Planetary Resource and In-Situ Material Habitat Outfitting for Space Exploration

COLORADO SCHOOL OF MINES
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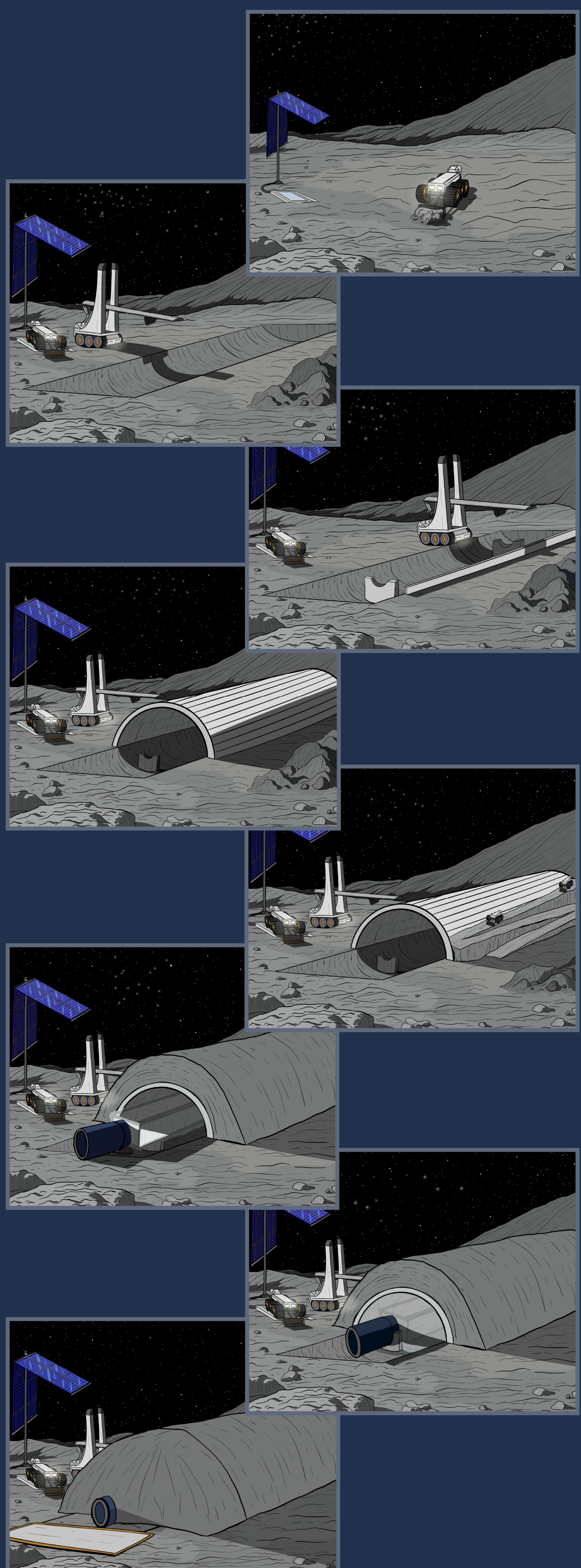
DEPLOYMENT



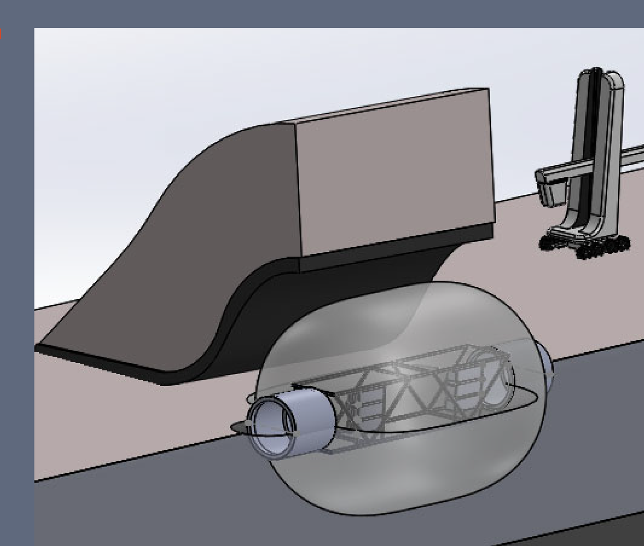
PRISM-HOUSE

The PRISM-HOUSE team participated in the NASA Moon to Mars Exploration Systems and Habitation (X-Hab) challenge for 2022 on behalf of the Colorado School of Mines. Our task was to design a system to deploy, outfit, and operate a habitat on the surface of the Moon, while maximizing use of in-situ lunar resources. We proposed a design, identified the requirements, conducted analysis, and evaluated technical capabilities of interest. The team is currently producing deliverables and conducting tests to evaluate design feasibility. The primary objective of the system is to provide a safe and livable habitat near the lunar south pole with an optimized balance between delivered material and In-Situ Resource Utilization (ISRU). A preliminary systems engineering design has been completed and reviewed by NASA, key system risks identified, and test plans defined to mitigate some of these risks. These test plans will be executed over the next several weeks and results evaluated to determine final risks to the system and recommendations for next steps.

SUBSYSTEMS

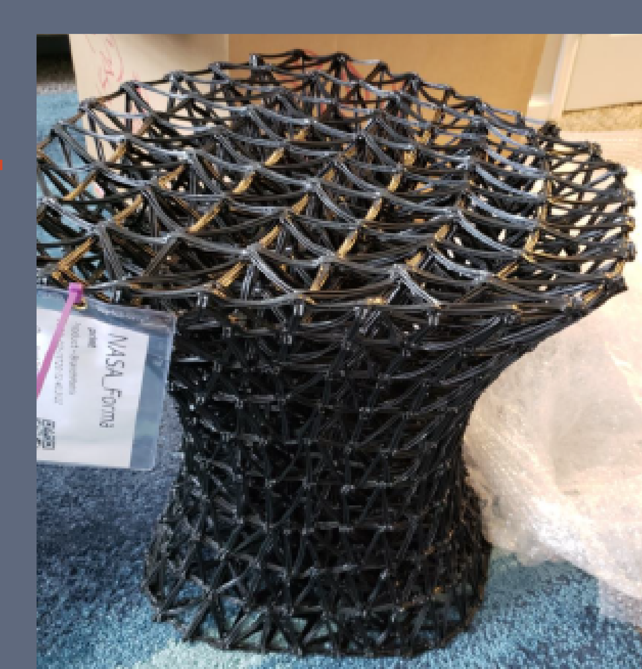
External Shell & Environmental Protection

Consisting of a shell structure created using additive manufacturing with lunar regolith as the feedstock, loose regolith material backfilled onto the shell structure, and openings designed to allow ingress and egress, the ESEP system provides protection from radiation and micrometeorites.



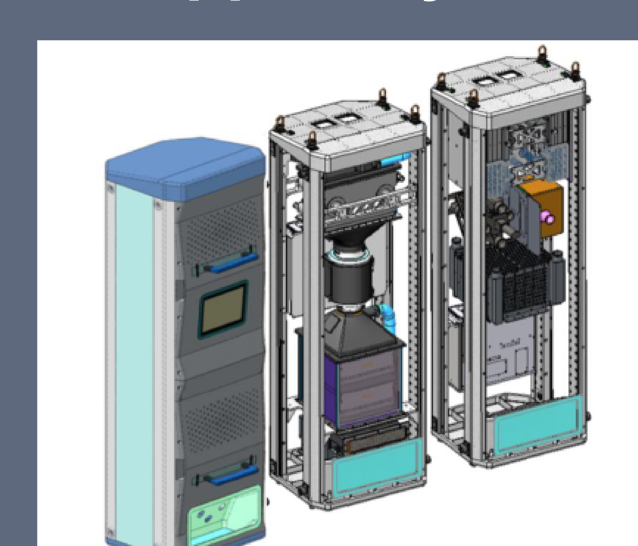
Human Interior Goods

Production of objects interior to the habitat used by human occupants, including floors, walls, chairs, tables, tools, utensils, and replacement parts for other systems. These objects are created utilizing additive manufacturing techniques with regolith feedstock and binding agents produced in situ.

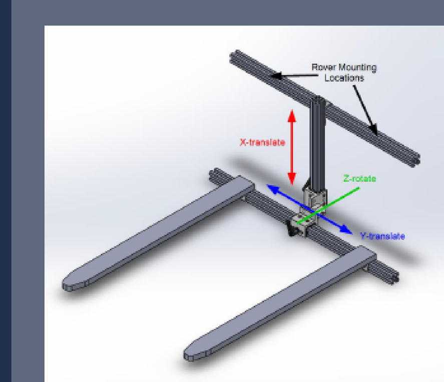


Environmental Control & Life Support Systems

Standard Environmental Control and Life Support Systems (ECLSS) as well as remote outfitting rovers and automation equipment which allow the system to be fully deployed, operational, and life-sustaining prior to astronaut arrival.



TESTS IN PROGRESS



External Component Manipulation Test

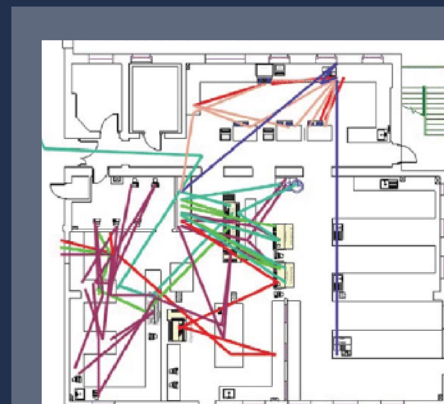
Using a prototype of a Lunar Outpost rover, we simulated interfacing with habitat components that are required to be deployed and emplaced remotely, such as solar power units and habitat modules. The rover utilized a manually controlled manipulator with 3 degrees of freedom (DOF). Data was gathered on each successful interface: time required, DOF utilized, total energy used, peak power used, and qualitative notes.

Printed Regolith Leaching Test

Additive manufacturing of lunar regolith could potentially be used to fabricate foodware (plates, cups, bowls, etc.) to improve astronaut quality-of-life. The team is testing samples of printed regolith simulant to assess the food safety of the samples and ensure such goods can be used safely. Samples of vitrified highlands (CSM-LHT-1) and mare (JSC-1A) simulants were tested in accordance with ASTM method C738 to measure the type and quantity of elements which would leach out of foodware during use.

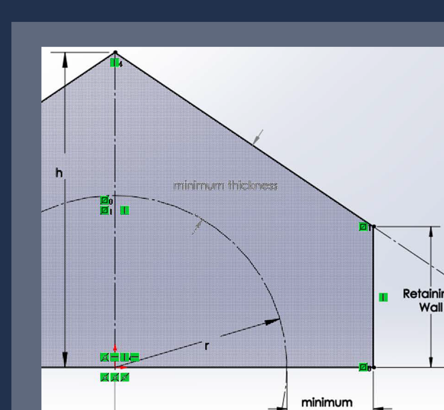
External Structure Print Test

The ESEP subsystem of the habitat relies on a self-supporting shell of additively manufactured vitrified regolith, to support the bulk regolith layer used for radiation shielding and micrometeoroid protection. The team worked with industry partner ICON to print test samples of regolith simulant with layers of varying in-fill percentage. Energy consumption was tracked and physical properties were measured, in order to incorporate the data and model power consumption and build time for the ESEP subsystem.



Lifestyle Habitat Study

Interior habitat design for space environments has been investigated extensively on the International Space Station (ISS) and in private industry. The team will utilize existing data to refine ECLSS requirements, understand the effects of human interface requirements on internal design, and evaluate potential differences between null-g and lunar gravity environments.



Radiation Shielding Modeling

Shielding from harmful radiation on the lunar surface is achieved through the external regolith layer. As it is a driving factor in total time, number of rovers, and additive manufacturing requirements, the team is targeting the minimum regolith thickness to achieve NASA radiation exposure limit requirements. NASA's On-Line Tool for Assessment of Radiation In Space (OLTARIS) will be utilized to determine optimal thickness and geometries.