RAPIDLY DEPLOYABLE BLAST BARRIERS FOR LUNAR SURFACE OPERATIONS. David J. Smith[1], Luke B. Roberson[1], Rob Mueller[1], and Phil Metzger[1], [1]NASA Kennedy Space Center, Mail Code: KT-E-3, Kennedy Space Center, Florida, 32899, USA, djsone@u.washington.edu or luke.b.roberson@nasa.gov

Introduction: Apollo landing footage shows rocket blast streaking from the Lunar Module engines as the spacecraft approached the lunar surface. This blast streak (or 'plume') was mainly composed of small particles (10-60 microns) of lunar dust estimated to be traveling at speeds between 1.0-2.5 kilometers per second. The plume also consisted of engine exhaust gases powerful enough to move rocks up to 15 cm in size. Samples of the Surveyor 3 spacecraft returned to Earth revealed substantial lunar plume damage from the Apollo 12 landing in close proximity. If spacecraft land repeatedly at a permanent Constellation Program lunar outpost, special precautions will have to be made to prevent the plume from eroding hardware or causing jams in critical surface equipment mechanisms.

Barrier Concepts: One possible blast solution is to use synthetic materials brought from Earth to build a mitigation barrier. The structure must be light-weight to reduce payload constraints and easy to deploy through robotic or astronaut surface operations. Our design concept for synthetic barriers focused primarily on two commercially available structures: inflatable barriers and textile fences.

Inflatable Barrier: The inflatable concept shown in Figure 1 offers semi-automated deployment (for reducing EVA construction time); flexibility (for use on rugged lunar terrain), packaging efficiency (for minimal volume transport to lunar surface), and durability (for plume impacts) [1,2]. All materials were suppliedby SPM S.p.A. (Brescia, Italy) and purchased through World Cup Supply (Vermont, USA). The systems were integrated and assemblyed by our team to model the basic architecture of blast barriers. Advanced materials and assembly techniques more appropriate for the lunar environment must be implemented for Phase II designs.

Inflatable Phase II Considerations: Weight reduction of our inflatable concept is a high priority (for reducing Earth-departure transportation cost). Our Phase II design will also explore pressurizing the barrier with a monopropellant generated gas. Any vacant spaces in the inflatable walls could then be injected with structural foam while the empty chamber space could be filled with compacted regolith to provide additional stability against strong blast forces [3]. To enhance lunar environment tolerance and prevent impact degradation, the intrinsic properties of the inflatable could consist of rigidizable materials (including Thin polymer film laminates and thermoplastic composite laminates) which become rigid when exposed to a specific external influence such as heat, cold, ultraviolet radiation, or the inflation gas itself [4].

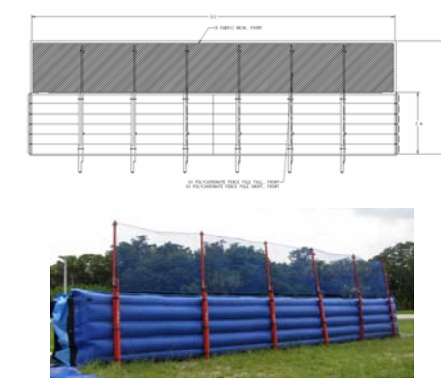

Figure 1: The KSC Phase I inflatable design stands 2.3 m tall and consists of two low pressure inflated walls, linked with a double zigzag tube chamber. The walls have loops for anchoring the structure with structural support poles (hollow, lightweight composites). These poles raise the height of the barrier with a fence extension. While only one section is depicted, multiple barrier sections can be linked, so the system may be made to any desired length or configuration.

Textile Fencing: Another vertical barrier concept that could prevent blast ejecta from impacting lunar architecture and equipment is textile fencing. Textiles can be made from commercial off-the-shelf materials such as Vectra or Kevlar and woven to impede particles ranging from micron-sized to larger gravel-sized impacts. Fabric should be attached (threaded or sewn) to poles made from advanced composites designed for flexibility during high velocity gas generation during ascent and landing. Securing fence poles deeply into the regolith will be essential to barrier performance. Apollo 15-17 demonstrated achievable depths for drilling in the lunar surface – soil which is characterized by a large increase in relative density proportional to increasing depth. Using manual techniques and specially modified drill core tubes, astronauts were able to successfully penetrate the cores 2-3 m – an acceptable depth for anchoring textile fence barriers [5].

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