National Aeronautics and Space Administration

Technology Development for Next Generation Ocean World Geodesy: Enceladus

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Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Next-Generation Ocean World Geodesy: Enceladus - Strategic Initiative Leader: Rosaly M Lopes

Objectives: This task has 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 number and 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 electronic model for deployable radio beacons that can perform two-way radio communication with the main spacecraft with velocity measurement accuracy ≤0.05 mm/s.

Objective 3: Develop a terrain analysis methodology for Enceladus conditions using repeat optical image cross- correlation techniques, to extract spatial deformation with accuracy ≤20 cm from a 50 km altitude orbit – using optical flow methods already applied in terrestrial studies.

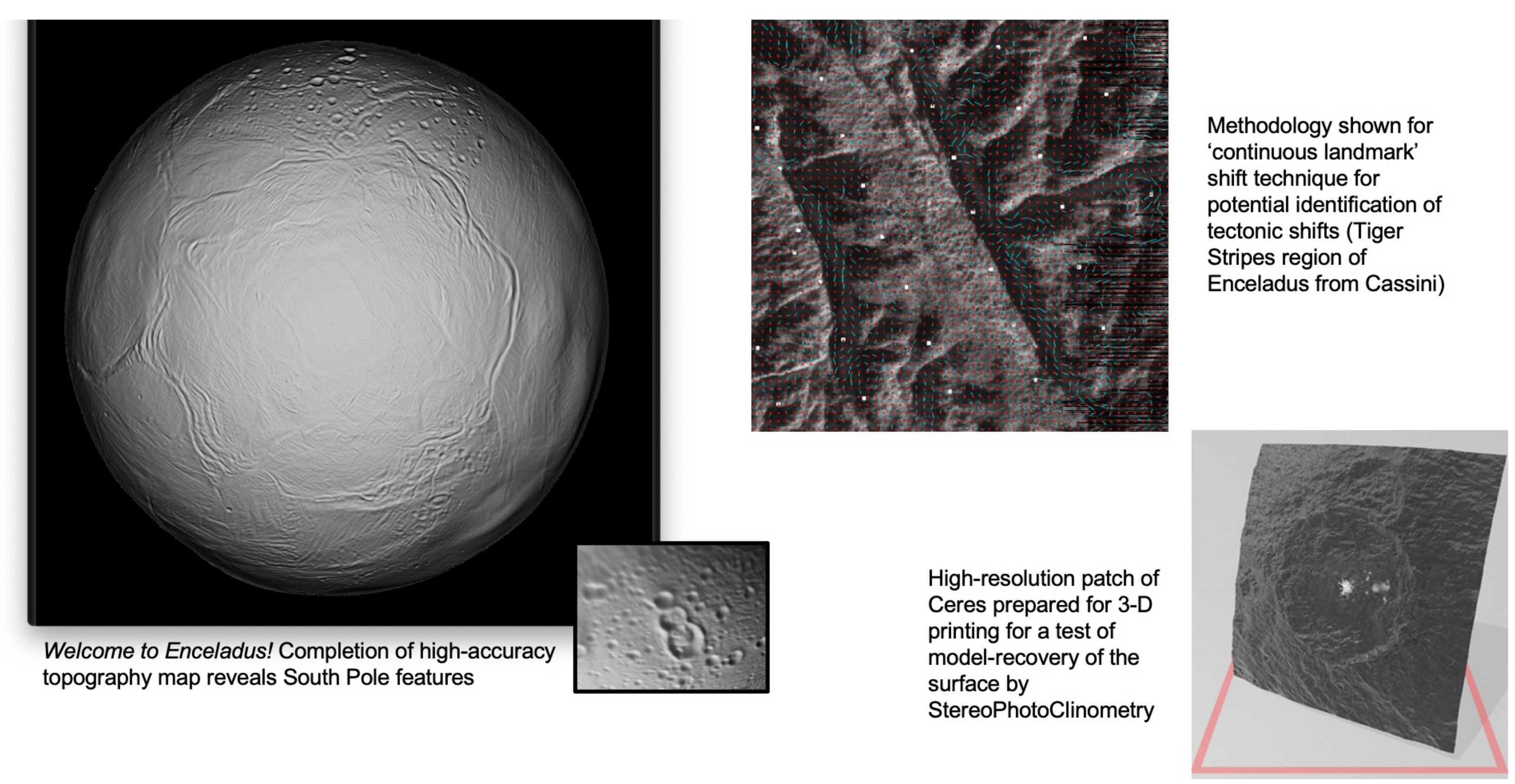

Figure 1. Subtask 3 accomplishments, including the development of the 'best available' Enceladus model based on Cassini and Voyager data (left) a methodology for detecting tectonic activity (applied to Cassini images – center), and creation of physical model of Ceres to test the ability of stereophotoclinometry to detect 'truth.'

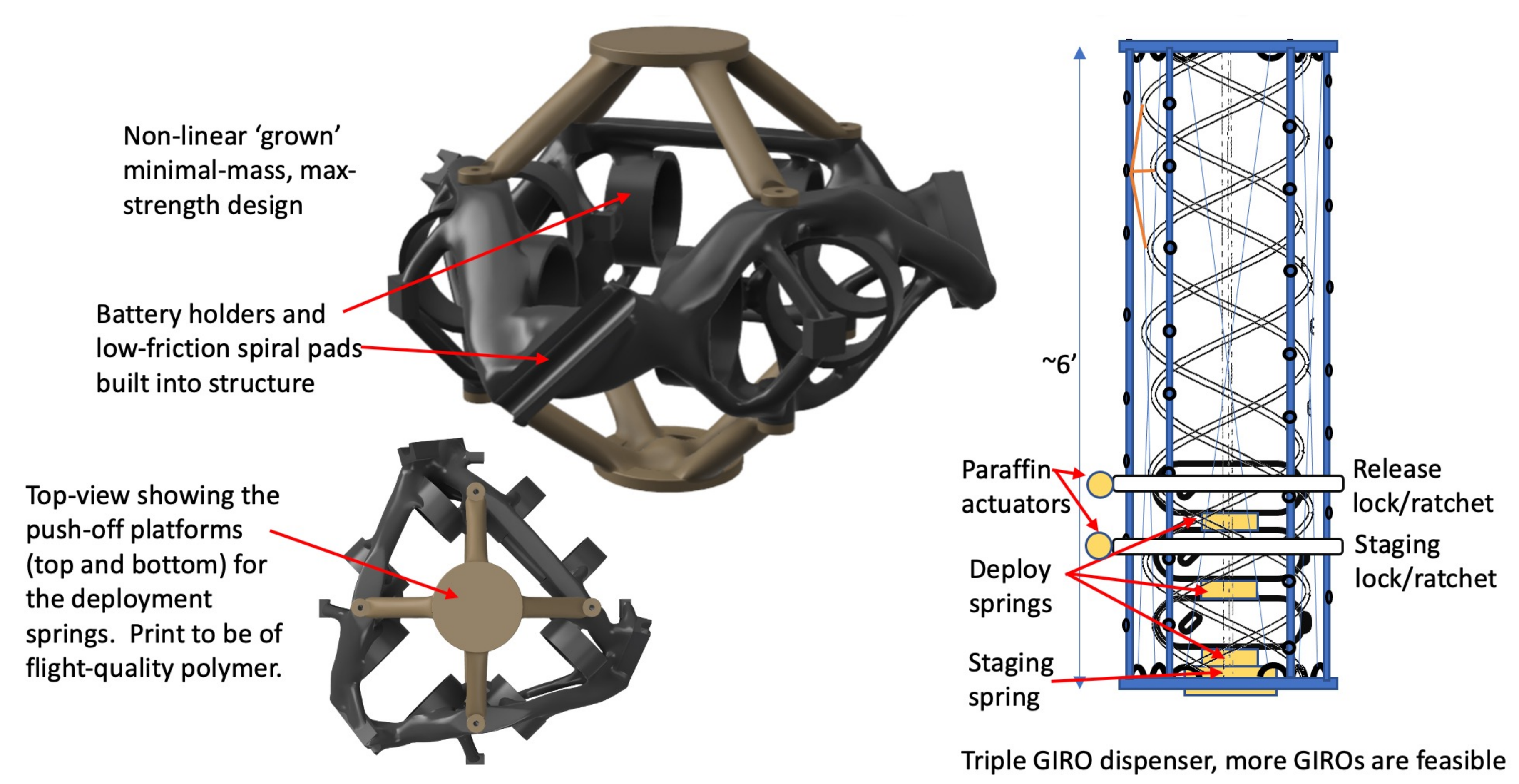

Figure 2. Subtask 2 progress, including development of structural design, and deployment mechanism. Both are under construction as of near-the-end of FY'22.

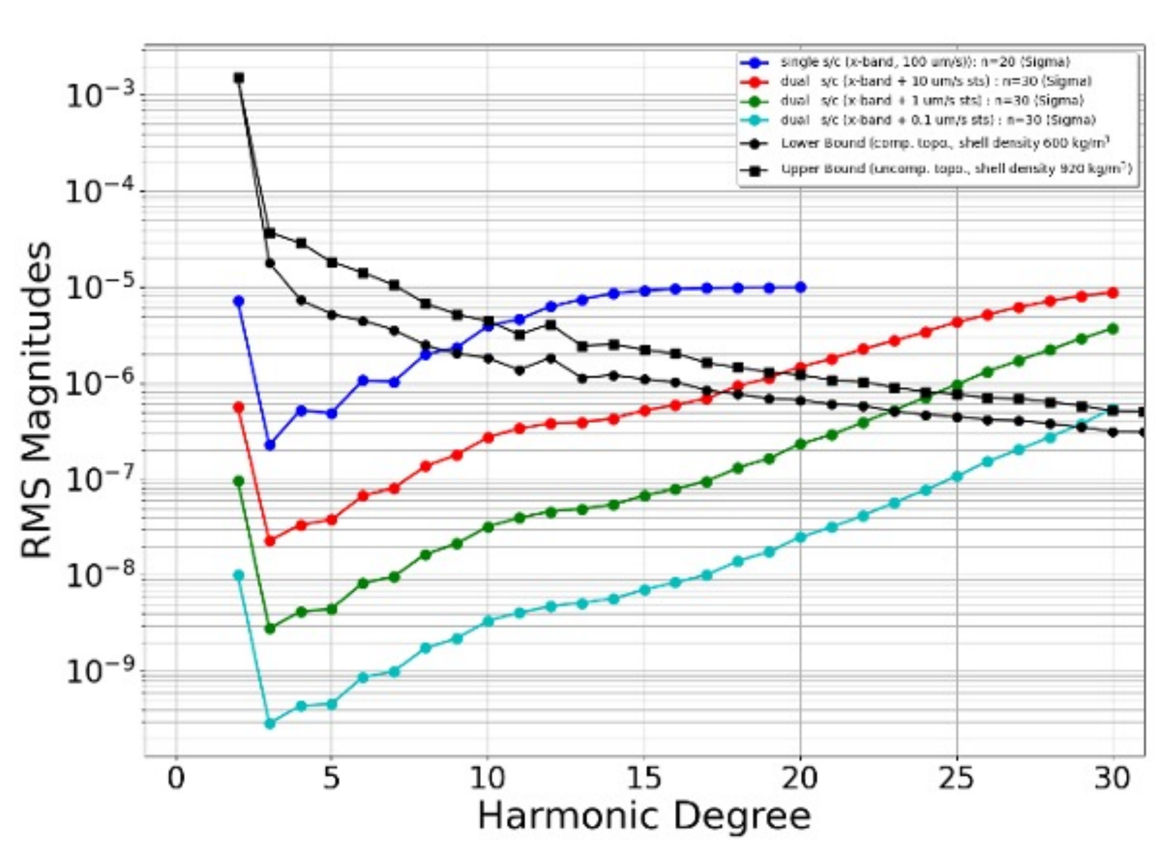

Figure 3. The ability of GIRO radio measurements to recover the gravity field of Enceladus under varying assumptions.

Table 1. Analysis of the expected performance of GIRO compared with SOE DSN tracking and GRAIL/GRACE.

Noise Sources (@60s)	CBE	CBE with Open-Loop Tracking
Link Budget	0.4 um/s	0.03 um/s
Relativistic Correction	negligible	negligible
Spacecraft Frequency Correction from DSN data	0.001 um/s	0.001 um/s
Clock Error	0.02 um/s	0.02 um/s
Total Error	**<1 um/s**	**~0.04 microns/s + hardware delay contribution**

- To be compared with:
  - DSN X-up/X-down: 20–100 um/s
  - GRAIL: 0.04 um/s @5s

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