PROSPECTS FOR APOPHIS WITH NGRADAR: THE NEXT GENERATION PLANETARY RADAR SYSTEM ON THE GREEN BANK TELESCOPE. P. A. Taylor[1,2], S. R. Wilkinson[3], F. Paganelli[1], R. Samaniego[3], B. Shamee[3], A. C. Wallace[3], and A. J. Beasley[1,4], [1]National Radio Astronomy Observatory (1180 Boxwood Estate Rd., Charlottesville, VA 22903, USA; ptaylor@nrao.edu), [2]Green Bank Observatory, [3]Raytheon Intelligence & Space, [4]Associated Universities, Inc.

Introduction: The National Radio Astronomy Observatory (NRAO), Green Bank Observatory (GBO), and Raytheon Intelligence & Space (RIS) are designing a high-power, next generation planetary radar system for the Green Bank Telescope (GBT) dubbed ngRADAR. As a pilot project, a low-power, Ku-band transmitter (up to 700 W of output power at 13.9 GHz) designed by RIS was integrated onto the 100-meter GBT at GBO, and radar echoes were received with NRAO's ten 25-meter Very Long Baseline Array (VLBA) antennas. These observations generated the highest resolution, ground-based, synthetic aperture radar (SAR) images ever collected of the Moon, enabled characterization of cislunar space debris, and detected a potentially hazardous near-Earth asteroid 2.1 million kilometers from Earth [1, 2].

Pilot Observations: The GBT/VLBA pilot radar system illuminated the Moon, space debris, and a near-Earth asteroid with its ~0.9-arcminute beam as a technology demonstration. Using advanced focusing algorithms, SAR images of the Moon show tremendous detail. An image of Tycho crater (Fig. 1) reached 5-m resolution (30 MHz) from a 40-minute integration. These high-resolution images are sensitive to motion at the mm/sec scale, roughly the fidelity of the dynamical models used for radar ephemeris prediction. Space-debris targets in the cislunar domain were also tracked and characterized, and asteroid (231937) 2001 FO32 was detected at more than 5.5 lunar distances from Earth. These observations give compelling evidence that the future ngRADAR system can track small bodies, operate on targets in cislunar space, and provide meter-scale resolution imagery.

Future Work: Design work continues toward the final objective of a 500 kW, Ku-band planetary radar system for GBT using the VLBA to receive. A high-power system would have nearly 1000 times the output power of the pilot system and several times the waveform bandwidth (up to 600 MHz) for even finer resolution. These properties will deliver a highly capable radar system for physical and dynamical characterization of solar system objects for planetary science and planetary defense.

Apophis Encounter: The close approach of (99942) Apophis in 2029 places an attainable goal for operations of the ngRADAR system of within six years. ngRADAR observations would complement those by Goldstone (and other transmitting antennas) with different frequency (13.7 GHz; 2.2 cm) observations and meter-scale resolution. Depending on the non-Apophis responsibilities of various transmitting antennas, ngRADAR could provide complementary availability for observations. The multi-static receiving nature of ngRADAR would also provide additional spin-state and shape constraints via different viewing geometries between the transmitter, target, and receivers. We will further discuss the science potential of using the future ngRADAR system during the 2029 Apophis encounter.

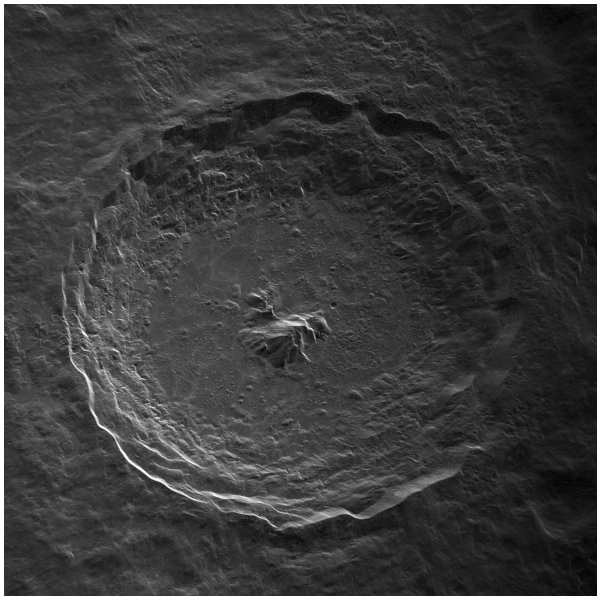

Figure 1. Tycho crater (~85 km) with 5 m/px resolution using the GBT/VLBA pilot radar system.

Acknowledgments: The National Radio Astronomy Observatory and Green Bank Observatory are facilities of the National Science Foundation operated under cooperative agreements by Associated Universities, Inc. (AUI). Part of this work was supported by Mid-Scale Research Infrastructure-1 award 2131866 from the NSF to AUI.

References: [1] Wilkinson S.R. et al. (2022) *Microwave Journal*, *65*, 1. [2] Taylor P.A. et al. (2022) *Proceedings of the Advanced Maui Optical and Space Surveillance Conference*, 2252.