The first lunar roads? Thermoplastic and regolith surface improvement vacuum demonstration and durability testing

G. Johnson[1], P. van Susante[2], D. Mallot[3], C. McLeod[4], L. Herrera[5]

[1,2] Michigan Technological University, 1400 Townsend Dr. Houghton, MI 49931, georgejo@mtu.edu, pjvansus@mtu.edu.

[3,4,5] Spacefactory, 4217 9th Ave SW, Suite 8, Huntsville, AL 35805, david@spacefactory.io, connor@spacefactory.io, leo@spacefactory.io

Introduction

Landing pads, roads, berms, and habitats are key lunar surface infrastructures that will be required for sustaining long term autonomous and human missions.

During a Phase 1 STTR grant, Spacefactory and MTU demonstrated the deployment and curing of a polymer-coated regolith feedstock in vacuum on a bed of regolith simulant. Durability testing of this surface improvement was conducted to characterize its performance as a lunar road surface.

Test Bed Preparation

A 1.6 m x 0.6 m x 0.2 m bed of MTU-LHT-1A was layered and compacted to an average density of 1.76 to 1.8 g/cc.

A 35 mm deep trench was dug, and size sorted regolith particles (>1mm) were layered between layers of regolith fines. Near the top of the trench a polymer mesh was included under the top 5 mm of regolith fines.

This method of layered subsurface preparation on a compacted bed of regolith improves the resulting bearing capacity of the final road surface. This method of improvement could easily be achieved using autonomous systems with trenching, compacting, and particle deposition mechanisms.

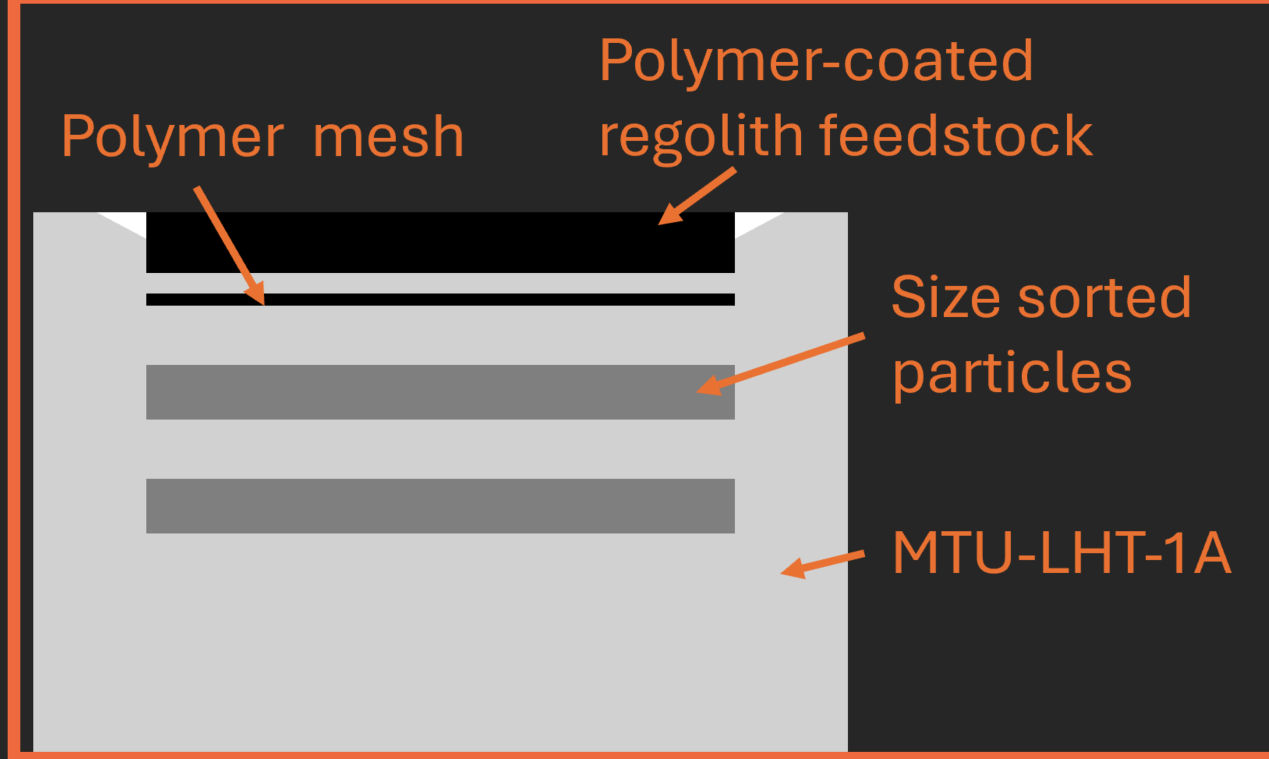

Figure 1: Test Bed Preparation and Surface Improvement Layering

Feedstock Deployment and Curing

Polymer coated regolith feedstock was dispensed and leveled in a 5mm thick layer from Spacefactory's hopper under 10E-3 Torr. Once 0.8 m of the feedstock was laid, an IR lamp was repeatedly passed over the surface to melt the polymer coatings and fuse the feedstock together. The material was allowed to cure under vacuum for over an hour. Figure 2 shows the resulting cured road surface.

Figure 2: Feedstock Deployment and Cured Road Surface

Durability Testing

The road surface was loaded with a constant 10 psi pressure from a tweel. A total distance of 0.7 km was traversed over the 0.8 m road surface (900 passes). No failures were observed and the tweel remained uncontaminated with regolith.

Additional tweel tests were ran on the subsurface layered improvements, compacted, and uncompacted regolith. ~500 passes for each of these tests Wheel sinkage was measured to be 12mm, 20mm, and 34mm respectively. These results provide comparative metrics for road durability and wheel contamination with and without layered and surface improvements.

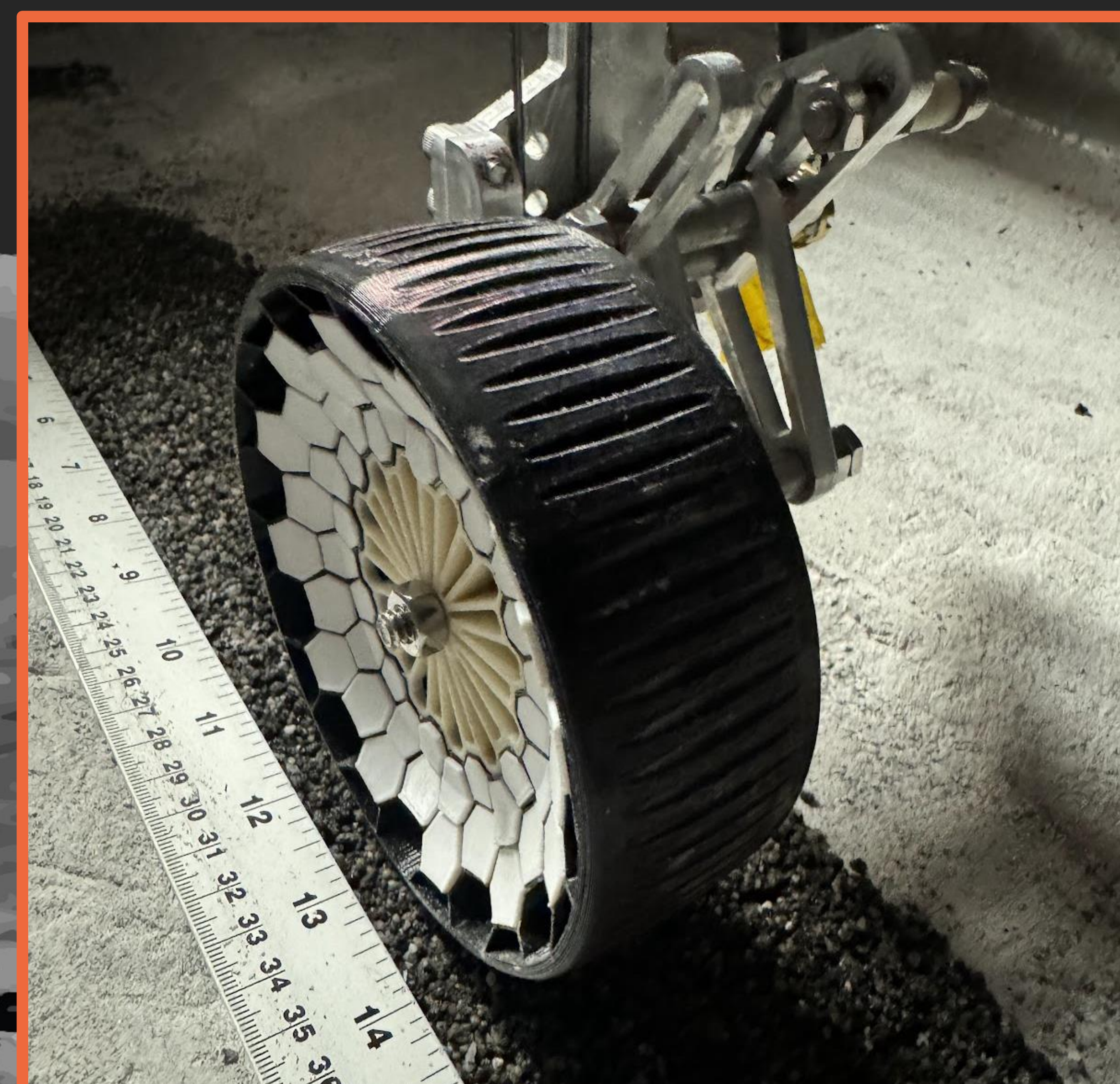

Figure 3: Constant Pressure Tweel Durability Testing

Road Surface Bending Tests

After the constant 10 psi tweel durability testing the final road surface was cut into 6 equal lengths. Bending test spans were 80 mm and sample widths of 60 mm. 3-point bending test results can be seen in Table 1.

Table 1: 3-Point Bending Test Results

Avg. Peak Load (lbf)	**4.6**
Avg. Peak Stress (psi)	237
Avg. Sample Span (mm)	80
Avg. Sample Width (mm)	60
Avg. Sample Thickness (mm)	5

Figure 4: 3-Point Bending Test