



TOPIC # - TDC - 106

## LUNAR & MARS SURFACE HABITAT MODULE MANUFACTURING

### PROBLEM/DESCRIPTION

Develop an innovative, manufacturable surface habitat or systems module for long-duration missions on the Moon or Mars. This includes structural, thermal, and operational designs optimized for in-situ manufacturing, Earth-to-orbit transport, or hybrid assembly using terrestrial and planetary resources. Competitors will address the technical, logistical, and operational challenges of manufacturing space modules for extraterrestrial deployment.

#### Competition Goals:

##### Modular Habitat Design

Develop a robust, scalable surface module that supports human habitation, science labs, life support systems, or energy systems. Must be adaptable for lunar and Martian conditions.

##### Manufacturability & Assembly

Design with manufacturability in mind: consider on-Earth prefabrication, in-space modular construction, or in-situ resource utilization (ISRU) techniques for 3D printing or regolith-based fabrication.

##### Mass & Packaging Efficiency

Optimize design for launch constraints—volume and mass reduction through foldable, inflatable, or interlocking module strategies.

##### Environmental Suitability

Ensure thermal, structural, and radiation protection for surface operations under extreme lunar ( $\pm 250^{\circ}\text{C}$ ) and Martian (dust, cold, low pressure) conditions.

##### Modularity & Interface Standards

Enable standardized interconnection across power, data, airlocks, and mechanical linkages—compatible with other Artemis or Mars Design Reference Mission systems.

##### ISRU (Optional)

Incorporate local regolith or 3D printed composites for radiation shielding, reinforcement, or structure (e.g., regolith-based concrete, sintered walls).

#### Competition Structure & Requirements:

##### Phase 1: Concept Design

- Define your module's purpose, layout, and core systems (structure, thermal, radiation protection).
- Submit architectural schematics and manufacturing philosophy.
- Identify materials and build sequence—what's prefabricated, printed, assembled?

##### Phase 2: Engineering Analysis & Validation

- Conduct mechanical, thermal, and structural analyses (FEA or equivalent).
- Analyze radiation protection strategies (shield thickness, regolith cover, material selection).
- Assess thermal control during day/night cycles or dust storms.





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### Phase 3: Deployment & Assembly Plan

- Define launch configuration and deployment on the Moon or Mars.
- Include robotics or EVA-based construction plans.
- Describe interface protocols (mechanical, power, data).
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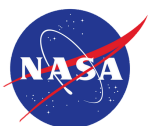
### Phase 4: Prototyping & Demonstration (Advanced/Optional)

- Develop physical scale models or virtual digital twins (CAD/VR).
- Demonstrate assembly process or robotic integration via animation or physical test.
- Test small-scale prints or structural components using regolith simulants.

### Key Constraints & Considerations:

- Mass Limit:  $\leq 10$  metric tons for launch configuration
- Surface Size per Module:  $\sim 50\text{--}80\text{ m}^2$  usable floor area
- Thermal Range: Survive  $-130^\circ\text{C}$  to  $+120^\circ\text{C}$  (lunar),  $-90^\circ\text{C}$  to  $+20^\circ\text{C}$  (Mars)
- Radiation Protection: At least  $10\text{ g/cm}^2$  equivalent shielding
- Assembly Time:  $< 30$  days with crew and/or robotic systems
- Power Interface:  $5\text{--}20\text{ kWe}$  capability, battery or fission-ready
- Airlocks/Birthing Ports: Should include standardized or novel airlock designs

CATEGORY	CRITERIA
<b>Innovation &amp; Technical Merit</b>	Novelty, architectural creativity, modularity
<b>Manufacturing Feasibility</b>	Compatibility with current or near-future 3D printing/ISRU systems
<b>Structural &amp; Thermal Performance</b>	Load-bearing, sealing, insulation, and survivability in surface conditions
<b>Mass &amp; Transport Optimization</b>	Packaging, launch, and deployment strategies
<b>Crew Safety &amp; Habitability</b>	Ergonomics, shielding, redundancy, life-support adaptability
<b>Modular Growth Potential</b>	Ease of scaling and interface compatibility with other surface systems
<b>Sustainability</b>	Minimal Earth-supplied materials, long-term durability, recyclability
<b>System Integration</b>	Interfaces with Artemis, Mars DRA, power/data networks, and mobility platforms





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### DESIGN TEAM PROFILE

<b>NASA MENTOR:</b>	Robert Nuckols (robert.s.nuckols@nasa.gov)
<b>LEVEL:</b>	Undergraduate students of any level
<b>MAJOR/DISCIPLINE:</b>	Open to all majors
<b>TEAMS:</b>	All teams eligible
<b>DURATION:</b>	One Semester (Second semester optional)

