TSGC: LUNAR SURFACE HABITAT MODULE MANUFACTURING

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Project Background

Since the return of Apollo 17 in 1972, humans have not traveled beyond Earth's orbit. NASA's Artemis program aims to establish a sustained human presence on the Moon and develop technologies for future crewed missions to Mars, creating a need for reliable long-term lunar habitation systems.

Inflatable habitat modules offer efficient transport and deployment by folding for launch and expanding on the lunar surface, reducing mass, volume, and astronaut exposure during setup. High-strength materials such as Kevlar and Vectran provide durability, while design features including a rounded exterior and protective ceramic coating help mitigate lunar dust and abrasion, with prefabrication on Earth selected over in-space assembly or regolith shielding for improved reliability.

Purpose

The purpose of this project is to design a modular lunar habitat for future long-term missions on the moon. The design must consider manufacturability: on-Earth prefabrication, in-space modular construction, or in-situ resource utilization (ISRU) techniques for 3D printing or regolith-based fabrication. Additionally, it should account for launch constraints volume and mass reduction through foldable, inflatable, or interlocking module strategies. Ensure thermal, structural, and radiation protection for surface operations under extreme lunar (±250°C, dust, cold, low pressure) conditions; and enable standardized interconnection across power, data, airlocks, and mechanical linkages compatible with other Artemis systems.

Objectives

Parameter	Specification
Mass Limit	≤ 10 metric tons
Surface Size	50-80 m² (floor area)
Thermal Range	-130°C to +120°C
Radiation Protection	>10 g/cm²
Assembly Time	< 30 days
Power Interface	5-20kWe
Airlocks/Birthing Ports	Include standard or novel airlock designs.

Design Model

Figure 1. The Rough Draft of the Lunar Habitat Module

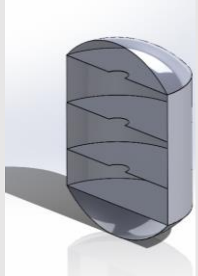

Figure 2. Inside View of Lunar Habitat

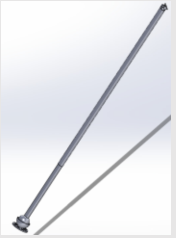

Figure 3. Leg

Figure 4. Rod with ball joint

Figure 5. Tube with pin hole

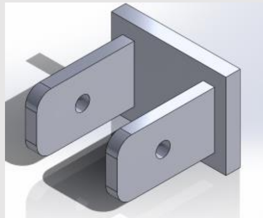

Figure 6. Hinge with pin hole

Figure 7. Foot plate with ball socket

System Features

The main body of the design consists of a layered inflatable skeleton that houses multiple compartments, including a two-story layout and an airlock system. The structure will use a honeycomb design with carbon fiber and polyurethane foam for insulation and structural support. Kevlar will also be incorporated to help provide radiation protection. To address the challenges of lunar dust, the exterior will be coated with a dust-repellent indium tin oxide (ITO) layer to reduce accumulation and maintain system efficiency. The crew and habitat are planned to be launched using SpaceX's Starship. Before deployment, all components will be fabricated and thoroughly tested on Earth to ensure proper performance and reliability in space conditions. Power for the habitat will be supplied by solar panels located on the top of the structure.

Future Work

Going forward, we will continue to refine our design by adding more detail, improving its overall functionality, and completing a full finite element analysis (FEA) to better evaluate its structural performance. We will also make sure the design continues to meet all required constraints and project specifications throughout the development process. In addition, we will focus on identifying ways to reduce overall cost and minimize assembly time while still maintaining the quality, safety, and effectiveness of the final design.

Conclusion

In conclusion, our lunar habitat design offers a practical and innovative concept for supporting future human life on the Moon. The habitat combines a layered inflatable skeleton, a two-story interior layout, and an airlock system to create a structure that is both functional and efficient. By using a honeycomb design with carbon fiber, polyurethane foam insulation, and Kevlar for added radiation protection, the design aims to provide strength, safety, and durability in the harsh lunar environment. The habitat is also designed to meet major project constraints, including mass, thermal protection, radiation shielding, power needs, and assembly time. Solar panels mounted on the top of the structure will provide a reliable power source, while fabrication and testing on Earth will help ensure the system performs as intended before launch. Overall, this design presents a strong foundation for a sustainable lunar habitat and highlights the importance of combining innovative materials, structural efficiency, and careful planning in future space exploration.

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