Physical Sciences Inc.

Space Resources Roundtable

LUCIDEON evenline

VG-2023-174
PSI-8106

Efficient Truss Structures From Regolith Glass

XXIII Space Resources Roundtable Conference

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Project Concept

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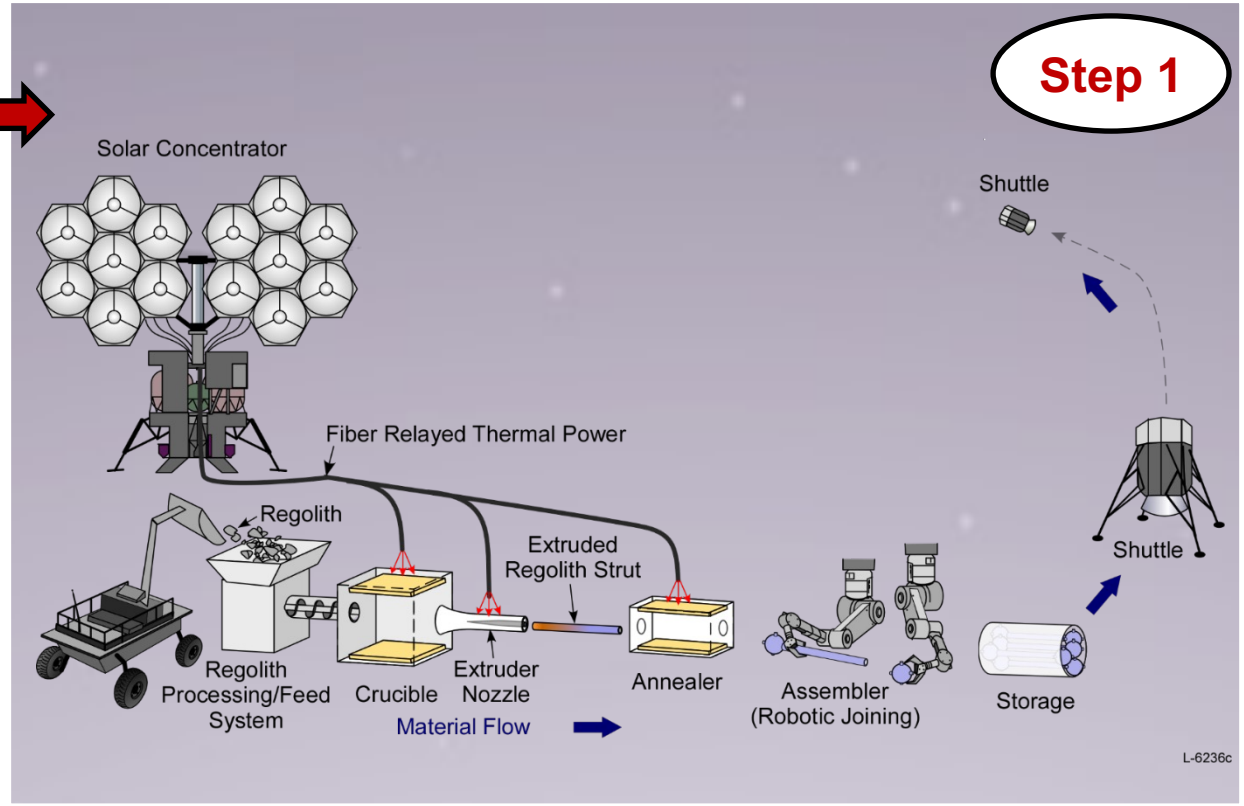
- **Goal:** **Develop processes and hardware to melt-process lunar regolith into building block parts for assembly into mass-efficient orbital structures**
- **Proposed solution:**
  - **Step 1:** Fabricate regolith glass rods (extruded) and nodes (molded) on the lunar surface
  - **Step 2:** Construct truss-based regolith glass struts on orbit
  - **Step 3:** Assemble very large structures from regolith glass struts and nodes
- **Technology Development:**
  - **Materials:** Feedstock properties and processing conditions
  - **Process:** Hardware to melt-process parts; Glass welding
  - **Structures:** High precision rods, nodes ⇨ trusses ⇨ assemblies



Future commercial effort envisioned to produce regolith glass rods and nodes on the lunar surface

Project Concept: Step 2

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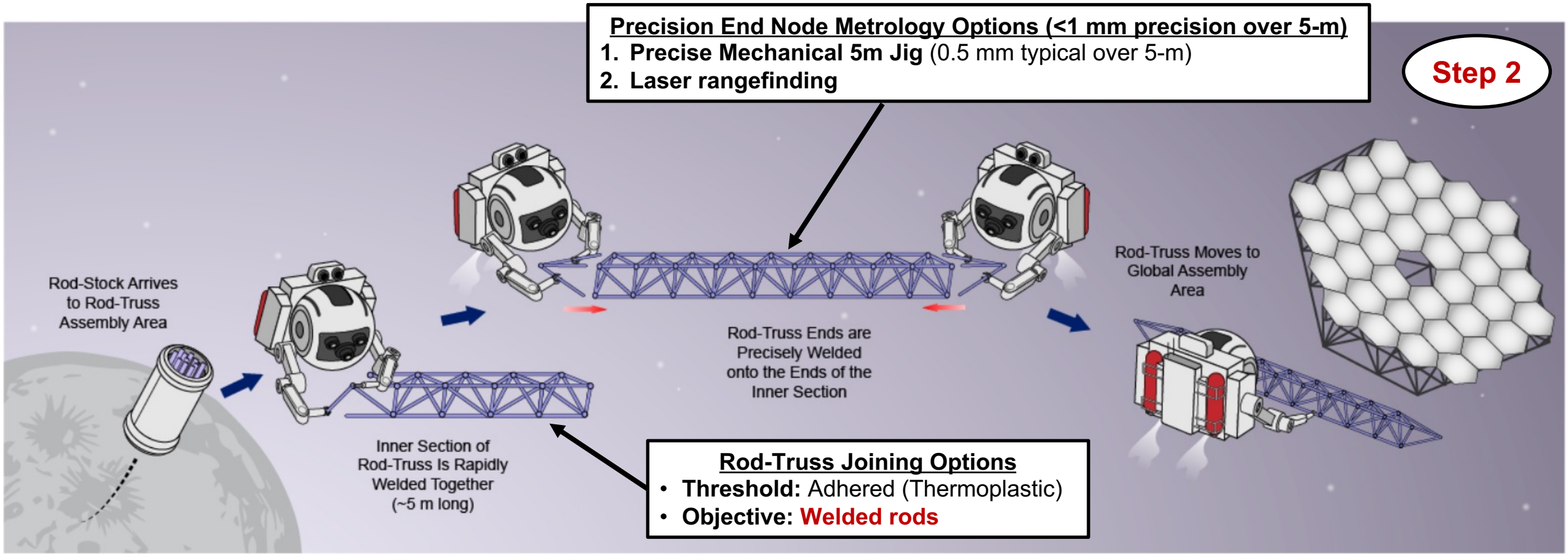
- **Construct truss-based regolith glass struts on orbit**



5m regolith glass rod-truss strut built on orbit

Project Concept: Step 3

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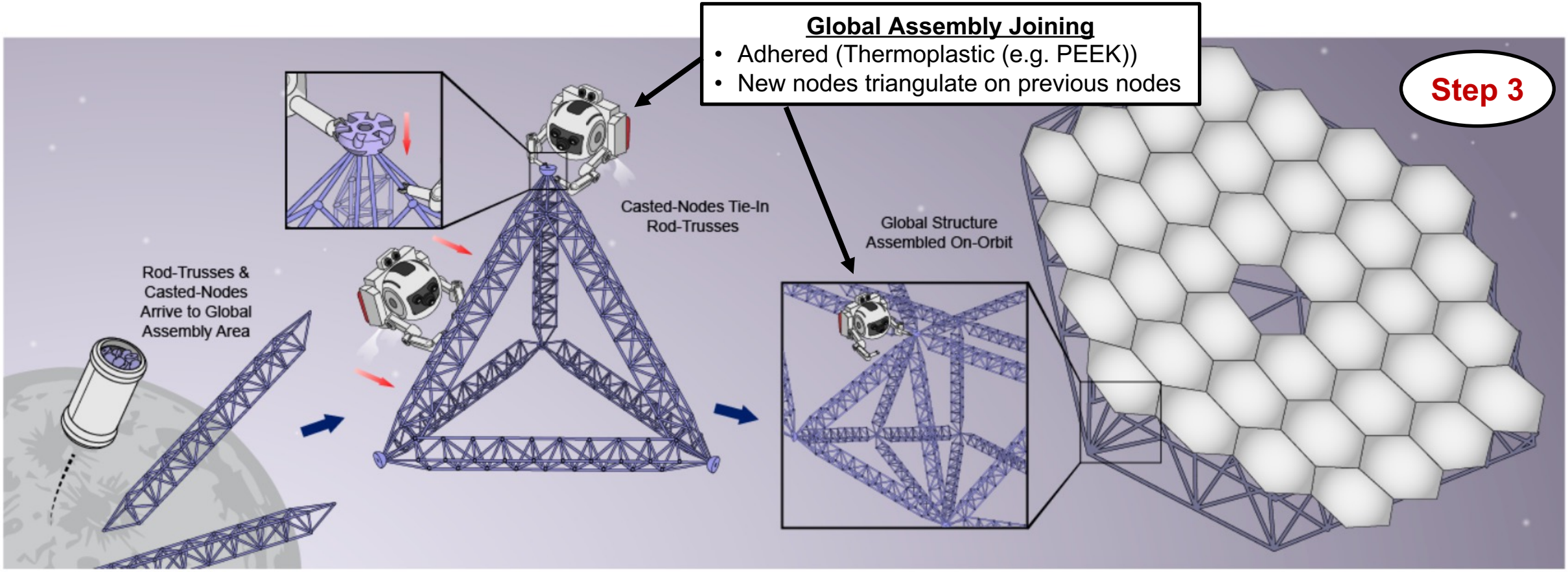
- **Assemble very large structures from regolith glass struts and nodes**



Full structure assembled from 5m struts and global nodes

Regolith Simulant Material Properties

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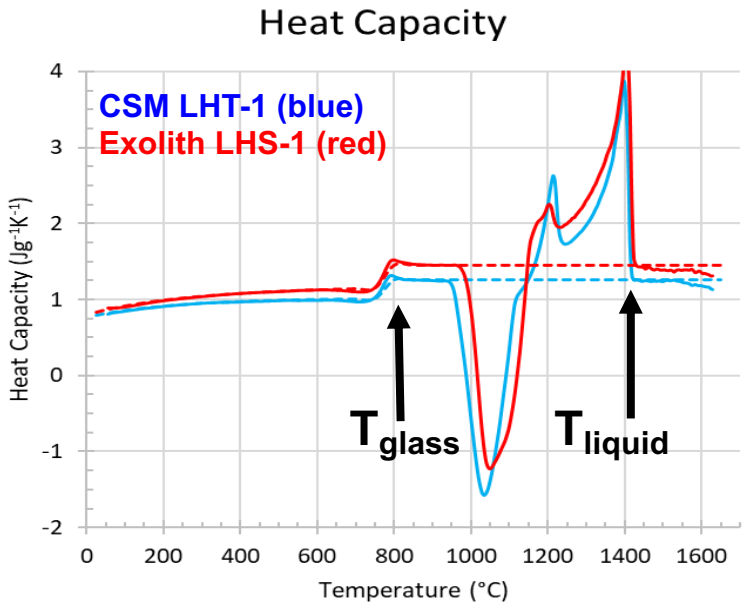
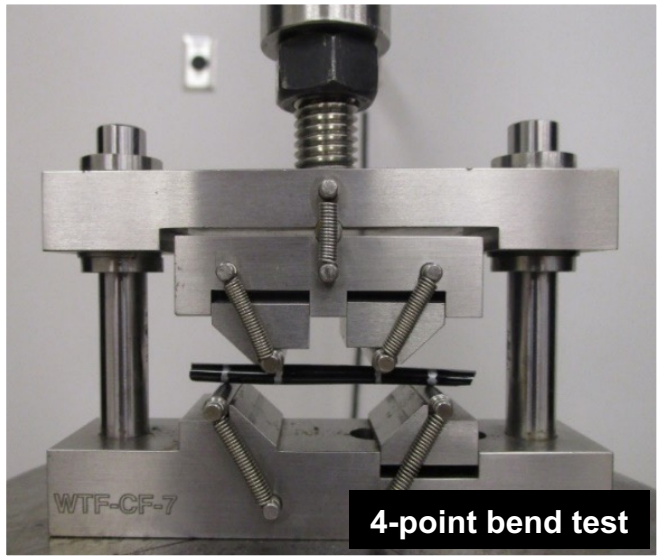
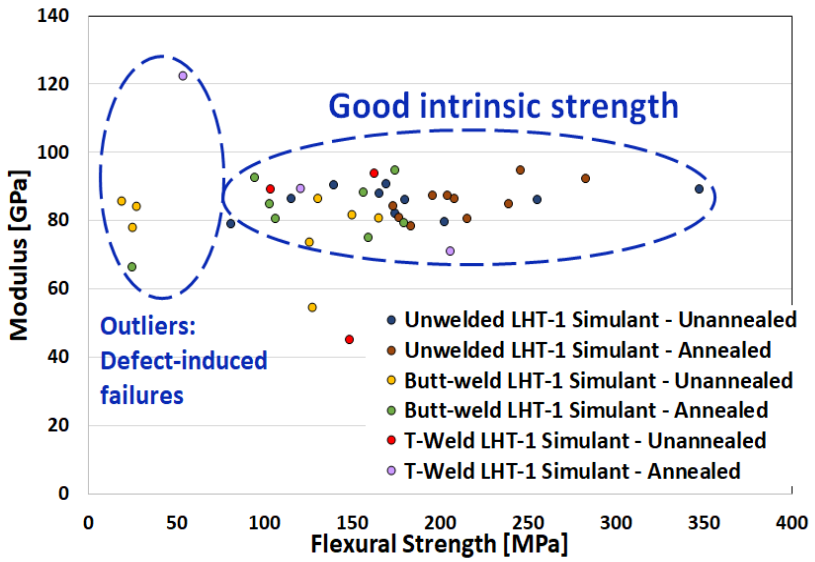
- **Measured intrinsic properties of Highlands lunar simulants (CSM LHT-1, Exolith LHS-1) to guide fabricator hardware and methods**

DSC Measurements



Flexural Test (for Elastic Modulus)





Excellent properties for orbital structures:
Elastic modulus = ~85GPa, CTE = ~5 μm/m-°C

Regolith Simulant Glass Processing

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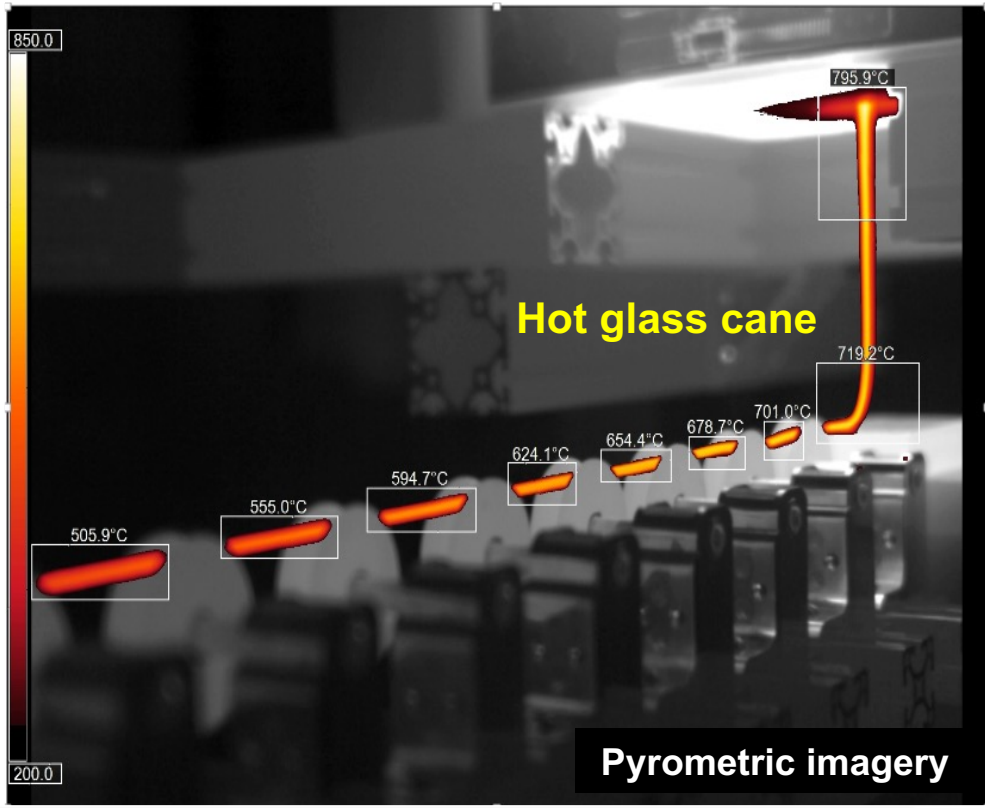
- **Developed processes to melt and re-form simulated regolith into precision glass forms (parts for trusses). Very high temperatures (>1600°C) and resilient materials are required to manipulate lunar lava.**

Extruded regolith simulant glass rod (“cane”)

Cane extrusion system



Pyrometric imagery

Most processes tested in conventional glass. Regolith simulant coming online.

Regolith Simulant Glass Processing - 2

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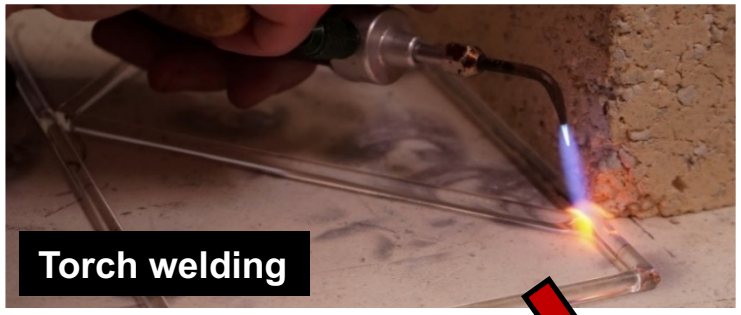
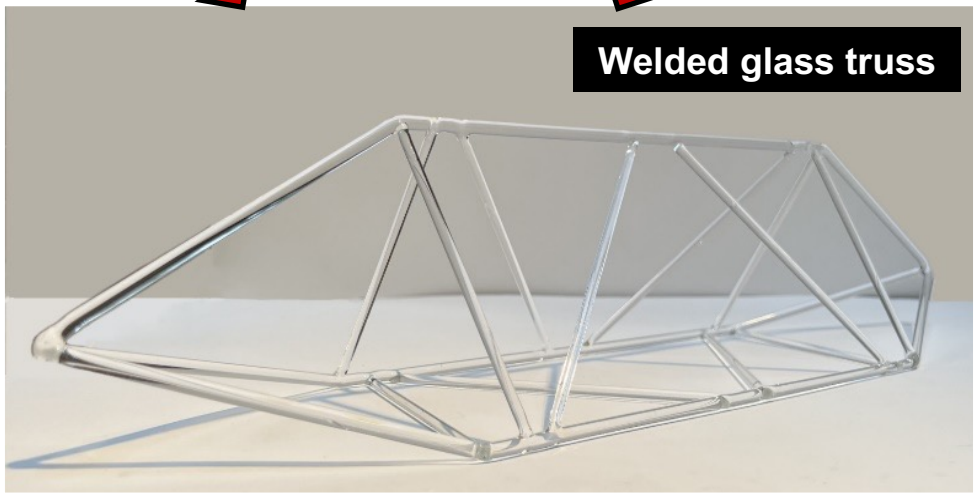
Welded Truss Fabrication

Surrogate Material: Borosilicate Glass



Regolith Simulant



Generated welded borosilicate glass trusses to 2m length

Regolith Simulant Glass Truss Design

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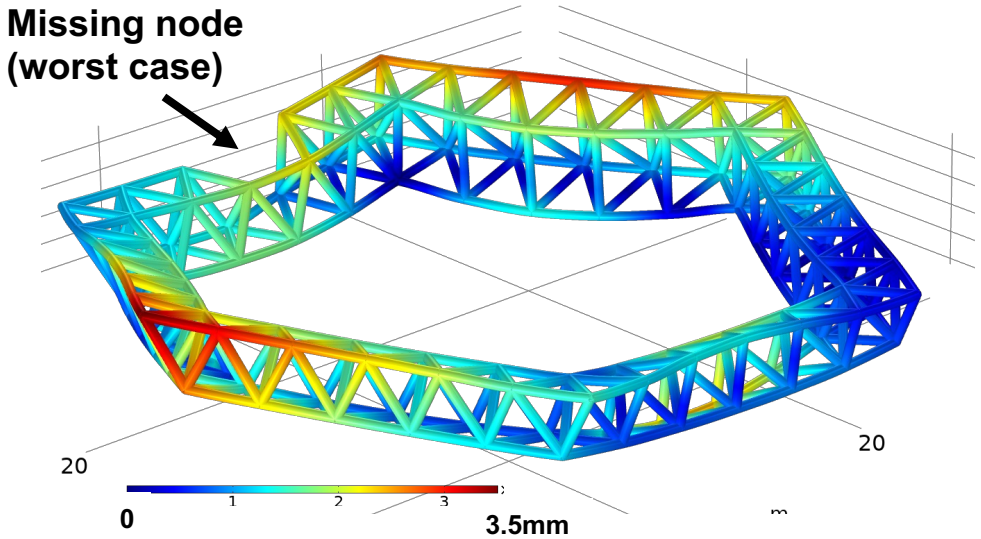
- **Created designs with tetrahedral assembly of (aspect ratio ~50) rod trusses. Regolith simulant glass properties incorporated. Structures modeled in realistic thermal and dynamic loadings.**

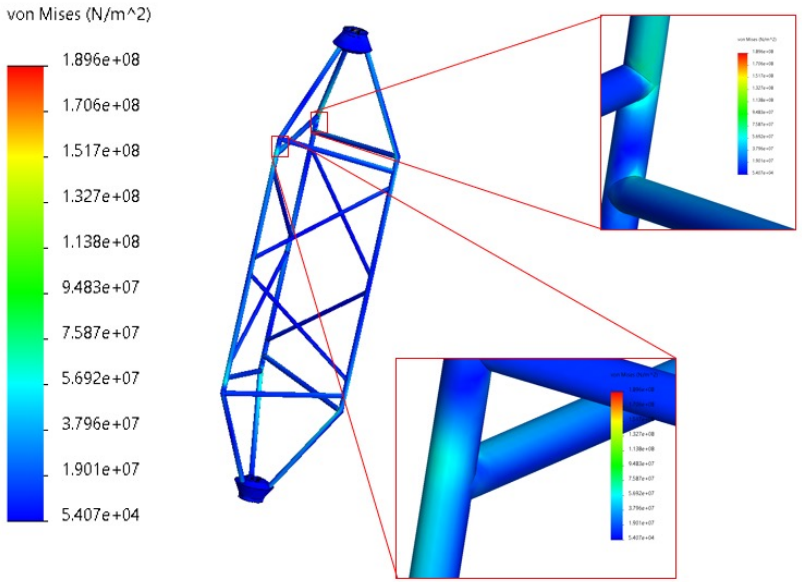
Truss Displacement: Global Buckling **FOS = 3.8**

Frame Displacement: Max Dynamic Load



Loads compared to failure conditions

Local Yielding **FOS = 2.6**



3 failure modes (global buckling, local buckling, local yield) have good factors of safety (>2.0)

Regolith Simulant Glass Truss Testing

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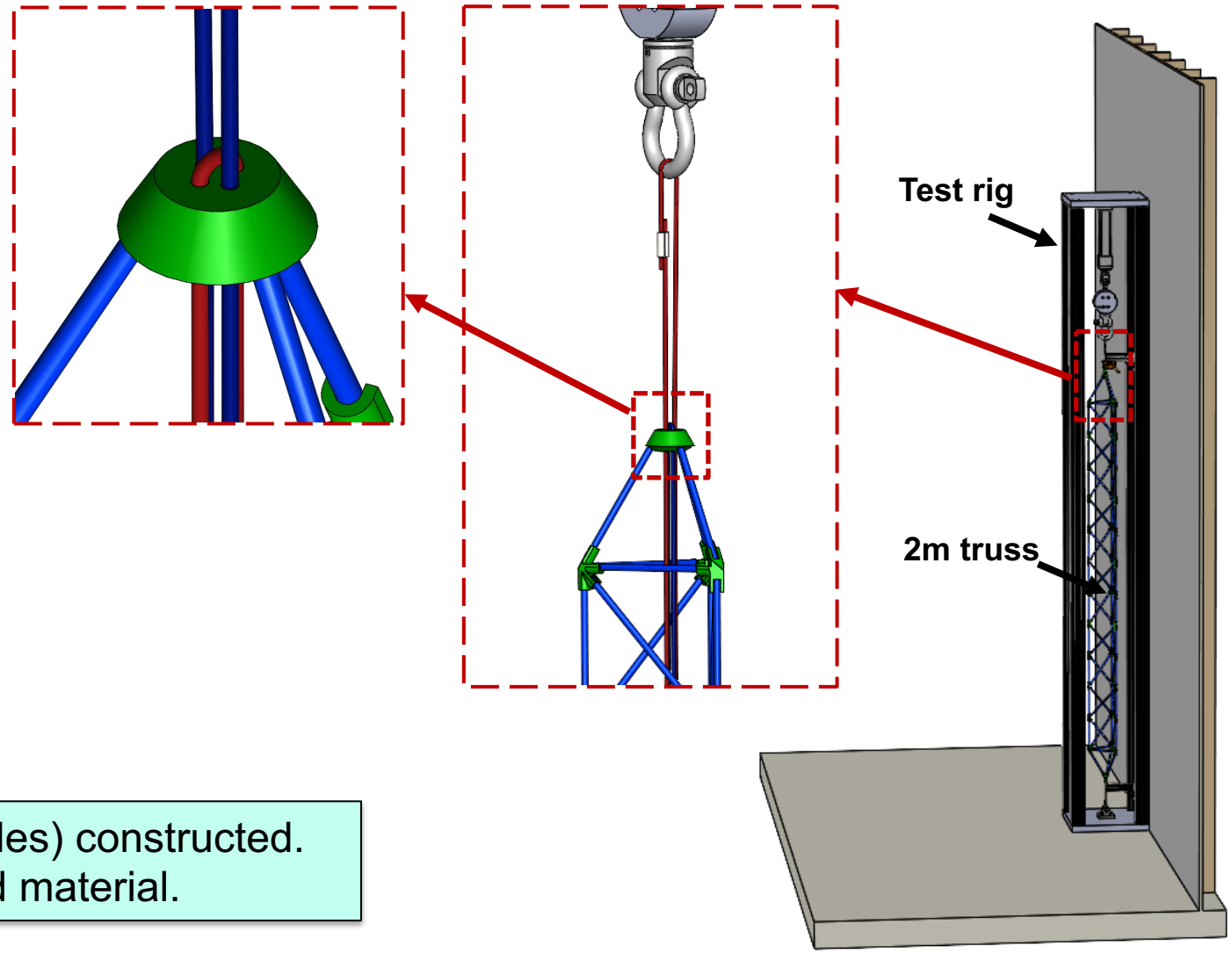
Tensile / Compressive Test Rig



Test rig (and coupling end nodes) constructed.
Rig tested on calibrated material.

Summary

- ✓ **Characterized intrinsic properties of regolith simulant from powder to liquid to solid**
  - Solid product very amenable to space structures. Elastic modulus = ~85GPa, CTE = ~5 μm/m-°C.
- ✓ **Built and tested glass cane extrusion system for borosilicate glass**
  - Awaiting regolith-capable furnace components to extrude regolith simulant
- ✓ **Applied pyrometric imaging for tight control of glass production parameters**
- ✓ **Demonstrated and strength-tested welding of regolith rods**
- ✓ **Built and tested jigging for welded glass truss structures**
- ✓ **Assembled (welded) 0.5m and 2m borosilicate glass trusses**
- ✓ **Constructed finite-element models for individual trusses and full space structure**
- ✓ **Applied realistic regolith properties, and thermal / dynamic loading to model strength and stiffness of components and full space structure**
  - >2.0 factor of safety for all failure modes
- ✓ **Designed and built test facilities to stress trusses (up to 2m) in tension, compression, or cantilever**