INTEGRATED ENGINEERING MODELING OF AN ISRU LUNAR BASE. A. Austin[1], J. O. Elliott, and B. Sherwood, [1]Jet Propulsion Laboratory, California Institute of Technology, (4800 Oak Grove Dr., Pasadena, CA 91109, alexander.austin@jpl.nasa.gov)

Introduction: The stage is set for sustained operations on the Moon. US Space Policy Directive 1 made this goal explicit: "the United States will lead the return of humans to the Moon for long-term exploration and utilization...[1]" Long-term human activities on the Moon will need to "live off the land", using local resources: ISRU (in-situ resource utilization).

While promoted in the literature for decades and widely accepted as a key objective, lunar ISRU will be a complicated and complex endeavor involving many unprecedented operations and systems; many architecture options have been proposed. Technology choices and programmatic considerations will need to be taken into account and balanced along with simple metrics like delivered mass, specific power, resources required, etc. Focusing on one or another subset of ideas and values guarantees sub-optimized results, or impractical or even invalid findings. Such analysis deficiencies cannot best serve a national decision environment that seeks velocity yet also real progress, serial successes, and cumulative capabilities. Very few prior studies have tackled synergistic design and analysis of the complete set of base elements and necessary operations[2].

Model-based Design Approach: JPL (Jet Propulsion Laboratory) is working to understand modern principles for practical lunar basing, and to discern holistic interdependencies of alternative ISRU operations scenarios for potential implementation over the next 20 years. An operations model under development integrates the performance of all base elements (ISRU systems, habitat, energy systems, mobility systems, landers and surface-basing infrastructure, siteworks including shielding, etc.). Our integrated modeling approach has many benefits including:

- Design methodology that starts "with the end in mind" ("steady-state" base operations) to inform relevant design decisions such as the base build-up sequence
- Systems model that captures interdependencies of the base elements to yield a holistic view of the integrated performance of the complete base architecture
- Adaptable model that can evaluate a wide range of point scenarios and ideas, including introduction of new base elements over time.

Our study's model-based approach develops and exercises a flexible tool whose insights can guide architecture-level decisions. To enhance the capabilities, the authors invite system providers to provide current system performance data (ISRU techniques and elements, energy system architectures, lunar lander designs, etc.) for inclusion in the model.

References:

[1] *Space Policy Directive-1*. Vol. 82, No. 239. December 14,2017.

[2] B. Sherwood et al. (1990) *Robotic Lunar Surface Operations: Engineering Analysis for the Design, Emplacement, Checkout and Performance of Robotic Lunar Surface Systems*. 179 pp, Boeing contractor report for NASA Ames Re-search Center contract NAS2-12108.