MINI-RF S- AND X-BAND BISTATIC RADAR OBSERVATIONS OF THE MOON.

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Introduction: NASA's Mini-RF instrument on the Lunar Reconnaissance Orbiter (LRO) is currently operating in concert with the Arecibo Observatory (AO) in Puerto Rico and the Goldstone deep space communications complex 34 meter antenna DSS-13 to collect bistatic radar data of the Moon. These data provide a means to characterize the scattering properties of the upper several meters of lunar materials, as a function of bistatic angle, at S-band (12.6 cm) and X-Band (4.2 cm) wavelengths. We will provide an update on science questions being addressed by the Mini-RF team in the current LRO extended mission.

Background: The transmitters for Mini-RF bistatic observations is the 305 m Arecibo Observatory radio telescope in Puerto Rico or the 34 m DSS-13 radio antenna at the Goldstone deep space communications complex. For each observation, a transmitting antenna is pointed at a target location on the moon and illuminates a fraction of the lunar surface around that location with a circularly polarized chirped signal. The data returned provide information on the structure (i.e., roughness) and dielectric properties of surface and buried materials within the penetration depth of the system (up to several meters for Mini-RF) [1-4]. The bistatic architecture allows examination of the scattering properties of a target surface for a variety of bistatic angles. Laboratory data and analog experiments, at optical wavelengths, have shown that the scattering properties of lunar materials can be sensitive to variations in bistatic angle [5-7].

Observations: In the current LRO extended mission, Mini-RF is targeting a variety of lunar terrains to address LRO science objectives related to fundamental, evolutionary, and contemporary processes involving the Moon. They include collecting data of: the floors of south polar craters to search for signatures indicative of the presence of water ice [8]; Copernican crater ejecta blankets to characterize rates of regolith breakdown/weathering [8,9]; the ejecta of newly-formed craters to characterize the size-distribution and density of wavelength-scale scatters as a function of distance from the impact; mare materials within the Imbium and Serenitatis basins to identify flow units and establish stratigraphic relationships; and irregular mare patches (IMPs) and pyroclastic deposits to characterize their radar properties.

Results: The first Mini-RF bistatic campaign (2012-2015) included 28 AO S-band observations of the lunar surface, polar and nonpolar. Those observations provided data used to suggest the presence of water ice within floor materials of the crater Cabeus [8] and to characterize the weathering of Copernican crater ejecta [8,9]. In the first 9 months of the current LRO extended mission, Mini-RF has acquired 4 additional AO S-band observations and 10 DSS-13 X-band observations of the lunar surface, polar and nonpolar.

Initial analysis of south polar targets acquired at X-band (4.2 cm) do not appear to show the possible water ice signature detected at S-band (12.6 cm). This would indicate that, if water ice is present in Cabeus crater floor materials, it is buried beneath ~0.5 m of regolith that does not include radar-detectible deposits of water ice. Observations of Copernican crater ejecta materials at S- and X-band wavelengths continue to show variations that can be attributed to variations in the age of the crater. Differences between S- and X-band observations of the same crater are also present, providing new insight into the size-distribution of radar scatters within the ejecta. S- and X-band Observations of mare materials in the Imbrium basin have been acquired and, combined with ground-based P-band observations, are providing important information on the locations, extents, and depths to individual flow units within the basin. Recent X-band observations have imaged the ejecta of 2 craters that formed during the LRO mission. Analysis of the ejecta deposits is ongoing.

References: [1] Campbell et al. (2010), *Icarus*, 208, 565-573; [2] Raney et al. (2012), *JGR,* 117, E00H21; [3] Carter et al. (2012), *JGR,* 117, E00H09; [4] Campbell (2012), *JGR*, 117, E06008; [5] Hapke et al. (1998), *Icarus*, 133, 89-97; [6] Nelson et al. (2000), *Icarus*, 147, 545-558; [7] Piatek et al. (2004), *Icarus*, 171, 531-545. [8] Patterson et al. (2017), *Icarus*, 283, 2-19; [9] Stickle et al. (2016), *47th LPSC* #2928.