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INFRASTRUCTURE FOR THE EXPLOITATION OF THE LUNAR SURFACE: AUTONOMOUS EXCAVATION, CONSTRUCTION, AND OUTFITTING

Abstract

The establishment of lunar infrastructure is critical for creating a permanent lunar settlement and vibrant space economy. Central to the establishment of this infrastructure is the ability to perform autonomous excavation, construction, and outfitting (ECO) tasks for the creation of roads, landing pads, habitable work and living spaces, and power infrastructure. Excavation capabilities serve several purposes. Autonomous excavation is needed to support infrastructure construction by performing site preparation tasks including rock clearing, grading, compacting, and trenching. These excavation capabilities can also provide some basic infrastructure needs such as roadbeds, berms, and placement of bulk regolith (overburden) over top of habitats to provide environmental protection for crew. In addition, excavation capabilities are needed to mine and deliver raw regolith material to ISRU processing facilities from which commodities, such as water, oxygen, and construction materials, such as metals and binders, can be produced. A permanent lunar settlement will require the construction of a variety of infrastructure elements such as solar power towers, roads, landing pads, blast shields, and habitable volumes. Construction of these structures is expected to be accomplished through a combination of methods including bulk regolith manipulation, structural assembly, and advanced techniques such as large-scale 3D printing. One of the primary challenges associated with construction is to develop approaches that maximize the use of in-situ materials while minimizing power consumption. Finally, methods for outfitting these structures with power, data, and ECLSS, are needed. Specifically, the installation of cables, pipes, air ducts, and interfaces for needed systems. NASA's Space Technology Mission Directorate is tasked with supporting the development and demonstration of capabilities needed by industry to create the infrastructure. These capabilities must be able to operate and survive extended periods of time in the extreme Lunar thermal, dust, and radiation environment. The highest priority ECO capabilities include: autonomous systems for site preparation, road construction, and the construction of tall towers for power, and the excavation and delivery of large quantities of regolith to ISRU processing facilities. NASA is supporting industry in creating the necessary capabilities through a range of partnership opportunities. The proposed paper will give a high-level overview of NASA's plans for the development of ECO capabilities, a description of the state of the art, capability goals, technical challenges and gaps, and thoughts on partnerships with industry and other agencies towards developing a robust lunar infrastructure and economy.