Comparing sonar suitability for AUV obstacle avoidance

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By introducing the ability to detect and avoid obstacles in real-time, operators can expand the use of Autonomous Underwater Vehicles (AUVs) while minimizing risk to vehicles, personnel, and undersea infrastructure.

We present the use of small, low resource mechanically scanned single beam sonars to accomplish this objective. Our team has previously demonstrated the integration of an Impact Subsea mechanically scanned ISS360 sonar onto a REMUS 100 vehicle and utilized a basic obstacle avoidance method [1]. This poster presents a stand-alone comparison of the new ISS360HD with the original ISS360 and its suitability to the AUV obstacle avoidance problem

Fig 1: ISS360

Table 1: ISS360HD and ISS360 Specs[2]

ISS360		ISS360HD
600 to 900kHz	Frequency Range	600 to 900kHz
90m	Max Range	100m
23˚	Vertical	30˚
2.2˚	Horizontal	1.0˚
95 mA @ 24V	Standby Power	84 mA @ 24V
240 mA @ 24V	Scanning Power	261 mA @ 24V
43 mm	Major Diameter	114mm

Fig 2: ISS360HD

Methods

The units were evaluated by taking scans using different operating modes at locations under and around the WHOI pier. For each location, multiple underwater features at a variety of ranges were opportunistically selected as "targets" and matched with the corresponding sonar return. Relative performance of the two units were evaluated on metrics including:

- Signal to Noise ratio
- Average target strength
- Average noise level
- Overall average intensity
- Level of sensor saturation

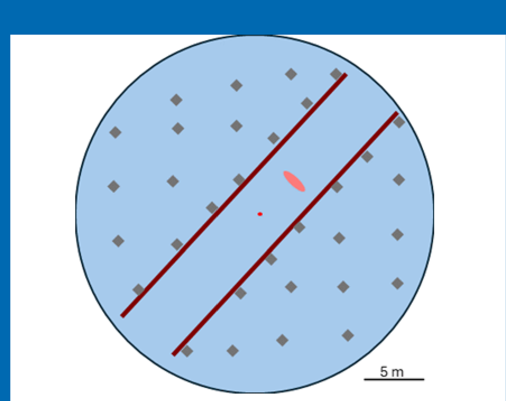


Figure 3a: Below WHOI pier with wooden walls, concrete pilings and a suspended net

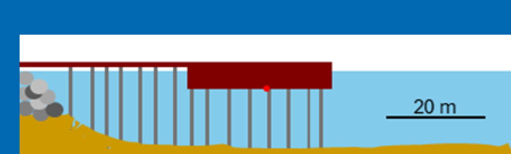


Figure 3b: Below WHOI pier with wooden walls, concrete pilings, and a sloping seabed

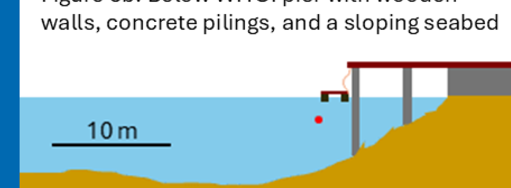


Figure 3c: Shallow seabed beside the pier with a floating dock above

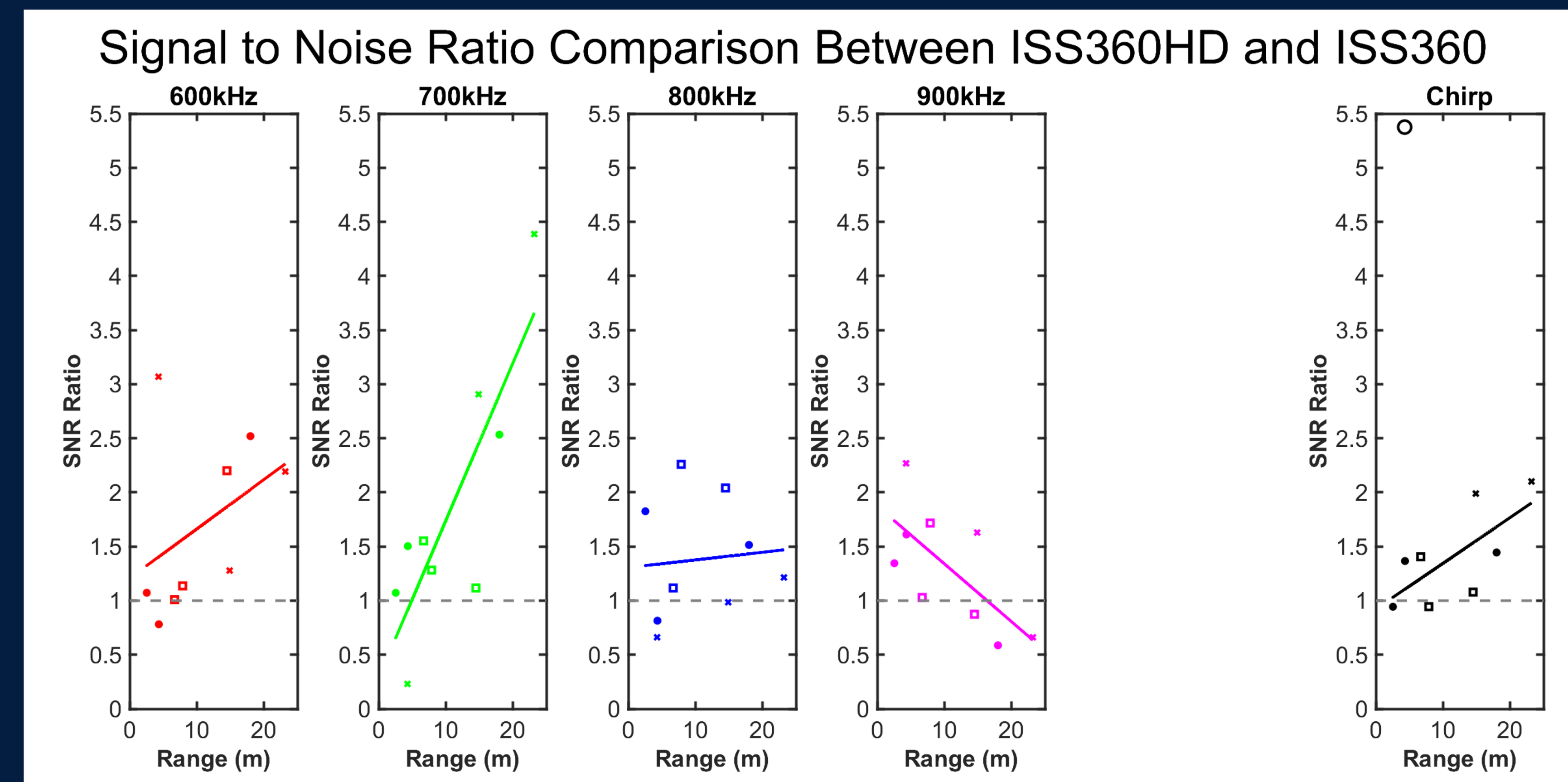
Acknowledgements

We would like to thank Impact Subsea for their ongoing support of our work and for generously loaning us an ISS360HD unit to test with. Additionally, we would like to thank to other members of OSL who provided valuable input and technical support. Lastly, Prof. Ken Foote for numerous consultations on acoustic analysis methods.

References

[1] N. McGuire, S. Whelan, S. Seeberger, C. Fiester, and J. W. Kaeli, "Obstacle avoidance pipeline for a REMUS 100 using an ISS360 sonar," inOCEANS 2021: San Diego – Porto, pp. 1–5
[2] "ISS360 - AUV & ROV Sonar." Impact Subsea, www.impactsubsea.co.uk/iss360-imaging-sonar.

The ISS360HD provides **significant improvements in SNR**, particularly **at longer ranges** and **lower frequencies.**



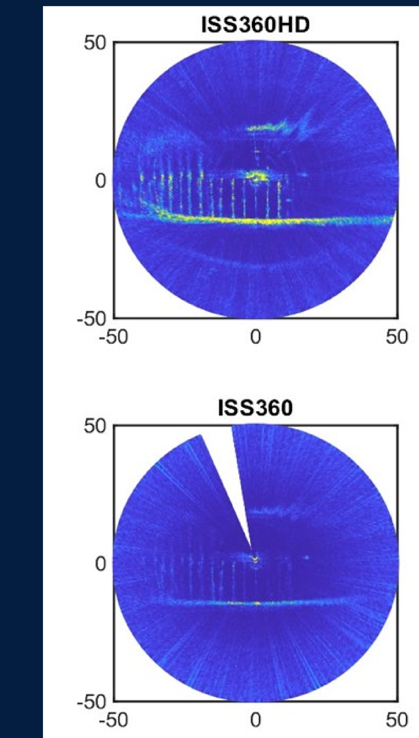


Figure 5: 600kHz example of the ISS360HD showing increased performance over the ISS360

AUVs operating at **higher speeds** or with **larger turning radiuses**, such as the REMUS vehicles, would **benefit from the ISS360HD**.

Why does this matter?

Path Planning

Mechanically scanning sonars take several seconds to complete a 360° scan. Higher intensity and SNR at greater distances provides greater reaction time. Vehicles with greater minimum detection radiuses will benefit from or require the ISS360HD for sufficient time to act.

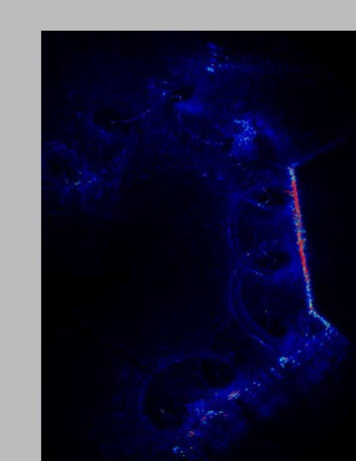


Figure 6: Reconstruction of sonar data from obstacle avoidance testing

AUV Design

While both units use an order of magnitude less power than other sonar systems, understanding when the ISS360HD performance is beneficial allows AUVs to save on power and drag when an ISS360 is sufficient.

What next?

We aim to build off our previous successful obstacle avoidance with the ISS360 on a REMUS 100 [1]. This includes:

- Applying computer vision to extract more detail about obstacles from the sonar return
- Developing advanced path planning algorithms which reflect vehicle limitations and dynamics
- Developing a dataset of ISS360 sonar images of common obstructions

Questions? Please ask us!

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Appendix

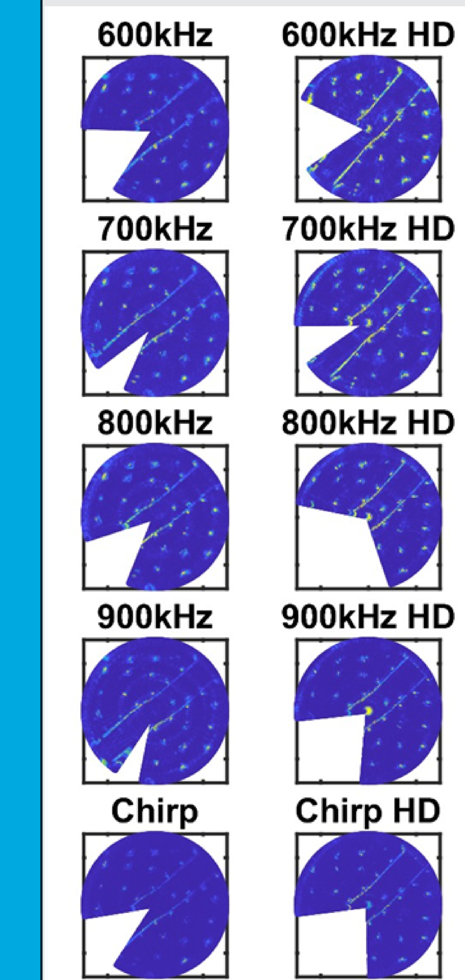

Figure A1: Sonar data looking horizontally underneath the WHOI pier out to 15m

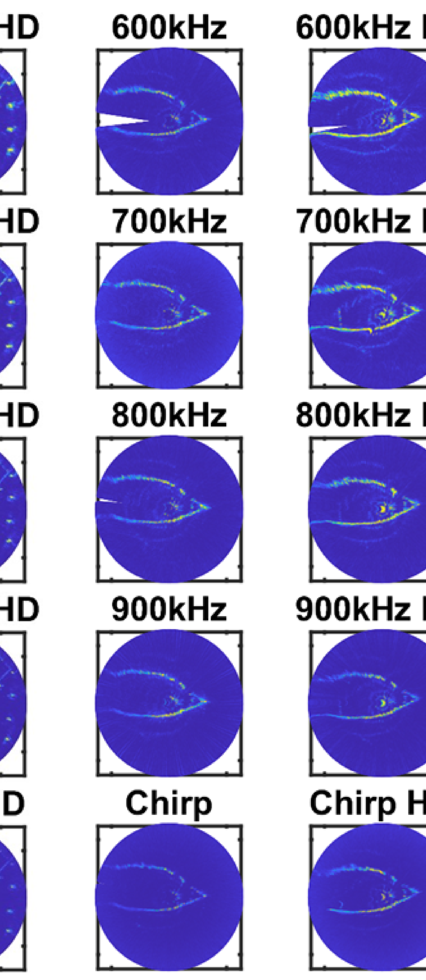

Figure A2: Sonar data looking at a shallow seabed below a floating dock out to 25m

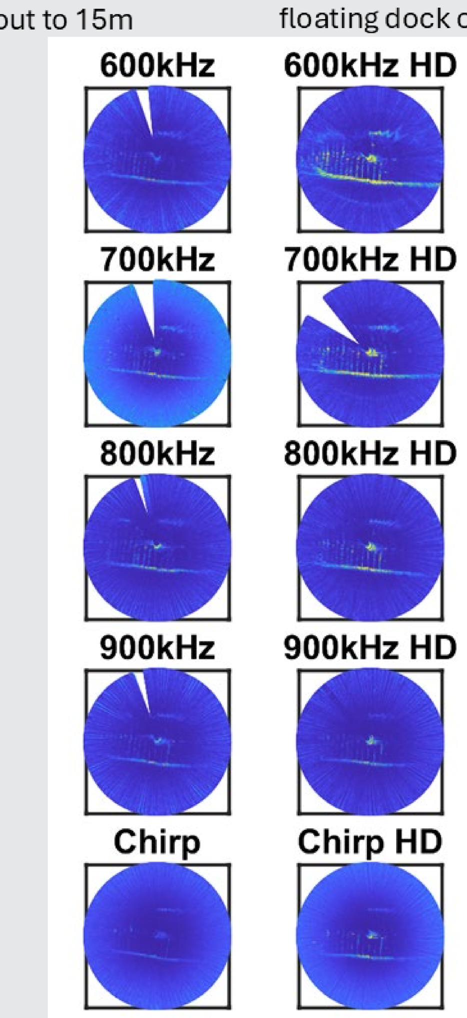

Figure A3: Sonar data looking vertically underneath the WHOI pier out to 50m

Table A1: ISS360HD relative comparison data across all trials

	600kHz	700kHz	800kHz	900kHz	Chirp
Average Intensity					
Location 1	2.005	1.283	1.423	1.144	1.616
Location 2	1.758	0.783	1.236	0.979	1.410
Location 3	2.262	1.546	1.351	1.258	1.812
Average	2.008	1.204	1.336	1.127	1.613
Percent Saturated					
	600kHz	700kHz	800kHz	900kHz	Chirp
Location 1	4.685	2.561	2.446	1.682	4.053
Location 2	16.246	6.597	3.465	3.731	4.494
Location 3	7.414	4.079	2.483	3.194	8.204
Average	9.449	4.412	2.798	2.869	5.584
Noise Level					
	600kHz	700kHz	800kHz	900kHz	Chirp
Target 1	2.013	0.864	1.397	0.676	1.148
Target 2	0.991	0.922	0.745	0.643	1.218
Target 3	1.150	0.729	0.988	0.774	1.326
Target 4	1.154	0.550	1.150	0.754	1.120
Target 5	1.230	0.421	1.086	0.842	1.286
Target 6	3.332	3.931	2.820	0.667	1.418
Target 7	2.061	1.284	1.240	0.842	1.164
Target 8	1.565	1.066	0.463	0.369	1.215
Target 9	1.271	1.240	1.126	2.267	1.001
Average	1.641	1.223	1.224	0.870	1.211
Target Strength					
	600kHz	700kHz	800kHz	900kHz	Chirp
Target 1	1.573	1.299	1.138	1.089	1.569
Target 2	1.063	0.988	0.921	0.841	1.149
Target 3	2.897	1.847	1.048	0.859	1.915
Target 4	1.475	1.600	1.132	1.228	2.227
Target 5	2.697	1.846	1.318	0.557	2.703
Target 6	10.226	0.906	1.865	1.513	7.624
Target 7	2.080	1.993	1.385	0.867	1.635
Target 8	1.779	1.366	1.045	0.633	1.146
Target 9	2.796	1.384	2.297	1.981	1.080
Average	2.954	1.470	1.350	1.063	2.339
Signal to Noise Ratio					
Ranges (Target #)	600kHz	700kHz	800kHz	900kHz	Chirp
2.55 (#2)	1.072	1.072	1.826	1.345	0.944
4.3 (#6)	3.069	0.230	0.661	2.268	5.376
4.35 (#1)	0.781	1.503	0.815	1.611	1.366
6.7 (#7)	1.009	1.552	1.117	1.029	1.405
7.9 (#8)	1.137	1.282	2.259	1.716	0.944
14.5 (#9)	2.200	1.117	2.041	0.873	1.079
14.9 (#4)	1.278	2.906	0.985	1.629	1.989
18.0 (#3)	2.520	2.534	1.515	0.587	1.445
23.2 (#5)	2.193	4.387	1.214	0.661	2.101