ROBOTIC LUNAR SURFACE OPERATIONS 2. B. Sherwood[1], A. Austin[1], T. Colaprete[2], J. Elliott[1], A.S. Howe[1], S. Magnus[3], P. Metzger[4], R. Polit-Casillas[1], H.H. Schmitt[3], M. Sims[5], G. Voecks[1], K. Zacny[6], [1]Jet Propulsion Laboratory (M/S 321-625, 4800 Oak Grove Dr, Pasadena CA 91001, brent.sherwood@jpl.nasa.gov), [2]NASA Ames Research Center, [3]Consultant, [4]Univ Central Florida, [5]Ceres Robotics, [6]Honeybee Robotics.

Introduction: Results are reported from a new, ongoing lunar base study with a concise architectural program: build and operate a habitable lunar base that produces enough oxygen and hydrogen from lunar polar ice resources for four flights per year of a reusable lander shuttling between Gateway and the base.

Context: The RLSO study [1][2] developed the first integrated design/operations analysis of a robotic, habitable, oxygen-producing lunar base. RLSO2 updates this work with new assumptions: 1) resources – lunar polar ice instead of ilmenite; 2) solar power – polar lighting conditions instead of the 28-day equatorial cycle; 3) transportation – based on multiple flight systems now in development and planning; 4) base site – a range of options near, straddling, and inside permanently shadowed regions; 5) ISRU scenarios – for harvesting ice and constructing radiation shielding from regolith.

Study structure: Like the original study, RLSO2 combines US experts in mission design, space architecture, robotic surface operations, autonomy, ISRU, operations analysis, and human space mission and lunar surface experience. Three members provide continuity from the original team. The integrated performance of purpose-designed base elements is captured in a numerical operations model, allowing rapid iteration to converge system sizing, and building a legacy analysis tool that can assess the performance benefits and impacts of any proposed system element in the context of the overall base.

We summarize study groundrules, assumptions, and methodology; present maturation status of the operations model, preliminary element designs comprising the base, and first-round base siting analyses; and describe quantitative findings to date.

RLSO2 follows the original RLSO statement of task, but with contemporary assumptions: 1) harvesting of water ice at a polar base rather than hydrogen reduction of ilmenite at a nearside mid-latitude base; 2) use of a DHRO Gateway transportation node rather than low lunar orbit; 3) logistics scenarios incorporating lander downmass capacities in three ranges: 10s, 1000s, and 10,000s kg rather than just a single, large NASA lander.

Base siting analysis is informed by the Traverse Planning Tool developed by the Resource Prospector pre-project; datasets from multiple LRO instruments are synthesized into a time-varying, latitude-longitude-specific illumination model, making insolation and power storage duty cycle variable with base location and element geometry.

Three resource and base siting schemes are analyzed: 1) entire base located in a PSR (permanently shadowed region), where the ice resource has highest concentration but the operating temperature is ≤100 K; 2) resource recovery in a PSR but with base habitat and depot located in a nearby PLR (persistently lit region); 3) entire base located in a PLR, where the ice resource has lowest concentration but large traverse distances are avoided.

Results: Findings are divided into two categories: 13 principles from RLSO [3] that RLSO2 validates to be generalizable; plus new conclusions specific to polar-ice ISRU in the 21st century. Some of these new findings are counterintuitive, or at least countercultural in contemporary discussions, and bear on key architecture options like exploration scenarios, resource choice, base and node siting, use of solar and nuclear power, and volatiles extraction approaches.

References:

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