Ping Digital Signal Processing (DSP) - Evaluation of Shallow Water Bathymetry and Object Detection Capability. (12404)

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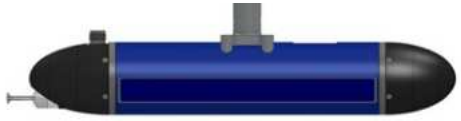
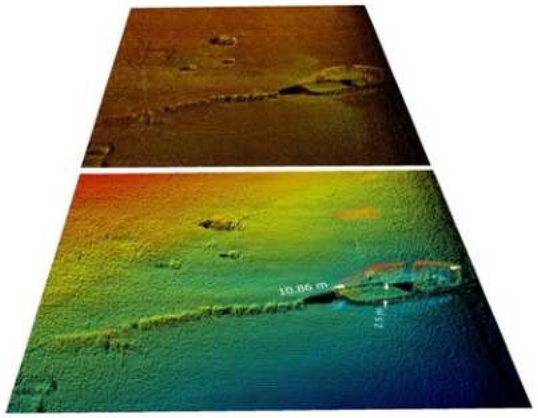
Overview

Interferometric Sonars for shallow-water swath surveys. Cost-effective techniques and solutions that impact survey capacity and productivity.





A multi-stave side-scan sonar using the angle of arrival of the seabed returns to collect wide swath of bathymetry and sonar amplitude data.

It employs patented Computed Angle-of-Arrival Transient Imaging (CAATI) with proprietary signal processing methodologies to;

- Minimizes multipath
- Improves bathymetry data over a swath width at nadir
- Detects multiple simultaneous backscatter arrivals
- Allows for water column targets
- Real time 3DSSTM high-definition imaging technology and MBES Bathymetry Engine.

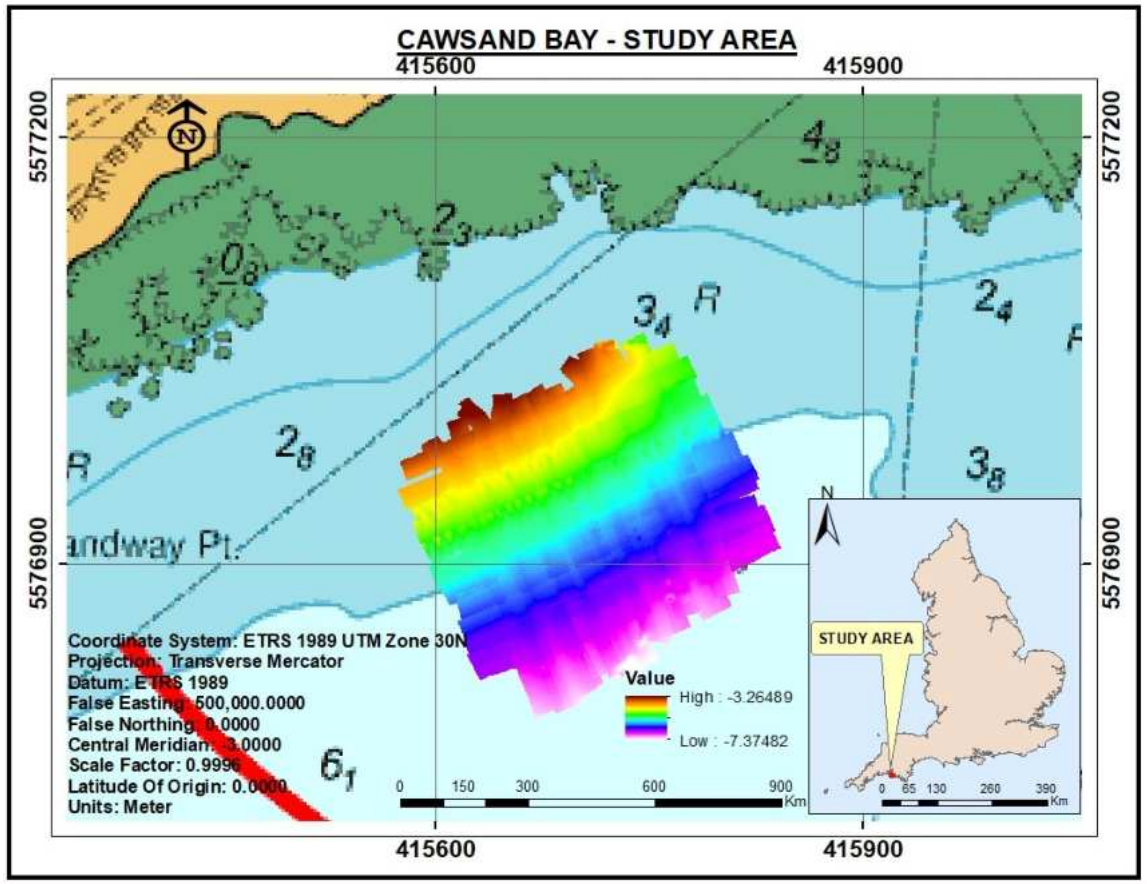
Study Objectives

Assess bathymetric uncertainty of 3DSS-IDX-450 and Norbit iWBMS sonars

Evaluate object detection capabilities (seabed and mid-water targets)

Compare the performance of the two sonar systems

Survey Location



Cawsand Bay, Cornwall, UK

shallow seabed with a steady slope to death of 10m below chart datum

Suitable for testing sonar systems with structured survey lines for reference surface analysis

has a 0.5m calibrated cube suitable for testing seabed object detection capabilities of acoustic sonars per IHO Standards.

Sonar Systems - 3DSS-IDX-450

high-resolution swath bathymetry coverage of up to 14 times the depth.

AML MicroX Sound Velocity Sensor, SBG Ellipse2-E IMU and Septentrio dual GNSS.

operates at 450 kHz

Sonar dimensions are 56.8 cm (length) x 9.8 cm (diameter)

10m depth rating, and it weighs 8kg in air

operates with a horizontal beam width (2-way) of 0.4^0 and vertical beam width (selectable) of 15^0 – 125^0 with 1440 soundings per Ping across the swath at a ping rate of 30Hz

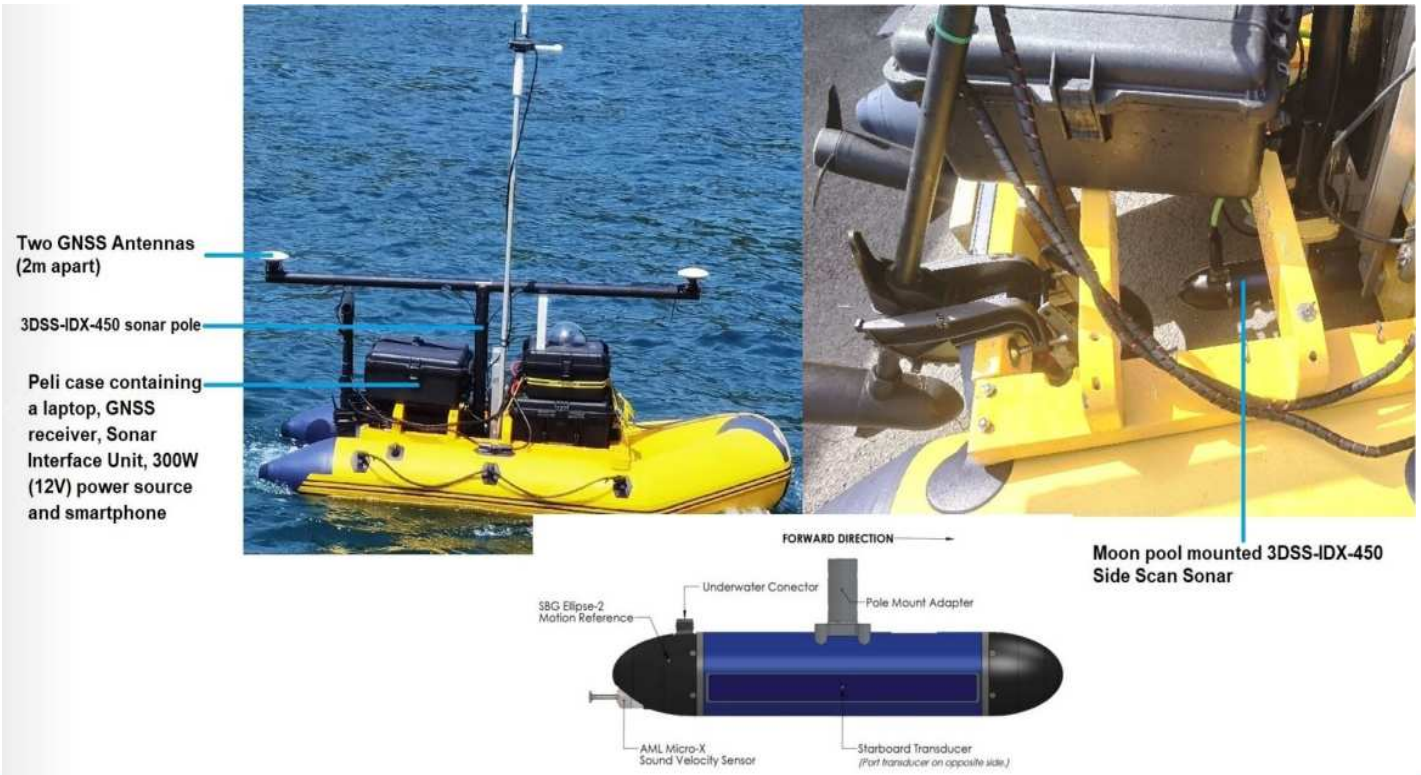
The integrated MRU have an accuracy of 0.5^0 for roll and pitch

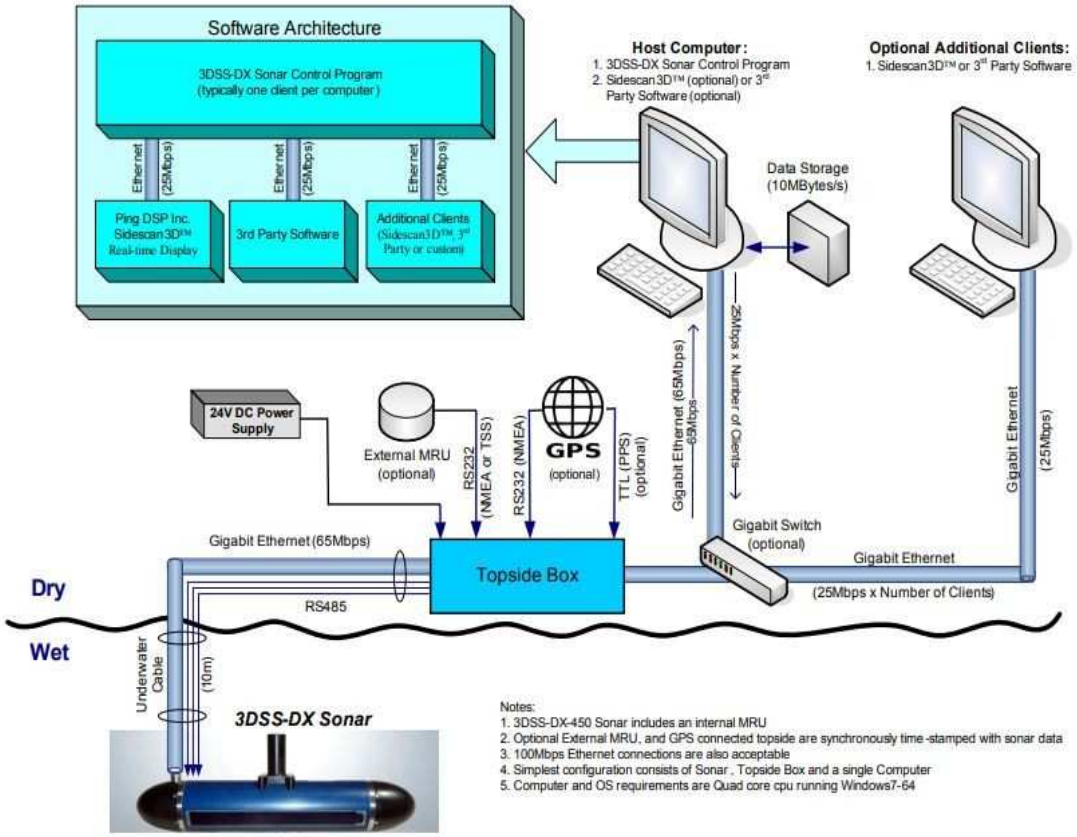
Sonar Systems - Norbit iWBMS

System Features	Specifications
Operating Frequency	Nominal 400kHz (selectable 200 – 700kHz)
Swath Coverage	0.5º - 210º Flexible selector
Range Resolution	<10mm Acoustic w. 80kHz bandwidth
Number of Beams	256 – 512 (1024 HDS) EA & ED
Ping Rate	Up to 60Hz, Adaptive
Depth Range	0.2-275m (>300m with 0.9ºx0.9º option)
Resolution (Across & Along Track)	0.9ºx0.9º @400kHz & 0.5ºx1.0º @700kHz.
Heading	0.03º (RTK) with 2m antenna separation
Roll and Pitch	0.02º Independent of antenna separation
Heave	2cm or 2% (true heave), 5cm or 5% (real-time)

Survey Setup

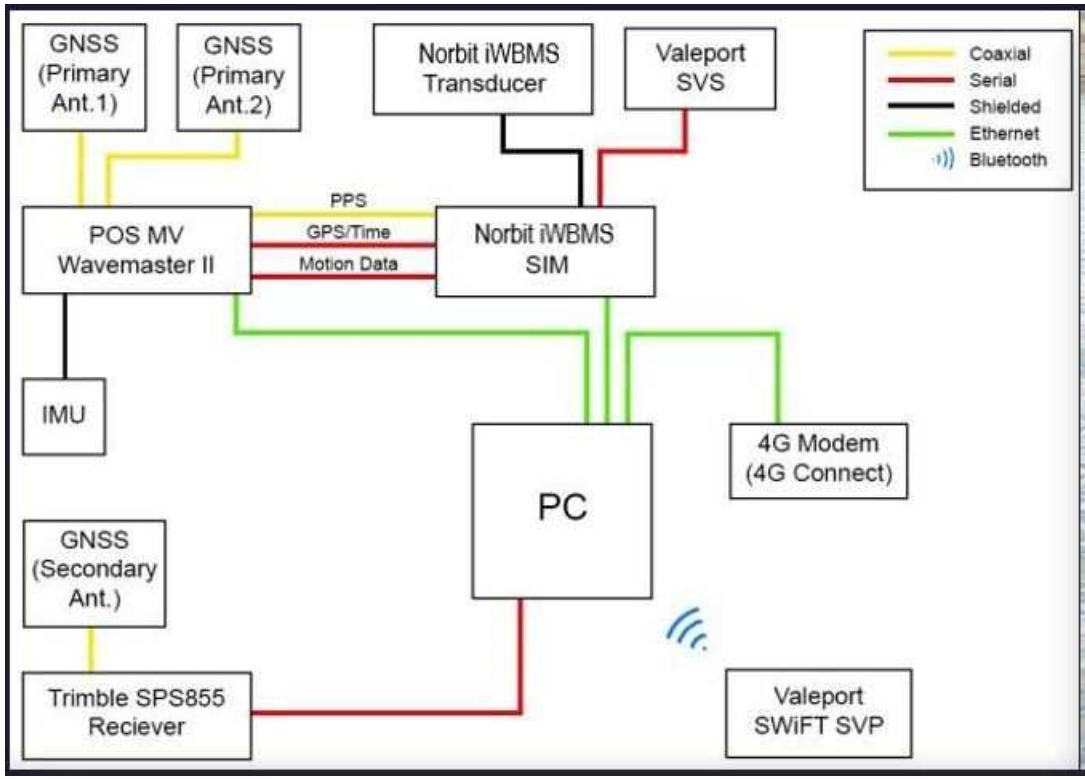
Yellow Pig USV (for 3DSS-IDX-450)





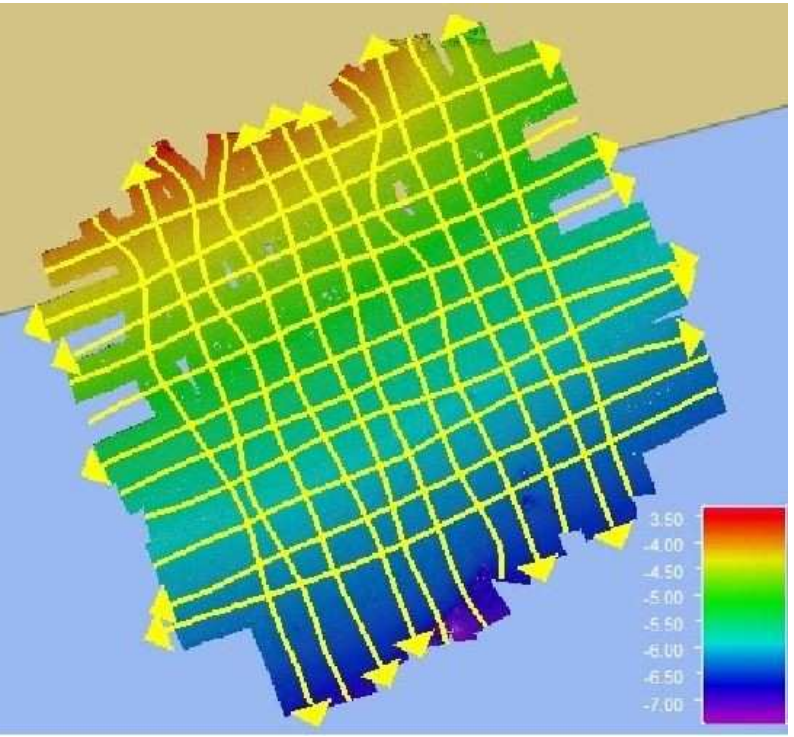
Survey Setup

Falcon Spirit (vessel for Norbit iWBMS)

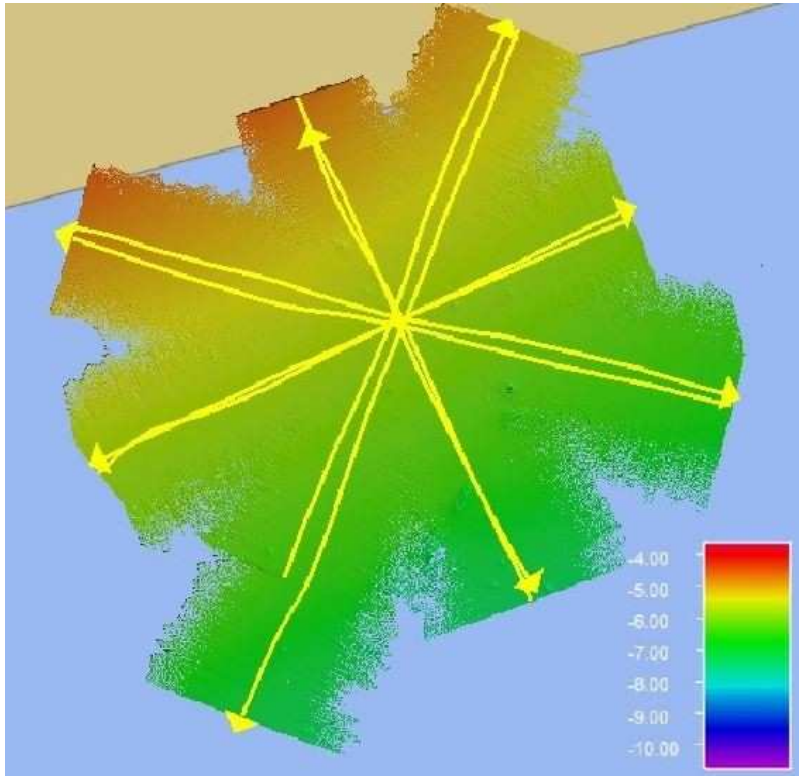


Data Collection - Bathymetric Uncertainty Test

A patch test was performed to detect multibeam transducer mounting angle errors relating to the MRU (and thus the vessel)



- Reference surface survey with grid lines perpendicular to shore and shore-parallel lines for cross-checking

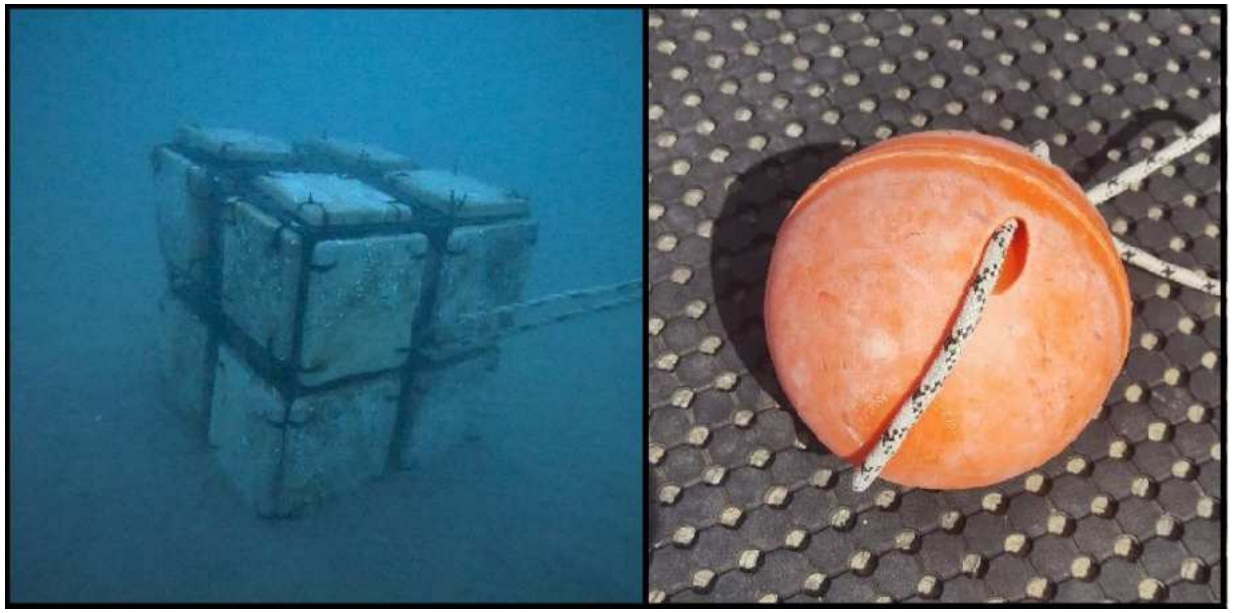


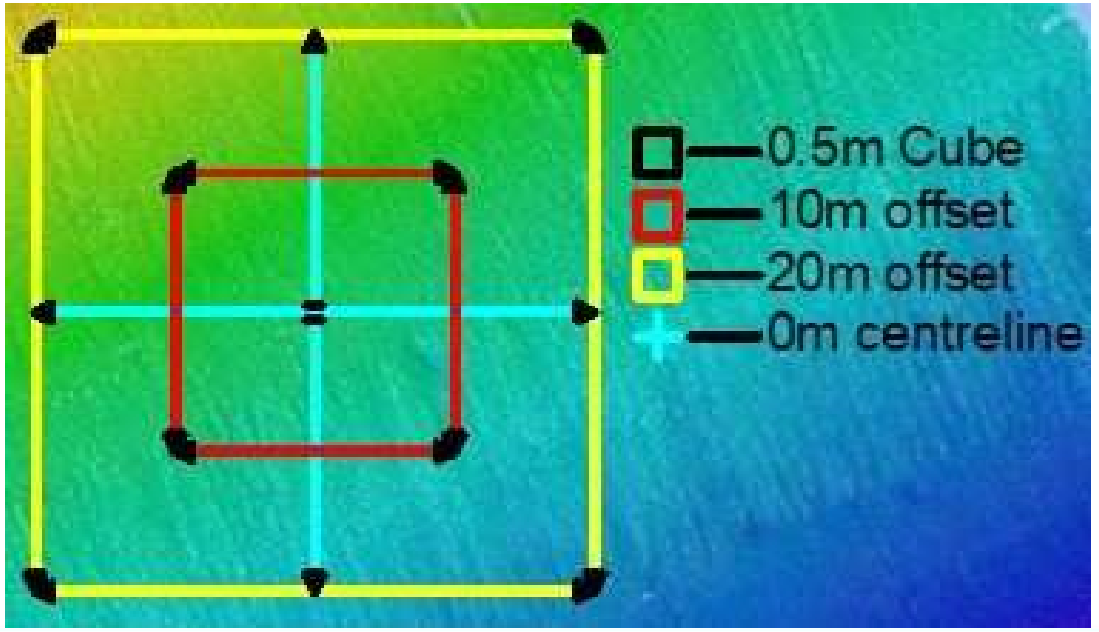
- Data for the bathymetric uncertainty tests was collected using a ‘star pattern’ across this high-resolution reference area to minimize the impact of wave motion on the dataset.

Data Collection - Object Detection Survey

- Object detection survey was planned around a pre-calibrated 0.5m cubic seabed target and a circular midwater object (0.65m in circumference) placed within a 15m radius of the cube

- This is to test the ability of both sonars to detect the object at the nadir (0^0-20^0), 10m (mid-swath 30^0-60^0) and 20m (outer swath 70^0-80^0) away from the object.





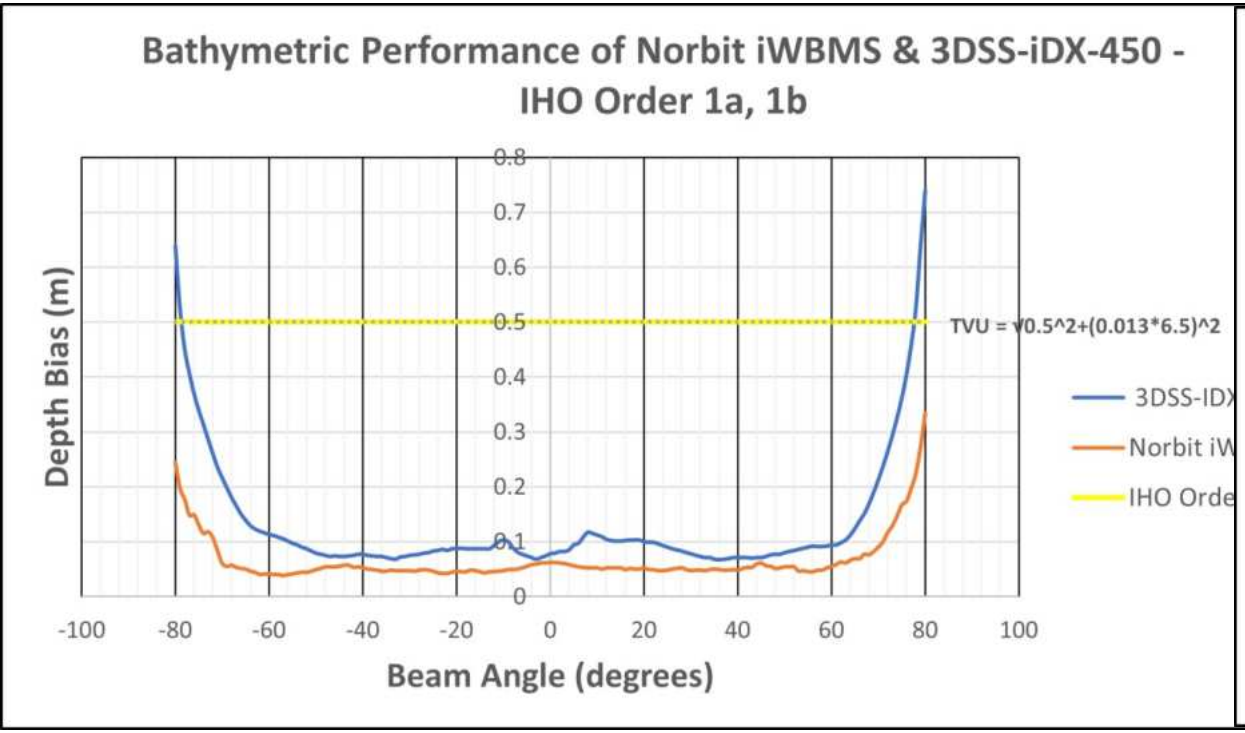
Data Processing

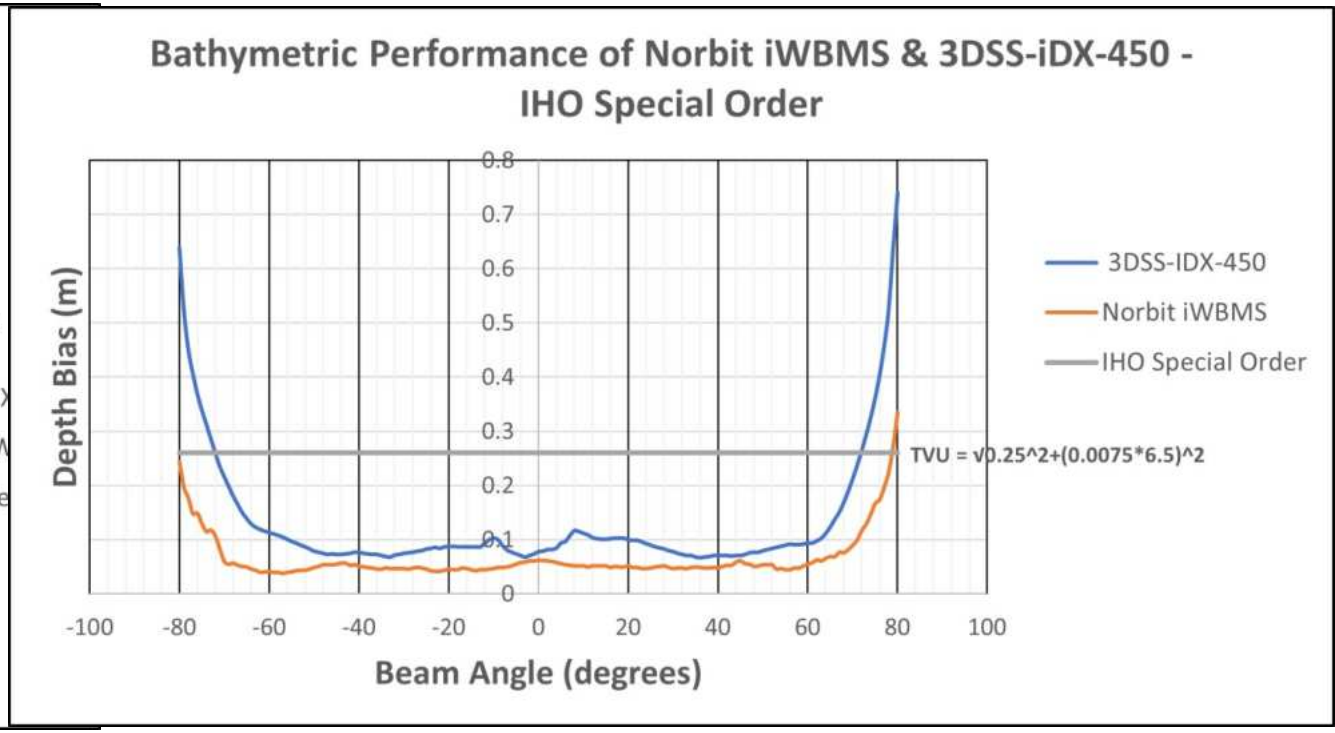
Data structuring and cleaning

Reference surface and cross-line analysis for bathymetric uncertainty

Object detection analysis (3D Editor, profile tool

Results - Bathymetric uncertainty comparison (IHO Order compliance)





Results - Bathymetric uncertainty comparison (Cross Check Statistics)

IHO Order 1 Statistics

Norbit iWBMS

Statistic	Value
Order 1 Error Limit	0.504947
Order 1 # Rejected	179
Order 1 P-Statistic	7.31914e-05
Order 1 Test	ACCEPTED
Number Of Points	2445643
Grid Cell Size	0.250
Difference Mean	0.011
Difference Median	0.010
Difference Std. Dev	0.034
Difference Range	[-1.159, 1.180]
Mean + 2*Stddev	0.078
Median + 2*Stddev	0.077
Data Mean	-5.413
Reference Mean	-5.424
Data Z-Range	[-7.406, -3.389]
Reference Z-Range	[-7.433, -3.637]

3DSS-IDX-450

Statistic	Value
Order 1 Error Limit	0.504903
Order 1 # Rejected	108466
Order 1 P-Statistic	0.0180014
Order 1 Test	ACCEPTED
Number Of Points	6025422
Grid Cell Size	0.500
Difference Mean	0.119
Difference Median	0.080
Difference Std. Dev	0.139
Difference Range	[-2.038, 1.994]
Mean + 2*Stddev	0.397
Median + 2*Stddev	0.358
Data Mean	-5.280
Reference Mean	-5.400
Data Z-Range	[-8.472, -3.043]
Reference Z-Range	[-6.768, -3.606]

IHO Special Order Statistics

Norbit IWBMS

Statistic	Value
Special Order Error Limit	0.253288
Special Order # Rejected	2704
Special Order P-Statistic	0.00110564
Special Order Test	ACCEPTED
Number Of Points	2445643
Grid Cell Size	0.250
Difference Mean	0.011
Difference Median	0.010
Difference Std. Dev	0.034
Difference Range	[-1.159, 1.180]
Mean + 2*Stddev	0.078
Median + 2*Stddev	0.077
Data Mean	-5.413
Reference Mean	-5.424
Data Z-Range	[-7.406, -3.389]
Reference Z-Range	[-7.433, -3.637]

3DSS-IDX-450

Statistic	Value
Special Order Error Limit	0.253259
Special Order # Rejected	949034
Special Order P-Statistic	0.157505
Special Order Test	REJECTED
Number Of Points	6025422
Grid Cell Size	0.500
Difference Mean	0.119
Difference Median	0.080
Difference Std. Dev	0.139
Difference Range	[-2.038, 1.994]
Mean + 2*Stddev	0.397
Median + 2*Stddev	0.358
Data Mean	-5.280
Reference Mean	-5.400
Data Z-Range	[-8.472, -3.043]
Reference Z-Range	[-6.768, -3.606]

Results - Object Detection (Bathymetric Repeatability)

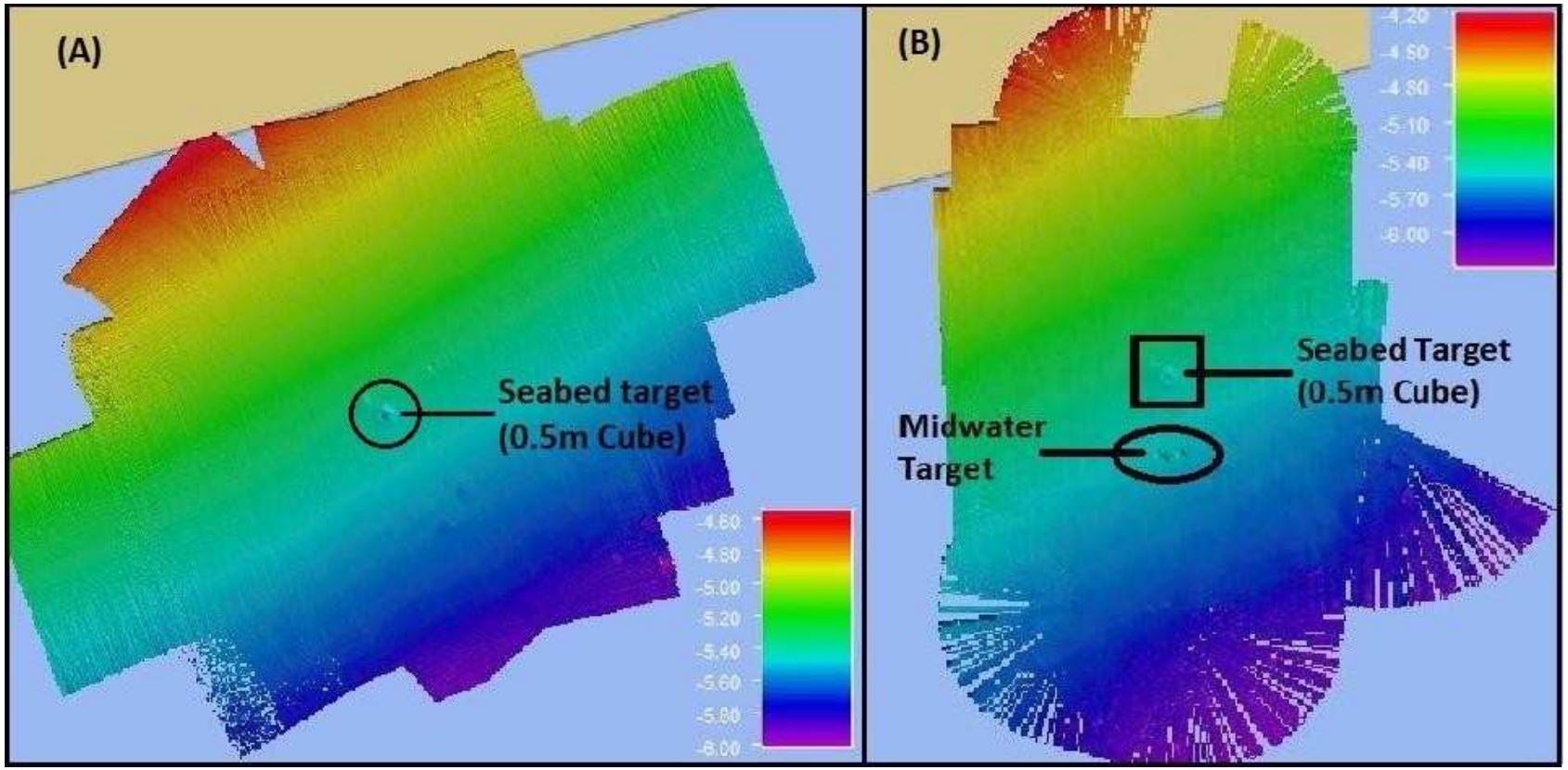
NORBIT	Nadir (0m - Over Target)			10m offsets			20m offsets		
Elements	E	N	Z	E	N	Z	E	N	Z
Average	415702.162	5576939.741	-5.218	415702.098	5576939.641	-5.211	415702.096	5576939.583	-5.221
StdDev	0.276	0.357	0.095	0.224	0.390	0.079	0.276	0.293	0.121
Minimum	415701.648	5576939.202	-5.543	415701.611	5576939.04	-5.517	415701.504	5576939.012	-5.499
Maximum	415702.92	5576940.442	-5.047	415702.704	5576940.488	-4.989	415702.887	5576940.229	-4.969
Total Hits	178			291			130		

3DSS-IDX-450	Nadir (0m - Over Target) - 3D			10m offsets - 3D			20m offsets - 3D
Elements	E	N	Z	E	N	Z	
Average	415702.417	5576939.701	-5.0998	415702.164	5576940.128	-5.412	
StdDev	0.348	0.320	0.089	0.240	0.368	0.171	
Minimum	415701.536	5576938.921	-5.594	415701.725	5576939.08	-5.641	No hits
Maximum	415702.346	5576940.592	-4.905	415702.769	5576940.477	-5.006	
Total Hits	83			861			

3DSS-IDX-450	Nadir (0m - Over Target) - MB			10m offsets - MB			20m offsets - MB		
Elements	E	N	Z	E	N	Z	E	N	Z
Average	415702.385	5576939.812	-5.214	415702.163	5576939.947	-5.391	415702.054	5576939.991	-5.390
StdDev	0.381	0.322	0.064	0.287	0.362	0.145	0.264	0.299	0.151
Minimum	415701.631	5576939.253	-5.34	415701.5	5576939.164	-5.677	415701.502	5576939.5	-5.594
Maximum	415702.581	5576940.42	-5.083	415702.45	5576940.102	-5.103	415702.543	5576940.738	-5.072
Total Hits	61			334			205		

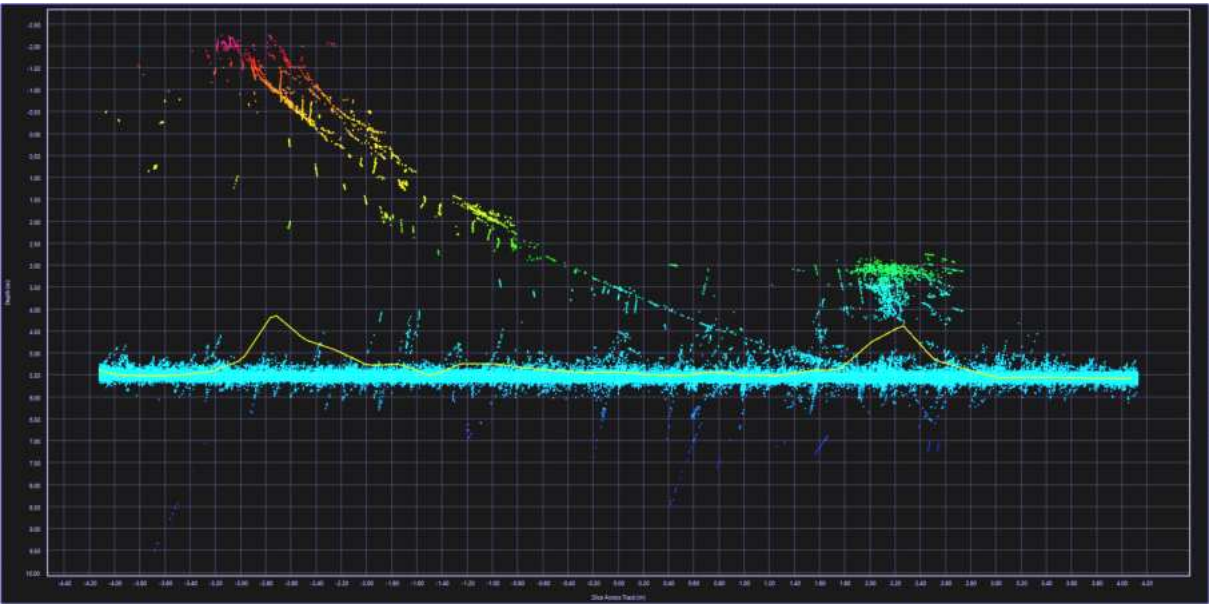
Components	Em	Nm
Known Coord. (A)	415702.000	5576940
Norbit 0m (B)	415702.162	5576939.741
Norbit 10m (C)	415702.098	5576939.641
Norbit 20m (D)	415702.096	5576939.583
3DSS 0m -3D (E)	415702.417	5576939.701
3DSS 10m -3D (F)	415702.164	5576940.128
3DSS 0m -MB (G)	415702.385	5576939.812
3DSS 10m -MB (H)	415702.163	5576939.947
3DSS 20m -MB (I)	415702.054	5576939.991
	ΔEm	ΔNm
Norbit 0m (A-B)	-0.162	0.260
Norbit 10m (A-C)	-0.098	0.359
Norbit 20m (A-D)	-0.096	0.417
3DSS 0m -3D (A-E)	-0.417	0.299
3DSS 10m -3D (A-F)	-0.164	-0.128
3DSS 0m -MB (A-G)	-0.385	0.188
3DSS 10m -MB (A-H)	-0.163	0.053
3DSS 20m -MB (A-I)	-0.054	0.009

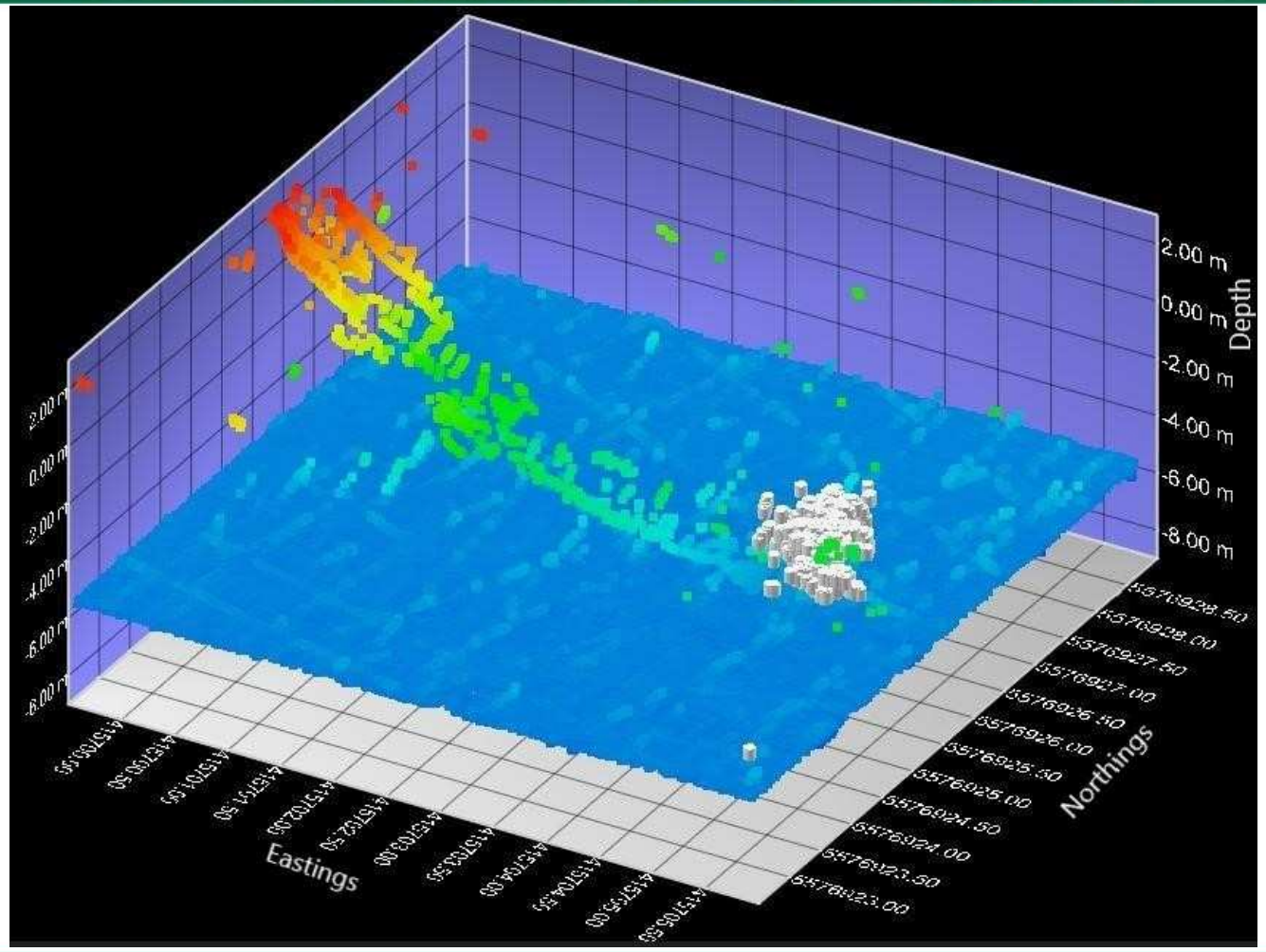
Results - Object Detection (Bathymetric Repeatability)



Sonar	E (95% CL)	N (95% CL)
Norbit iWBMS	0.029 m	0.062 m
3DSS-IDX-450 3D	0.120 m	0.203 m
3DSS-IDX-450 MB	0.103 m	0.072 m

Object Detection (Mid-water Target) 2D & 3D





Conclusion – Bathymetry

The Ping DSP's 3DSS- IDX-450 Sonar produces bathymetric soundings comparable to an ideal multibeam sonar without sidelobes, beam spreading, or asymmetrical beam sensitivity inherent in traditional beam steering systems.

3DSS- IDX-450 Sonar has demonstrated its ability to meet the TVU and THU standards of IHO Order 1 and Special Order (within 20^0-140^0 swath).

Delivers high-sounding densities and 3D imagery together with bathymetric data.

The patented CAATI and 3DSS MBES engine have been seen to overcome many of the limitations inherent in traditional interferometric systems, achieving an overall depth uncertainty of 0.110m (95% c.l.) compared to Norbit iWBMS with 0.042m on a shallow seabed.

Conclusion – Object Detection

The 3DSS-IDX-450 Sonar was highly efficient (100%) in distinguishing the midwater target, including the mooring cable and the anchor, which is one of its primary capabilities.

During this testing, the 3D side scan sonar could effectively detect seabed targets in shallow water (2– 6.5m depth below CD).

The CAATI design provided low shadow signal levels in areas with multipath existence for the MBES data, allowing the seabed target to be identified.

Seabed objects within the study area were identifiable and distinguishable based on their highlights.

Thank you

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