3D UXO Detection – A Case Study in Darwin Harbour, Australia

Subsea Expo 2024

Presented by: Christopher Williams

Kraken Robotics | **Underwater.Understood.**™

Contents

- Who are Kraken Robotics?
- Our equipment - Sub-Bottom Imager™
- Our equipment - Seakite
- Our equipment - Acoustic Corer
- Our equipment - Katfish
- Case Study - Sub-Bottom Imager™ UXO Survey

Who are Kraken Robotics?

- Kraken Robotics is a marine technology company providing subsea sensors, batteries and robotic systems. Our high-resolution 3D acoustic imaging services enable clients to overcome the various challenges faced in our oceans – safely, efficiently and sustainably.
- We work regularly with Offshore Energy, Defense and Ocean Exploration markets worldwide.
- We have offices in Canada, UK, Germany and Brazil.
- Kraken Robotics acquired Pangeo Subsea in July 2021, obtaining the Sub-bottom Imager™ (SBI) and Acoustic Corer.

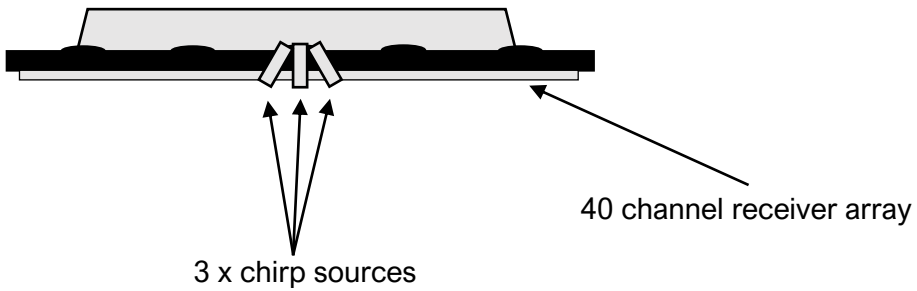
SBI Equipment – ROV Mounted

Equipment:

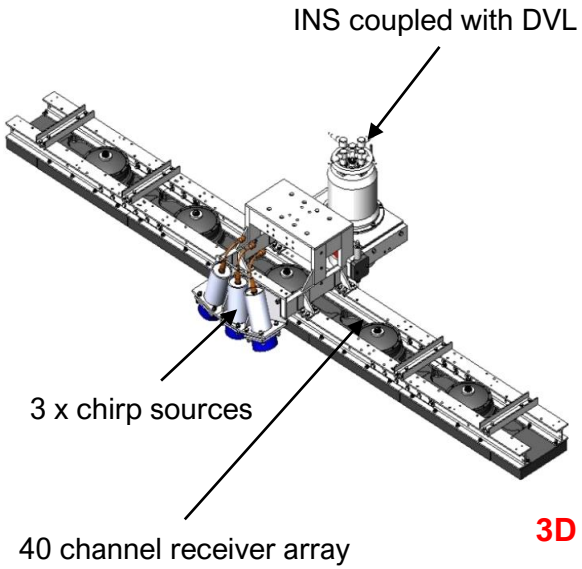
- 40 channel receiver array
- 3 x sources
- INS and DVL
- Depth sensor
- Sound velocity sensor

Max. speed (vehicle limited):

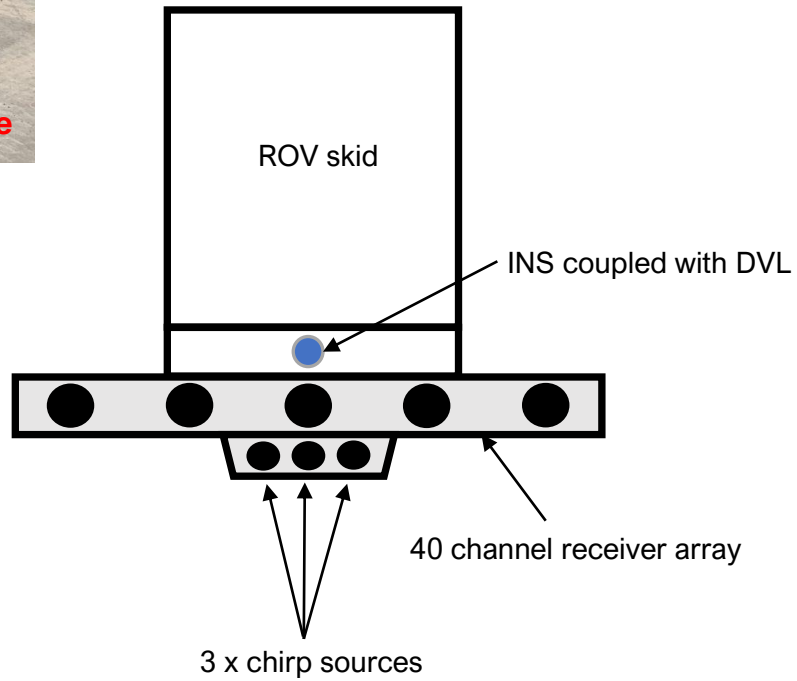
- 1.5 knots (0.75 m per sec)



Front-view



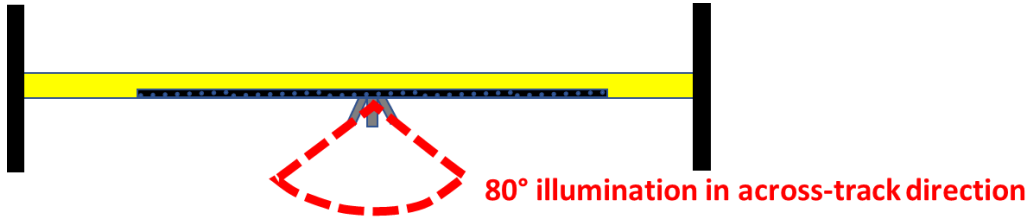
3D view



Plan-view (top down)

SBI data acquisition

- The three chirp sources trigger incrementally (starboard-centre-port).
- The port and starboard sources are angled outwards from the centre so that an 80° angled field in the across-track direction is captured.
- The sources fire 45 times a second (45 Hz) to ensure that sufficient insonification of the seabed and shallow soils is achieved (the three sources insonify the full array swath 15 times per second).



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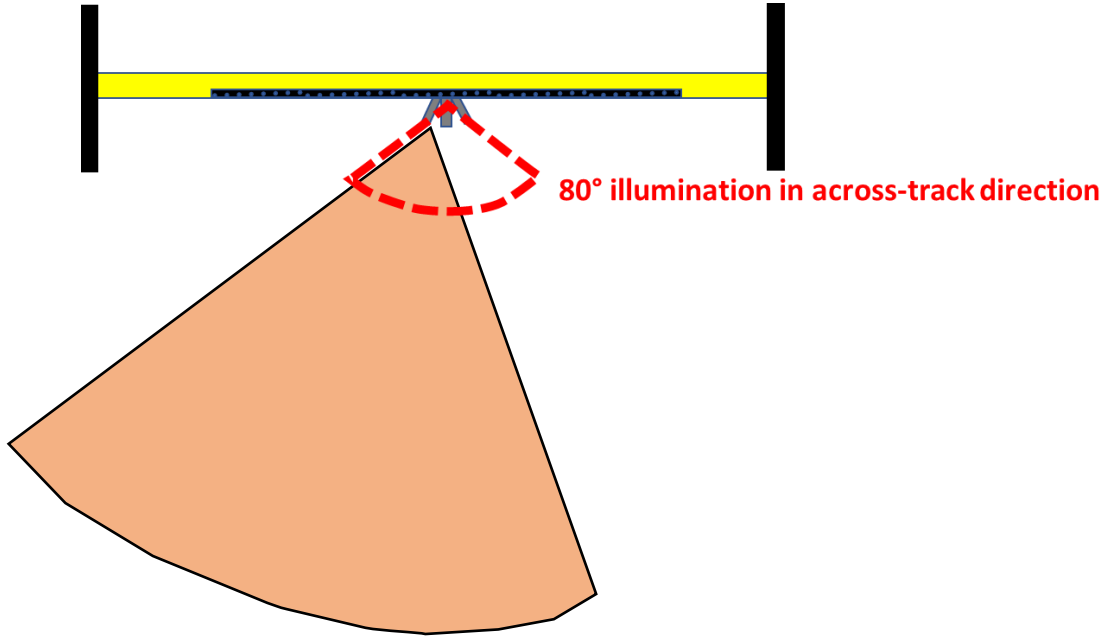

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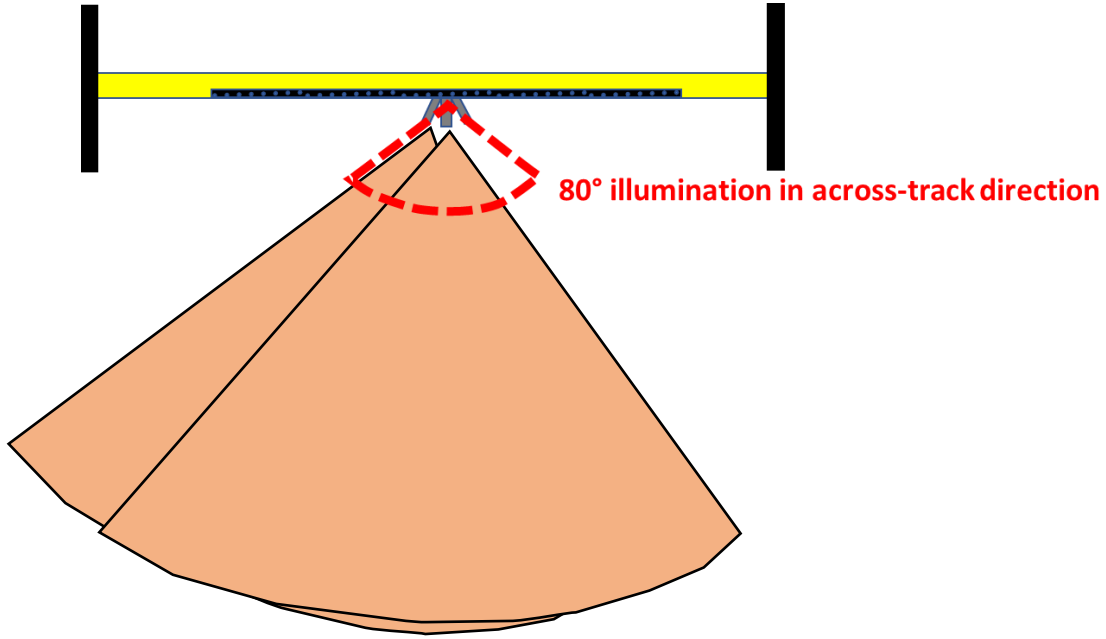

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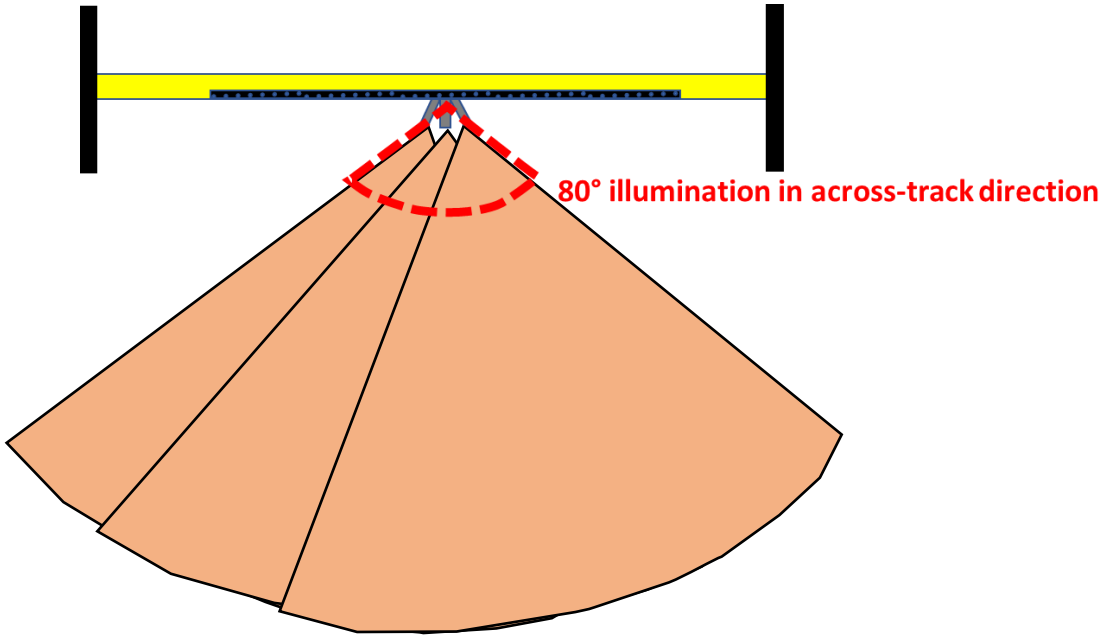
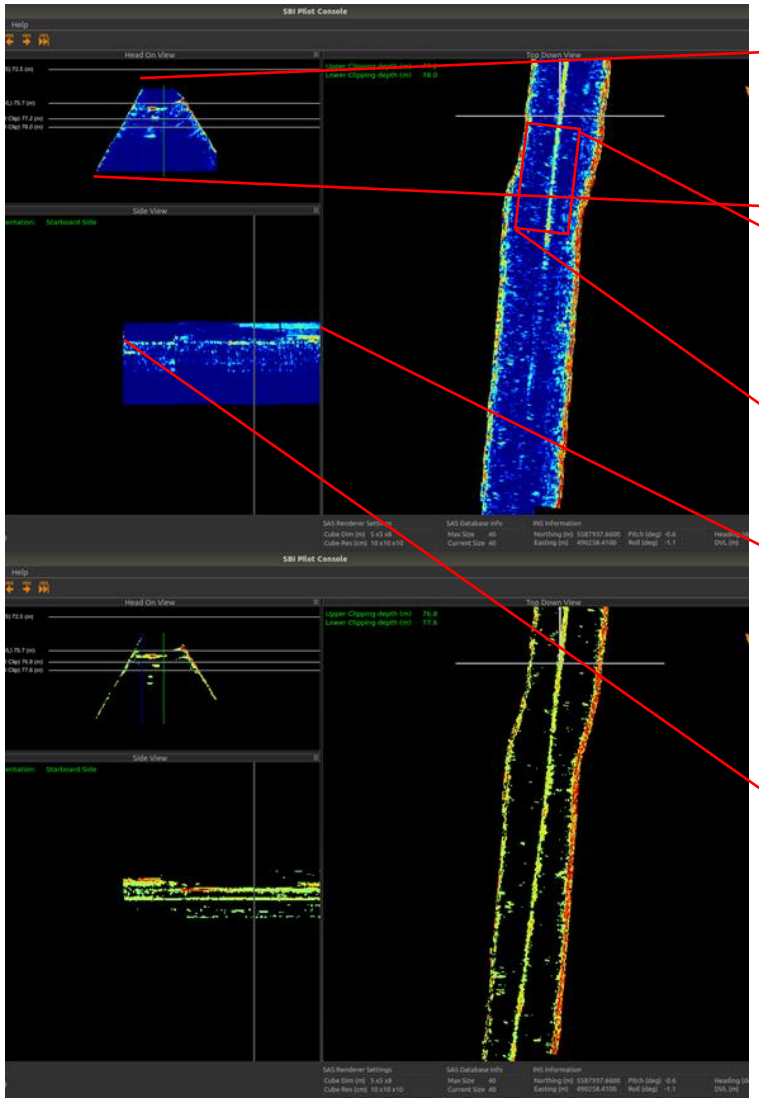
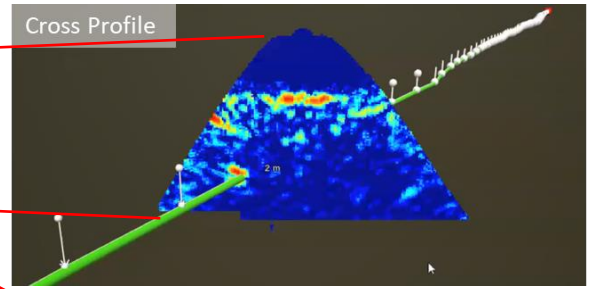
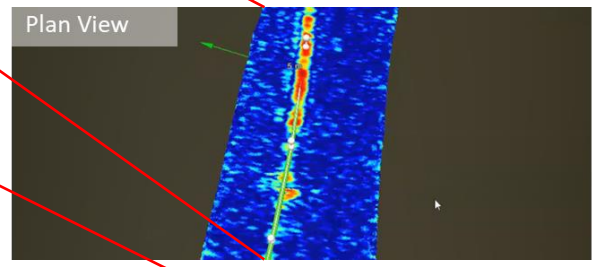
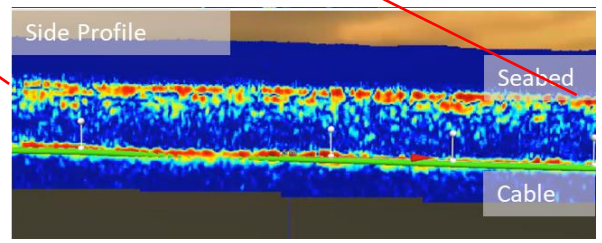


Live Data Visualisation







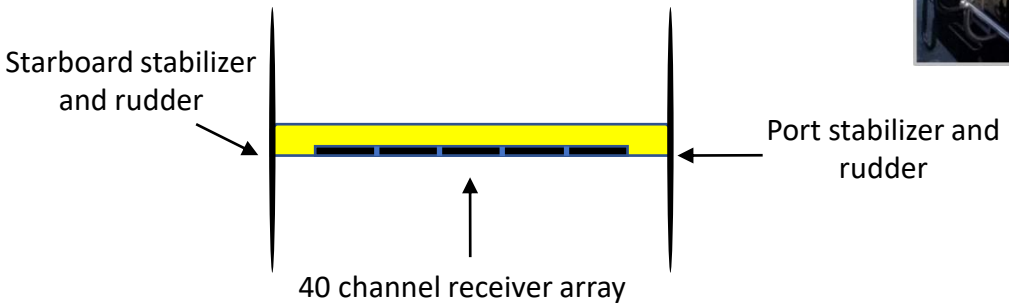


- Continuous acoustic data set: Swath 5m wide.
- Depth of penetration 5 - 7 m sub-seabed.
- Voxel resolution of 0.1 m throughout dataset.
- Cables remains fully operational during survey.
- Images exterior cable so can detect split bundles, coiled cables and the surrounding seabed to check location within trench/surrounding lithologies.
- Delineate size, shape, orientation and depth of possible geohazards and UXOs.

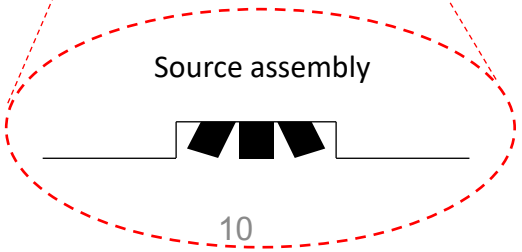
SBI Equipment – SeaKite

Equipment:

- 40 channel receiver array
- 3 x sources
- INS and DVL
- Depth sensor
- Sound velocity sensor

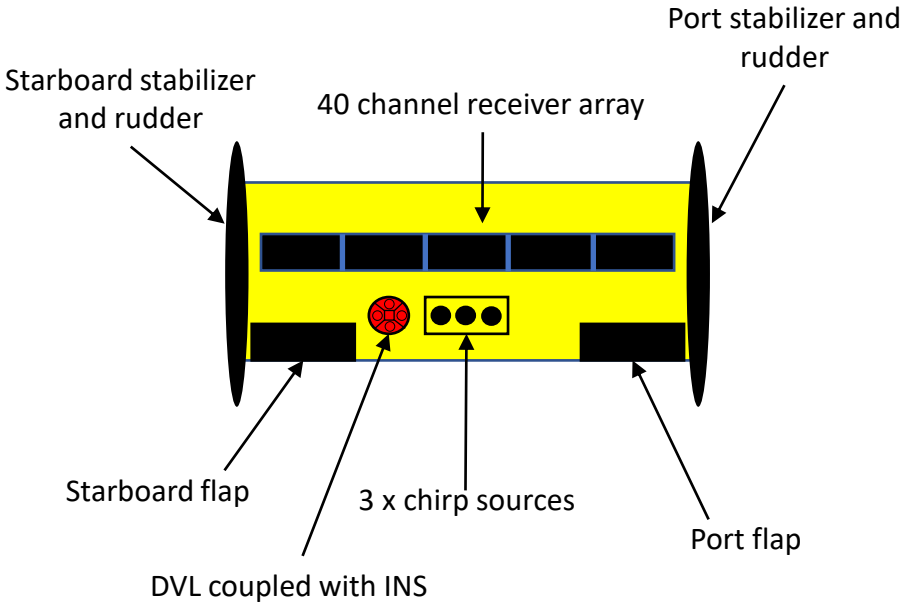


Front-view



Max. speed (SBI limited):

- 3.7 knots (1.85 m per sec)

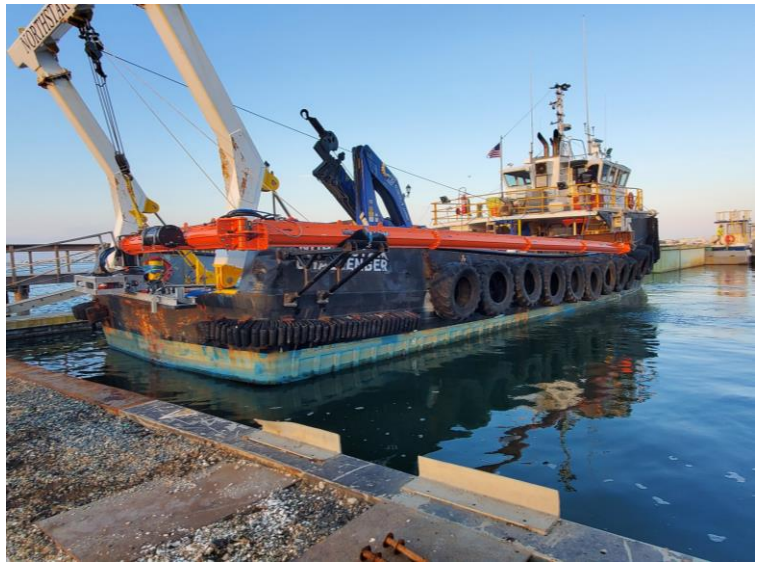


Plan-view (bottom up)

Further Survey Techniqes

GeoLink (up to 8m WD)

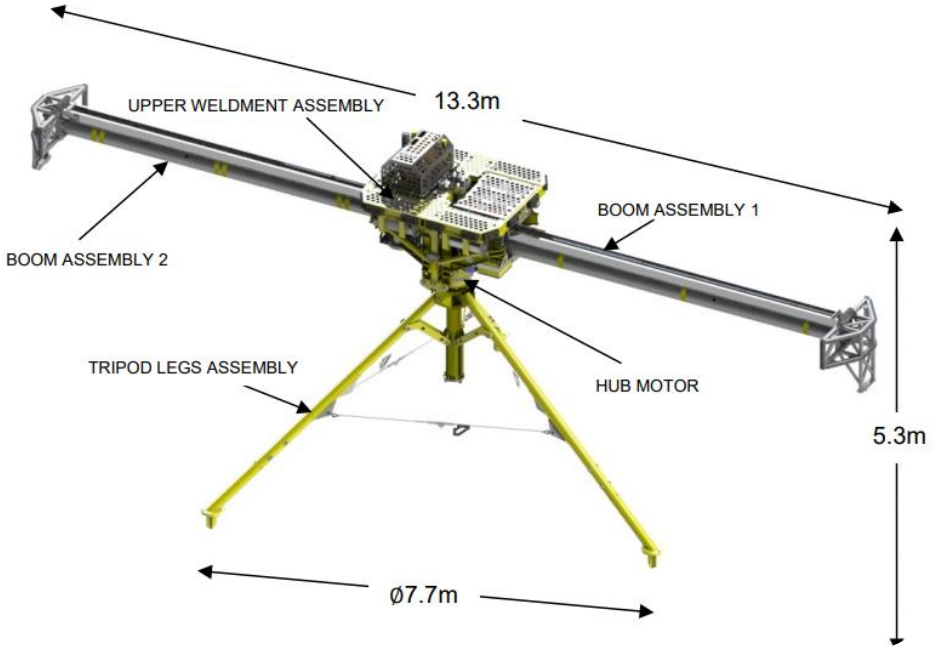
GeoArm (up to 16m WD)

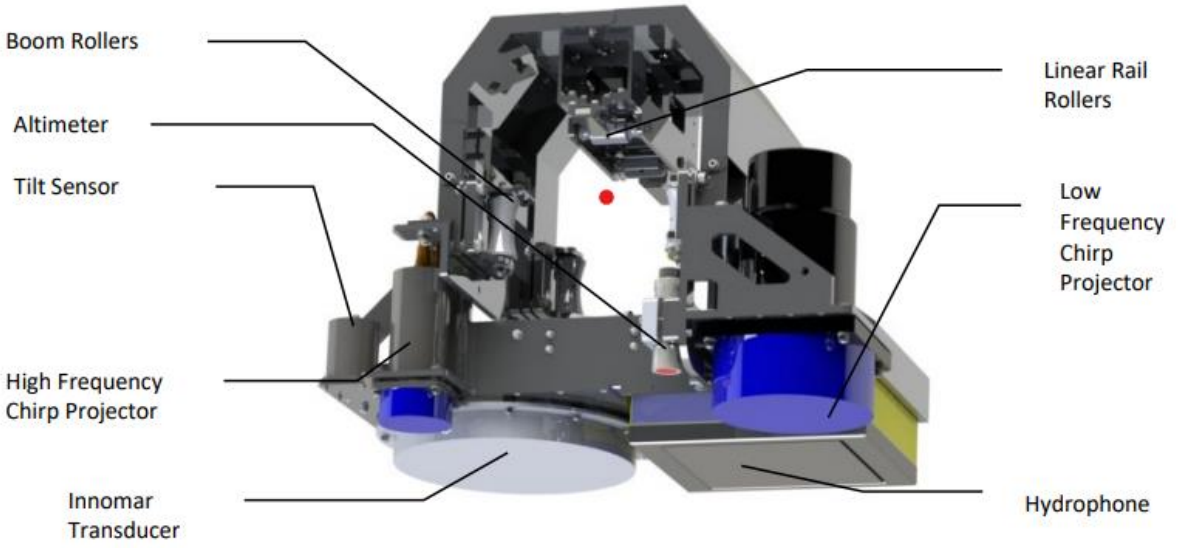


Acoustic Corer – Specifications

- The Acoustic Corer uses acoustic imaging to delineate sub-seabed stratigraphy and buried geohazards such as boulders, debris, ferrous and non-ferrous UXOs and abandoned seabed infrastructure.

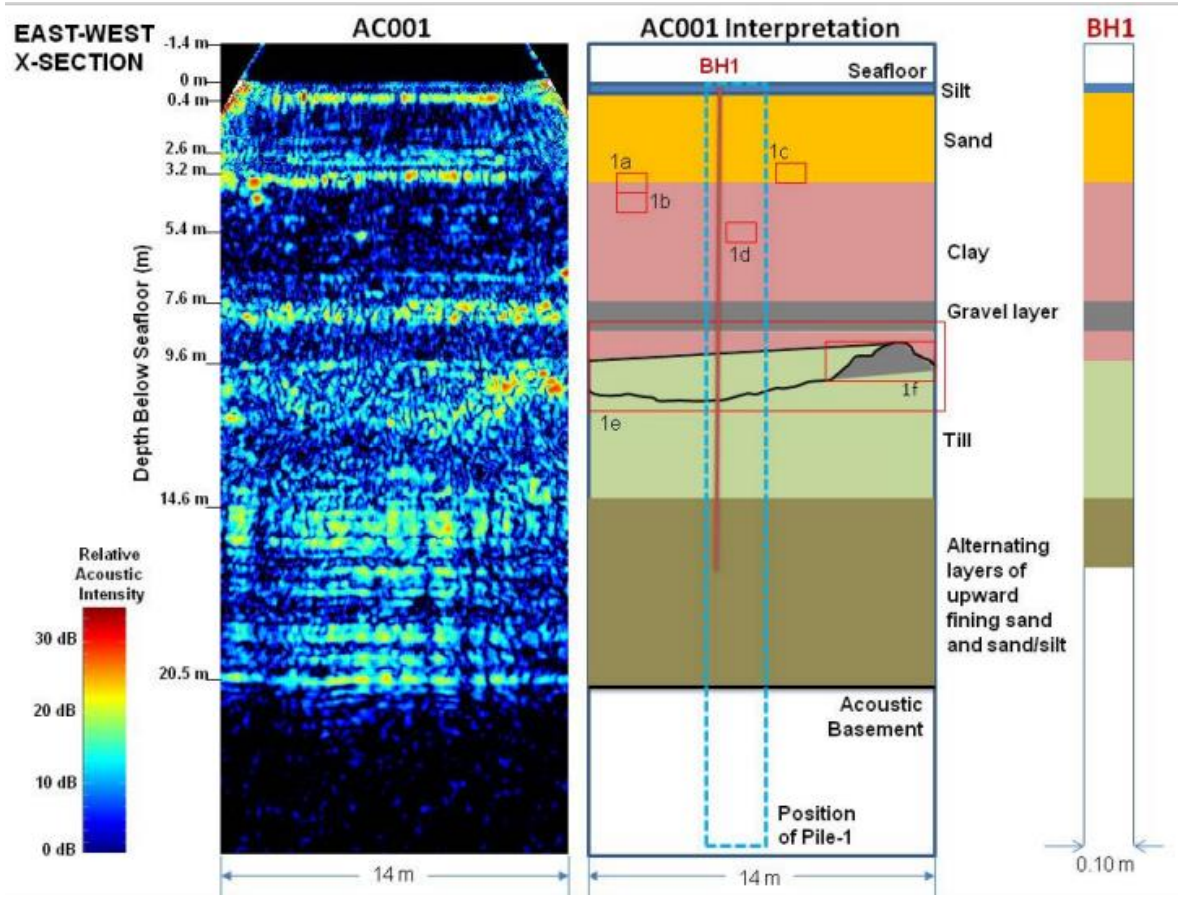
SUB-SYSTEM	OPERATIONAL FREQUENCY
Linear frequency modulated, low frequency chirp sonar	1.5 kHz to 6.5 kHz
Linear frequency modulated, high frequency chirp sonar	4.5 kHz to 14 kHz
Innomar Parametric Transducer	Primary frequency = 100 kHz Secondary frequency = 4 kHz to 15 kHz



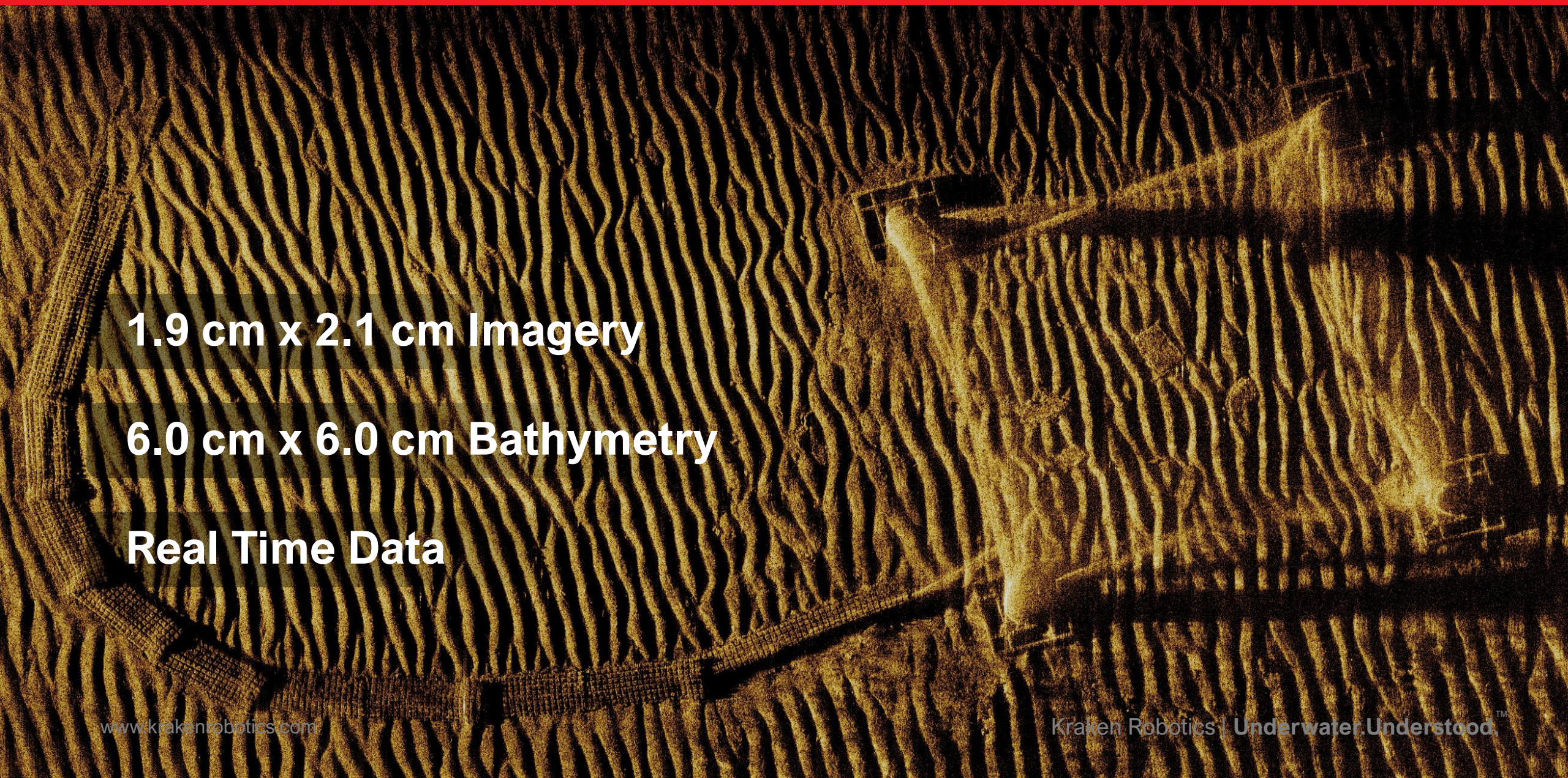


Acoustic Corer – Acquisition and Processing

- The Acoustic Corer acquires a 3D cylindrical image of the subsurface.
- An initial JYGs scan is undertaken to create a velocity model for each location.
- Applications for the AC include subsea infrastructure and anchor piling, jack-up rig emplacement, wind farm installation and decommissioning surveys.
- Total scan time completion is around 16 hours.
- Up to 60m penetration can be achieved.



Synthetic Aperture Sonar

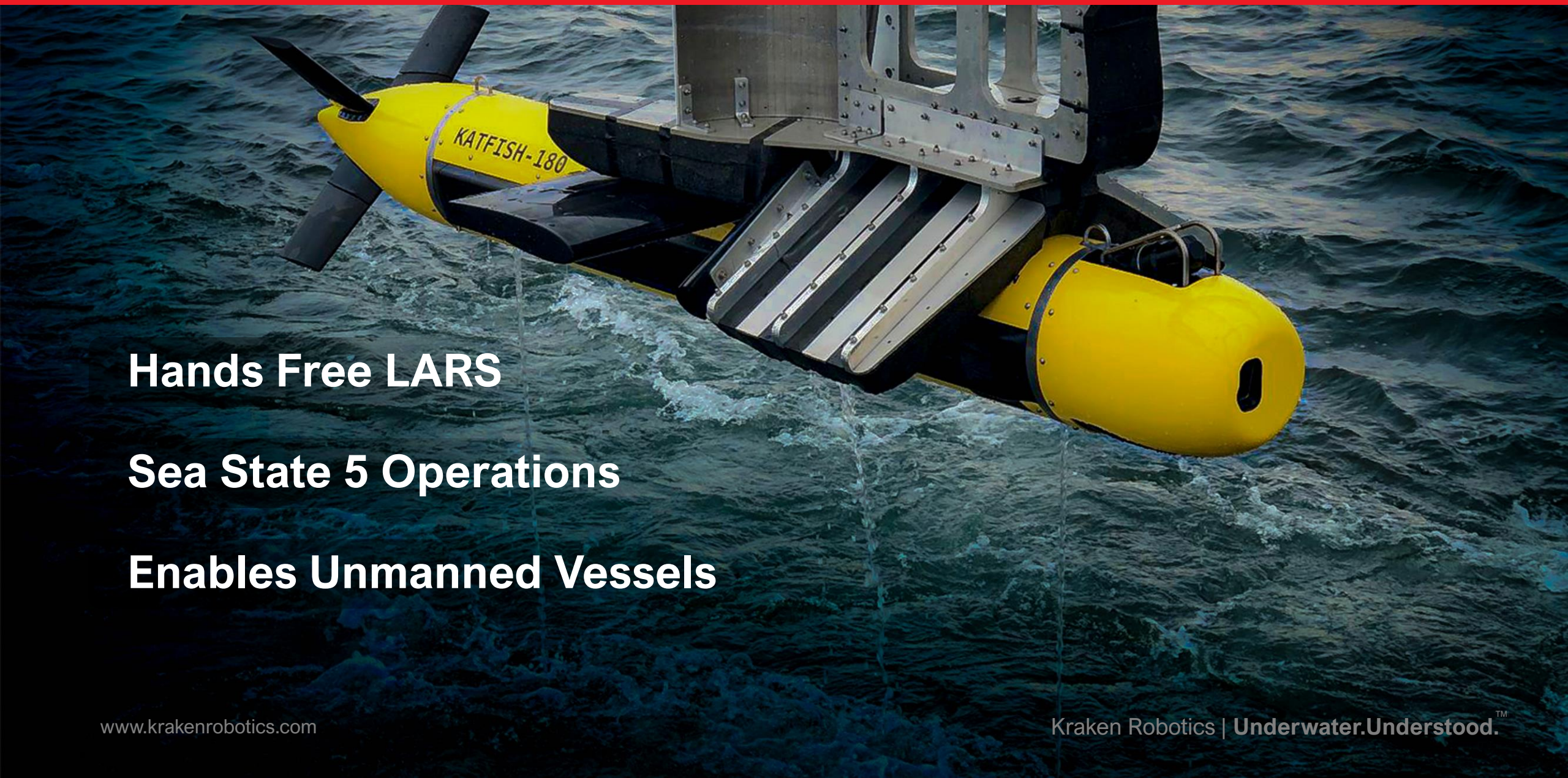


1.9 cm x 2.1 cm Imagery

6.0 cm x 6.0 cm Bathymetry

Real Time Data

Autonomous LARS

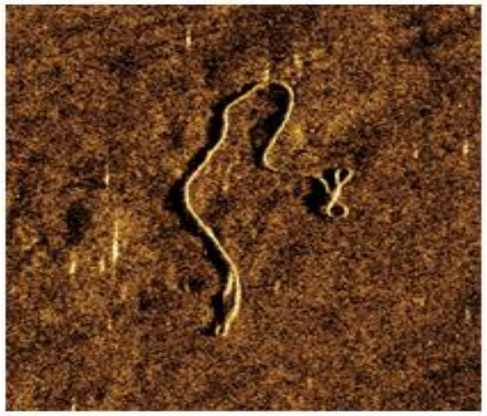


Hands Free LARS

Sea State 5 Operations

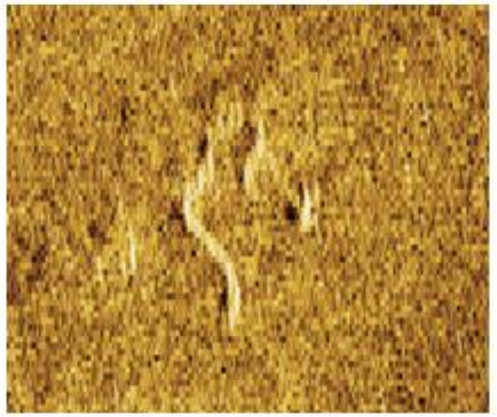
Enables Unmanned Vessels

SAS vs SSS

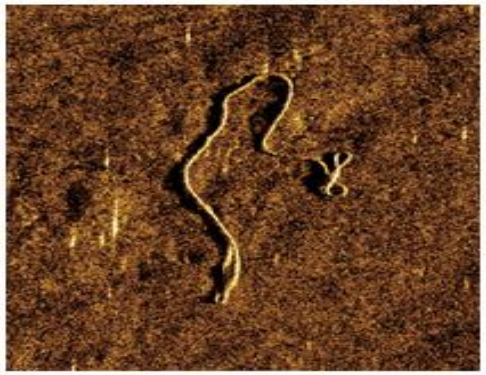


SSS at 5m

SSS - Degrades Resolution with Range

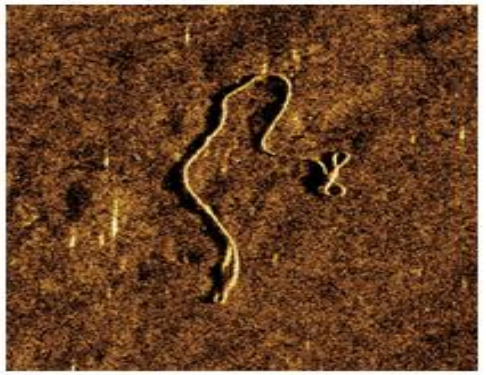


SSS at 100m



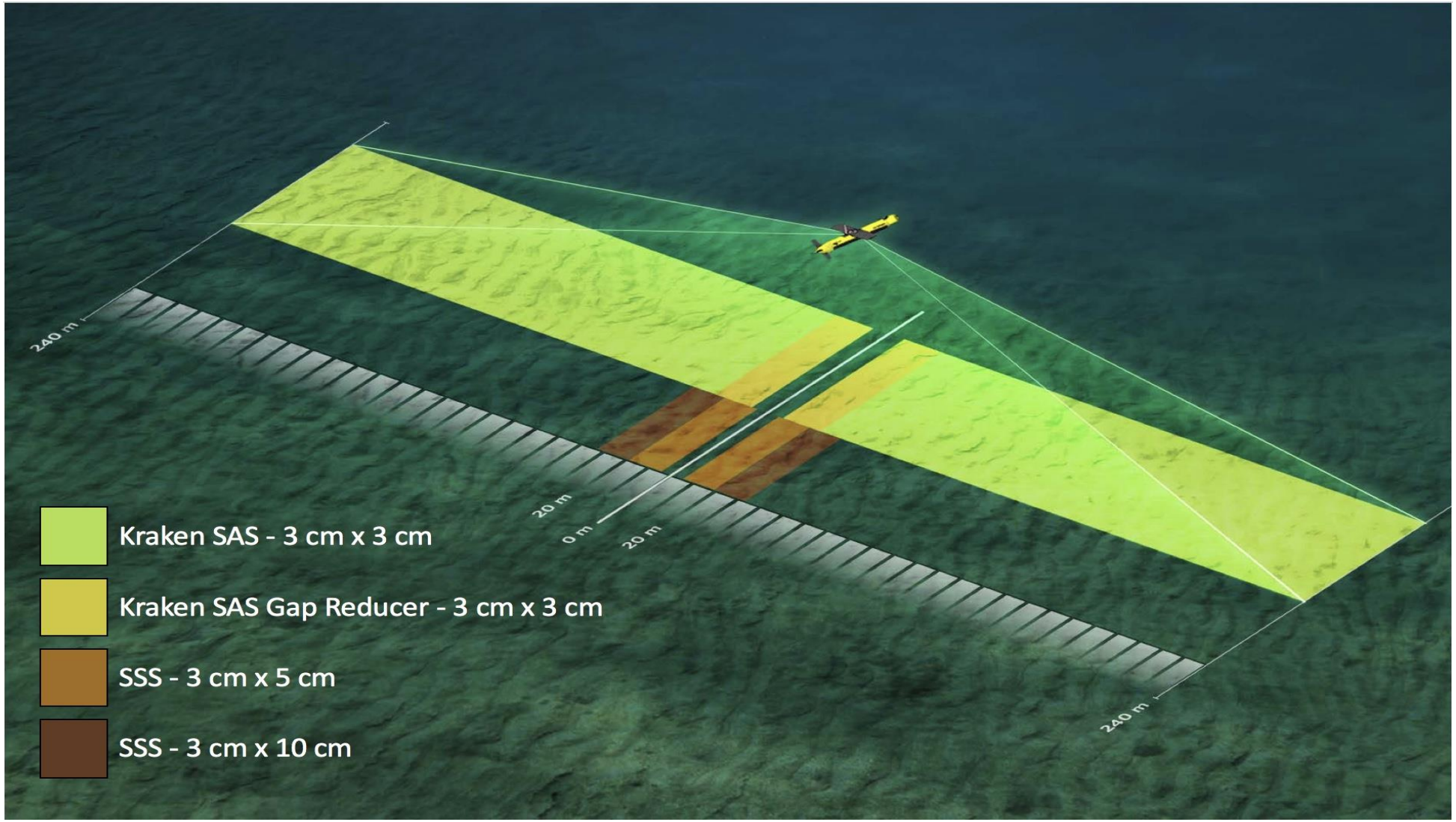
SAS at 5m

SAS - Constant Resolution with Range



SAS at 100m

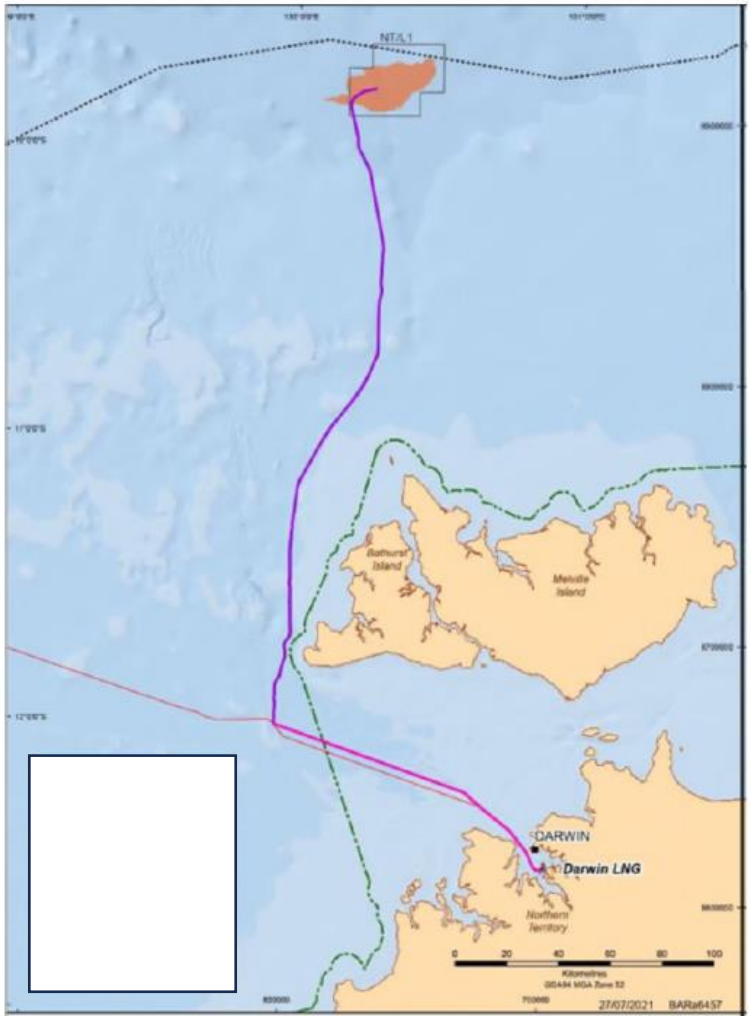
10x Area Coverage Rate of SSS



Scope of Work – Darwin Harbour, Australia

- Kraken Robotics performed a Sub-Bottom Imager™ ferrous pUXO survey within Darwin Harbour, supporting a pipeline project.
- We were contracted to verify 39 possible targets, identified in previously acquired magnetometer data.

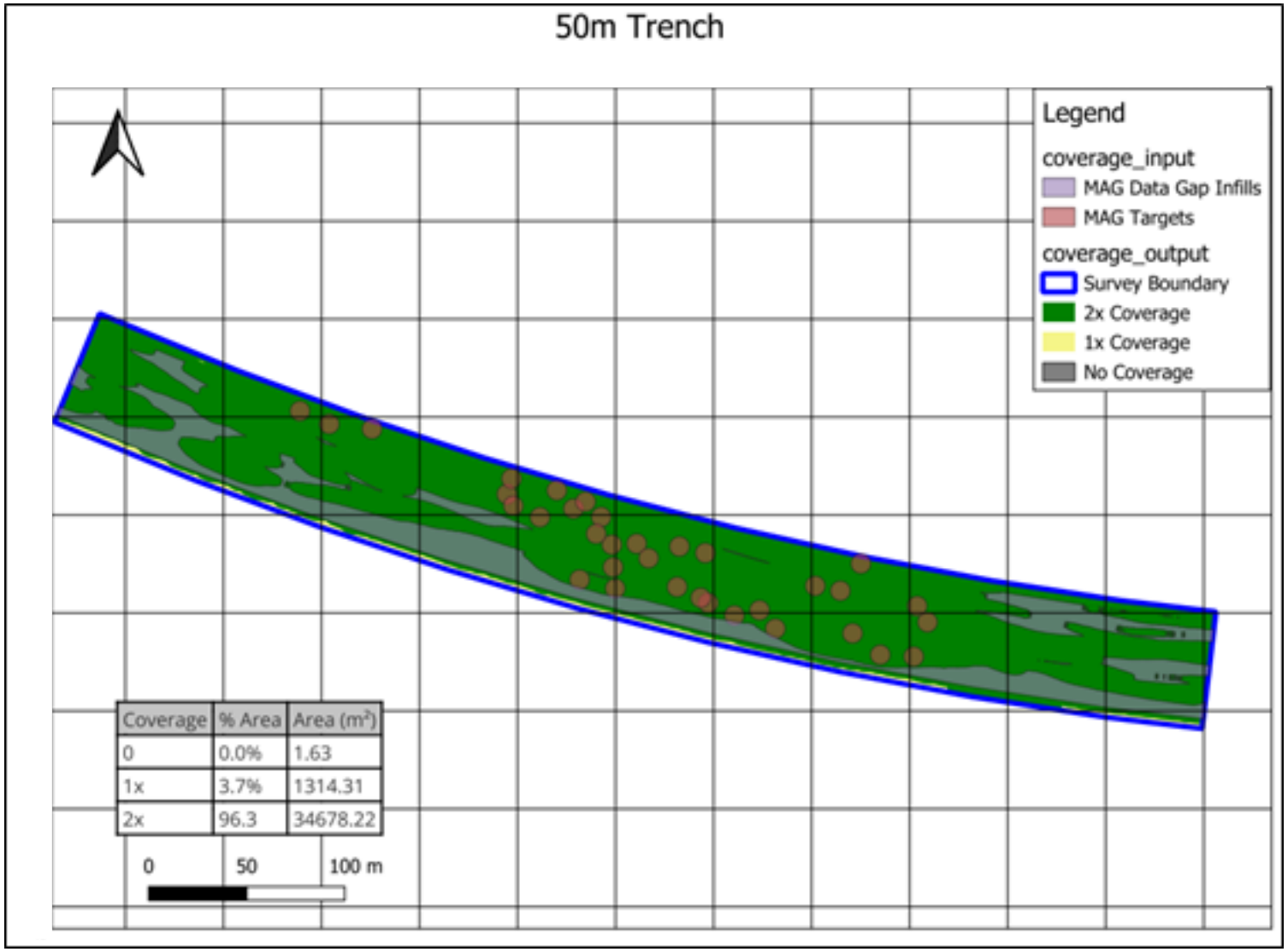
TARGET DESCRIPTION			
TYPE OF FERROUS UXO	**ANOMALY LENGTH (M)**	**ANOMALY DIAMETER/WIDTH (M)**	**SHAPE OF UXO EXPECTED IN SBI SAS DATA**
Japanese 250 kg air dropped bomb	0.8 (± 0.2)	0.2 (+ 0.2)	Rectangular / cylindrical / elliptical
Japanese 60 kg and 63 kg are dropped bombs	0.8 (± 0.2)	0.2 (+ 0.2)	
Japanese 800 kg air dropped bomb	1.64 (± 0.2)	0.4 (+ 0.2)	



Methodology – Darwin Harbour, Australia

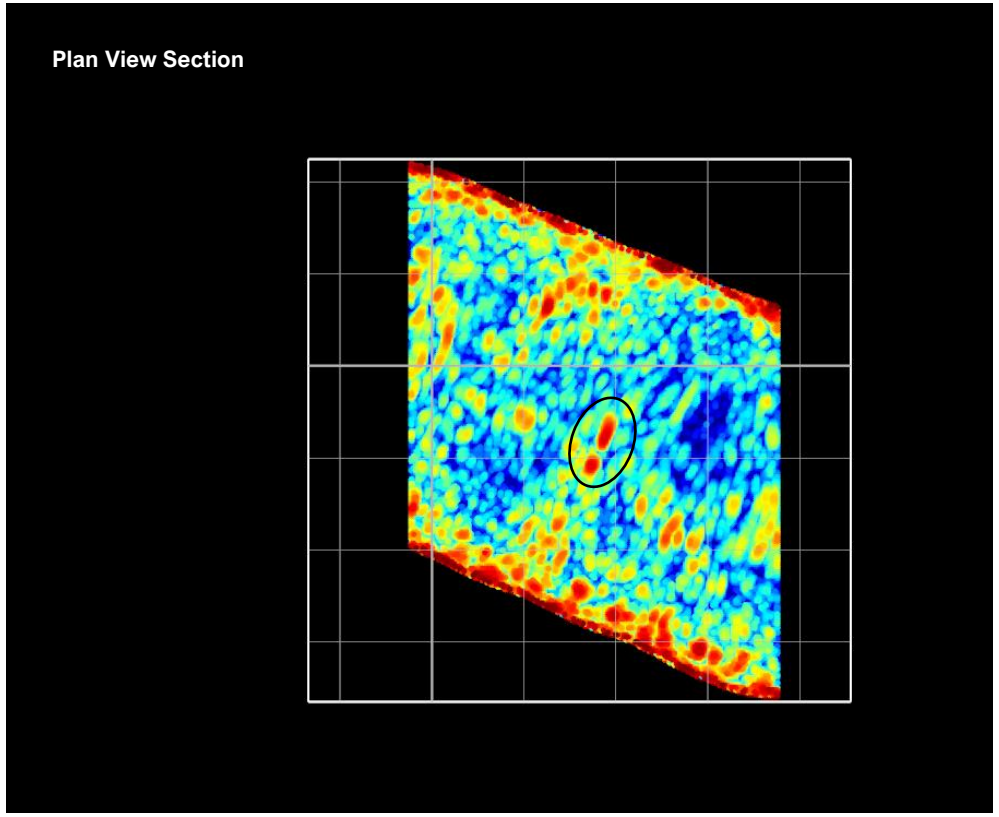
- Data acquisition was to be carried out over 2 survey areas to fill the gaps in the magnetometer data as well as confirming the pUXO targets.
- Kraken Robotics mobilised all equipment required to carry out the survey.
- Due to it being a UXO survey, 3m line spacings were recommended to the client, ensuring 200% coverage to eliminate false positives.

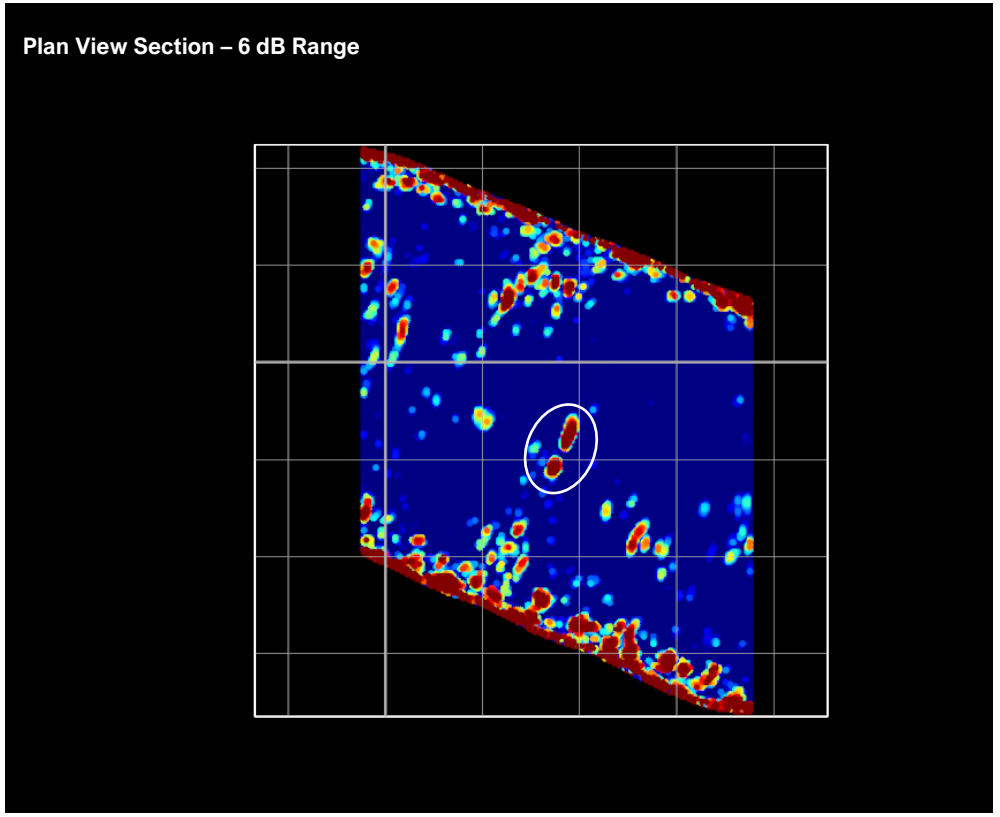
Results – Coverage Report



Results – Anomaly Observation (Found in Magnetometer Data Gap)

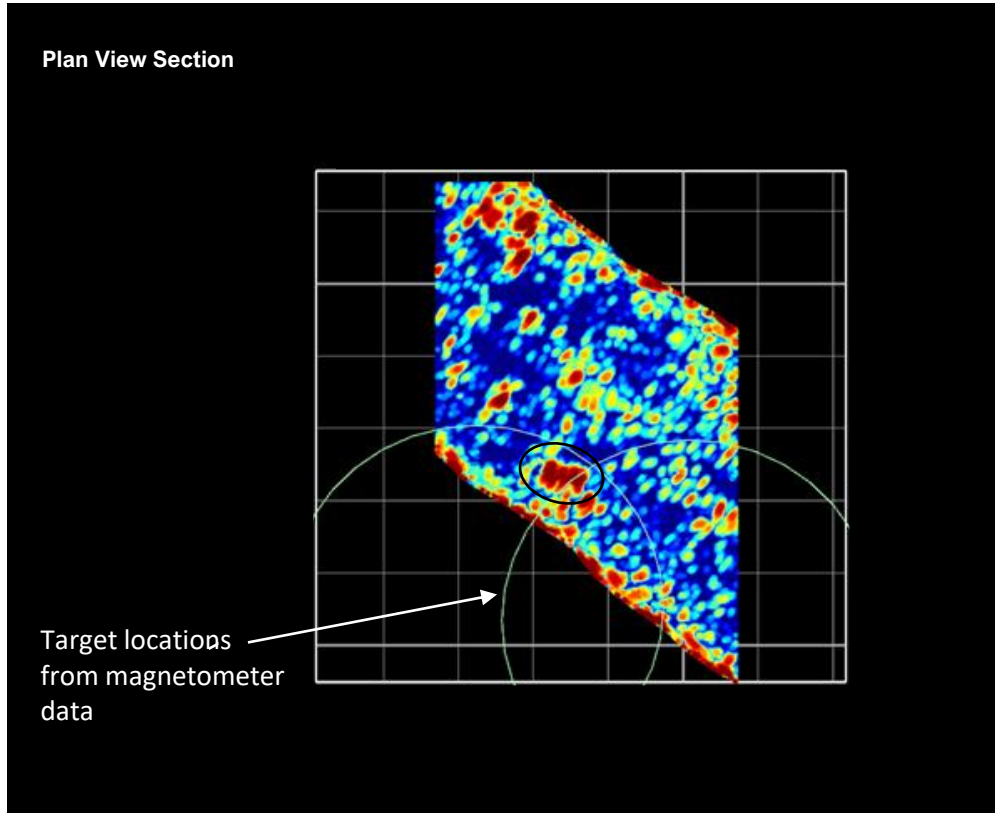
Easting (GDA94)	Northing (GDA94)	DBSF (m)	6db Length and Width (m)		Shape	Relative Amplitude	Total Confidence Rank
		0.8	1.4	0.2	Elliptical	15	3.5

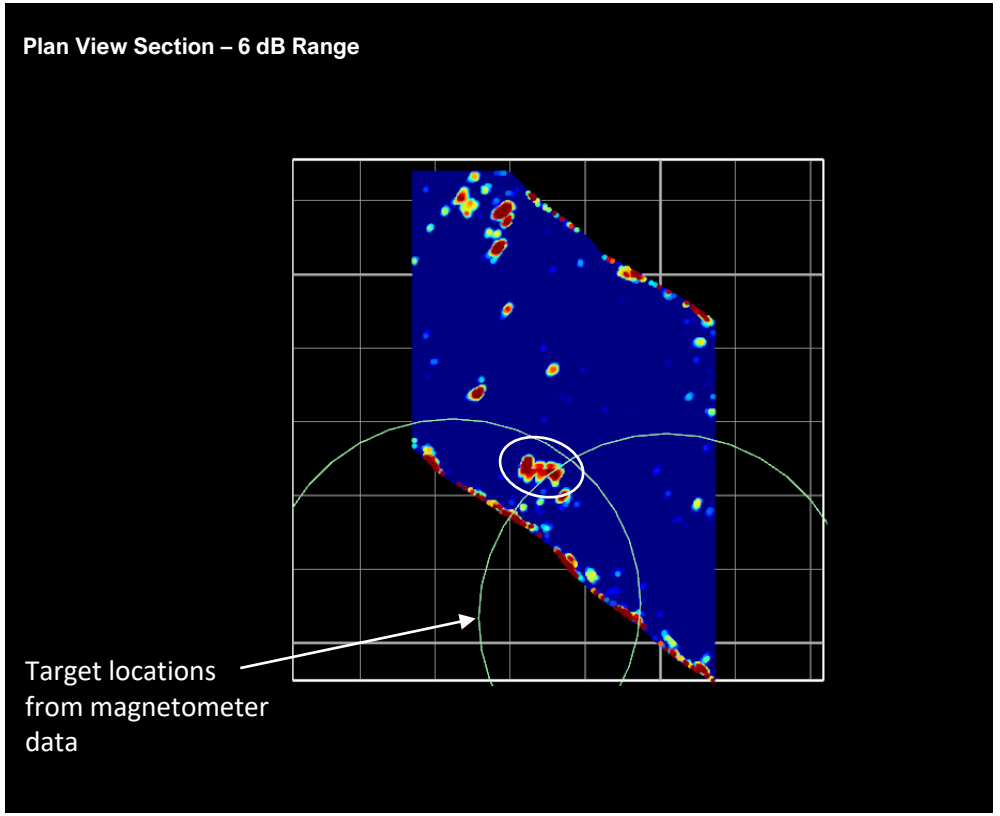




Results – Anomaly Observation (Correlation with Mag Data)

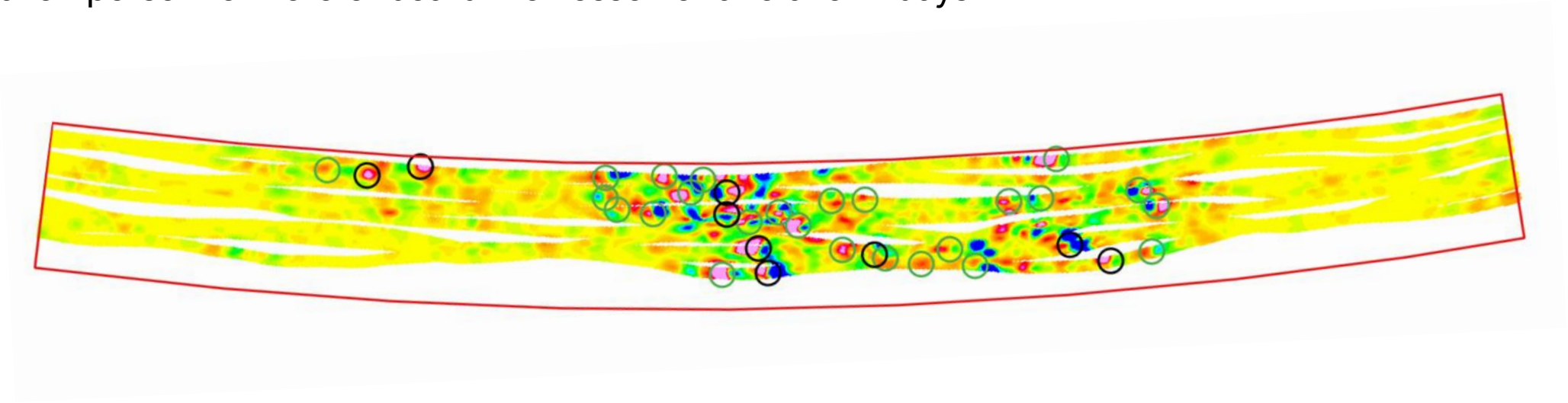
Easting (GDA94)	Northing (GDA94)	DBSF (m)	6db Length and Width (m)		Shape	Relative Amplitude	Total Confidence Rank
		0.4	1.0	0.7	Rectangular	13	2





Conclusion – Darwin Harbour, Australia

- Kraken Robotics personnel interpreted and reported on all anomalies whilst onboard the vessel.
- In conjunction with the EOD experts, we reduced the initial target listing from 39 to 25 pUXOs.
- Within the gaps of the magnetic data, Kraken Robotics found an additional 7 pUXOs during the interpretation.
- Kraken personnel were onboard the vessel for a total of 7 days.



KRAKEN

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Thank You

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