THERMAL WADIS AND COMPACT ROVERS: CREATING AN AFFORDABLE LUNAR INFRASTRUCTURE TO ENABLE RESOURCE EVALUATIONS AND TECHNOLOGY DEMONSTRATIONS.

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Introduction: Many in the space resources community, including scientists, engineers, entrepreneurs, economists and others, have arrived at the conclusion that identifying, locating, harvesting and processing of resources on the moon is possibly the most compelling theme around which to discuss why, when and how humans should return to the moon. While it is clear from ongoing data coming from recent lunar probes that promising resources including water and other volatile species are present, the true abundance and accessibility of these materials cannot be quantitatively established without substantial and widespread in-situ prospecting assays and demonstrations of mining and processing - all in the challenging lunar environment. The potential significance of these resources is clear to lunar and planetary science, but also to the economic sustainability of human space travel to both the moon and beyond. Consequently, robotic “ground truthing” of orbital observations is essential to adequately informed determinations about the value of sending humans back to the moon.

Because it is unlikely that one or two robotic resource prospecting and processing missions could adequately evaluate the resource potential of the moon, advocates of completing a resource mapping must consider affordable ways this can be achieved. Improving lunar prospecting productivity must involve surviving the thermal challenges on the moon, especially the cold lunar darkness, and reducing the unit cost and size of individual rover-based assets to enable economies of scale in production and transportation.

Thermal Wadis and Compact Rovers: The *Thermal Wadi* concept[1] is an approach to utilizing modified lunar regolith as solar-thermal energy storage media that can be heated during periods of solar illumination and used as a thermal energy source for mobile assets during periods of darkness. Lunar regolith is modified to improve its thermal properties, then heated using a sun-tracking reflector. During dark periods, the reflector is reconfigured as a radiation umbrella to limit the radiative cooling of the thermal mass and the assets it protects.

Ongoing simulations of the thermal performance of the thermal wadi concept have suggested that in equatorial sites a thermal mass no deeper than 50 cm and heated during the lunar day would sustain rover assets for the 300+ hour lunar night within the working temperature range of conventional electronics. This protection is provided without requiring the rover to carry insulation or internal energy sources for nighttime thermal protection. Near-polar locations have irregular illumination and thermal simulations have shown that for at least one such site, similar thermal protection can be provided by a thermal wadi configuration.

Laboratory work has been conducted to validate the thermal property values used in the wadi thermal simulation, and to consider methods for modifying lunar regolith simulant to produced thermal mass, including: the use of concentrated solar energy, resistive heating, or SHS reactions to melt and consolidate simulant into continuous slabs, and collecting partially metalized byproducts of ISRU oxygen production. Each method has advantages and disadvantages related to equipment mass and power consumption needed to form thermal mass with the needed properties.

Related thermal simulations[2] of small lunar rover designs have indicated that as rover size decreases, the mass of energy storage capacity, i.e. batteries, needed for nighttime survival overwhelms any reasonable rover payload mass. Hence, offloading nighttime thermal protection from small rovers increases the instrument payload mass and/or allows the rovers to be smaller than they could otherwise be. Further reductions in rover mass might be realized by creating other simple lunar surface infrastructure, perhaps integrated with the thermal wadi, that offloads communication, battery charging and other functions from a lightened rover. Moreover, standardizing rover design to utilize this distributed support infrastructure leads to the possibility of amortizing rover development cost, approximately $2-5M/kg for contemporary Mars rovers, over what could become a fleet of affordable rovers.

Conclusion: Affordable distributed lunar surface infrastructure, including thermal wadis, that supports affordable lunar prospecting rovers provides a basis for lunar resource mapping that encompasses sufficient geographical diversity and intense local abundance and accessibility determinations. With detailed knowledge of exploitable lunar resources, governments and commercial enterprise will be able to make sound decisions about investing in the human return to the moon.

References: [1]Balasubramaniam, et.al., (2010) AIAA–2010–797, NASA TM 2010-216255. [2]Thornton, et. al., (2010) AIAA–2010–798.