GLOVe: Gateway-Lunar Operations Vehicle

Northeastern University
College of Engineering

Jared Brauser, Matthew Dottinger, Nolan Hobart, Owen Hughes, Weston Smith, Jack Tuthill, Andris Zonies
Advisor: Dr. Samuel Felton

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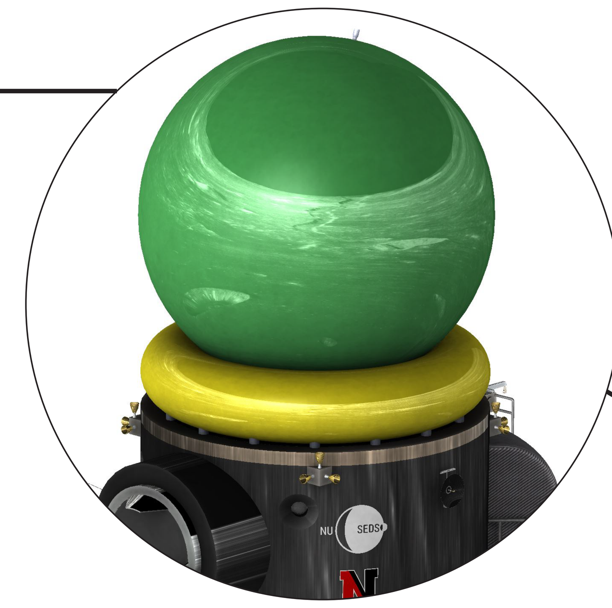
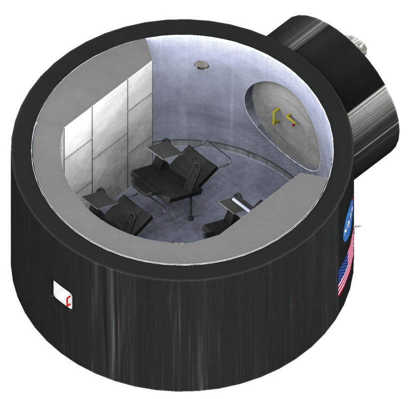
Fuel Tank Geometry

The primary factor considered for GLOVe's fuel candidates was specific impulse. The maximization of this property is essential to reducing the cost of supplying fuel to the lander in lunar orbit. Liquid Oxygen and Liquid Hydrogen were identified as being the most mass efficient fuel.

To keep GLOVe's center of mass as low as possible, the denser LOX will be kept in a toroidal tank directly above the habitation element, shown in yellow, and the LH2 will be stored in a spherical tank, shown in green, nested in the toroidal LOX tank.

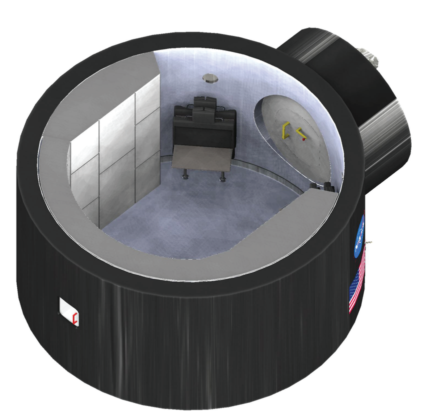


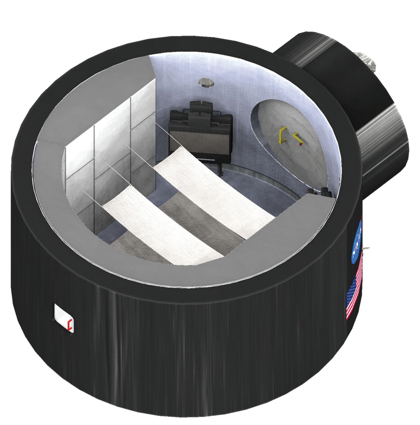
Configurable Habitation Element



Flight configuration is strictly designed for the journey between Gateway and the Lunar surface. It contains launch seats and necessary navigation controls.

Surface configuration requires the launch seats from the flight configuration to be stowed, the backs of which contain fold-out desks. It is in this configuration that the habitation element reaches its maximum habitable volume of 28 cubic meters.





Sleep configuration gives the crew the ability to fold away unnecessary items and deploy sleeping hammocks.

Life Support

GLOVe's living space will be actively cooled using a circulating water-glycol loop that runs between the habitation element and its external heat radiators.
Its interior atmosphere will match that of Gateway - 21% oxygen at 14.7 psi. This environment will be maintained by atmospheric life support systems including a zeolite Carbon Dioxide scrubbing unit.

DSMs: Deployable Surface Modules

GLOVe's primary purpose is to deliver modular cargo capable of building a lunar research station. This modular cargo takes the form of DSMs which will establish this research station in discrete parts. Each DSM will have unique cargo and is solely constrained by mass and volume.

Integration and Impact to Gateway

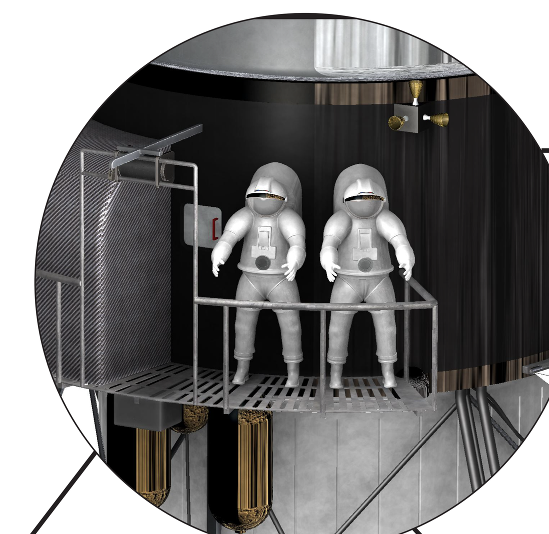
GLOVe is designed to be parasitic to certain Gateway systems while docked. Such systems include required refueling and resupply services, DSM loading capability via its robotic arm, trace contaminant removal before each crewed mission, and solar power for fuel thermal control.

Costing

Item	First Unit Cost ($M)	Recurring Cost ($M/mission)
GLOVe main body	2,015	130
Launch	1,000	74
MATE	475	0
DSMs	0	500
Fuel	0.06	0.06
Total	3490.06	704.06

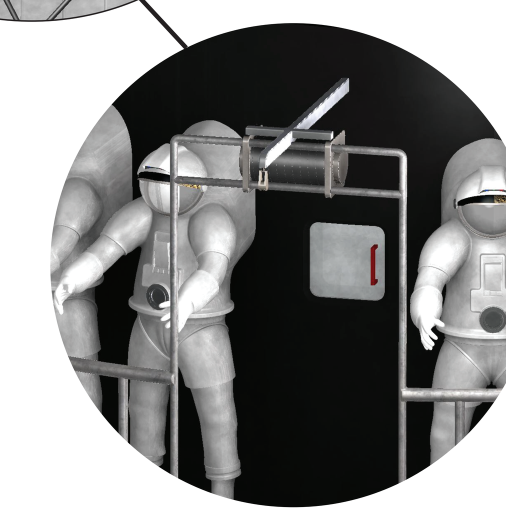
MATE: Module Arrangement and Transportation Element

DSMs will be deployed by the 2.5 MT MATE, delivered to the lunar surface on GLOVe's first mission in place of a DSM. This battery powered low-speed rover equipped with a scissor lift lowers DSMs from GLOVe's DSM chamber and transports them to their deployment locations. This process is illustrated below.



Suitports and Airlock

On the back side of the habitation element, GLOVe has four suitports and a small pass-through airlock. The suitports allow astronauts to efficiently don a suit from the interior of the habitation element and detach from the outer wall for extravehicular activity. These reduce volume, mass, and power compared to traditional airlocks; they also minimize the concern of lunar dust entering the habitation element.
The pass-through airlock allows small samples and tools to be passed from the habitation element to the exterior of the vehicle.

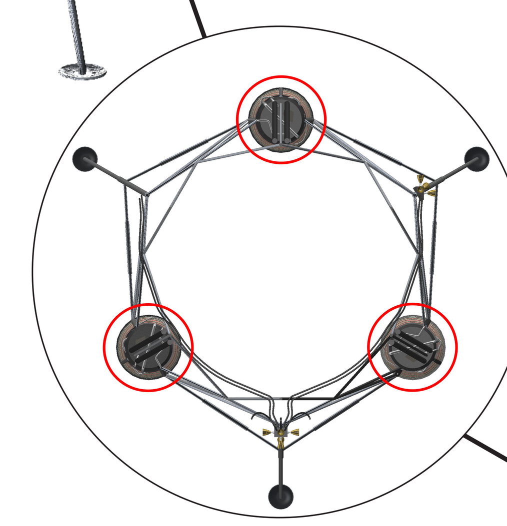


Crew Descent System

Once crew members have detached from the exterior of the habitation element via the suitports, they will secure themselves to a tethered winch that will lower them to the surface in a controlled fashion.

Communications

If GLOVe has line of sight with Earth, radio transmissions in the X-Band frequency range will be carried out using phased array antenna (PAA) to communicate directly with a station on Earth.
If GLOVe is on the far side of the Moon, GLOVe will use the PAA to communicate with a relay satellite similar to China's Queqiao satellite.



Engines

Three modified RL-10A-4-2 engines will be implemented in a circular arrangement on the frame surrounding the DSM chamber. These engines strike a desirable balance between specific impulse and physical size.

Development Timeline

Mission Campaign

Mission	Year	Mission Goal	DSMs
1	2028	**Establish Lunar Presence.** Deploy MATE, lunar surface power generation, and ground communications. Power generation will be provided by a variant of the roll out solar arrays as demonstrated on the ISS.	MATE Roll Out Solar Array Ground Communications
2	2029	**Water Prospecting I.** Begin water prospecting and fuel generation. Use robotic ice mining system to collect lunar water and an electrolysis unit to convert water to fuel.	Robotic Water Collection Inflatable Water and Fuel Tanks Electrolysis Unit
3	2030	**Surface Habitation I.** Set up a habitable space on the surface. An inflatable habitat will be deployed as well as lunar regolith 3D-printing robots that can construct a protective layer around the inflatable.	Inflatable Habitat Regolith Printing Robots Surface Habitat Life Support
4	2031	**Surface Habitation II.** Continue establishing surface habitation. Includes further life support systems, scientific equipment, workbenches, etc. begin	Habitat Interior Items Scientific Experiments
5	2032	**Water Prospecting II.** Expand water prospecting capabilities to increase fuel production rate.	Robotic Water Collection Inflatable Water and Fuel Tanks
6	2033	**Mobile Capabilities.** Deploy a lunar rover for surface experiments capabaility and a lunar buggy for astronaut mobility.	Rover Buggy
7+	2034+	**Experimental Opening and Station Development.** Continue sending scientific experiments to the surface, opening space for industry experiments. Continue expanding power, water, and habitation capabitilies as needed.	Scientific Experiments Roll Out Solar Array Robotic Water Collection Inflatable Habitat

From the Moon to Mars

Space Policy Directive 1 outlines the plan to use the moon as a proving ground for crewed missions to Mars. With this understanding, GLOVe's mission concepts were designed to be adapted for future missions to the red planet. A larger version of GLOVe built for missions to Mars could begin to develop a permanent settlement through DSMs. This larger version would likely be capable of carrying more DSMs, entry through Mars' atmosphere, and a sealing operation that would allow an emptied DSM chamber to become habitable volume. With some physical adaptations, GLOVe's concept of operations could be expanded to accommodate more crew, more cargo, and longer missions in the next phase of space exploration.