# TDC 106: Lunar & Mars Surface Habitat Module Manufacturing

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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

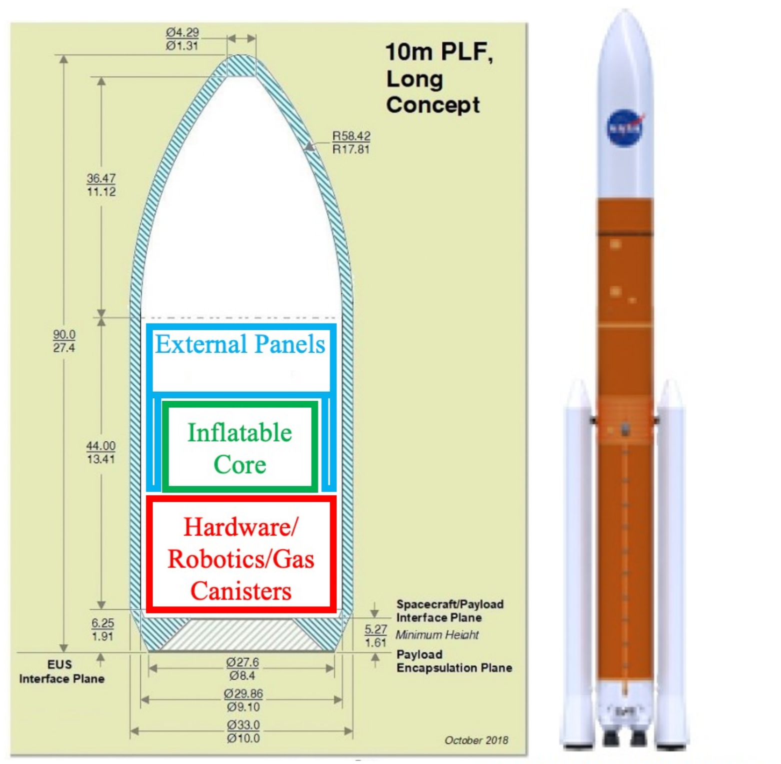
## System Architecture

- **Structural:** Internal inflatable structure and rigid external MMOD shielding panels. Structure is 8 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:** Kilopower-style nuclear reactor

## Hybrid Method

The module utilizes a combined approach with an inflatable interior and rigid exterior shell, using a "clip-on" panel mechanism, allowing for compact stowing, ease of assembly, and repair and maintainability.
**Fastening Techniques:** Rotating locker**,** Connecting Hinge, Lock and Pin, Ball and Socket joints

## Launch and Assembly



*SLS Block 2 Cargo*

**Launch Plan:** The module will be launched using the SLS Block 2 Cargo configuration with the 10m payload fairing.
**Deployment Strategy:** Module 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:** Payload pallet is anchored and exposed → **Phase 2:** Payload is unloaded → **Phase 3:** Module bladder is inflated → **Phase 4:** Exterior panels are installed and aligned → **Phase 5:** Airlocks installed and seals verified → **Phase 6:** Subsystems are integrated and operational

## Models

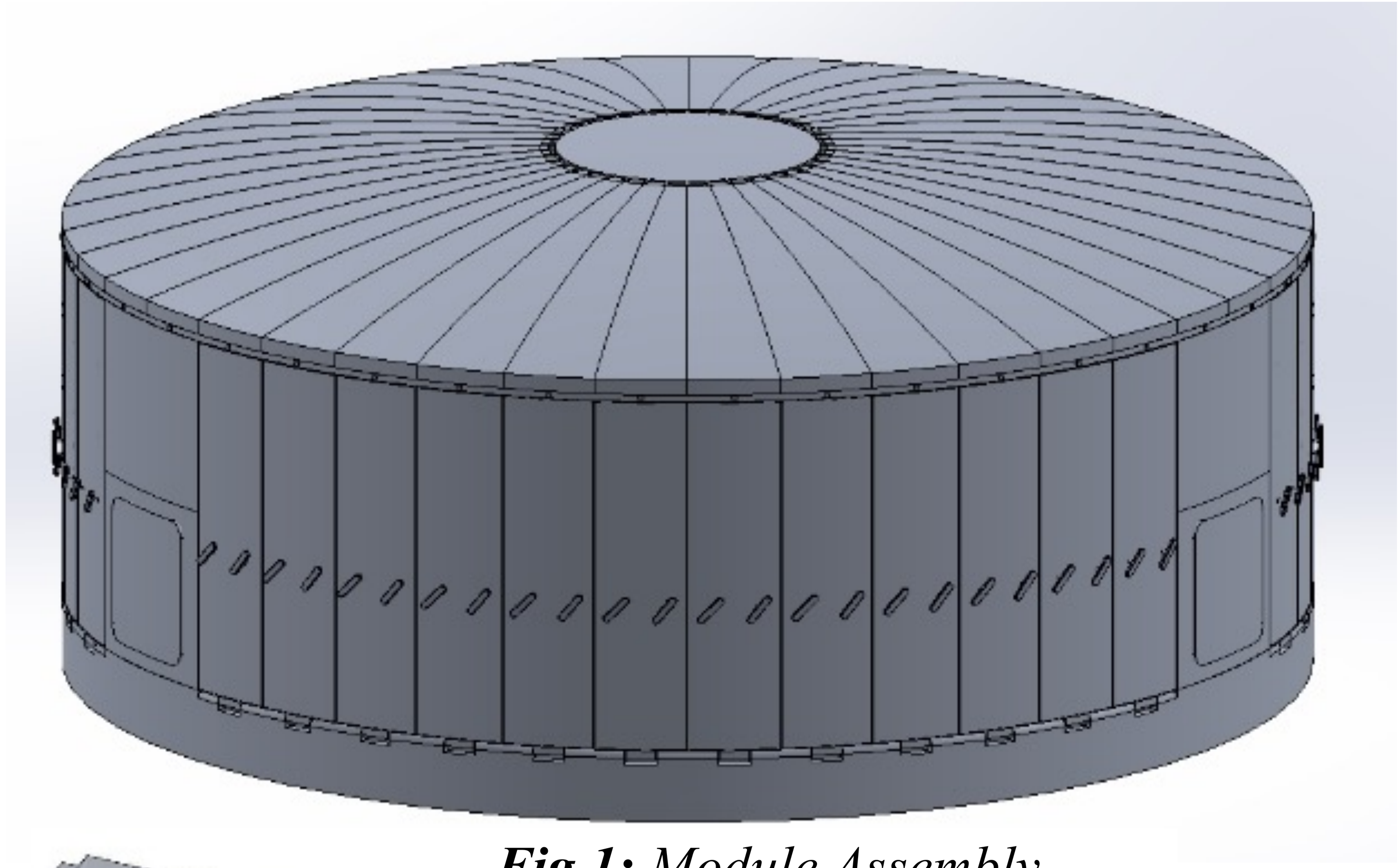


***Fig 1:*** *Module Assembly*

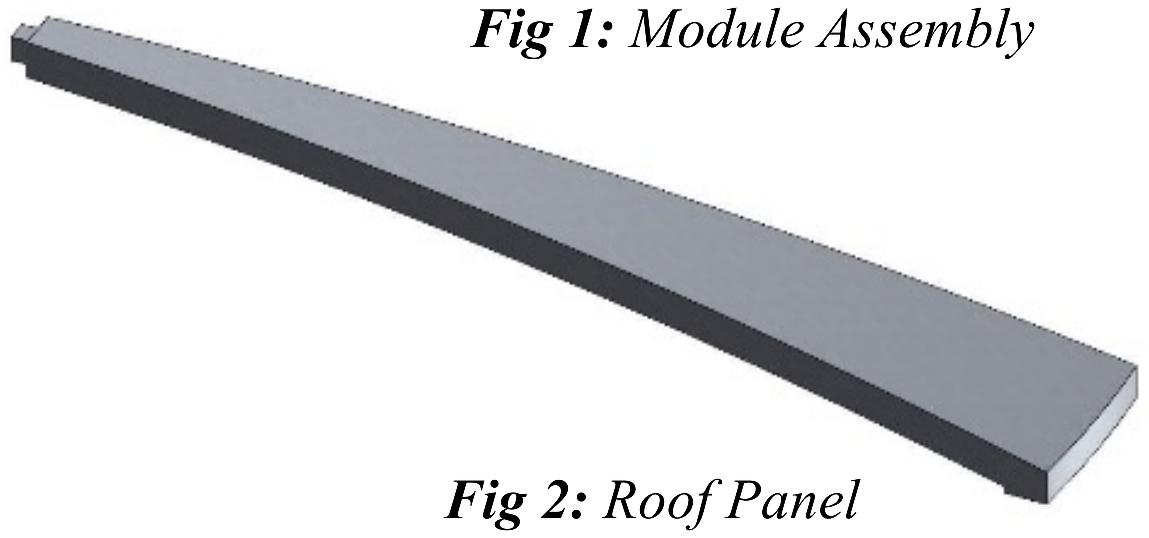


***Fig 2:*** *Roof Panel*


***Fig 3:*** *Side Panel*

## 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 | Weight (kg) | Material |
|---|---|---|
| Inflatable Interior | 500 | Nomex, Rubber, Vectran, MLI |
| Compressed Air Tanks | 377.4 | Steel |
| HAB Module Base | 6900 | Aluminum 2090 |
| HAB Module Floor | 742.3 | Aluminum 2090 |
| MMOD External Wall | 1643.7 | Aluminum 2090, Nextel, Kevlar |
| MMOD External Roof | 1392 | Aluminum 2090, Nextel, Kevlar |
| Total | 11555 | |
| Max | 10000 | |

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

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

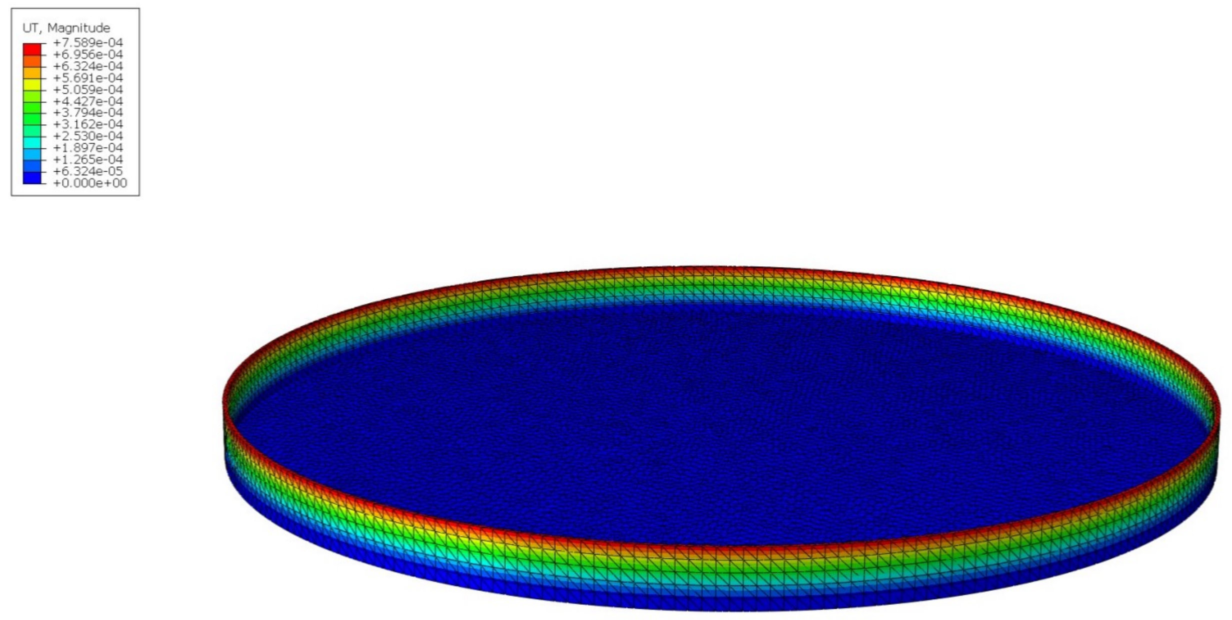


***Fig 4:*** *Displacement of Module Base on Moon*

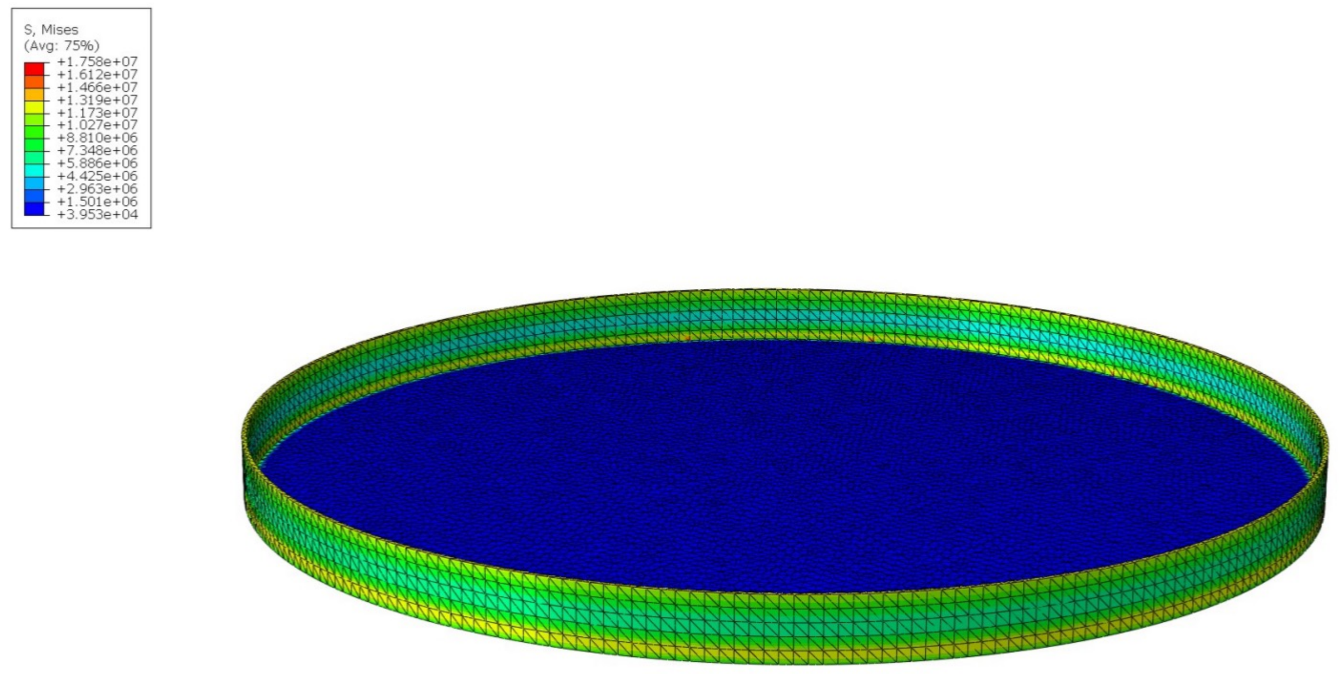


***Fig 5:*** *Stress of Module Base on Moon*

## Acknowledgements

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