INFLATABLE LUNAR LANDING PAD SYSTEM

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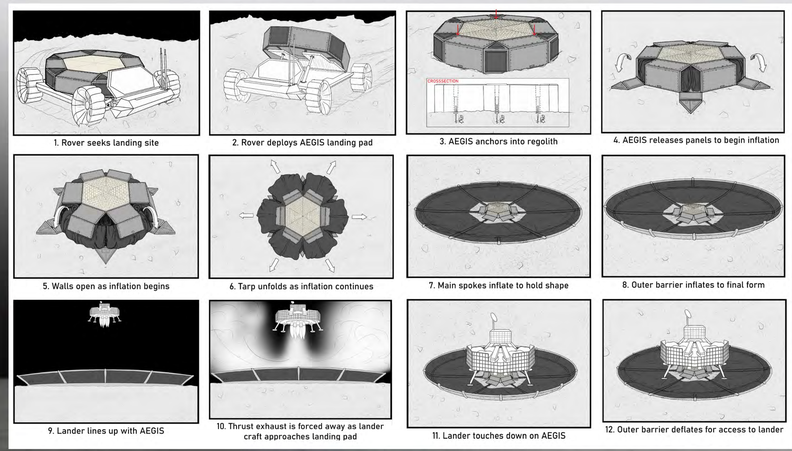
Problem Statement

Regolith ejecta generated by lunar landers can cause immense damage to nearby structures and instrumentation [1]. It has been shown that these fine-grained particles are prone to create debris clouds caused by landers and can travel at typical speeds of 2 km/s, potentially resulting in damage to nearby landers or equipment. Some debris could even be ejected into lunar orbit, resulting in damage to orbiting spacecraft and further damage up-on re-entry to the lunar surface [2][3] Current solutions include expansive safety zones to distance debris clouds from bases of operations, but if more established bases are to be constructed on the Lunar surface, these safety zones should be minimized to remove unnecessary resource consumption in relocating long distances.

Concept of Operations

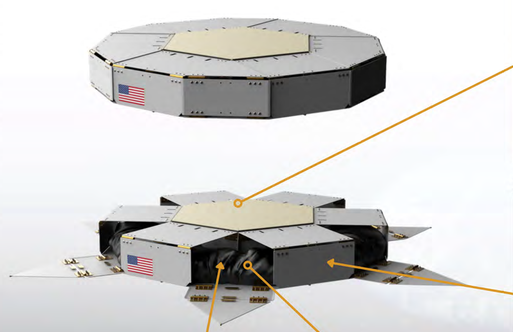
Upon delivery by a CLPS lander, Aegis will be deployed ~50 meters away by means of a small rover. Subsequently, Aegis will use a set of central anchors to affix itself to the lunar surface prior to deploying to its full size of 14 meters in diameter. After Aegis is done with its inflation procedure, it is ready to receive an incoming lander. As the lander descends, the exhaust gases will be deflected upward at a 32.5 degree angle, redirecting them away from the lunar surface while also mitigating undesired turbulence around the lander. Upon a successful landing, the structure will partially deflate letting the deflector walls fall to the ground. Payloads carried by the lander can then be unloaded before the deflector walls are reinflated for the empty lander to take off.



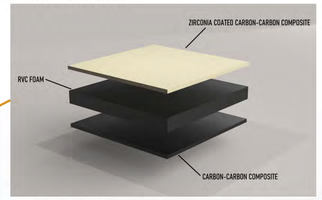
Design

Aegis comprises five sub-systems: the enclosure (A), anchors (B), heat shield (C), tarp (D), and inflated skeleton (E). The enclosure is designed to safely contain the system during transport. Affixed in the enclosure are the 6 anchors which auger into the Lunar surface to stabilize the system. The central rigid heat shield constructed using reticulated vitreous carbon (RVC) foam encased by two sheets of carbon fiber-reinforced carbon composite (CFRC) along with a zirconia coating on the topmost layer to improve thermal resistance and combat degradation. The tarp is constructed from a novel stack-up of a knit carbon fiber fabric, alumina felt, and aluminized Kapton which work together to create a robust, thermally insulative, and structurally sound stack-up. Finally, the inflated skeleton is made of an elastomeric bladder encased in Kevlar restraint layer.

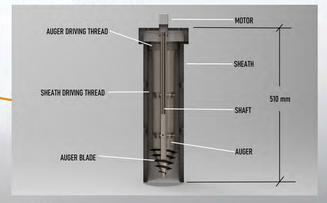
STOWED CONFIGURATION



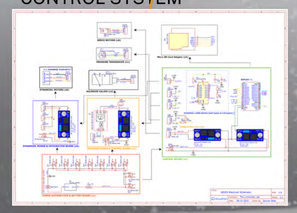
HEAT SHIELD



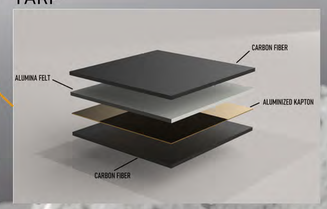
BASE ANCHOR



CONTROL SYSTEM



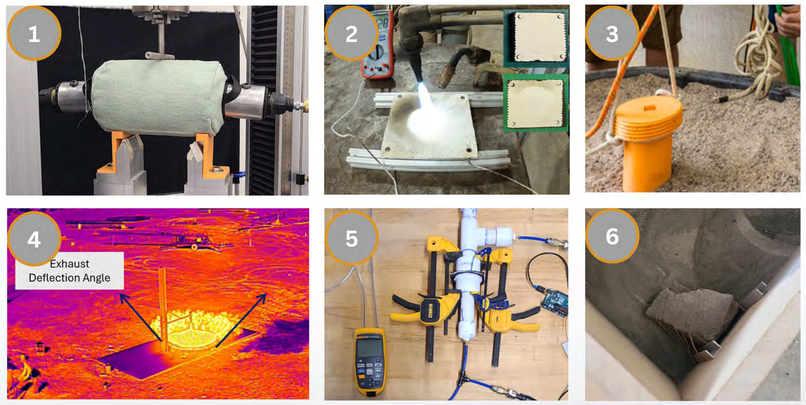
TARP



Testing

Comprehensive analysis and testing have been performed to verify Aegis's ability to endure the relevant environmental conditions it will be exposed to. Tests of note include: compressive and three-point bend tests for inflated beams (1), thermal ablative tests exposing both heat shield and tarp test articles to 3000K (2), anchor pull out testing (3), gas deflection tests with a solid rocket motor and system at 1/5th scale (4), air permeability testing (5), lunar regolith abrasion testing (6), and deployment testing in a Earth analog environment (7).

RELAVENT ENVIRONMENT TESTING



EARTH ANALOG TESTING - SP CRATER 35°35'21.3"N 111°38'13.4"W

[1] Mishra, Sanjeev. Prasad, Durga. Nath, Pranav. Agarwal, Deepak. Kumar, Sunil. Bhardwaj, Anil. (2022) Planetary and Space Sci. 211, 105398. [2] M. Wittal, J. Phillips Iii, P. Metzger, B. Link, J. Mantovani, and D. Batcheldor, AAS 20-511 [3] D. Fontes, J. G. Mantovani, and P. Metzger, Acta Astronautica, vol. 195, pp. 169– 182, Jun. 2022, doi: https://doi.org/10.1016/j.actaastro.2022.02.016.