Antenna design to improve AUVs Docking Process

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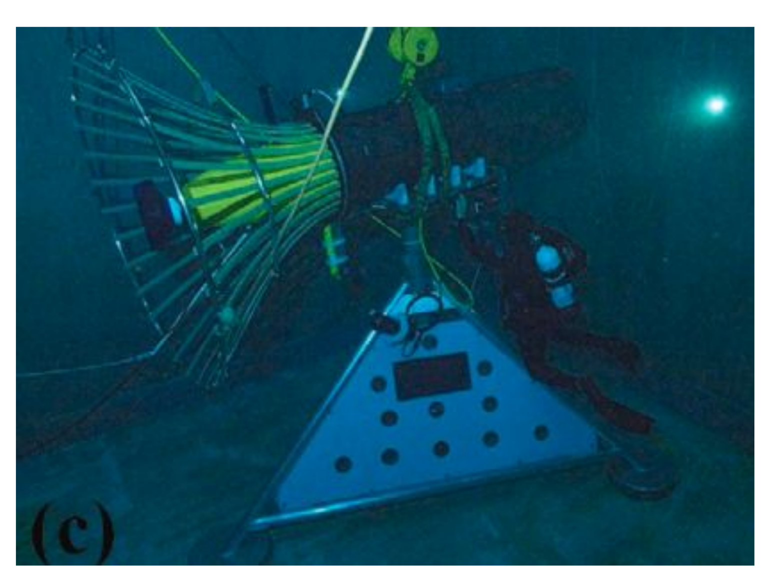
Background

- Oceans cover 70% of the Earth, but they remain under-explored.
- Autonomous underwater vehicles (AUVs) are among the most versatile and recent technologies developed to aid human exploration of the ocean [1].
- However, AUVs cannot perform prolonged underwater operations due to various technological difficulties. The main obstacle to developing underwater vehicles for prolonged underwater projects is the lack of technology to design stable docking stations where AUVs can charge and exchange information [2].
- The docking procedure consists of several steps, including localization, charging, and more. One of the most crucial aspects of this process is wireless data exchange. The current data exchange process requires a very accurate location of AUVs, which creates many potential reasons for failure.
- Effective antenna design can improve the data exchange process, simplifying the stringent requirements for docking, which ultimately leads to higher success rates in docking.

Some examples of AUVs and docking stations



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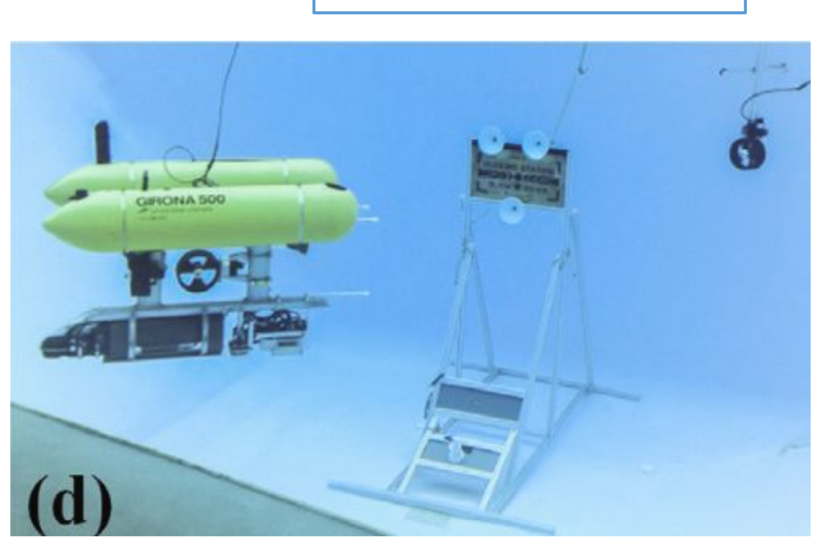

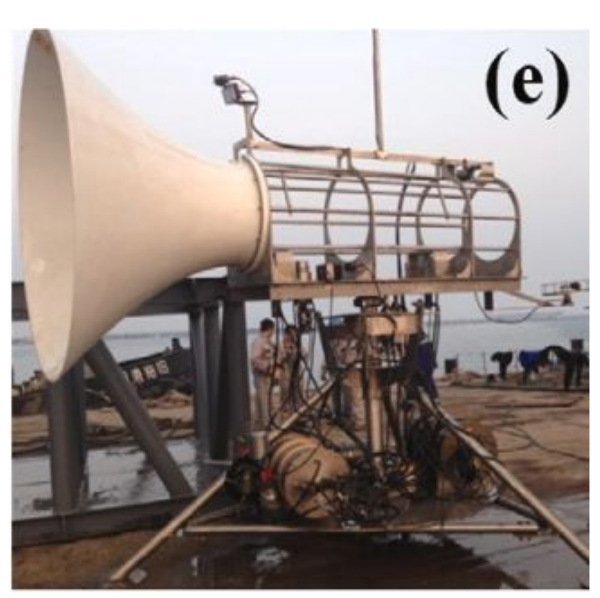

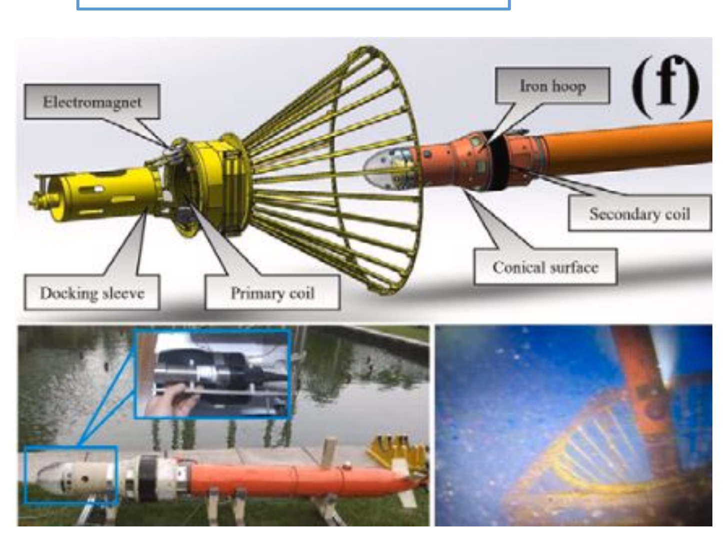

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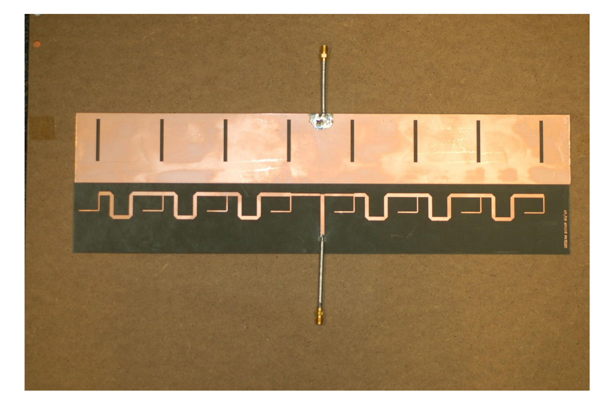
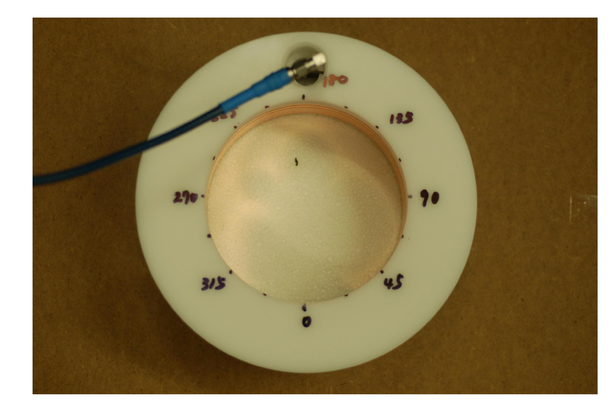
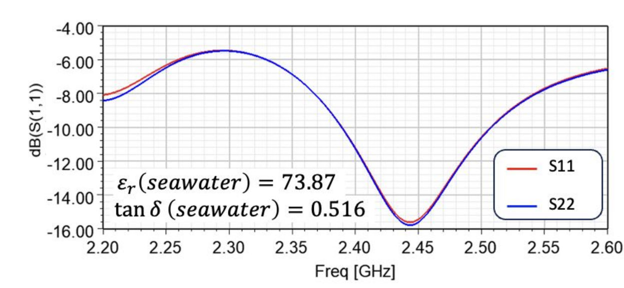
Two types of antennas simulated, designed and manufactured to improve the docking process

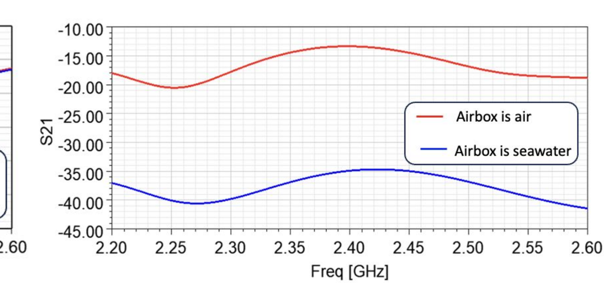
2.4GHz WiFi Antenna to allow AUVs to dock with any orientations

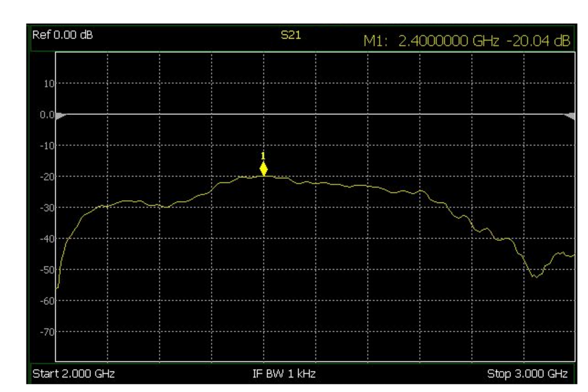


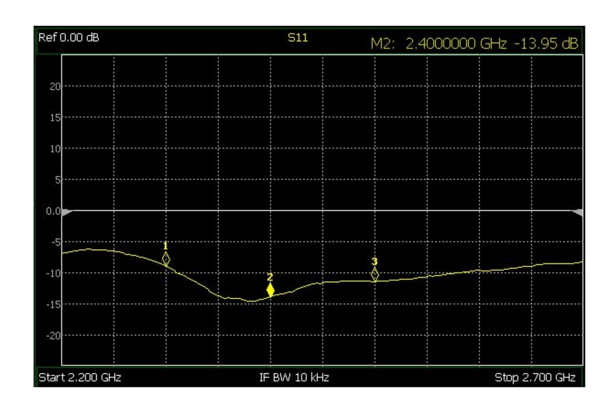


Out-of-line series feed slot antenna and wrapped around a station



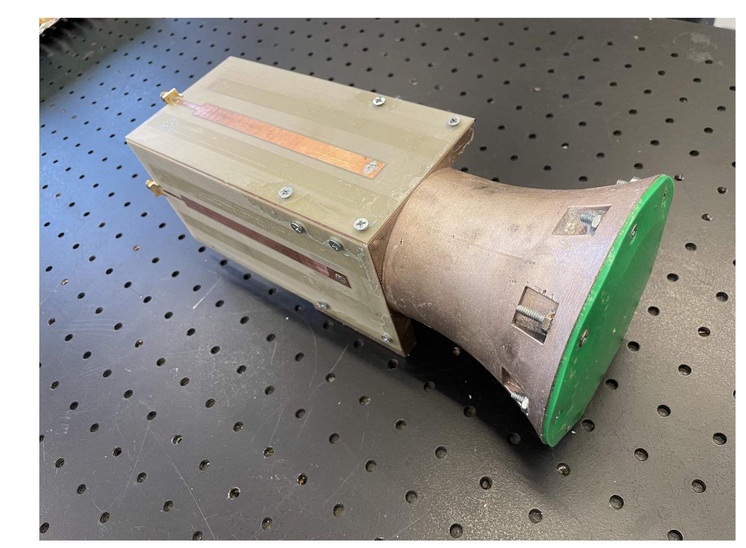


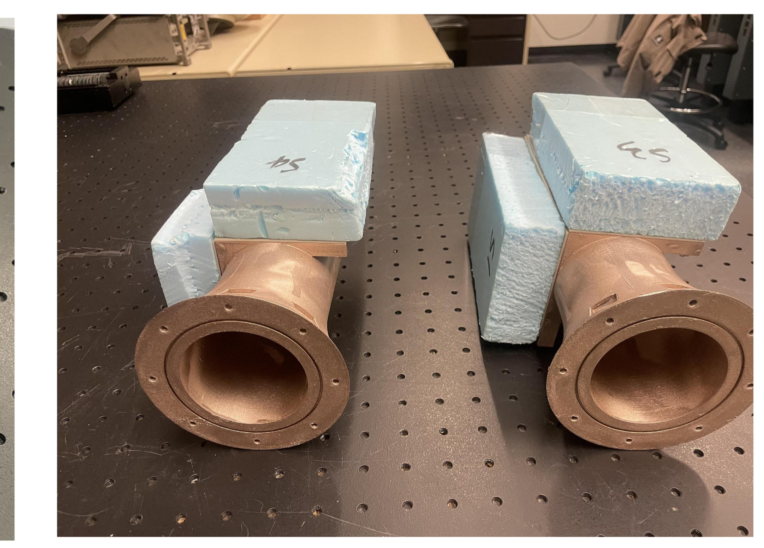




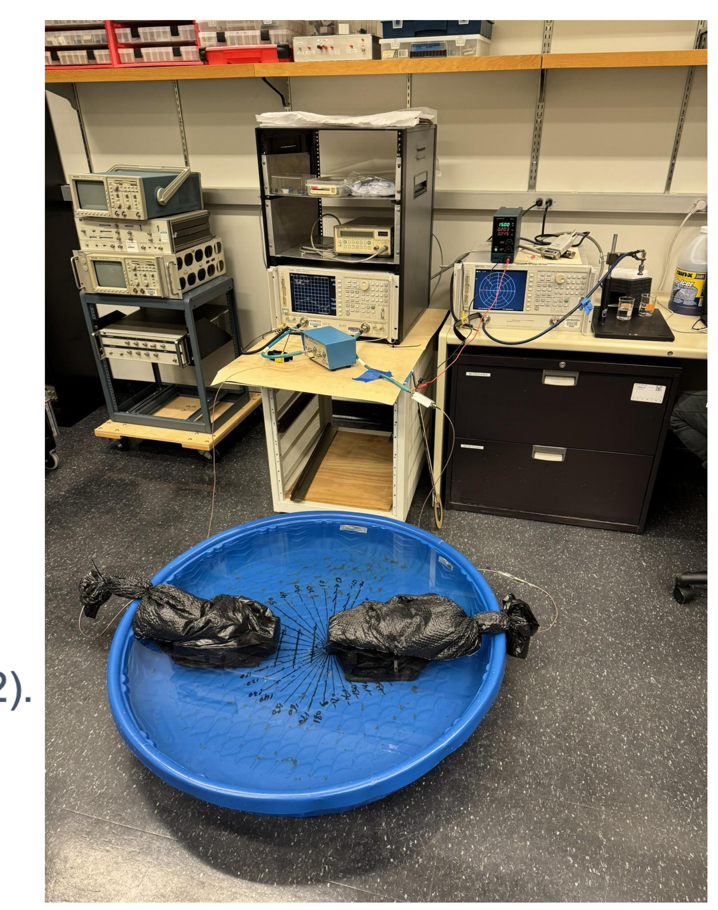
- The reflection coefficient of each antenna is measured (S11&S22).
- The transmission coefficient (S21) is measured in both air and seawater.
- The seawater is modeled by Debye's formula[3].
- 2cm seawater introduces about -20dB loss.
- The angle coverage, S11, and S21 are also measured through experiments, and the results are matched with the simulations.
- S21 is large enough in a range of 260°.

300 MHz waveguide antenna to enable AUVs to dock at greater distances from the docking station.



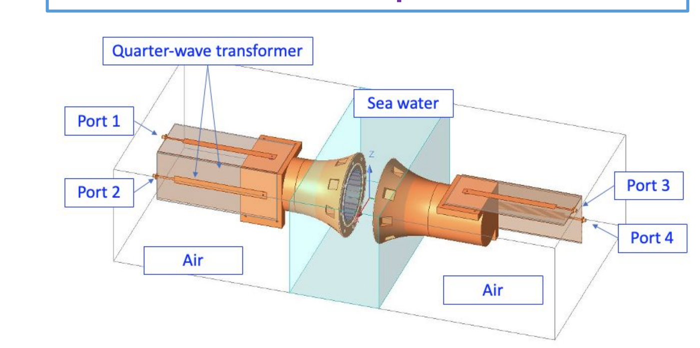


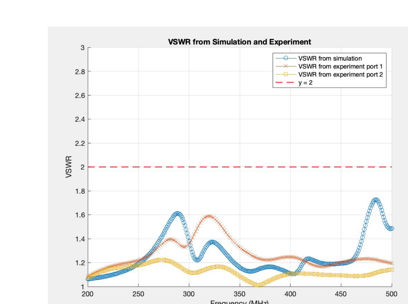
Antennas manufactured for underwater communication

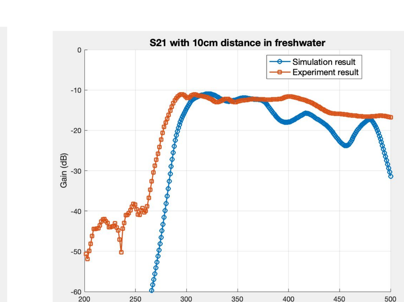


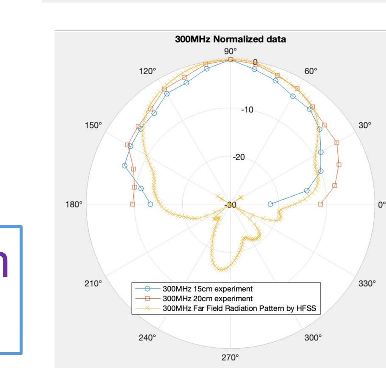
Experiment setup: measure S21 in a salted water environment.

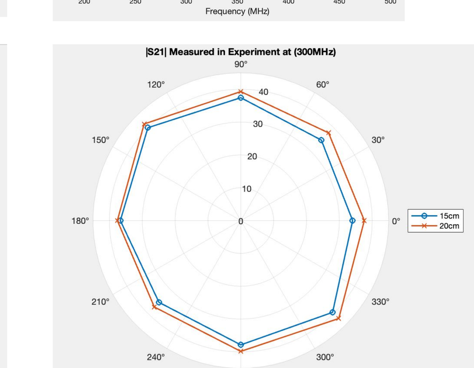
Simulation setup and results











References, and Acknowledgments

[1] T. Podder, M. Sibenac, and J. Bellingham, "Auv docking system for sustainable science missions," in IEEE International Conference on Robotics and Automation, 2004. Proceedings. ICRA'04. 2004, vol. 5. IEEE, 2004, pp. 4478–4484.
[2] N. A. Cruz, A. C. Matos, R. M. Almeida, and B. M. Ferreira, "A lightweight docking station for a hovering auv," in 2017 IEEE Underwater Technology (UT). IEEE, 2017, pp. 1–7.
[3] F. T. Ulaby, R. K. Moore, and A. K. Fung, "Microwave remote sensing: Active and passive. volume 1-microwave remote sensing fundamentals and radiometry," 1981.

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