LIVING ON THE LUNAR SURFACE – A MINIMALIST APPROACH. A. N. Guest, W. K. Hofstetter, P. M. Cunio, R. McLinko, E. Grosse, and J. A. Hoffman. Massachusetts Institute of Technology.

Introduction: NASA's current plans for returning to the Moon include the build-up of a lunar outpost at the South Pole [1]. Currently planned architectures propose an outpost consisting of several connected modules, each one being delivered on its own cargo flight. This concept requires three discrete, complex operations: offloading the elements from the lander, translation of the elements along the surface, and in-situ assembly and connection.

Due to their complex nature, these operations introduce several disadvantages into the campaign architecture including:

- Increase in operational cost and risk
- Increase in development cost and risk
- Mass penalty
- Potential program schedule delay

Because of these disadvantages, it is beneficial to examine other possible architectures that eliminate these operations.

The Non-Connected Architecture: To "side-step" the technical challenges of developing the required hardware for offloading, translation, and assembly, the authors present a revolutionary lunar outpost architecture that focuses on transporting the crew and supplies across the lunar surface instead of the habitation modules. This architecture is made feasible by the use of the Small Pressurized Rovers (SPRs) that are included in the campaign for long-distance surface exploration.

The outpost infrastructure includes a habitat module, a laboratory module, and several pressurized logistics modules. Each of these elements remains on the lunar surface and the crew uses the SPR to transfer between them as necessary. Two types of transits are envisioned: hab-lab transits and logistical re-supply transits. Analysis shows that only 5% of the crew's productive time will be spent on these transits. Using the mass savings made available through this architecture to deliver extra logistics to extend the overall campaign surface time can offset this loss of time.

Element Design: This paper includes discussion of the required design of the subsystems of the major elements in the architecture (habitat, laboratory, and Pressurized Logistics Modules) that both make a "non-connected architecture" feasible and optimize the elements for the new architecture. The main design features analyzed are the structural components, such as tunnels and berthing adapters, necessary for allowing the crew to transfer from the habitat, situated on top of the lander, to the SPR on the lunar surface, and the Environmental Control and Life Support System (ECLSS). The architecture incorporates an ECLSS system that is split between the habitat and laboratory, which is made feasible by having the crew transfer consumables during their transits.

Assessment of Program-Level Impact: The programmatic details involving cost, schedule, and risk are discussed in terms relative to NASA's proposed architecture. Several metrics are developed to demonstrate the benefits of the proposed architecture in terms of performance, cost, schedule, and risk. The non-connected architecture is either similar or better for all metrics considered when compared to NASA's currently planned architecture.

Public Outreach: As part of this projects, the team members visited a local elementary school in Boston to discuss how humans will live and work on the moon. A 30-minute presentation was followed by one-on-one time with each of the students to answer their various questions about space exploration.

Conclusion: This report outlines a minimalist lunar surface system architecture concept, which significantly reduces the amount of surface assembly operations and associated infrastructure required. By having the crew transit between elements on the lunar surface, as opposed to offloading, translating, and assembling habitation modules, lower risk and cost is achieved without any loss in performance for the overall lunar campaign when compared to NASA's currently planned architecture.

References: [1] Cooke, D. et al. (2008) *Lunar Architecture Update*, AIAA 3rd Space Exploration Conference. Denver, CO.