

Construction of Lunar Surface Structures Using Regolith-filled Sandbags

C. S. Dickinson¹, A. E. Dinkel², R. Emami³, J. Empey⁴, Theodora Girgis⁵, P. Grouchy¹, R. Mukherjee⁶, K. McIsaac⁶, P. Maghoul⁷, M. Montañó⁸, T. Newson⁶, A. Polit², S. Tuohy¹, W. Watson¹ and J. Thangavelautham². ¹MDA 18050 Saturn Lane, Suite 200, Houston, TX, USA ²University of Arizona, 2300 E 15th St, Tucson AZ, USA ³University of Toronto, 160-500 University Avenue, Toronto ON, Canada ⁴University of Waterloo, 200 University Avenue West, Waterloo ON, Canada ⁵JPL 4800 Oak Grove Drive, Pasadena, CA, USA ⁶Western University, 1151 Richmond Street, London ON, Canada ⁷Polytechnique Montréal, 2900 Édouard-Montpetit Boul., Montréal QC, Canada ⁸Embry-Riddle Aeronautical University 3700 Willow Creek Road, Prescott, AZ, USA (Contact: cameron.dickinson@mda.space)



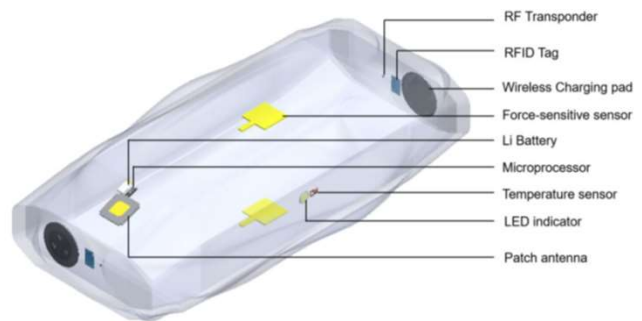
Introduction: NASA's Artemis program has set forth an ambitious plan to return humans to the Moon [1]. It is expected that the return of humans will call for the development of a semi-permanent or permanent base on the Moon. Site preparation and construction methods that can be adapted to changing site conditions and enable base mobility would be ideal because they reduce the overall mission planning constraint and minimize end-structure variability. We are investigating the use of regolith-filled sandbags, which are simple, multifunctional building blocks. These can be used in a wide variety of applications such as berms, landing pads, radiation shelters, ballast (e.g., solar towers), and in future habitat construction [2]. Their modular design, modest upmass to launch vehicle mass constraints, and ability to be reused, make them a low-cost, attractive option for early lunar structures.

Goals: A demonstration mission to the lunar surface is currently being considered, with the goal of constructing a simple berm. This allows for the validation of several technologies such as: regolith excavation, regolith bagging, construction using a building block architecture, as well as the measurement of radiation effects (both protected and unprotected by the berm) and any lunar seismic activity. A demonstration mission such as this would be the first step in creating larger structures, that would require increasing knowledge of lunar civil engineering, and could allow for a wide variety of architectures for any permanent or semi-permanent robotic and astronaut habitats.

Regolith excavation involves not only removing material from the surface, but also sorting out any large materials (e.g., impact ejecta littering the surface) [3]. Several methods were considered including rotating drums, mechanized scoops, and shovel based technologies. An example of the NASA KSC RASSOR (rotating drums) is shown below.



Regolith bagging will create the "sandbag" units (called here: Regolith Containment Units or RCUs), as well as manipulate the completed RCU for transfer to the construction element. Several bag materials are being considered, as they must be durable enough to contain the regolith, but must also be sealable while exposed to its abrasive properties.



Construction involves manipulation of the completed bag into a logical "building block" architecture. The bags must be carefully laid, and must contain locking features to avoid slippage.

The **Verification step** will provide some assurance that the bags are properly stacked, in a way that they will not put undue stress on other portions of the structure and to ensure that they could withstand any lunar seismic activity. This could be achieved through both visual means and "smartbag" technologies [4].

Future Applications: Once demonstrated, the sandbag building methods used to build a simple berm could be applied to larger and more complicated structures such as full blast berms, landing pads, adobe domes, and rover shelters.

References: [1] Creech, S et al., (2022) *IEEE Aerospace Conference, Big Sky, Montana, USA*. [2] Thirupathi, A et al., (2022) *Proc. 18th Biennial Int. Conf. Engineering, Science, Construction, and Operations in Challenging Environments, Denver Colorado, USA* [3] Thangavelautham, J., (2017) *Robotica*, 35, 12, p. 2330-2362. [4] Xu Y. et al. (2023) *8th Biennial International Conference on Engineering, Science, Construction, and Operations in Challenging Environments*.