Inflatable Habitats for Lunar Base Development

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A human-tended base on the Moon can serve as a stepping stone for human exploration and development of space beyond the International Space Station. Achievement of this goal in the twenty-first century depends upon the development of low-cost and light-weight structures capable of accommodating humans and supporting life on the lunar surface. Since an almost absolute vacuum prevails on the Moon, any habitat on the lunar surface is a pressure vessel and the pressure of the internal artificial atmosphere within a habitat is the dominant structural loading.

One type of structure suitable for the unique conditions present on the Moon is an inflatable structure made of a thin membrane. A novel inflatable structure concept that takes advantage of the specific environmental conditions on the Moon has been investigated at the Center for Engineering Infrastructure and Sciences in Space (CEISS) at Colorado State University (CSU). The inflatable structure consists of nominally identical modules which incorporate a pressurized framing system that deforms the structure into a prismoidal geometry. CEISS has determined that the development of such an inflatable structure for use on the lunar surface is feasible, desirable and economical.

A generic inflatable structure must meet a host of design, on-site and construction requirements. The main requirements for a design of a lunar structure are selection of the proper materials and optimization for the specific loads imposed upon it. It must be easily deployable, durable over time and have minimum maintenance requirements. Another significant functional parameter is use of modules. Modularity of the structure is required for base expansion needs and for combining base functions, such as living quarters, laboratories and manufacturing, within a single structure. An investigation of this concept was initiated involving a single inflatable module made of a Kevlar-49 and neoprene composite material. The significance of this concept lies in its low mass and straightforward design which results in an efficient and economical structure from both a transportation and deployment viewpoint. Lunar regolith-based radiation shielding protection would be placed on top of the structure to protect crews and contents from cosmic radiation, temperature extremes and micrometeoroid impacts.

This paper will discuss the results of this investigation as it relates to the following project objectives:

(1) definition of system requirements and environmental conditions affecting structural design and performance at the lunar surface; (2) geometric definition, computer modeling and structural analysis of single and multiple inflatable module configurations which includes computer graphic visualization of the structural response with and without regolith-based radiation shielding; (3) materials selection, considering manufacturing constraints, structural requirements and other performance/system requirements;

(4) identification and evaluation of various options for joining membrane components and determining the optimum method of maintaining structural integrity across connections; (5) structural behavior of the pressurized framing system; and (6) exploratory examination of manufacturing techniques, constraints and planning steps needed to facilitate efficient fabrication of a full-scale inflatable modular prototype.