2023 NASA Entrepreneurs Challenge

Technical Submission Template

Applicant Name: Jeffrey Morse

Applicant Affiliation: Widgetblender LCC

Technology Focus Area Chosen: *Lunar Payloads*

LASSIE (Lunar Adaptable Smart Surface Integrated Experiment) and LSS (Lunar Smart Surfaces)

SECTION ONE: ***Relevance, Impact & Significance (30%)***

1. **Relevance to Challenge Technology Focus Area**
    - LASSIE/LSS aligns will all suggestions from https://www.herox.com/NASAEntrepreneurChallenge/245-technology-focus-areas and particularly "Lunar engineering experiments". LASSIE is a TRL building experiment to support design of the Lunar Smart Surface (LSS) product, but LSS can proceed if LASSIE can't secure a low-cost ride on a CLPS mission, in which case LSS will have a lower TRL and more technical risk (but as a simple concept with high TRL components this maybe be acceptable).
    - LASSIE is a compact, lightweight experiment (<5 kg) that can be attached in various locations to the mounting decks of various CLPS landers. LASSIE tests the materials that will be used in larger scale Lunar Smart Surface solutions that may be made of 5m x 5m x 1cm "surface tarp" solutions that can be combined to cover large "manned mission scale" surfaces. If needed a 50 kg unit of LSS itself could be placed on a CLPS lander.
    - LSS creates a key part of a dust mitigation strategy that should work on both the Lunar and Martian surface (but without EM dust removal on Mars) that includes a EM-dust movement functionality and controlled dust observations. This is called out in "Moon to Mars Objectives" LI-6L "Demonstrate local, regional, and global surface transportation and mobility capabilities in support of continuous human lunar presence and a robust lunar economy" with the potential of LSS based dust minimizing paths/roads between habitats and equipment. Also, HS-3, AS-1, TH-4 and OP-12 may apply.
2. **Impact & Significance of Objective**
    - Managing lunar dust will be a key issue in manned lunar operations. LASSIE leading to LSS can help mitigate this issue, perhaps reducing the dust within habitats by 90% (when paired with proper procedures like specific walking patterns and motions, and reusing compressed CO_2 from the CO_2 scrubber to blast dust from parts of LSS when it collects over time).
    - Both LASSIE and LSS have potential benefits for the science community as well. LASSIE will test a theory of using electrical currents to move lunar dust. Later

LASSIE 2.0 can also be reused to test other surface materials and designs. LSS has the potential to test, in the long term, how much Smart Surfaces can help with dust management on the Moon, Mars and potentially difficult Earth terrains. From a pure science perspective, it offers a specific camera monitored surface where dust accumulations can be measured over time, improving models of lunar dust movement. Embedded sensors may find correlations of dust motion with solar intensity and temperatures.

SECTION TWO: ***Innovation of Approach (10%)***

3. Solution Novelty, Competition and Technology Superiority

- There is no comparative product on the market or in development.
- By reviewing NASA provided renders of expected manned lunar surface operations there appears to be no tarp like lunar surface used. Some research has suggested a way to convert lunar regolith to lunar concrete. This "concrete" approach will require novel equipment, consumables and labor. Even then, it is likely that this won't be a complete surface dust solution as it won't abrade and actively remove dust from boots. By comparison, LSS should be very low cost to fabricate (on Earth), given the maturity and industrial availability of the components. LSS has very low labor requirements for deployment, low technical risk (LSS has been Earth tested and ready to deploy quickly). A "concrete" approach will require a great deal of dust collection and processing operations.
- LSS is expected to cost < $10,000/per square meter to fabricate, test, deliver to customer and support via video from the Moon during deployment.

SECTION THREE: ***Technical Credibility of Approach (20%)***

4. Technical Feasibility

- Figure 1 depicts a cross section of LSS. The chain mail itself has been operationally used on the Mars Insight Lander for flexible protection, and thus has a TRL of 5-6 for LSS. Beta Cloth has a TRL=5-6 for this application. All other common support components, such as wires, solar cells, batteries, controllers, cameras, and LEDs will be chosen to have high TRLs in at least the space environment.

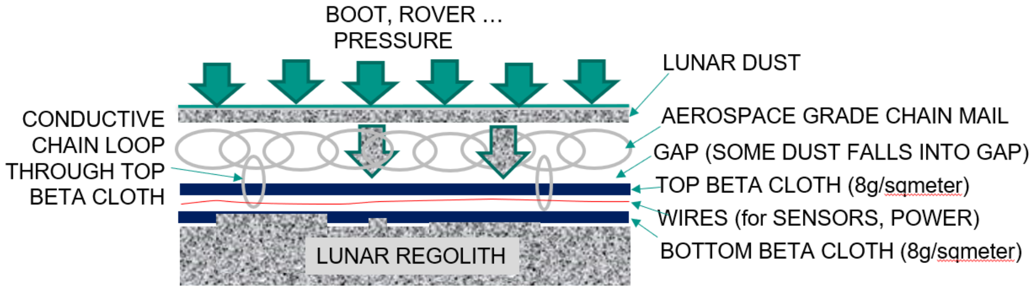

Figure 1. Cross Section of Lunar Smart Surface

The basic LSS product is essentially a ground cover tarp that has been engineered to resist the lunar environment and provide extra features, such as active electronic dust removal sensor feedback of the parts of the LSS. Fabrication is straight forward. Beta Cloth is readily available in rolls, and chain mail in long 1 meter strips and squares. "Sewing" with wires in the right location binds the chain mail to Beta Cloth and the power wires that are above the bottom surface of Beta Cloth. Figure 2 shows major components of the proposed ~5 kg LASSIE payload that would be used to validate the performance of the LSS concept and boost TRL from 5-6 to 7-8. LASSIE is approximately the size of a thin briefcase. LASSIE is pushed off its location on the CLPS lander so it makes contact with the lunar surface. LASSIE has 2 experiments, one to test the resilience of LSS to lunar conditions, and another to see if current applied to chain mail strips can move electrostatically charged lunar dust. Experiment 1, as a long term experiment, the Test Arms will be rotated by controller/battery/motor arrangement to contact and push on the samples perhaps daily or weekly for as long as the lander can support comms to send back test observations. While nighttime operations would be helpful, good data can be gained simply though daytime testing over many months. Lights and cameras support data collection that is sent back as static images as the lander's comm system permits. The motor force and force pattern can be modified from Earth controllers to maximize effective data collection. Experiment 2 will be run as soon as possible in case the CLPS lander does not survive the lunar night. Here small motors are run to kick some dust onto the Chain Mail on Beta Cloth sample that has been wired to create an EM field that will hopefully interact with the electrostatically charged dust to move that dust (see figure 3 for an excerpt from the technical paper).

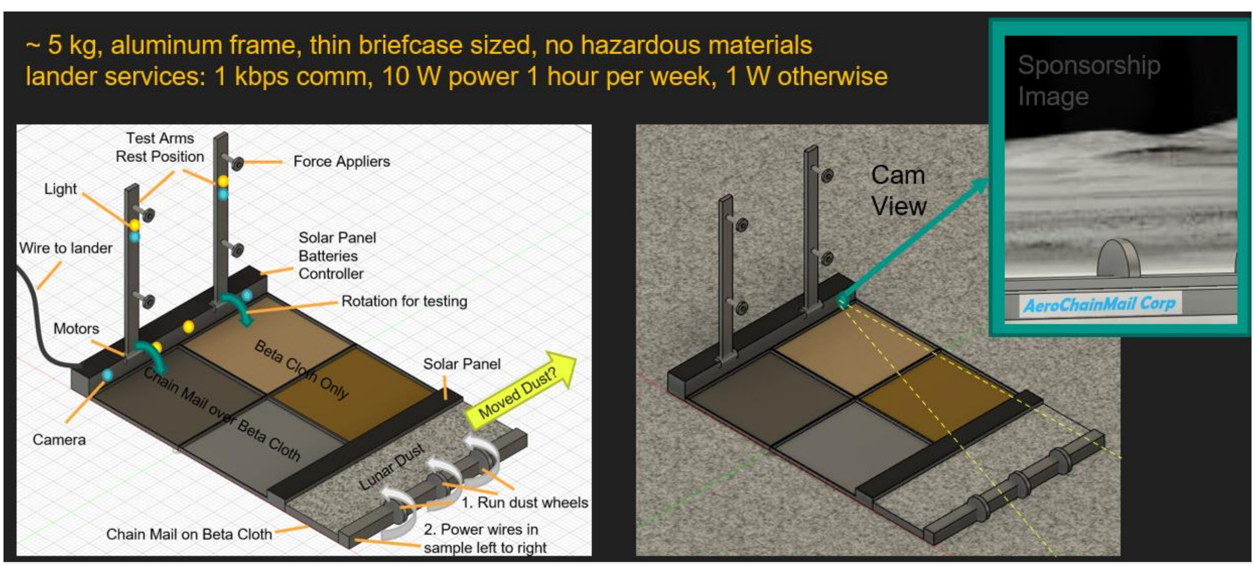

Figure 2. Overview of LASSIE (major components)

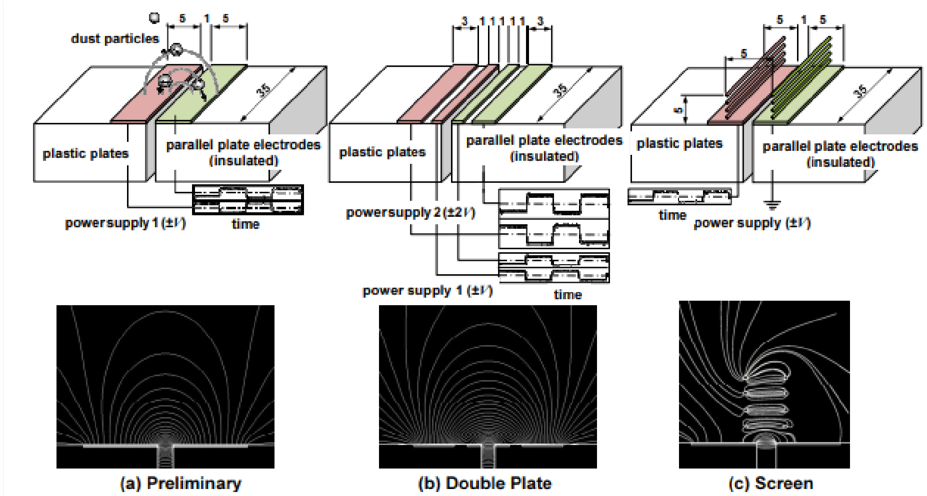

Figure 3. Electrostatic Movement of Lunar Dust (https://ttu-ir.tdl.org/bitstream/handle/2346/59744/ICES-2014-279.pdf)

- Figure 4 shows a potential design for a unit of LSS, and how multiple units of LSS might be deployed around a lunar habitat. On the left there is a top view of a default layout of beta fabric (5mx5m) with 9 sqmeters of walkway. For scale an astronaut is depicted from above. Locking carbon composite rods ensure the shape is retained over time, as well as the "dust tight" edges that connect with other LSS units. The mass of chain mail also improves shape resilience. Additional mass (equipment, rocks) can be added to the edges and non-chain mail areas to also improve stability. The exact position of the chain mail will be custom to support a greater design depicted on the right. Small flexible solar panels that pop-up at 90 deg to the surface and a battery, controller enable sensors, possible LED patterns for human night ops, and EM based dust removal.

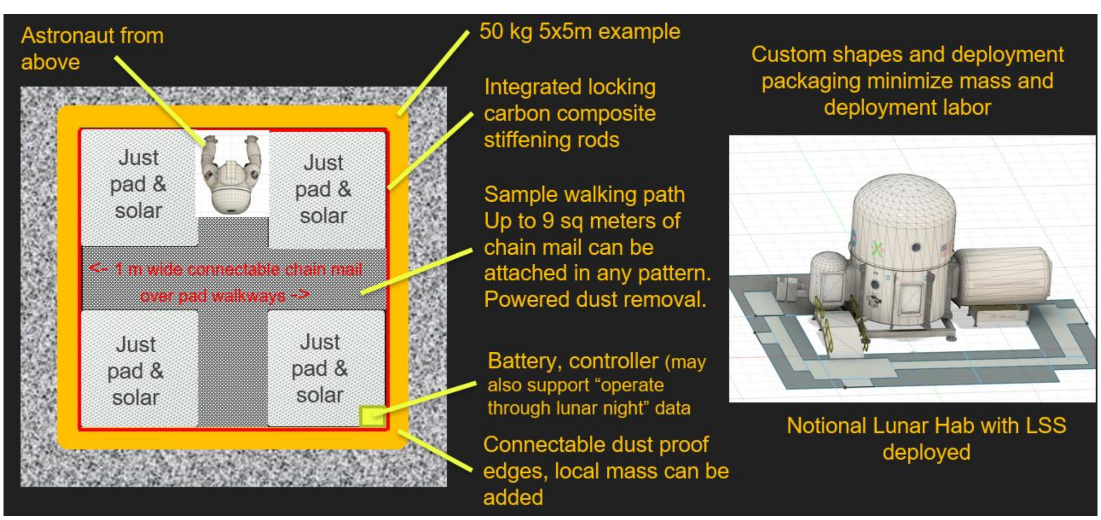

Figure 4. Top view of an LSS unit, how many LSS units may be assembled around a hab

- As the main product is LSS, with LASSIE on CLPS as a design validator and TRL builder, attracting investors with both patent pending and a patent for LSS is key. But an award for this competition is critical to create credibility to engage partners that can contribute funds and resources (for fractions of the patent value). While we hope for a low-cost ride on a CLPS lander, the high TRLs (5-6) of LSS components make it possible to prototype and sell LSS without this.

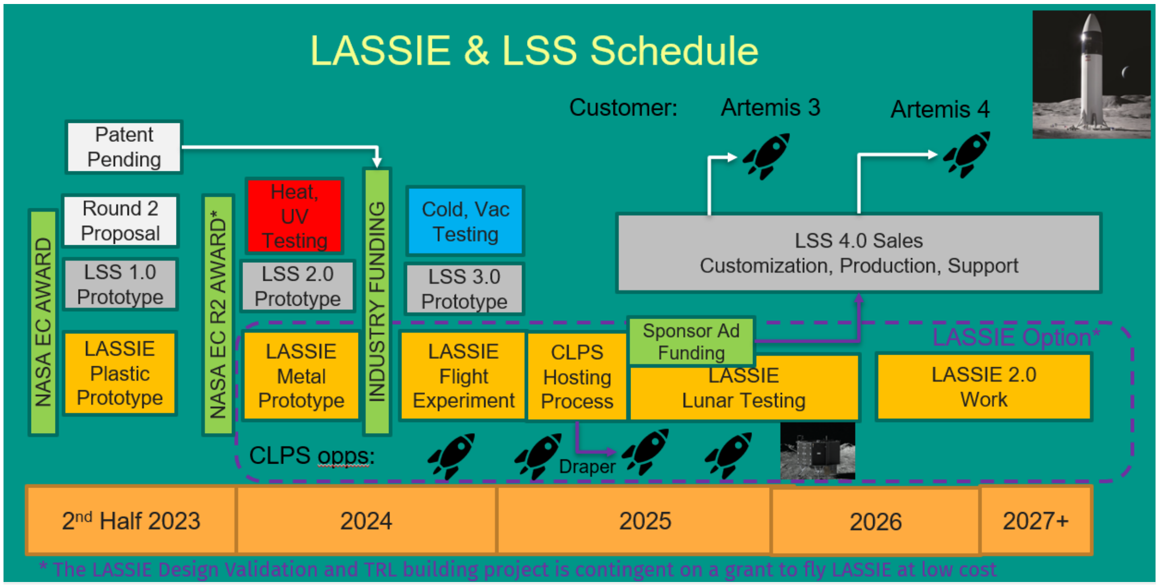

Figure 5. LASSIE & LSS High Level Schedule

- LSS will only require a short period of time (perhaps a man-hour per LSS unit) to deploy and connect to other LSS units. LSS packaging will be matched to manned mission capabilities, perhaps a roll for HLS Starship, or a cube for Blue Moon. LSS should be easy to fabricate for prototypes as beta cloth and chain mail are easy to acquire. Heat and UV testing can be done in garage level facilities. Later cold and vacuum testing facilities need to be located and used. We expect to apply to a NASA center for this level of testing.

5. Risks and Barriers

- From a technical perspective LSS is a low-risk product that can be made to order with a downpayment from the customer. The risk remains that until tested on a small scale with LASSIE, LSS will not have the TRL of 7-8 that may allow it a part of the manifest of a manned lunar surface operation like Artemis 3 or 4.
- LASSIE is also technically straight forward and can be built with components with TRLs ranging from 5-7. The cost of building LASSIE is perhaps $50K with testing, but as with any CLPS payload, even at 5 kg it may prove impossible to fund raise for it. Fortunately, LASSIE is not needed for a LSS with a TRL of 5-6.
- We expect the patent will lead to additional investors or the sale of the idea to a small aerospace company with more resources.