Shifting the Paradigm of Coping with Nyx on the Moon – a Ground-Penetrating Radar Case. D. C. Nunes[1], K. Carpenter[1], Mark Haynes[1], Jean Pierre de la Croix[1]. [1]Jet Propulsion Laboratory, California Institute of Technology (4800 Oak Grove Drive, Pasadena CA 91109, Daniel.Nunes@jpl.caltech.edu)

Introduction: Radar has played a key role in characterizing the properties and geology of the Moon, from ground-based [1] to bi-static [2], sounders [3] and a ground-penetrating radar [4]. Currently, a higher level of fidelity in data is needed to fully characterize and interpret the lunar geologic and to be able to exploit its resources. Radar will continue to be a key tool in this effort, and this belief is supported by the needs outlined in the Lunar Exploration Road Map and the Lunar Knowledge Gaps document.

Detection and mapping of polar volatiles, of pyroclastic deposits and regolith stratigraphy, and of lunar lava tubes are among the primary science cases for ground-penetrating radar instruments. Aside from the ice deposits expected in and around the permanently shaded areas near the poles, primary science targets are distributed around the Moon in the equatorial and tropical latitudinal bands.

MARGE: We are currently developing a ground-penetrating radar (GPR) instrument that is an intrinsic part of a compact, autonomous rover. The size of the Multi-static Autonomous Roving Ground-penetrating-radar Explorer (MARGE) is driven by the size of the GPR antenna, which is approximately 50×50 cm and capable of transmitting and receiving an ultra-wide frequency band from 120 MHz to 2 GHz. This operational band permits penetrations of up to ~20 m while providing depth resolution of for typical lunar regolith and rock dielectric constants [5] and a dynamic range of 120 dB; see Figure 1 for the link analysis.

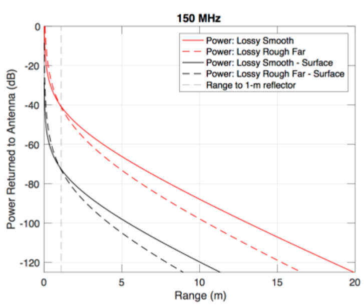

Figure 1- *Link analysis for a reflection arising from a regolith/rock dielectric interface for increasing depth (range).*

Common strategies: Since Sojourner, survivability has depended on active and passive thermal management, through a combination of battery-powered heaters, small radiogenic sources and thermal insulation like aerogel [6]. These have worked reasonably well in the past. The long dark period on the moon makes heating a power hungry option. Commercial landers will not allow radioisotope heating units at least in the beginning. Our heritage solutions for Mars or the past lunar missions may not apply to this new opportunity.

New Strategy: To survive the relatively long lunar night we propose to shift the strategy from one of full dependence on thermal management to one of increasing thermal tolerance. For example, special components and electrical traces that are tolerant to variations on the order of 300°C can be used. This comes down to material and alloy selection and architecture. Specific power storage solutions tailored to survival of freeze/thaw cycles and the heat of the lunar day as well as concepts of operations that allow for opportunistic operation between thermal extremes are needed. We will present some possible solutions to these challenges based off our current effort on MARGE.

Expanding Surveys: An average speed of 2.5 cm/sec for autonomous planetary rovers [6,7] may allow traverses comparable to ~1 km during a lunar day, depending on operational constraints, such as data storage and downlink and 6 earth-days of amenable thermal conditions.

The biggest benefit for a GPR to survive the night is expanding the survey area to multi-km, which would maximize science and characterization in the vicinity of the landing site.

References:
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