ME 2.01: Lunar & Mars Surface Habitat Module Manufacturing

TEXAS STATE UNIVERSITY. Mechanical Engineering

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TEXAS SPACE GRANT CONSORTIUM DESIGN CHALLENGE

Project Description

NASA's plans for Lunar and Martian exploration require sustainable surface habitat modules that are not only safe and functional, but are also manufacturable, modular, and adaptable to extreme conditions. This project envisions the design of a **scalable habitat module**, designed for operation in the harshest of both Lunar and Martian environments that will balance crew **safety**, **manufacturability**, product **longevity**, and efficient **transport** from the Earth to the Moon or Mars.

Module Functions

- Provide habitable pressurized volume
- Protect crew from external hazards
- Enable surface operations, crew mobility, scalability, and modularity
- Maintain thermal control
- Allow safe assembly, deployment, and operation
- Allow efficient maintenance and repair

Constraints

Mass Limit: ≤ 10 metric tons for launch configuration
Surface Size per Module: ~50-80 m^2 useable floor area
Thermal Range: Survive -130°C to +120°C(lunar), -90°C to +20°C(Mars)
Radiation Protection: At least 10 g/cm^2 equivalent shielding
Assembly Time: < 30 days with crew and/or robotic systems
Power Interface: 5-20 kWe capability, battery or fission ready

System Architecture

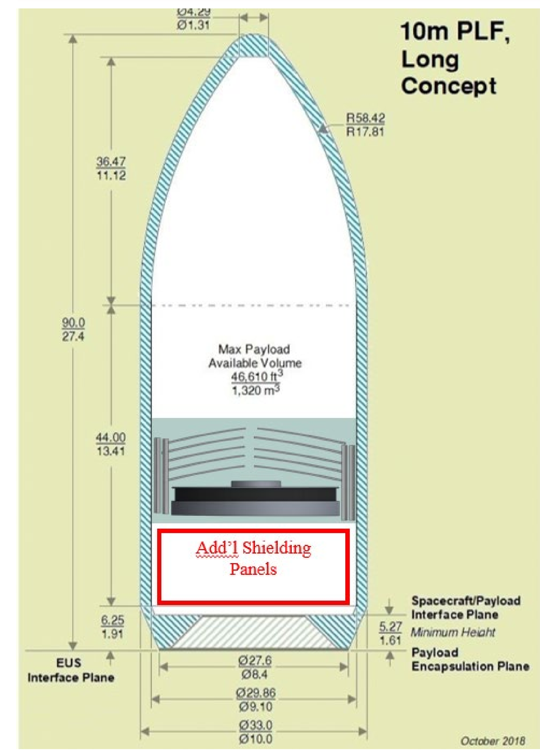
•**Structural:**	Internal inflatable structure and rigid external MMOD shielding panels. Structure is 8.5 meters in diameter and 3.5 meters tall.
•**Thermal:**	MLI layer and ECLSS
•**Radiation:**	MMOD external and MLI internal layers
•**Integration/ Interfacing:**	Quest Airlock and Common Berthing Mechanism
•**Power:**	Nuclear reactor (Stirling radioisotope generator)

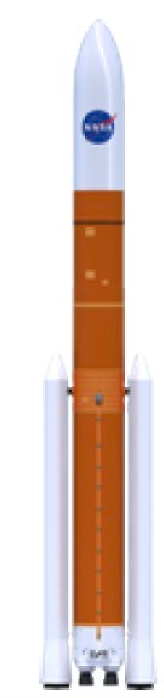
Hybrid Method

The B.E.D.H (Bobcat Extraterrestrial Deployable Habitat) module uses an inflatable interior protected from dust and space debris by an array of rigid, modular panels. Using a "clip-on" mechanism, the panels can be easily attached and detached, allowing for compact stowing, ease of assembly, repair, and maintainability.

Fastening Techniques: Rotating locker, Connecting Hinge, Locking Pin, Ball and Socket joints

Launch and Assembly





SLS Block 2 Cargo

Launch Plan: The BEDH will be launched using the SLS Block 2 Cargo configuration with the 10m payload fairing.
Deployment Strategy: BEDH will arrive in deflated state. Once moved to site, roof panels will attach to inflatable first, then inflatable will be pressurized allowing for final attachment of side panels and subsystem integrations.
Assembly Time: Each phase of the assembly can be completed within 1-2 days.

Phase 0: Lander touches down, site location prepped for placement → **Phase 1:** BEDH is removed from the payload fairing → **Phase 2:** Roof panels are installed → **Phase 3:** BEDH pressure bladder is inflated → **Phase 4:** Vertical panels are installed and aligned → **Phase 5:** Airlocks are installed and seals are verified → **Phase 6:** Subsystems are integrated and operational

The B.E.D.H.

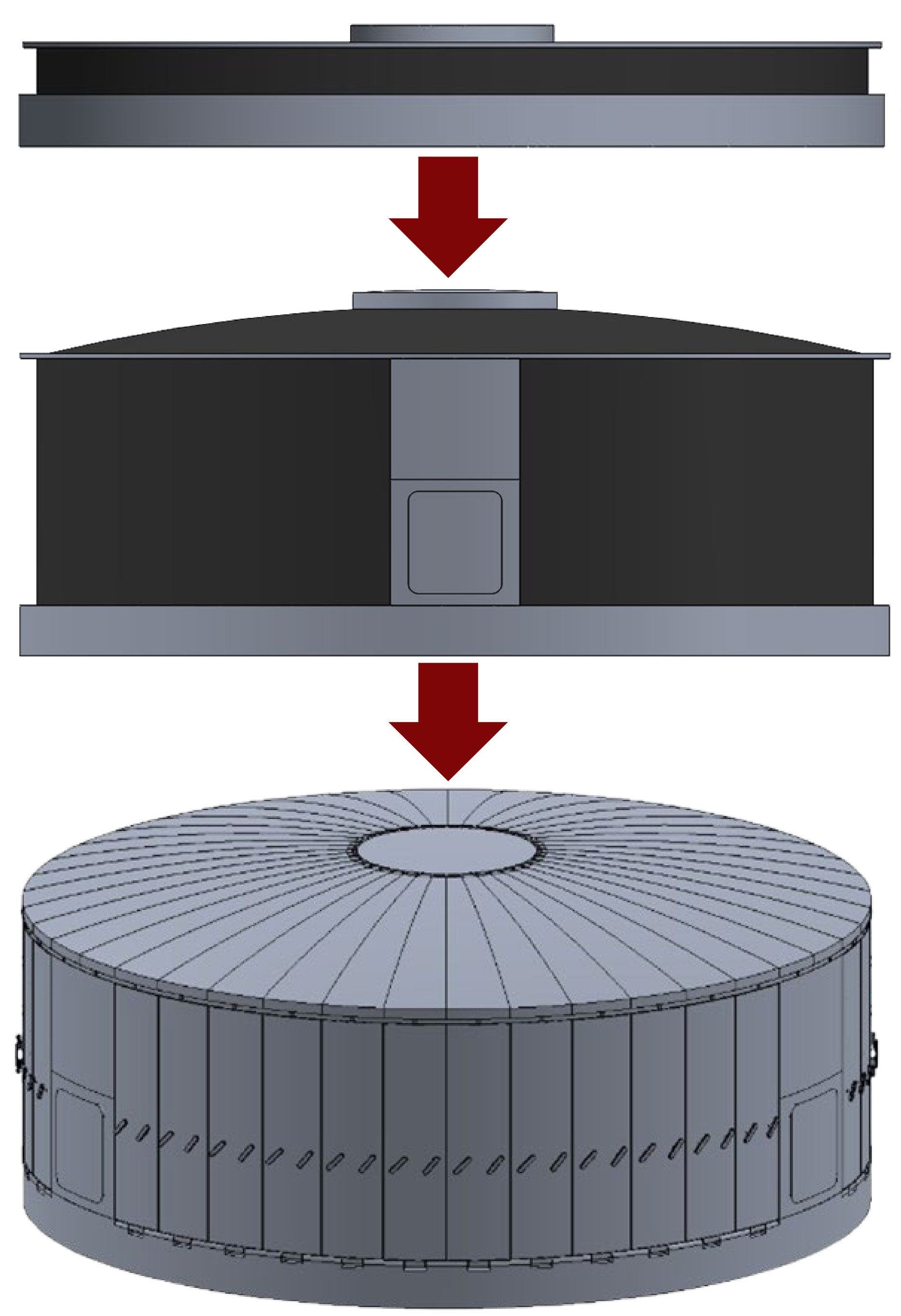


Fig 1: *Module Assembly*

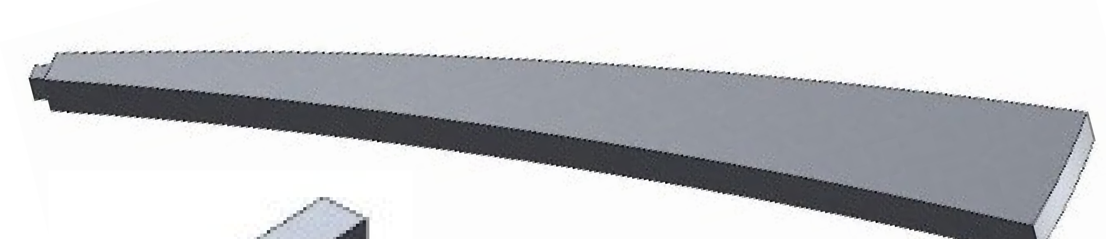


Fig 2: *Roof Panel*

Fig 3*: Side Panel*

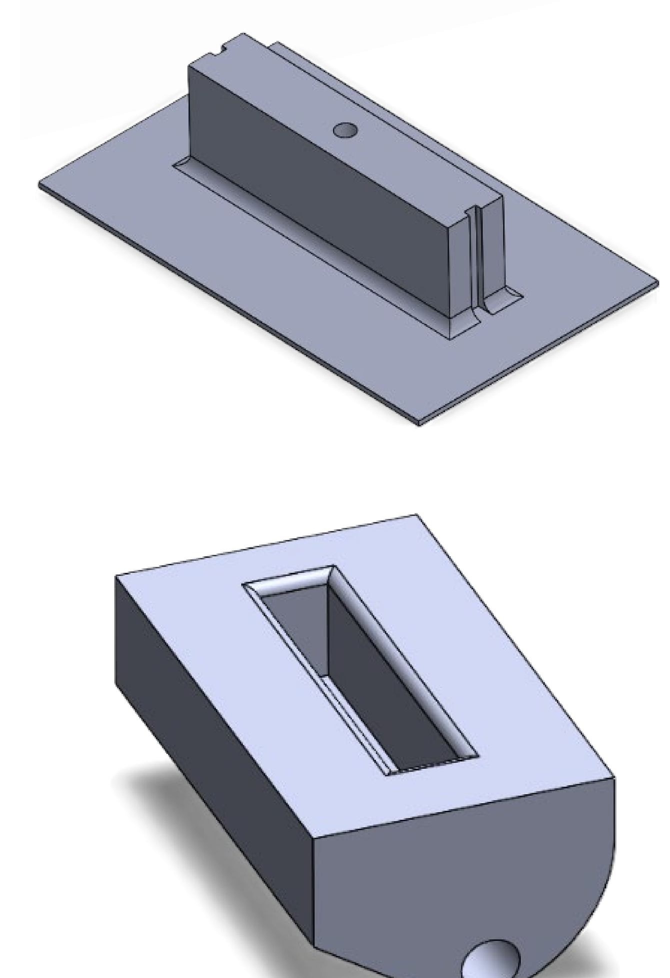


Fig 4 & 5: *Peg (top) and Hinge (bottom) Fasteners*

Conclusions and Next Steps

The modular habitat designed provides a balance between crew safety and ease of assembly, while maintaining a way for the external structure to be repaired without losing pressure inside. Moving forward, weight reduction, packaging optimization, and assessment of manufacturing and ISRU options will be explored.

Analysis

Item	Mass (kg)	Material
Inflatable Interior	500	Nomex, Rubber, Vectran, MLI
Compressed Air Tanks	377.4	Steel
Module Base	6900	Aluminum 2090
Module Floor	742.3	Aluminum 2090
MMOD Wall Panels	1643.7	Aluminum 2090, Nextel, Kevlar
MMOD Roof Panels	1392	Aluminum 2090, Nextel, Kevlar
Total	11555	

Hoop Stress: $\sigma_{hoop} = \frac{Pr}{t} = 12.3$ MPa

Axial Stress: $\sigma_{axial} = \frac{Pr}{2t} = 6.15$ MPa

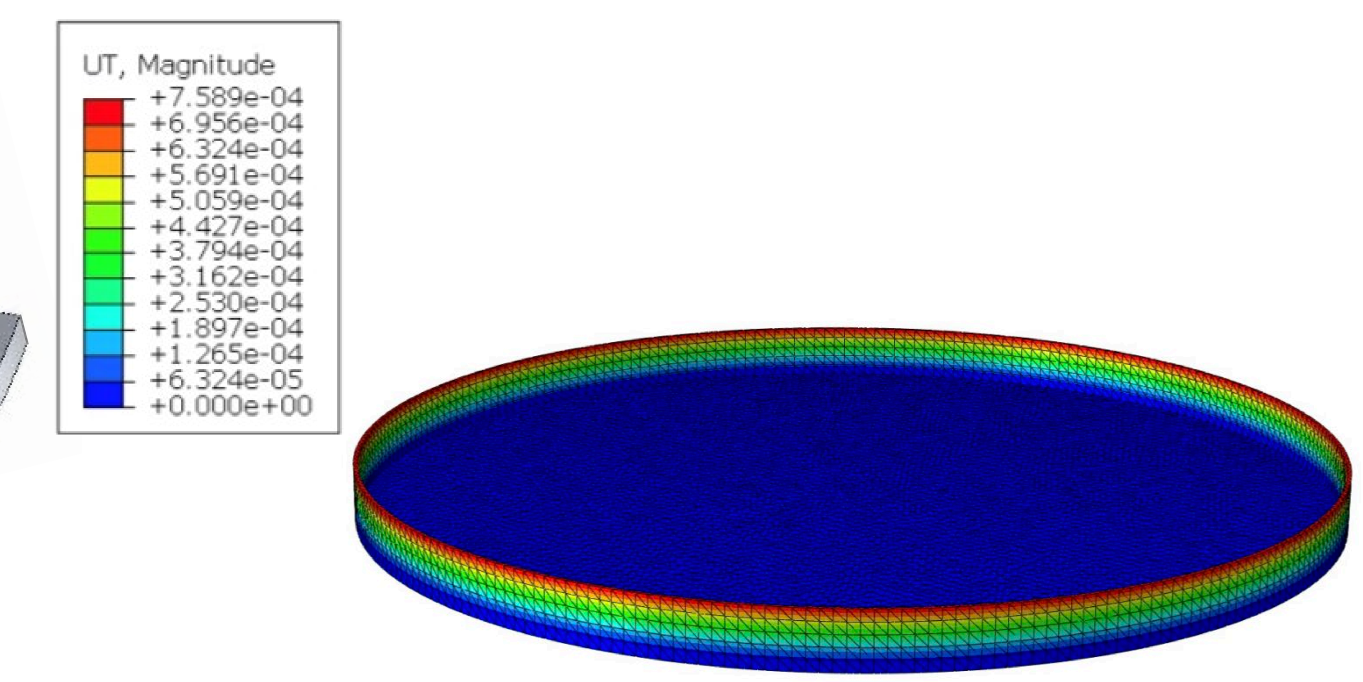


Fig 6: *Displacement of Module Base on Moon*

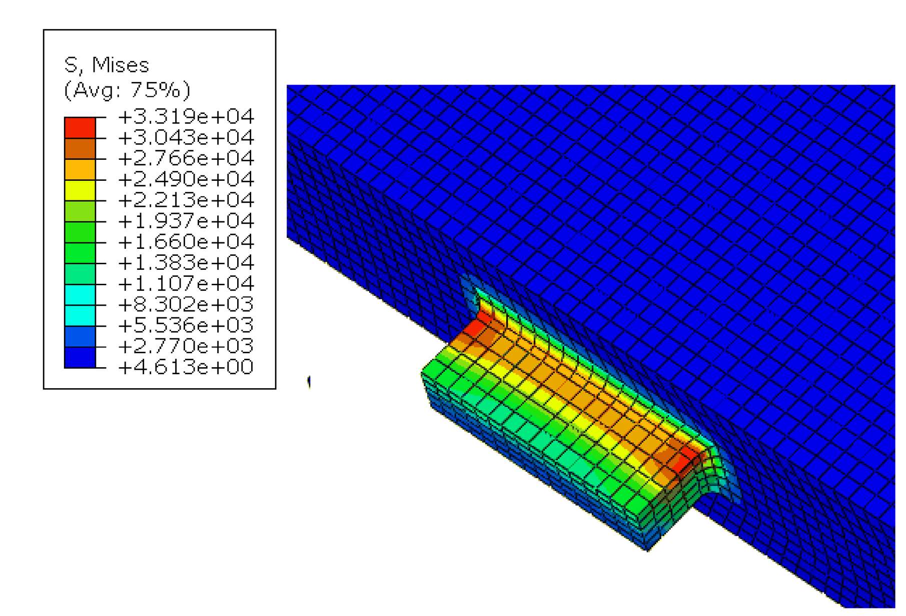


Fig 7: *Stress of Vertical Panel Peg on Mars*

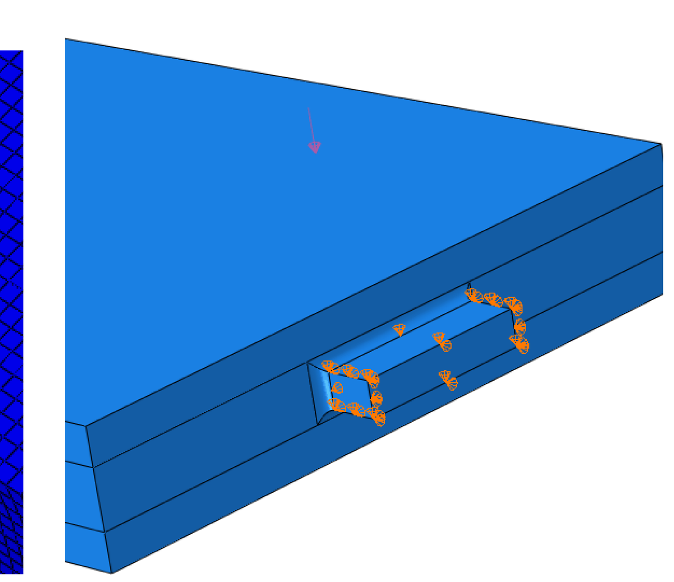


Fig 8: *Loads and Boundary Conditions on Panel Peg*

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