TEXAS SPACE GRANT CONSORTIUM
DESIGN CHALLENGE

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. All modules must be fully manufactured, integrated, assembled, and qualification-tested on Earth prior to launch to validate structural integrity, thermal performance, radiation protection, and system functionality under relevant simulated environments. Designs may incorporate features that enable post-deployment ISRU enhancement, but primary structural qualification must be demonstrated through Earth-based fabrication and testing prior to flight. Inflatable habitat concepts are not permitted. Habitat pressure shells and primary structural systems must be rigid-body designs manufactured on Earth.

Competition Goals:

Modular Habitat Design: Develop a robust, scalable rigid-body surface module that supports human habitation, science labs, life support systems, logistics, or energy systems. Designs must be adaptable for both lunar and Martian environments and capable of long-duration operation.

Manufacturability & Assembly: Design with manufacturability in mind, emphasizing full Earth-based fabrication, integration, and qualification testing prior to launch. Participants shall demonstrate how their module can be produced using terrestrial manufacturing processes and verified through structural, thermal, pressure, vibration, and systems-level testing. In-space modular construction or ISRU-enabled augmentation may only occur after the baseline rigid-body module has been fully validated on Earth.

Mass & Packaging Efficiency: Optimize design for launch constraints through volume reduction, foldable rigid-body structures, segmented assemblies, or interlocking module concepts. Inflatable deployment systems are not permitted.

Environmental Suitability: Ensure thermal, structural, and radiation protection for surface operations under extreme lunar (±250°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, berms, landing pads, or 3D printed composites for supplemental shielding or reinforcement only after baseline Earth validation and deployment of the primary habitat structure.

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Competition Structure & Requirements:

Phase 1: Concept Design:

- Define module purpose, layout, systems, structural approach, and manufacturing philosophy. Submit schematics, deployment concepts, and preliminary Earth-based testing plans.

Phase 2: Engineering Analysis & Validation

- Conduct structural, thermal, radiation, pressure, and FEA analyses. All analytical results must be supported by Earth-based verification testing plans including structural load testing, thermal vacuum testing, vibration testing, pressure/leak testing, and radiation validation.

Phase 3: Deployment & Assembly Plan

- Define launch configuration and deployment on the Moon or Mars using robotics or EVA. Modules must be launched as pre-manufactured Earth-built systems in completed, segmented, or folded rigid-body configurations.

Phase 4: Prototyping & Demonstration (Advanced/Optional)

- Develop full-scale prototypes, conduct qualification-level structural, pressure, vibration, thermal vacuum, and deployment testing, and validate assembly using terrestrial robotic or crew-assisted simulations prior to launch readiness.

Key Constraints & Considerations:

- Mass Limit: ≤ 10 metric tons for launch configuration
- Surface Size per Module: ~50–80 m² usable floor area
- Thermal Range: Survive -130°C to +120°C (lunar), -90°C to +20°C (Mars)
- Radiation Protection: At least 10 g/cm² equivalent shielding
- Assembly Time: < 30 days with crew and/or robotic systems
- Power Interface: 5–20 kWe capability, battery or fission-ready
- Airlocks/Birthing Ports: Should include standardized or novel airlock designs
- Structural Requirement: Habitats must be rigid-body systems capable of surviving launch loads, landing loads, and long-duration surface operations without reliance on inflatable structural components.

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EVALUATION CRITERIA

CATEGORY	CRITERIA
Innovation & Technical Merit	Novelty, architectural creativity, modularity
Manufacturing Feasibility	Compatibility with terrestrial manufacturing methods, Earth-based assembly, and qualification testing
Structural & Thermal Performance	Load-bearing, sealing, insulation, and survivability in surface conditions
Mass & Transport Optimization	Packaging, launch, and deployment strategies
Crew Safety & Habitability	Ergonomics, shielding, redundancy, life-support adaptability
Modular Growth Potential	Ease of scaling and interface compatibility with other surface systems
Sustainability	Long-term durability, recyclability, and reduced resupply demand
System Integration	Interfaces with Artemis, Mars DRA, power/data networks, and mobility platforms

DESIGN TEAM PROFILE

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

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