Grappling with Psyche

NASA Psyche Landing System
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Project Members: Ahmed Almansouri, Jack Duncan, John Parks, & Joseph Pittman

Arizona State University (ASU) leads a team of researchers in the analysis of the asteroid "Psyche" as a part of NASA's Discovery Program. The findings will educate the conglomerate of humankind on the history of solar system formation. The Psyche mission is an orbiter mission that will not land; however, future proposals to land on the asteroid are possible. This project focused on the foot subsystem for a prospective lander proposal.

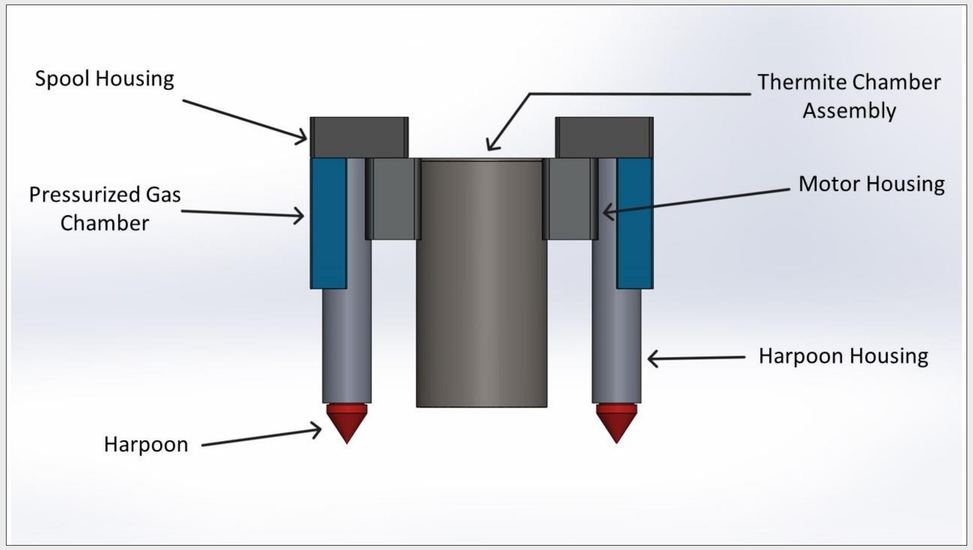

Figure 1: Proposed Foot Assembly.

Exploring the Unknown

ASU formulated Psyche Capstone Project 611 to design a landing system for a possible Psyche lander to cope with variabilities of an asteroid environment.

Due to the distance between Earth and "Psyche", there are limitations on the known properties of the asteroid. A proper system ensures success in unpredictable conditions while preventing damage.

Psyche Properties:

- 0.144 m/s^2 surface gravity
- Hypothesized metallic composition
- Unconfirmed composition densities
  - Possibilities of rock, metal, loose regolith, etc.
- Potential remanent magnetic field
- Avg diameter: ~140 miles (as a perfect sphere)
- Hypothesized extreme geological features

The orbiter mission has not been conducted, changes in these attributes would be recorded after a successful mission. The orbiter launch is expected to take place October 5th, 2023.

Acknowledgments:
Parker Choc, Tyler McHuron-Guss, Kelton Orth, Sheriff Jerry Williams, and the Refuge.

Nuts and Bolts

Goals:

- Reduced surface rebound
- Maximum surface contact and static rest
- Multiple anchor mechanisms as fail-safes
  - A thermite cylinder and dual-harpoon systems work in conjunction
  - 9 total anchor points across 3 feet
- Ensure the safety of on-board research instruments

How does it work?

1. Harpoons fire to secure an initial anchoring point.
2. Winches within the harpoon subsystem retract to pull the foot closer to the surface.
3. Thermite within the middle cylinder ignites and melts into the surface of Psyche creating artificial roots.

The foot is designed to bind with multiple hypothesized surface compositions that may be found during landing. The harpoon and thermite allow the lander to anchor itself to rock, metal, or other surface compositions.

Thermite Anchor

Exothermic reactions between Iron (III) Oxide and Aluminium powder provide heat to anchor a stabilizer to the surface of Psyche. The design utilizes molten thermite products to penetrate porous surfaces, creating artificial "roots" that promote static rest. The ignition source consists of a Lithium-Polymer battery that autonomously discharges current into a nichrome wire.

Initial Design

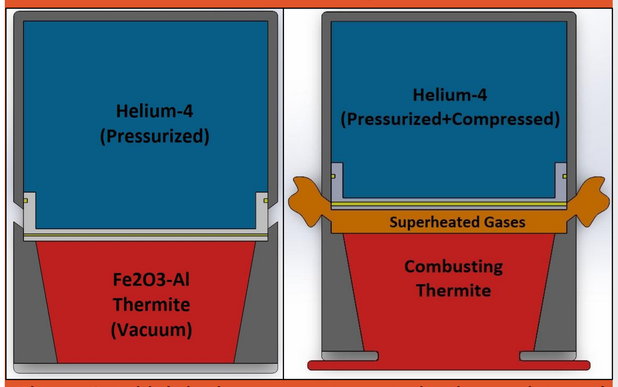

Figure 2: Initial design concept created using an internal gas plate and vent holes to equalize pressure.

Final Design

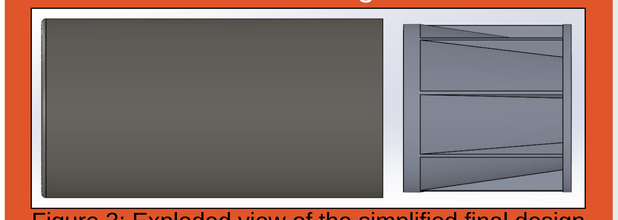

Figure 3: Exploded view of the simplified final design including the outer housing (left) and nozzle (right).

System Specifications

- Material Selection
  - Outer Housing: Ti-13V-11Cr-3Al (Solution Treated)
  - Nozzle: Al 1060
- Thermite Composition by Mass Percentage
  - 10% Mg + 20% Al + 70% Fe2O3

Future Work

- "Preheating" charge to increase penetration depth of thermite.
- Thermally reflective coating to increase efficiency.
- Further optimization of thermite reactants.

Oregon State University

Harpoon Anchor

The harpoon will utilize a gas cylinder to deploy and penetrate into any combination of soft regolith, rock, or metallic surface. The system is designed with a motor and tethering cable attached to the foot of the lander to secure the lander to the surface of Psyche.

Initial Design

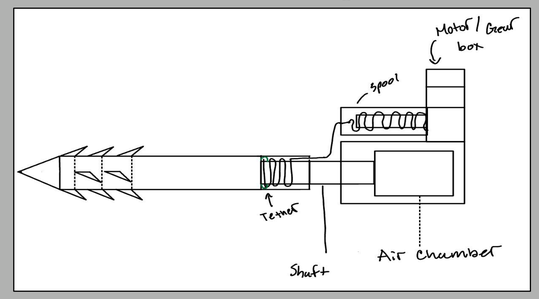

Figure 4: Initial design concept of the harpoon system.

Final Design

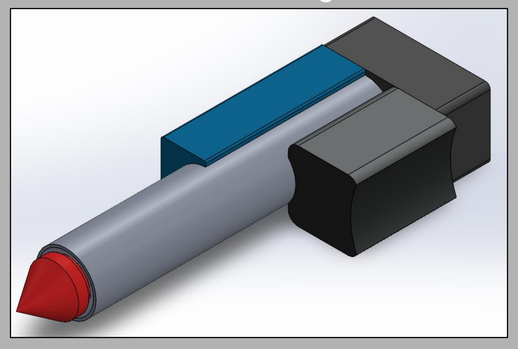

Figure 5 : The full model of the harpoon system.

System Specifications

- Titanium harpoon
- Compressed air at 4000 psi
- Galvanized aluminum cable
- 80 rpm turbine geared motor
- High pressure storage cylinder

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