Lunar Reconnaissance Orbiter: Mini-RF Calibration Using the 21 m Ground Station at Morehead State University

Morehead State University

Ground Station Task for Johns Hopkins Applied Physics Laboratory

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INTRODUCTION and OBJECTIVE:

The Lunar Reconnaissance Orbiter (LRO) is a NASA robotic spacecraft launched into Lunar orbit in 2009 and remains operational (SSC 35315). LRO is managed by the Goddard Space Flight Center. The instruments on LRO include the Mini-RF synthetic aperture radar (SAR), which operates at X-band (7140 or 7147 MHz). Mini-RF is managed by the Johns Hopkins University Applied Physics Laboratory (JHU/APL).

The Mini-RF radar has two linearly polarized receiver channels. The data from these two channels is processed to provide polarimetric products that are used to infer the possible presence of water ice within the Lunar regolith. This processing includes adjustments of the power and phase of the two receiver channels to compensate for imbalances in the receiver system. These adjustments are made based on measurements made in laboratory tests prior to launch of the orbiter and measurements made during flight. These measurements have not all been consistent. The proposed task will provide data that will contribute to understanding these inconsistencies and determining the proper adjustments that should be made to during the data processing.

Some of the receiver calibration measurements that have been made during flight involve pointing the Mini-RF antenna to a transmitter on Earth. X-band measurements have been made using the 21-m antenna at Morehead State University (MSU) and using one of the NASA Deep Space Network antennas in Goldstone, California (DSS-13). Those X-band measurements have not been consistent with measurements made prior to launch and measurements made using the Lunar backscatter.

The power flux density at the antenna during Earth-pointing measurements is higher than that present due to Lunar backscatter. It is possible that the difference in power levels between these two situations is responsible for the difference in the balance of power in the two receiver channels as a result of some unknown nonlinearity in the end-to-end system. A range of power levels were injected into the Mini-RF receiver channels prior to flight did not show the imbalance observed during the Earth-pointing measurements. It is possible that some element of the receiver chain has changed behavior during flight. It is therefore of interest to vary the power flux density at the antenna across a range of levels spanning that present during lunar backscatter and that present during Earth-pointing. Obtaining that is the purpose or the proposed task.

EXPERIMENT/MEASUREMENT

The proposed experiment will use the existing infrastructure of the MSU 21-m DSN station to radiate a range of power levels for reception by the Mini-RF radar package aboard the LRO. This signal, of known power level, will be used to establish a baseline amplitude so that a received power level at the Mini-RF Antenna can be establish. In order to perform the radar signal level experiment at the correct levels, the existing high power amplifier (klystron type, KPA) used in the 21 m DSN station system will be operated at the appropriate reduced power. This will be set according to APL specification to the level required to simulate a typical reflected lunar radar signal. This will entail some small modifications to the transmitter system to permit reliable operation at a reduced power level and at the correct frequency. A synthesized signal generator,

locked to the internal Hydrogen Maser system will be used to generate a carrier at 7140 MHz (per APL specification). Sufficient testing will be performed to insure correct levels. Stability of the transmitted power level is important and, if needed, a closed loop power control system will be used to correct/maintain the transmitter power at a pre-established level.

LRO will be commanded to point the Mini-RF antenna to the Earth (toward Morehead, KY specifically). While this pointing is maintained, the transmit power level will be repeatably swept between two extremes according a schedule to be negotiated between JHU/APL and MSU. The JHU/APL team will record the received signal level during these scans, while stepping through the receiver attenuator settings. This will allow a mapping of the input and output power levels of the two receiver channels that can be applied to re-calibration of the Mini-RF attenuators.