Requirements and Progress Towards a Planetary Surface Simulation Facility

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Abstract. The development of systems to gather and utilize in-situ resources at exploration destinations such as the moon, Mars, the moons of Mars, or asteroids will be required to facilitate long term stays on the surface, provide critical backup systems, and lead to the economic use of extraterrestrial resources. The components of an in-situ utilization (ISRU) system must perform some or all of the following functions:

- prospecting to identify potential resources and their concentrations,
- excavation/drilling to gather loose or compacted regolith,
- atmosphere acquisition, compression, and filtering,
- material handling and transportation to deliver the excavated regolith to a processing plant,
- thermal and/or chemical extraction of desired element(s) from the mineral resources and/or atmospheric gases,
- extraction of potential frozen ice or hydrated minerals,
- extraction of solar wind implanted volatiles,
- liquefaction, storage, and transfer of gases and liquids for use in ascent/descent vehicles, in-space transportation, or life support, and
- storage and transfer of metal or other solid products for use in fabrication and construction.

The development of this equipment will require ground-based test facilities that can simulate the expected environments in which the equipment is intended to operate. The most stringent environment will require high vacuum, thermal conditioning systems, and, for some tests, the ability to operate with large quantities of simulated regolith ('simulant') present. It is recognized that the need to test some equipment in the presence of simulant in high vacuum conditions will generally not be a welcome requirement in most standard thermal vacuum test facilities. Efforts are underway to define the requirements for a dedicated dirty thermal vacuum chamber, to develop the special test equipment that will be needed to set up the simulant bed, and to develop procedures for operating the chamber and special equipment while protecting the facility components.

A series of tests have been planned to incrementally increase our understanding of the issues and challenges of setting up a large simulant bed inside a vacuum chamber. These include permeability, facility component protection, soil drying and compaction, soil bed characterization methods and instruments, and controlled moisture dosing techniques. These plans will be discussed, and the results of the completed tests will be summarized. An overview of a recently completed requirements document for a large facility will also be presented, along with plans for the procedure to be used to select a facility for conversion to a dirty thermal vacuum chamber should funds become available.