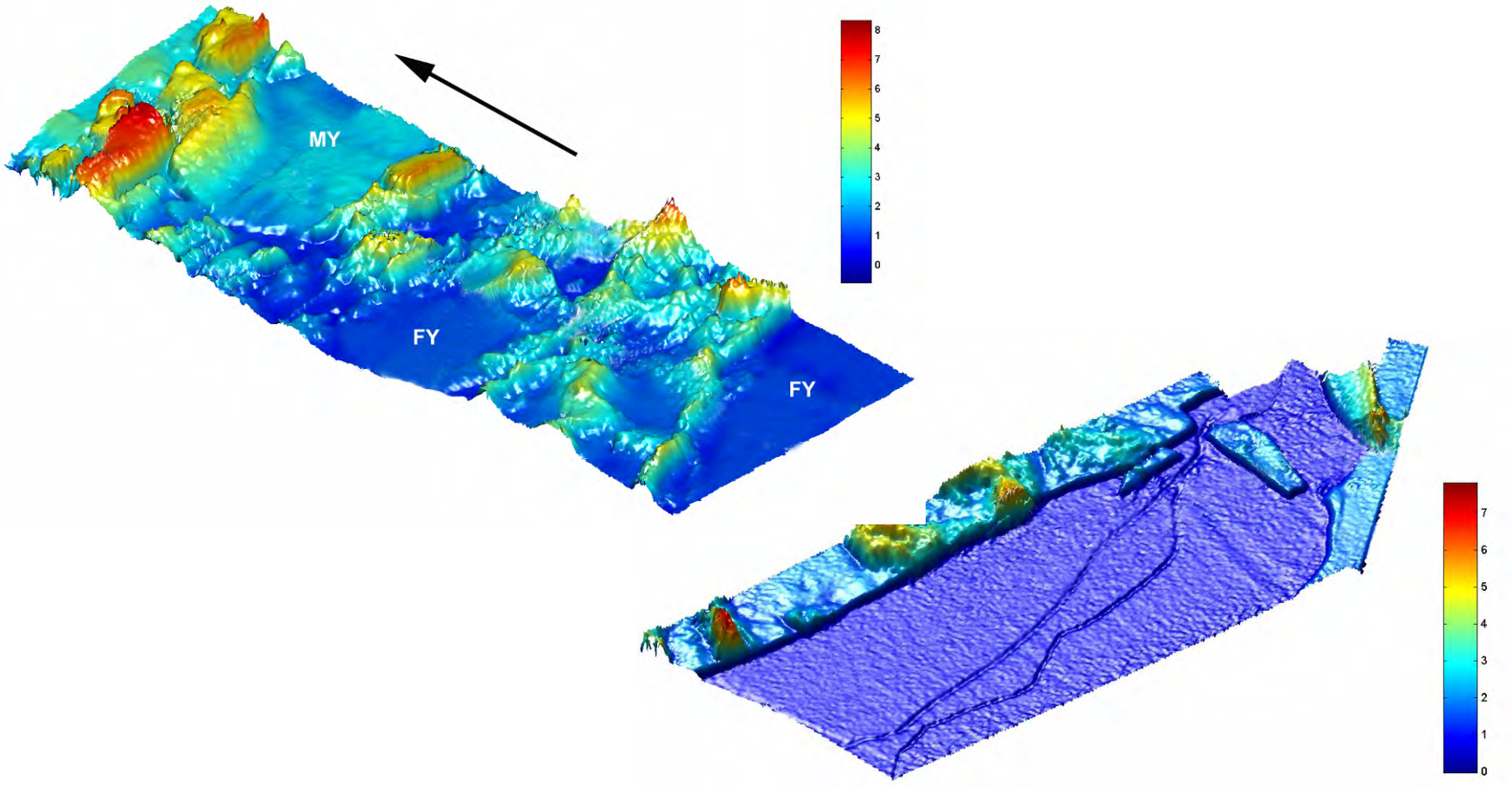

- Doble M. J. and Wadhams P. "First Through- Ice Use Of A Small Auv For Mapping The Arctic Sea Ice Underside." GeoPhysics Research Letters (in press)
- Doble M. J and Wadhams P. "Digital terrain mapping of the underside of sea ice from a small AUV" Journal of Atmospheric and Oceanic Technology (submitted)

GeoSwath Plus on Gavia France Oct07

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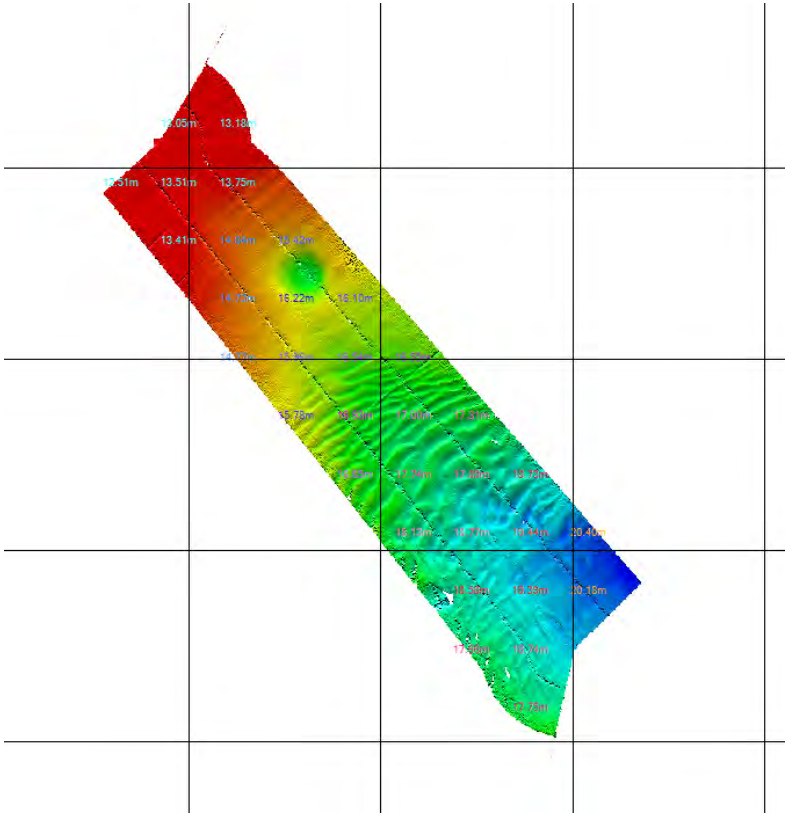

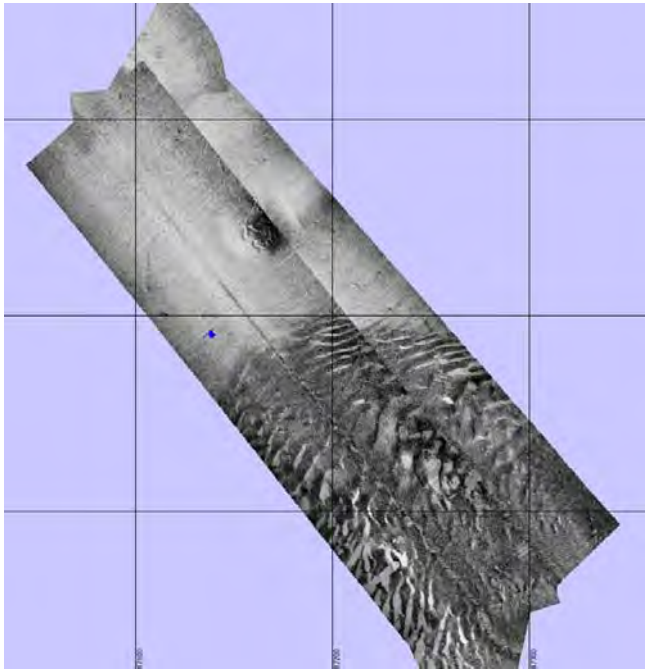

GeoSwath Plus on Gavia AUV
Pipeline Iceland Nov07

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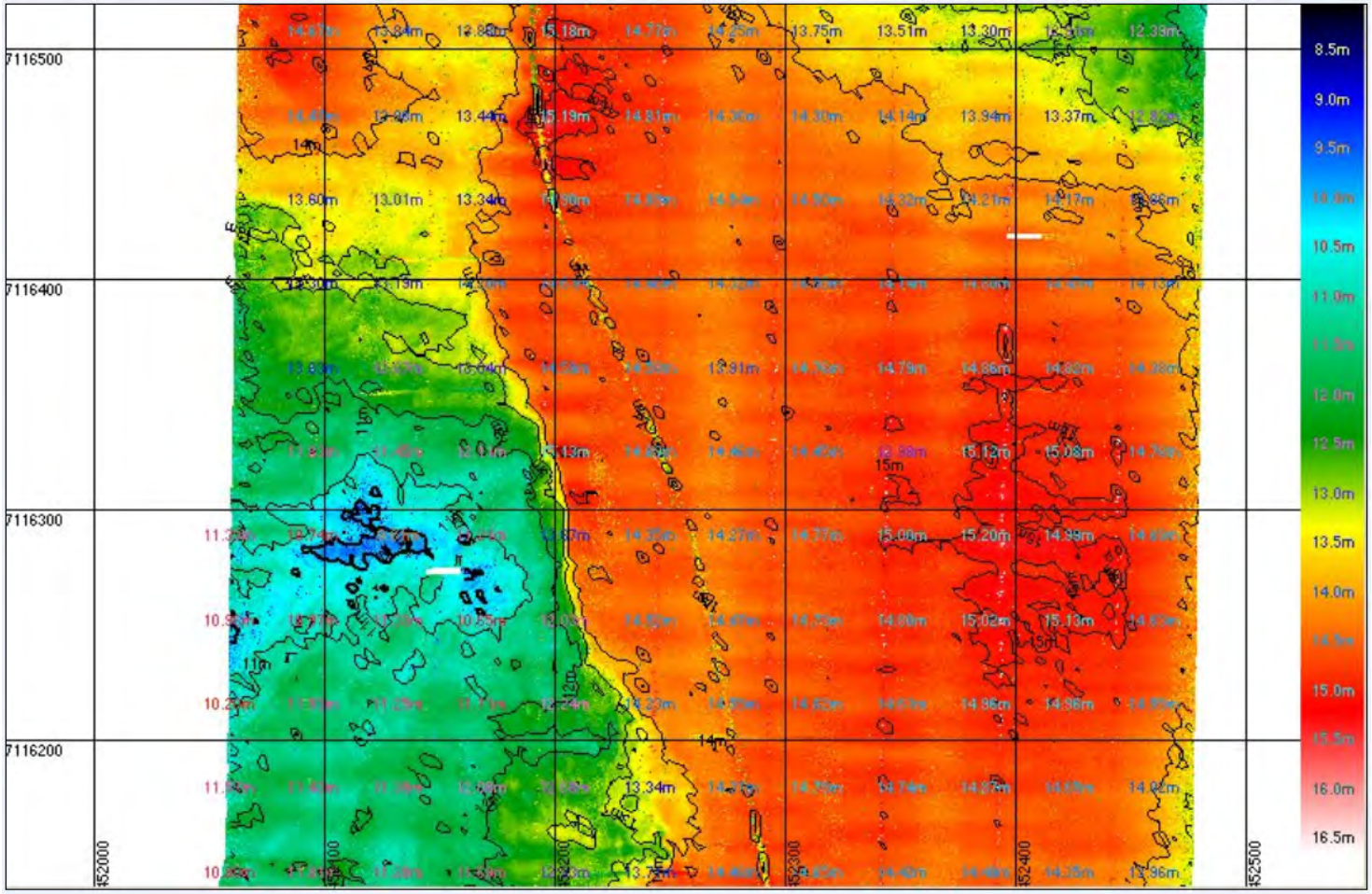

GeoSwath Plus on Gavia
Bonaire 2008

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GeoSwath Plus on Gavia Bonaire 2008

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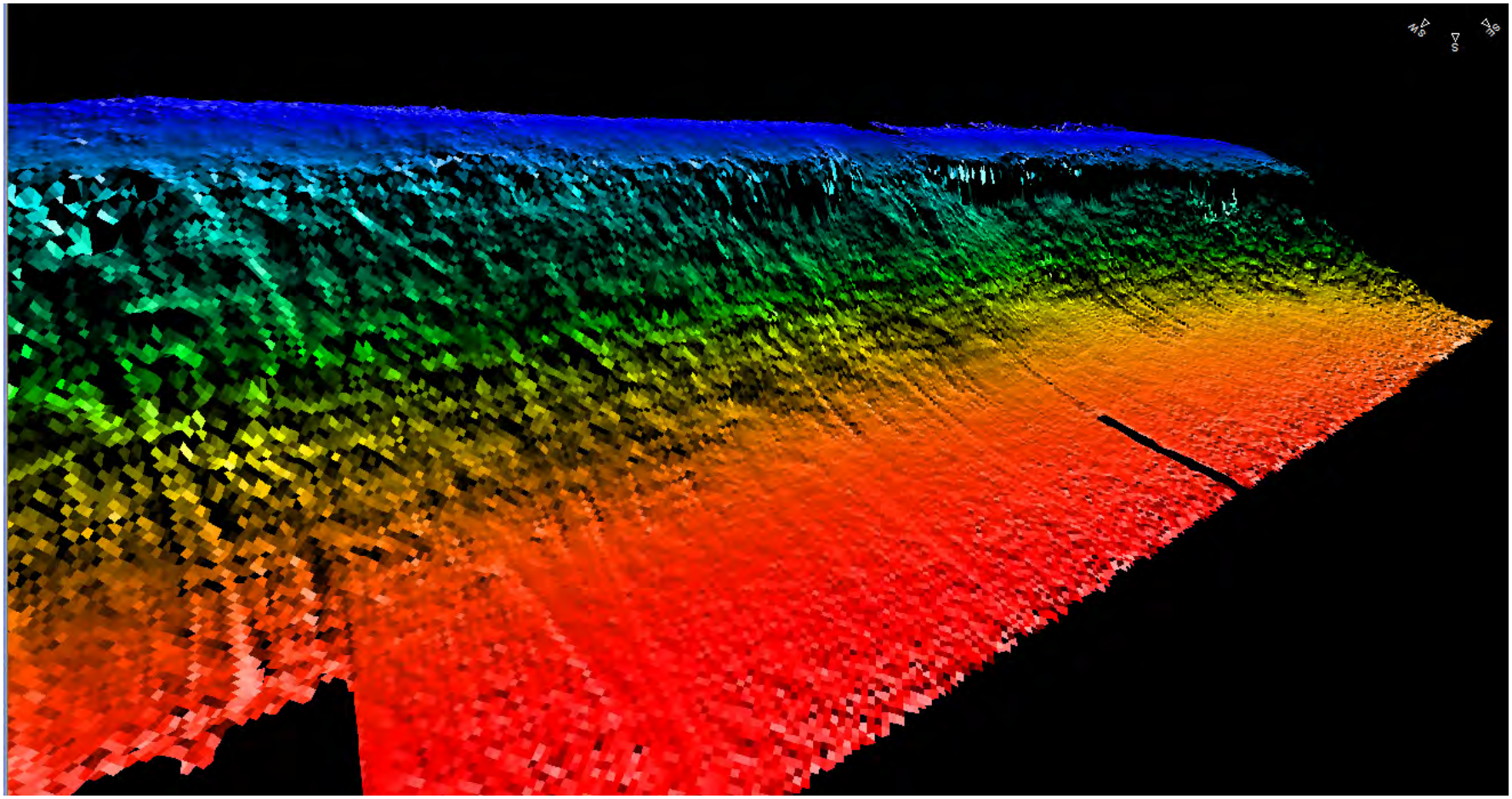

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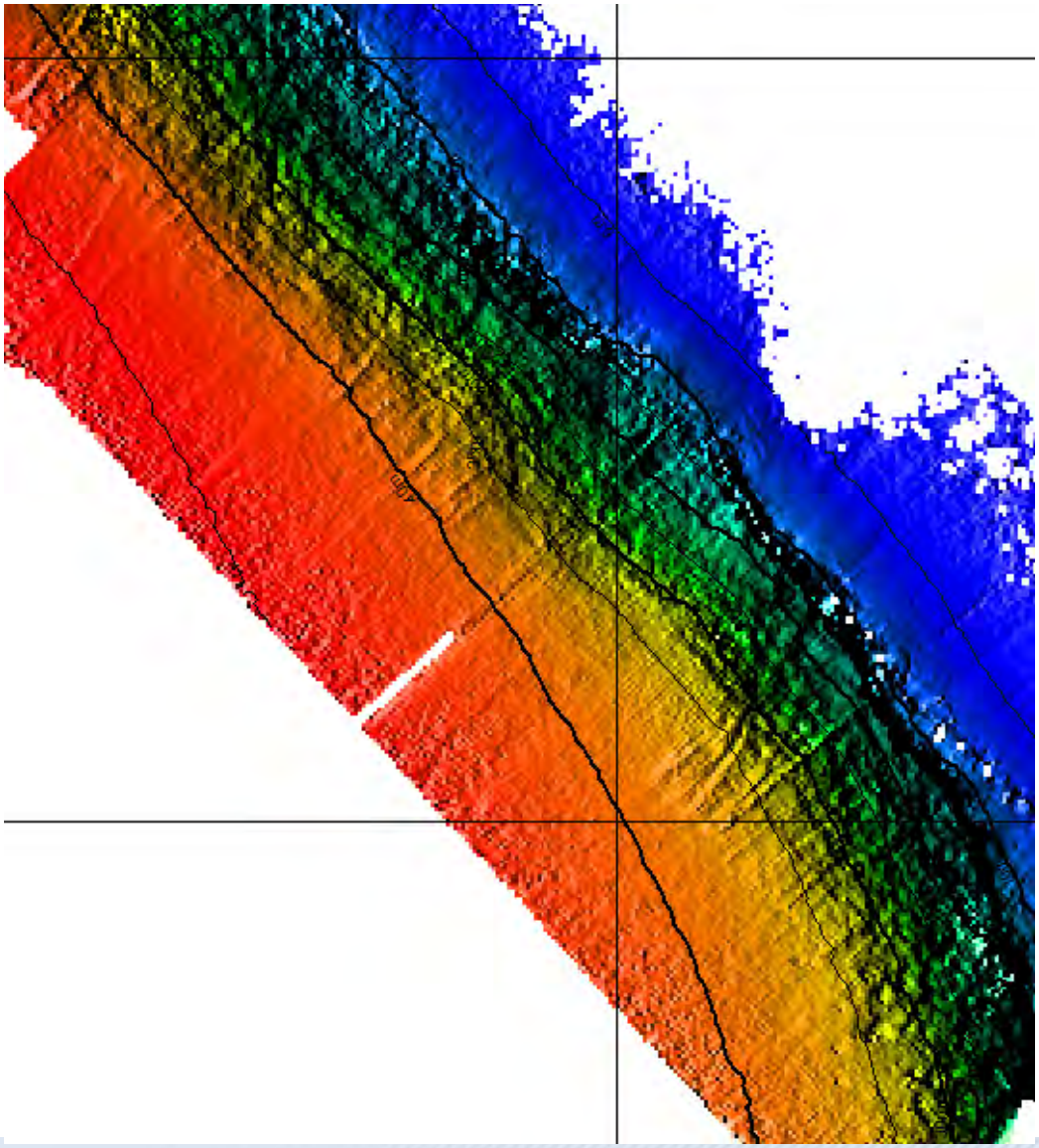

Bonaire 2008

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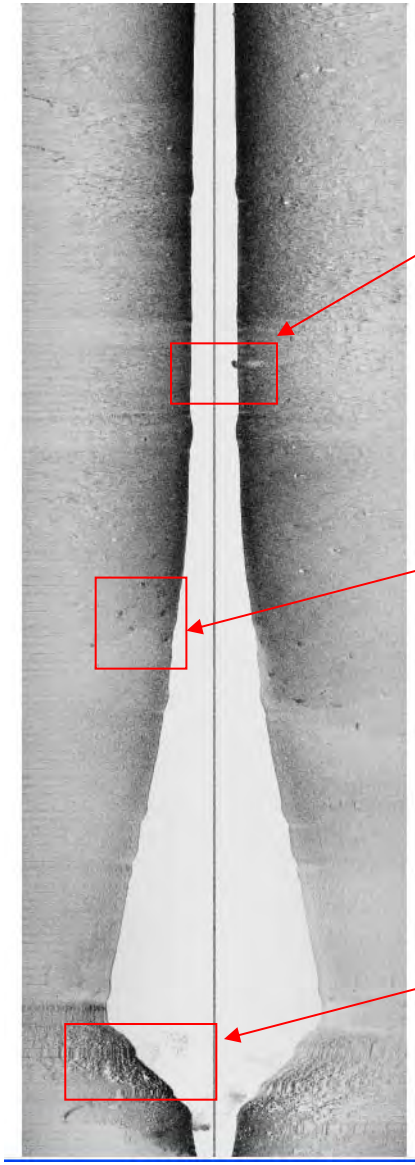

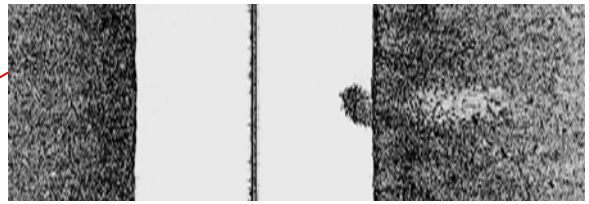

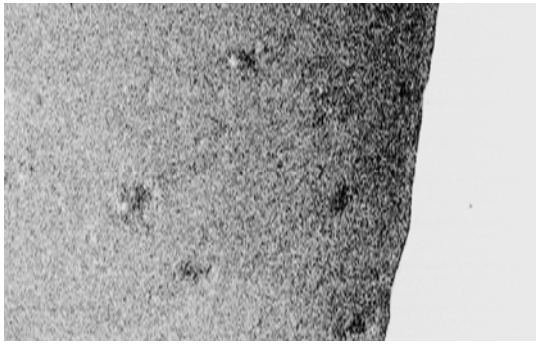

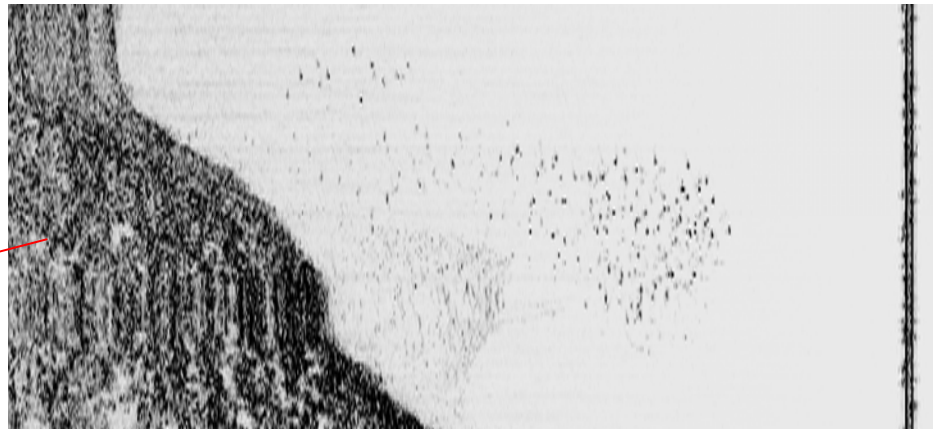

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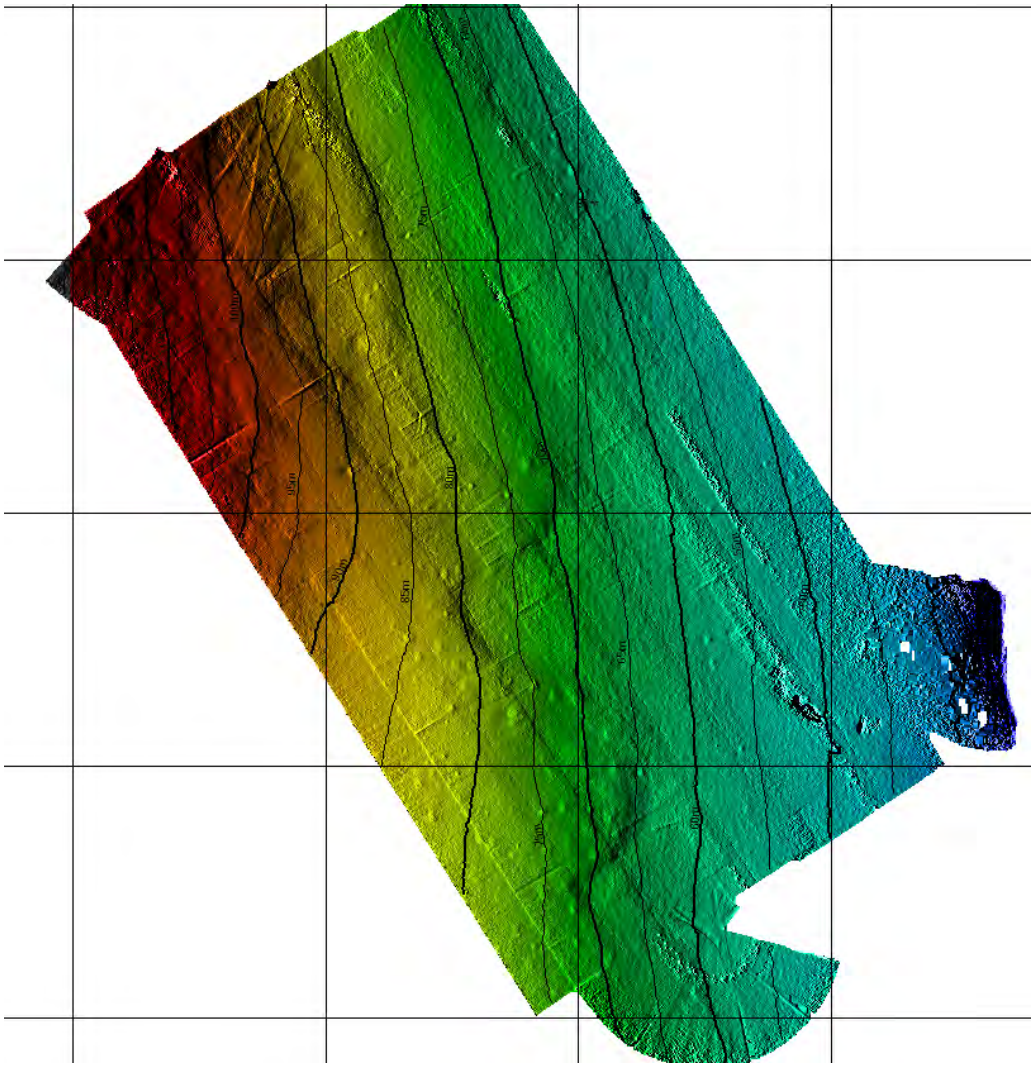

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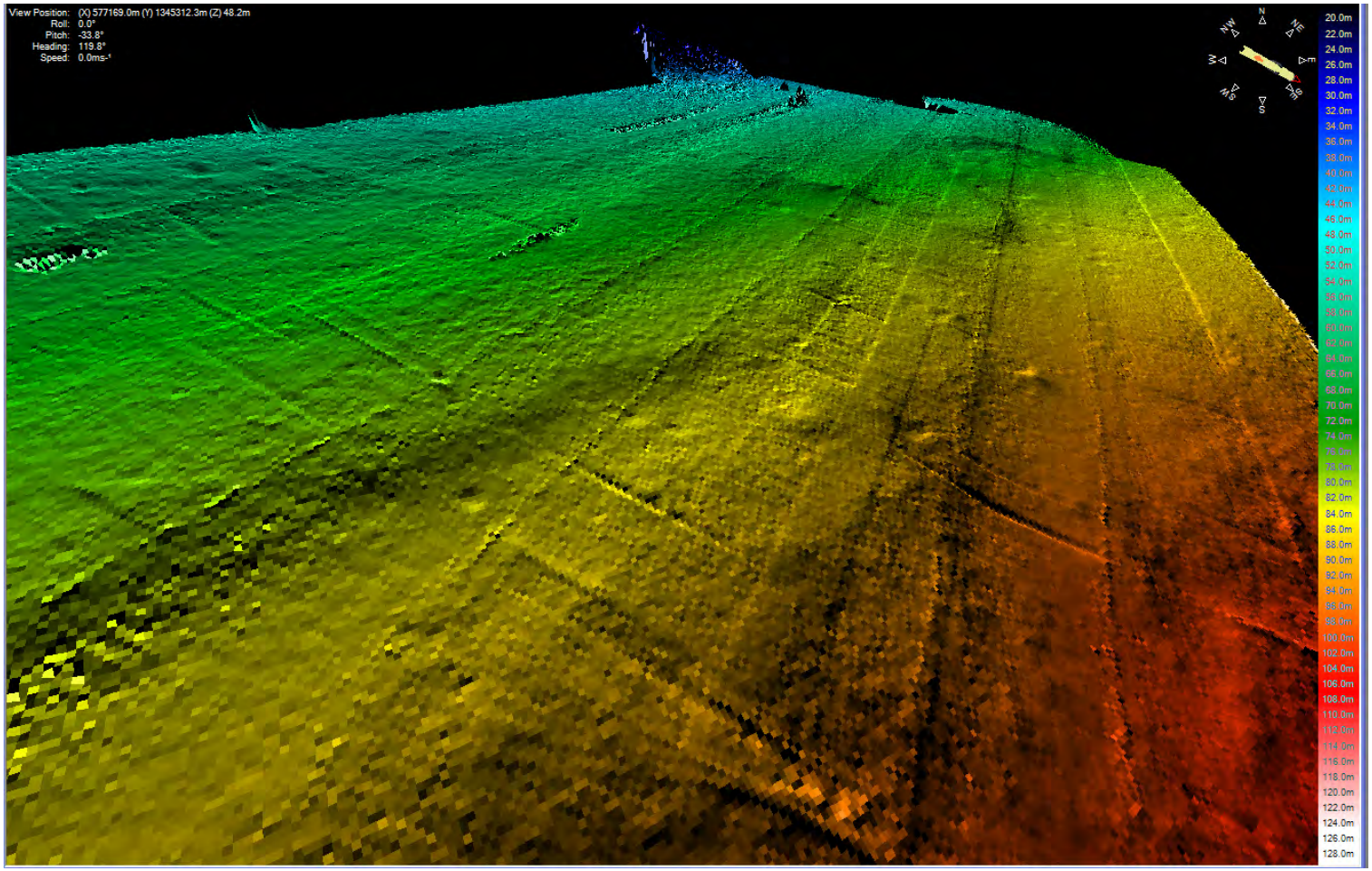

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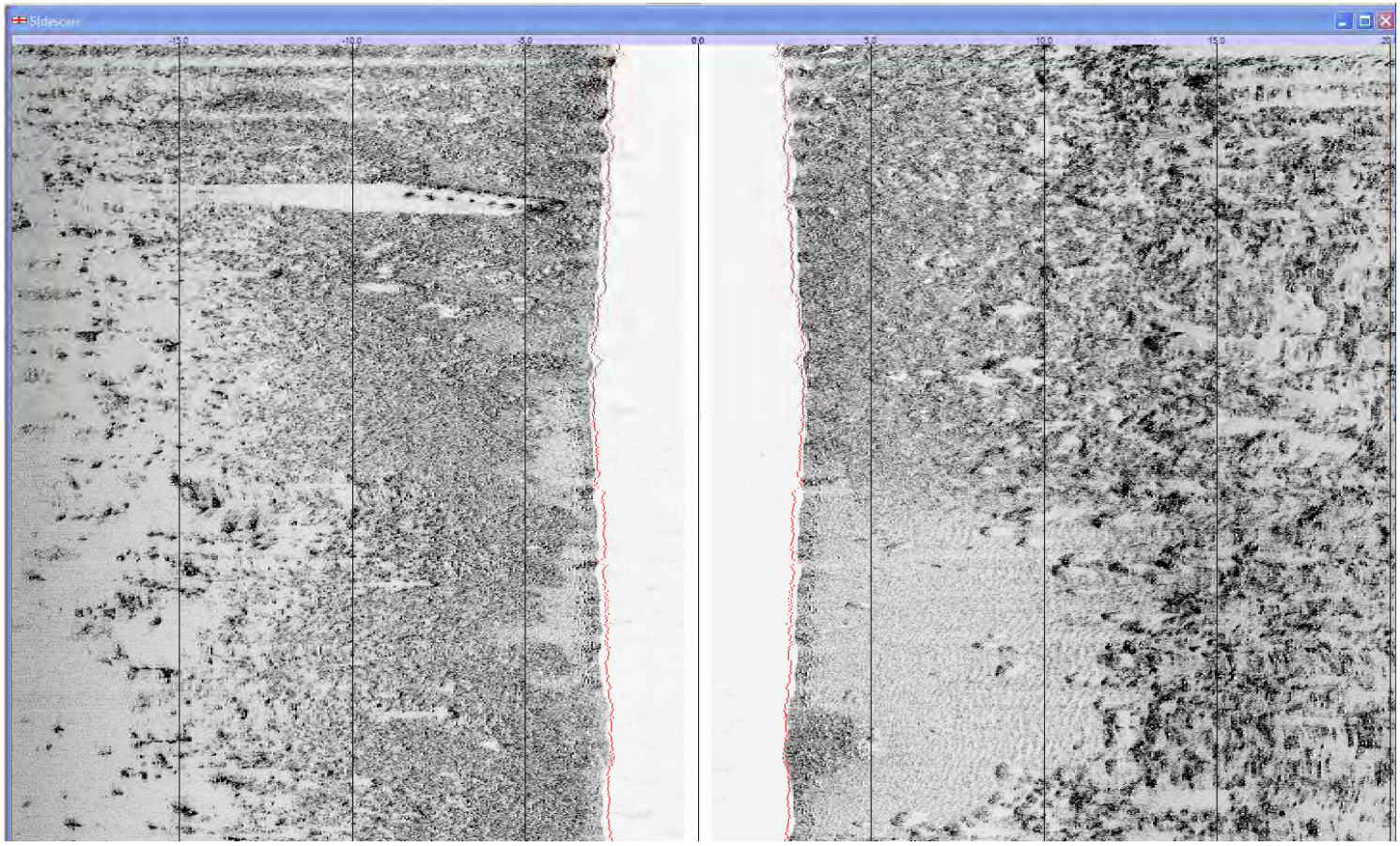

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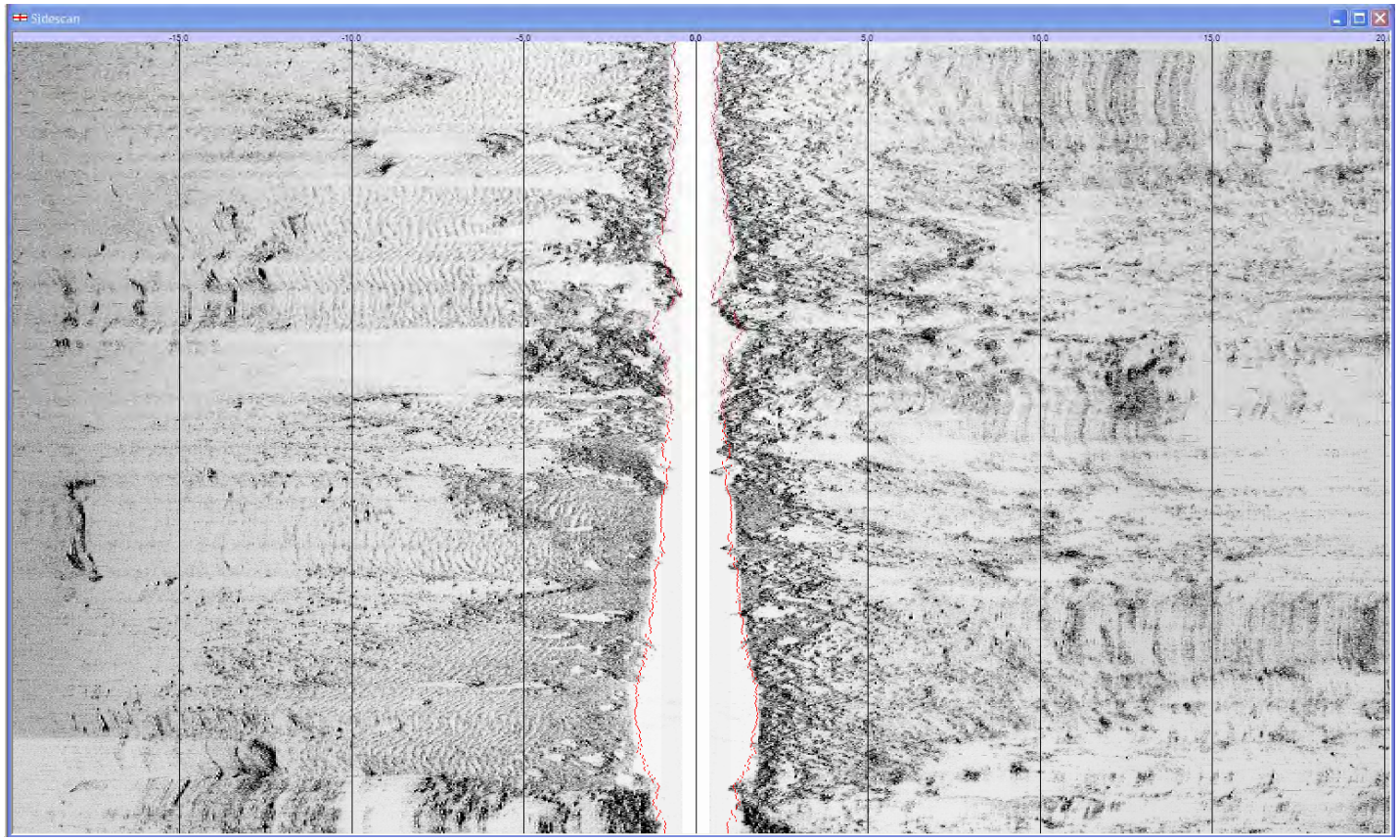

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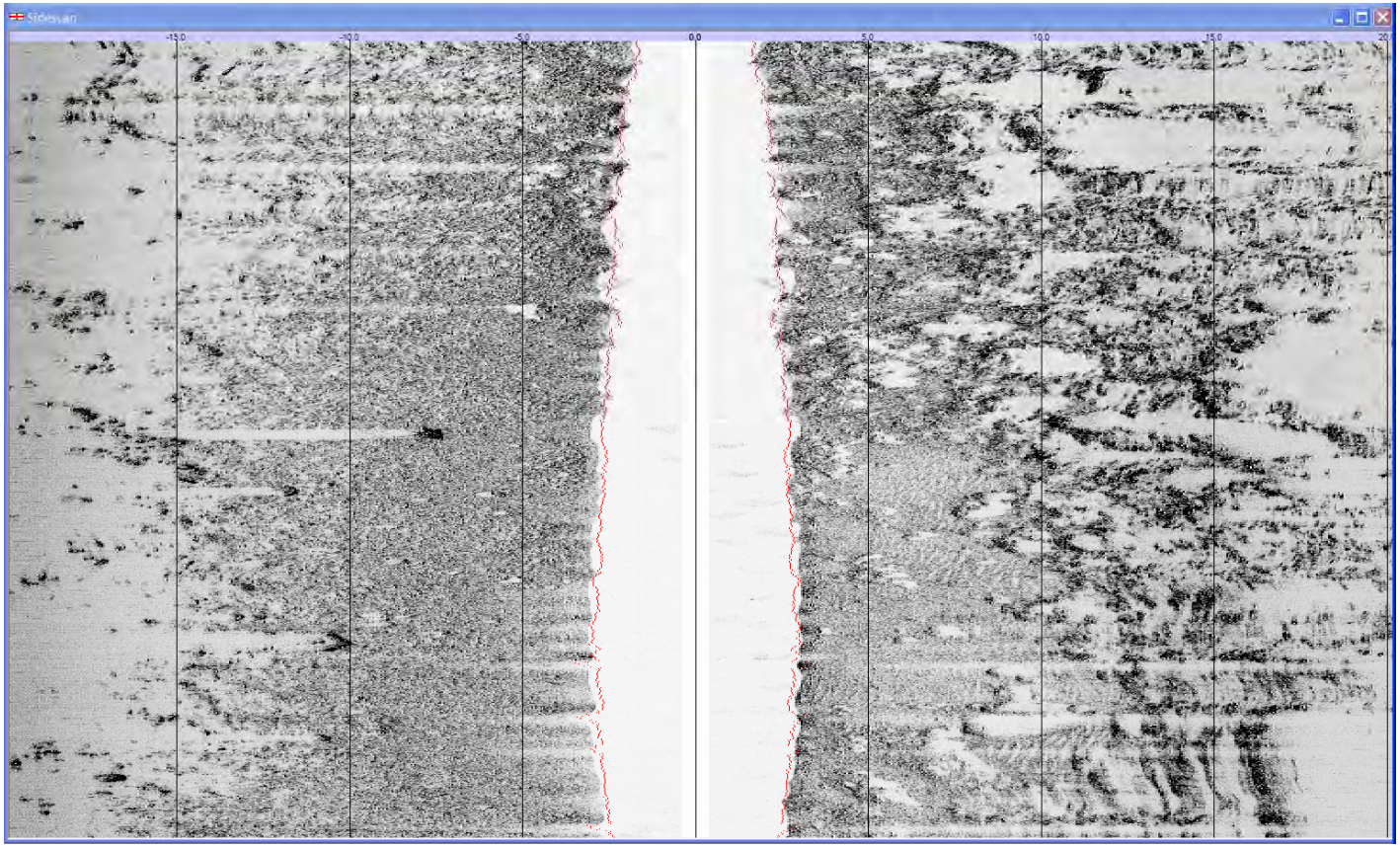

BAE Systems, Talisman UUV

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Talisman GeoSwath Side Scan

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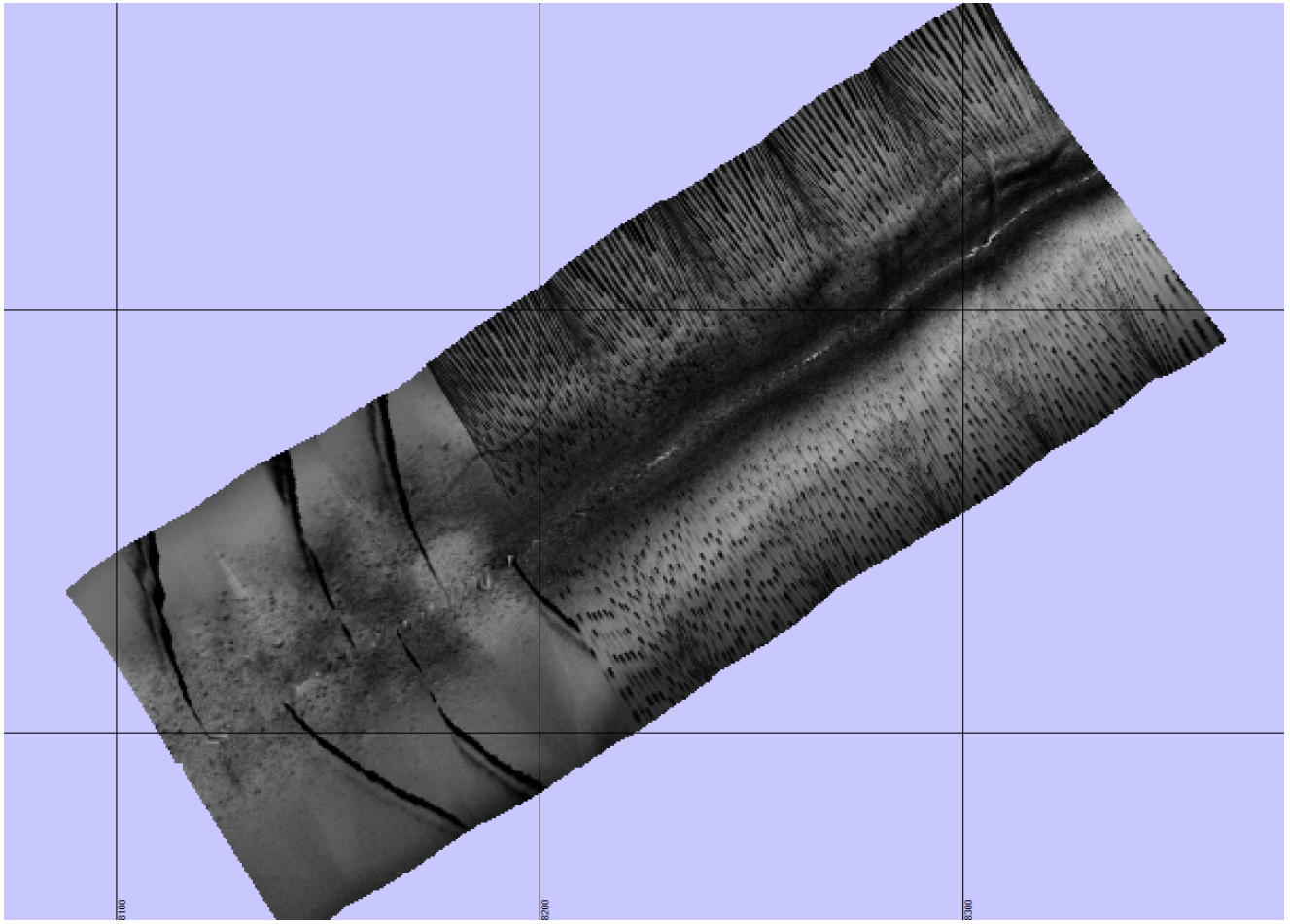

What happens with a 250kHz GeoSwath and 300kHz DVL when the ping synch fails (data from 13th Nov 2007).

Talisman GeoSwath Side Scan detail

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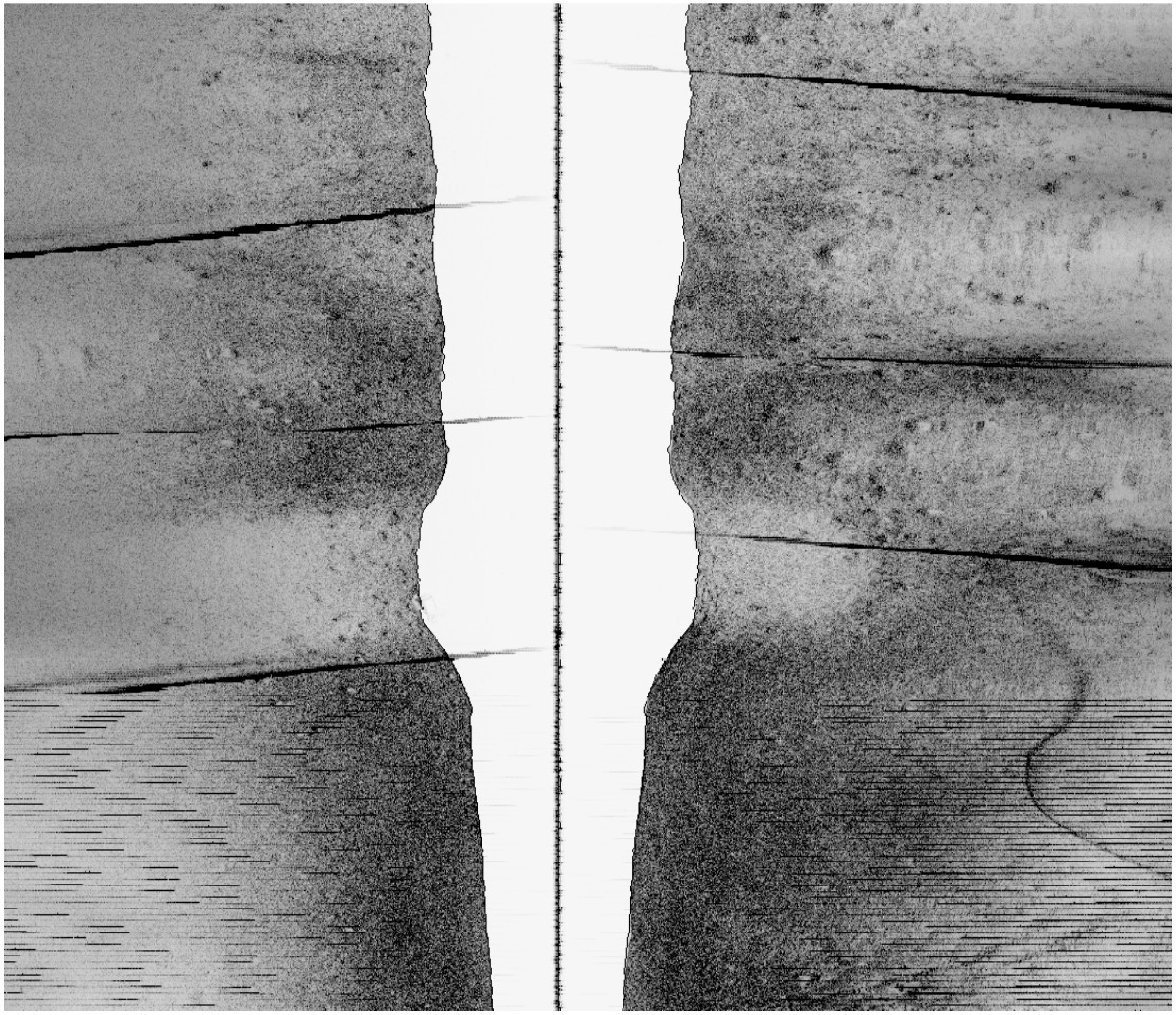

Talisman GeoSwath bathymetry

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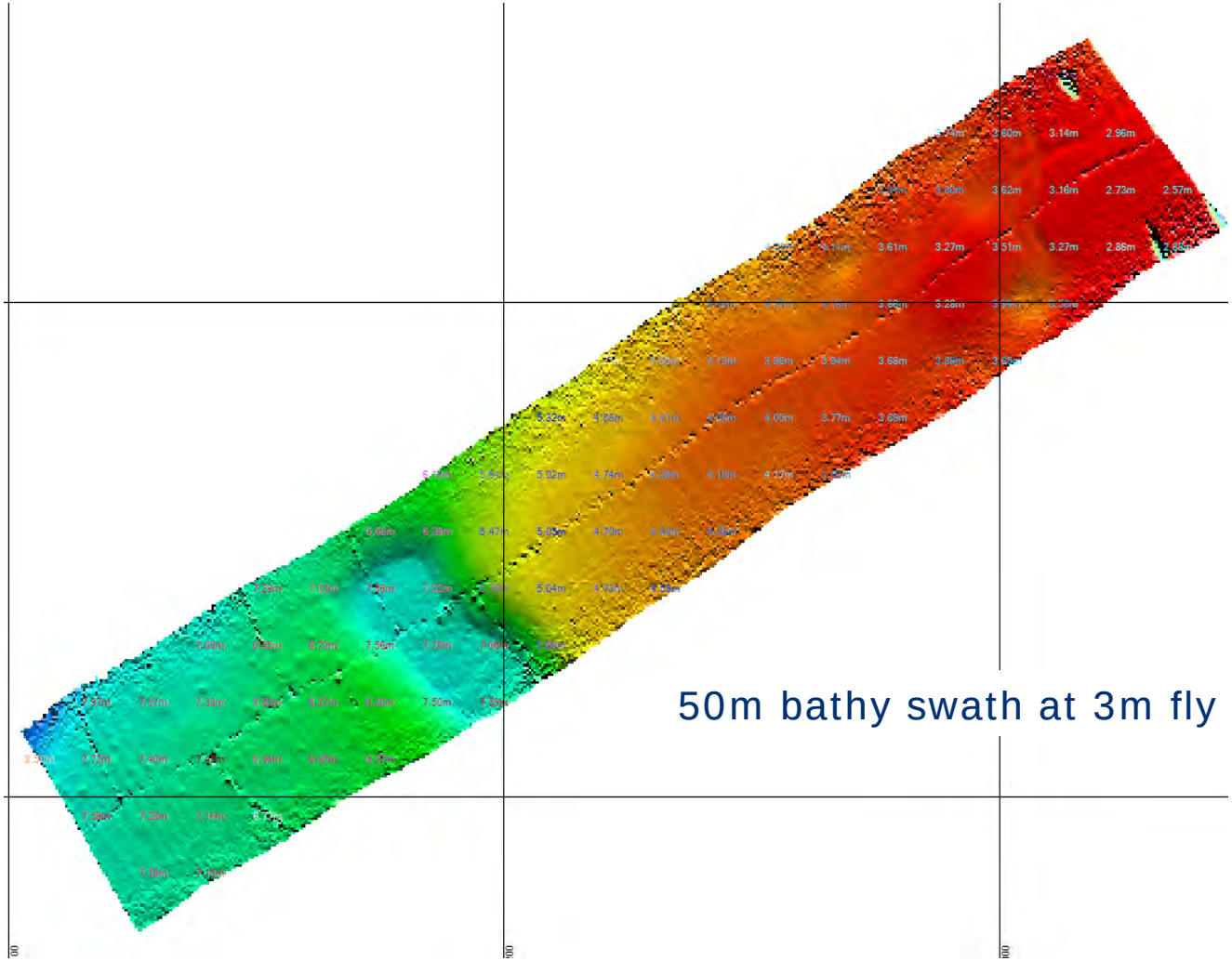

50m bathy swath at 3m fly height

Nezha AUV, Harbin Engineering University, China

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Harbin Engineering University

Precise engineering Academic excellence Pursuit of truth

- Underwater Robotics Lab
- **Application:** Pipeline survey research.
- **Funding:** China Ocean Mineral Resources R & D Association (COMRA) Organization for coordinating the activities of deep seabed exploration and exploitation.

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