FY24 Strategic Initiatives Research and Technology Development (SRTD)

Technology Development for Next Generation Ocean World Geodesy: Enceladus

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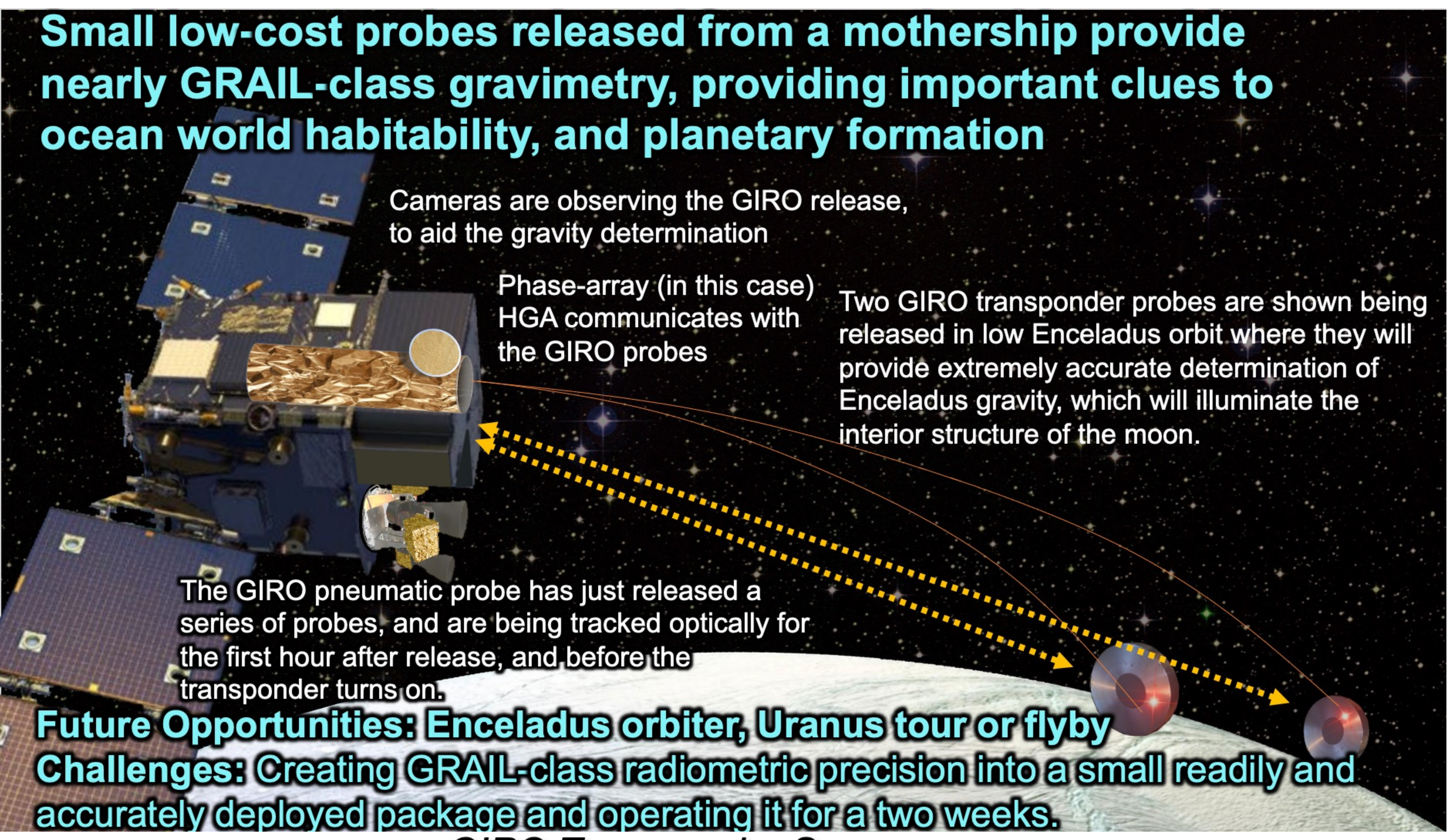
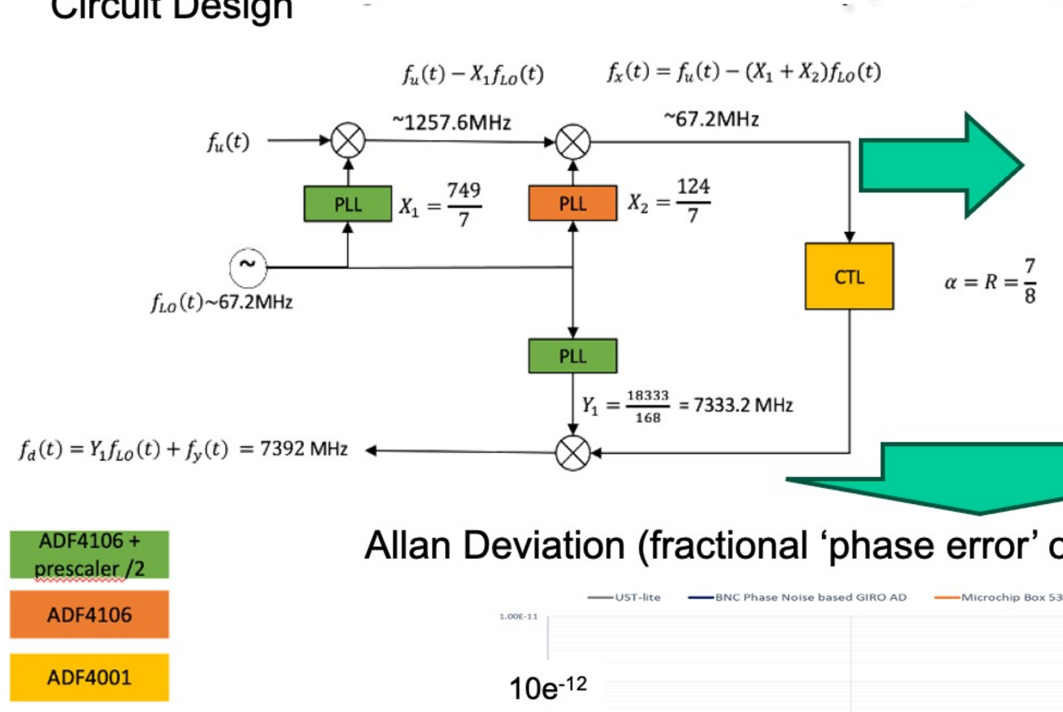
Strategic Focus Area: Next-Generation Ocean World Geodesy: Enceladus | **Strategic Initiative Leader:** Steve Vance

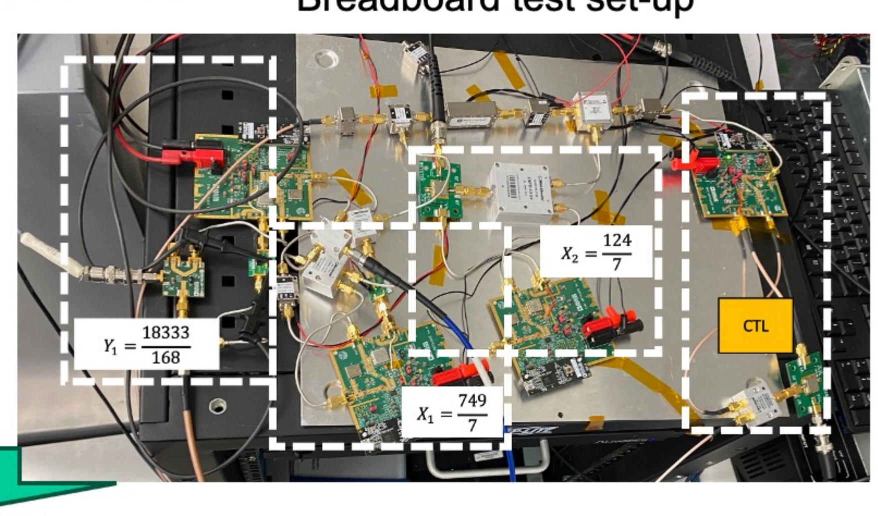


GIRO Transponder Success

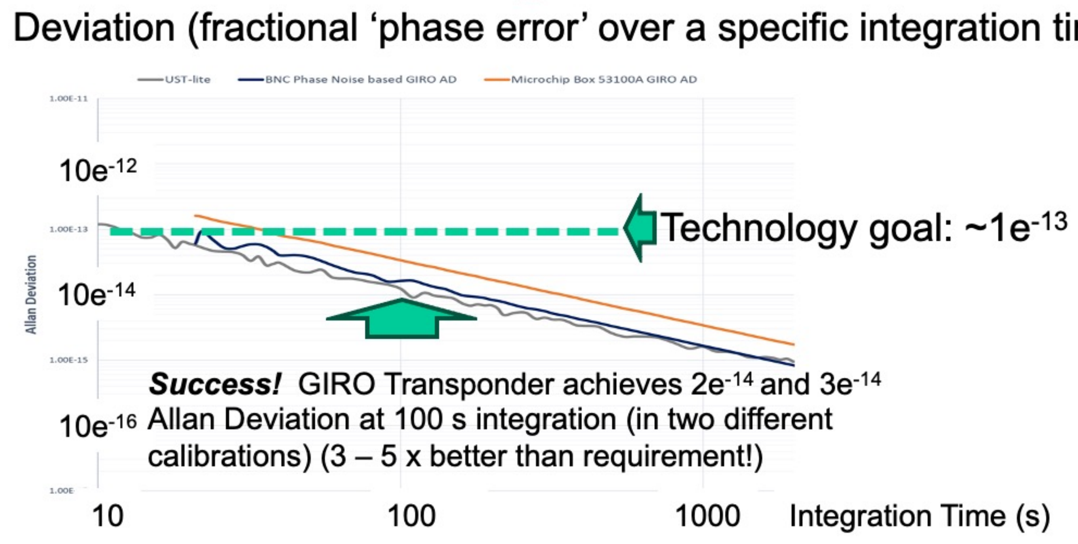
Circuit Design



Breadboard test set-up



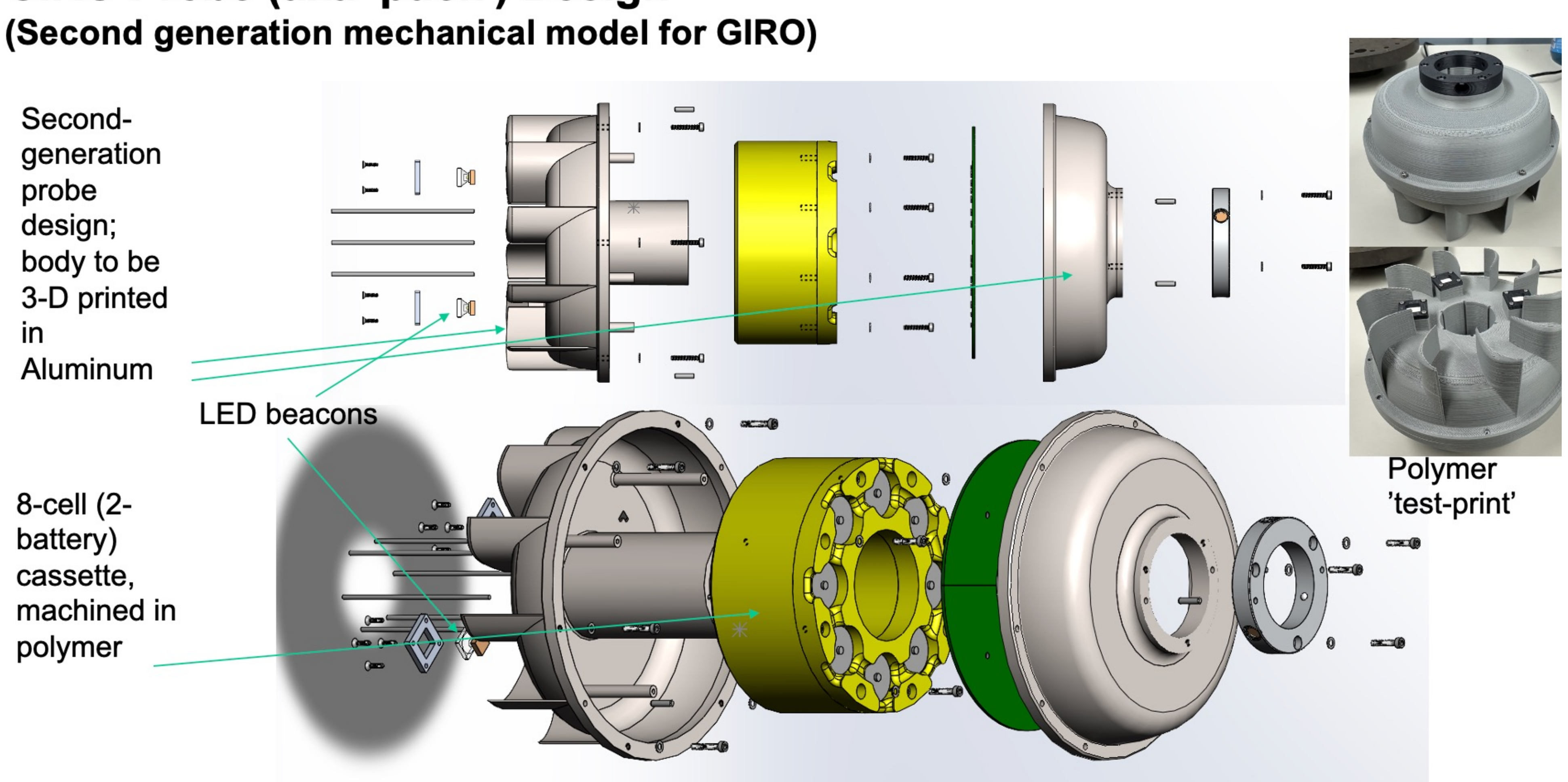
Allan Deviation (fractional 'phase error' over a specific integration time)



A brass-board working-model of the GIRO transponder has been built, and has been thoroughly tested. The results are successful! With two independent means of testing (the difficult to measure) Allan Deviation, the simple, analog transponder exceeds the requirement by factors of 2-3.

GIRO Probe (aka 'puck') Design

(Second generation mechanical model for GIRO)



The 3-D printed aluminum probe structure

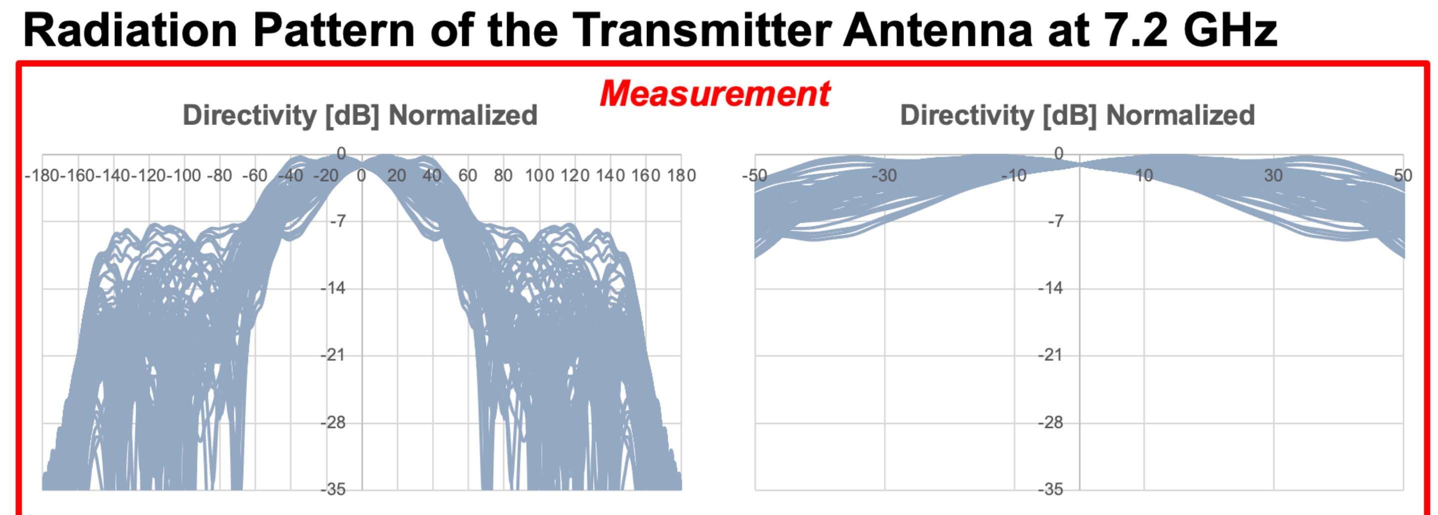
Objectives: Three principal objectives addressing the question of how to economically obtain accurate and detailed gravity and surface deformation fields of a dynamic body that might harbor life-habitats. Understanding the gravity and its changes in time as well as the surface deformation fields give strong evidence of the energy flow above, on, and inside the body, and thus reveals where, when, and for how long liquid water may exist and have existed on these bodies. In this respect, we are driven by the companion science-focused proposal in this initiative.

Objective 1: Determine the configuration of radio beacons required to recover a static and time-dependent gravity field of a given degree and order for Enceladus, which will constrain spatial variations in shell thickness and ocean density.

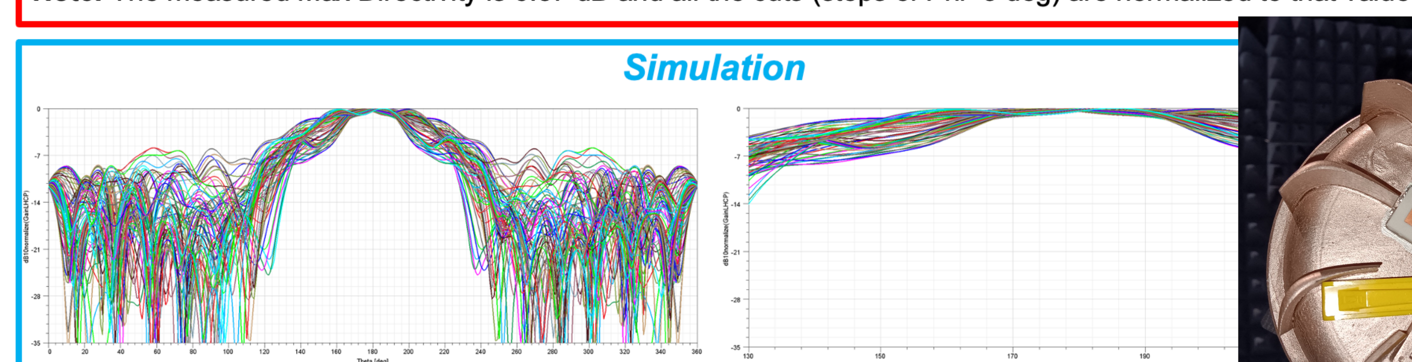
Objective 2: Develop an engineering model for deployable radio beacons that can perform two-way radio communication with the main spacecraft with velocity measurement accuracy ≤0.01 mm/s. Also develop mechanical models for the beacon and deployment mechanisms, packaging and safety requirements and designs for the high- energy battery packaging, and advance at least a mass-model (for batteries) prototype to environment testing.

Objective 3: Develop a high-resolution topography model for Enceladus using the existing Cassini imaging data and assess optimal/efficient imaging geometry and configuration based on a realistic future mission scenario.

Radiation Pattern of the Transmitter Antenna at 7.2 GHz

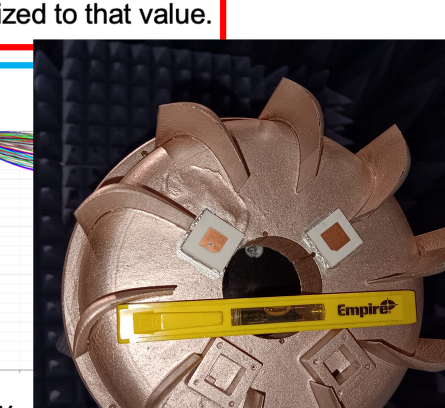


Note: The measured Max Directivity is 6.87 dB and all the cuts (steps of Phi=5 deg) are normalized to that value.

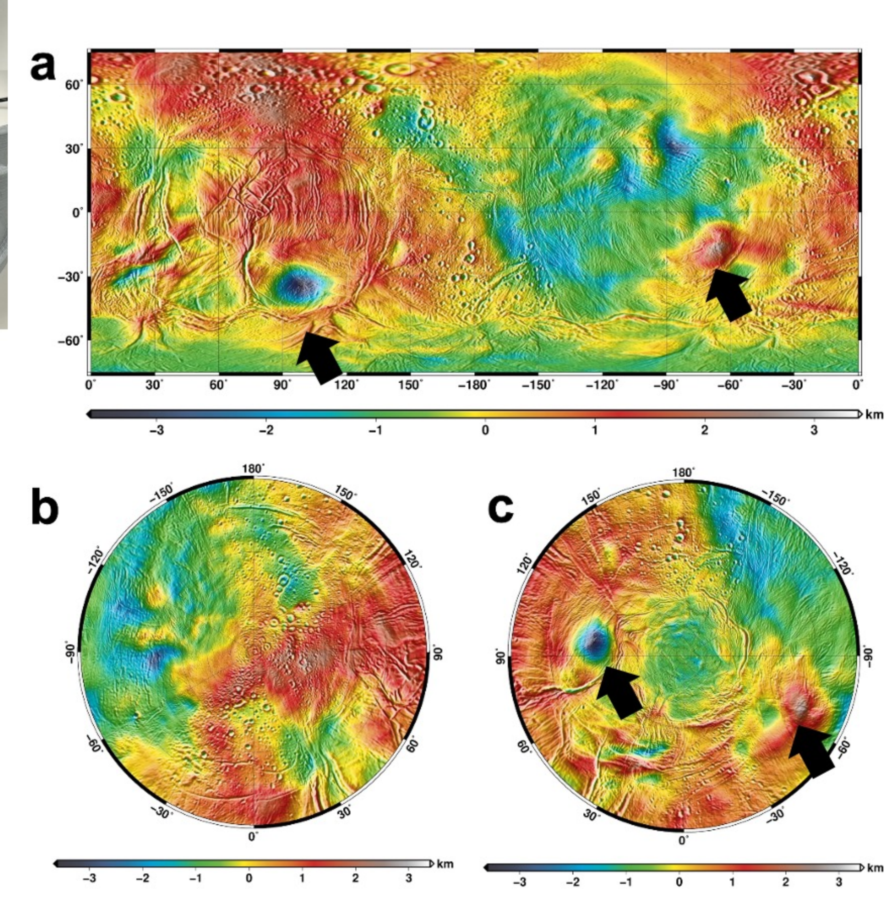


Note: The simulated Max Directivity and the Realized Gain are 7.14 dB and 6.75 dB accordingly.

- Since we did not measure the gain, the estimated measured realized gain will be 6.5 dB.



Surprising but gratifying performance! With the expectation of 0dB from a body-mounted dipole antenna, a shell-grounded and resonant patch antenna achieves over 6dB Rx and Tx performance, matching simulations when measured in the chamber. Test article shown (inset)



The cylindrical projection of the SPC topography for ±75° latitude (a), stereo projection of the Northern hemisphere topography for 90° to 0° latitude (b), and stereo projection of the Southern hemisphere topography for -90° to 0° latitude (c). The horizontal map resolution is 500 m. The topography height ranges from -3.6 km to 3.4 km. Arrows indicate nearly antipodal extreme depression and rise.

Using techniques developed as part of this research, a new model of Enceladus has been developed, which reveals important features of that body unseen heretofore.

Publication: **The global shape, gravity field, and libration of Enceladus** R. S. Park, N. Mastrodemos, R. A. Jacobson, A. Berne, A. T. Vaughan,D. J. Hemingway, J. C. Castillo-Rogez, J. T. Keane, A. S. Konopliv, E. J. Leonard, F. Nimmo, J. E. Riedel, M. Simons, and S. Vance

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