EAS4700 – Group 3- Fall 2021
Aaron Nevalga, Alena Golda, Colin Mac Leod, Jonathan Cowart Luzier, Jose Aguilar, Natalia Rivera-Marín, Nathan Ball

Project MMXL

Martian Moon Exploration Lander

UF Herbert Wertheim College of Engineering
UNIVERSITY of FLORIDA

Abstract

Much could be learned about Martian geology based on the findings of the moons. This includes determining how Mars came to acquire the moons. The objective of this project is to fulfill this goal of human exploration by landing on the moons Phobos and Deimos via an Exploration and Excursion Vehicle (EEV), retrieving samples, and successfully returning the uncontaminated samples to the Deep Space Transport (DST). MMXL (2040) is utilizing innovation, engineering excellence and creativity to accomplish this goal.

Requirements

- EEV should have the capability to support 2 crew members to visit both Martian moons
- Total mission should not exceed 30 days, including transit from the DST to the moons and back
- A minimum of 50 kg of samples should be returned to the DST from each moon
- The crew members shall not leave the EEV at any point in the mission
- The EEV should be in a 5-sol parking orbit before January 1, 2040
- Total cost should not exceed $1 billion (USD)

Launch Vehicle

- SpaceX's Starship Vehicle will be used in an expendable configuration
- Estimated cost: $250 M with 200 tons of cargo
- Large payload volume enables a more comfortable ship for the crew

Propulsion System

- Primary propulsion: 3 Orion Main Engines
- Total thrust: 18,000 lbs
- RCS: 24 R-4D-11
- Propellant: 54 metric tons of MMH+NTO
- Tanks: 7 helium-pressurized metal bellows tanks

Thermal Control System

- Polyethylene glycol and water mixture will be pumped through spacecraft walls
- Aluminum and Vantablack surfaces provide hot and cold surfaces for heat transfer
- Four fluid loops are possible with solenoids ensuring a comfortable temperature and no freezing/evaporation of thermal fluid or propellants

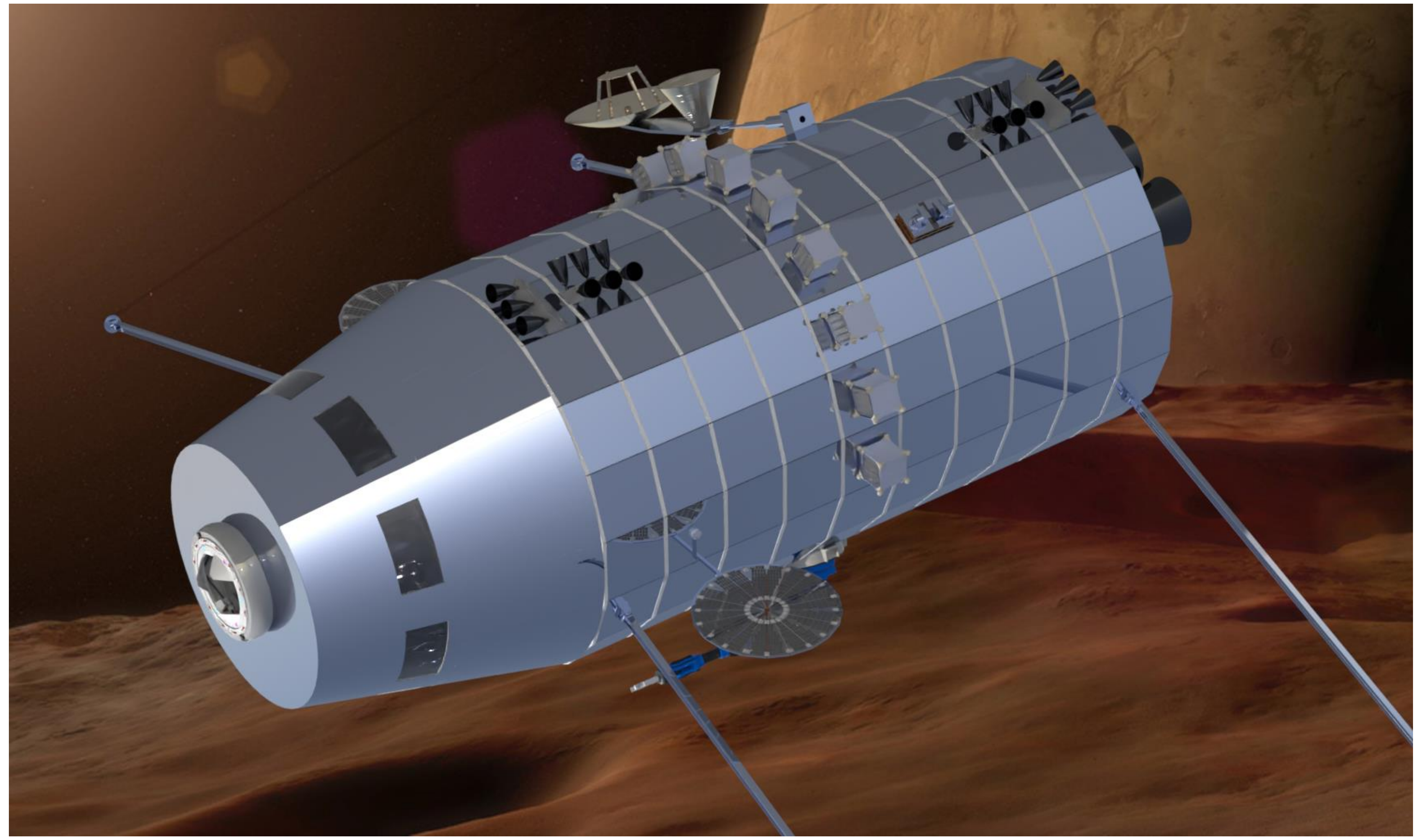

Figure 1.0 Full EEV Assembly

Sample Collection

- MMXL Sample Rover:
    - Cubic frame that is 0.46 m on each side
    - 3 orthogonal flywheels, DC motor at 3000RPM
    - Travel 3 m/min via rolling maneuver, up to 8 m by jumping maneuver
    - Spin maneuver about the z-axis
    - 16 tubes made of PEEK plastic
    - 1 hedgehog can collect 1042.5 grams with a FS of 10
- Sample Containment:
    - Robotic arm to maneuver samples from moon to EEV
    - Kevlar membrane barrier envelops sample tray
    - 30 trays needed per moon, 60 trays total

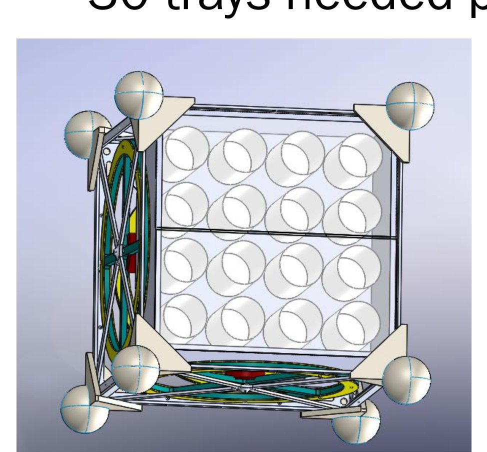

Figure 2.0 Hedgehog Assembly

Scientific Equipment

- Neutron Spectrometer
    - Measure the Hydrogen abundances on the moons in the top meter of the regolith to find traces of water
- Mastcam-Z
    - Two duplicate camera systems providing a 3-D view of the moons surface with a zoom function to see details of far away targets
- LIDAR System
    - Emits laser pulses at the moons surface which reflect back to the LIDAR detector to compute the distance
    - Provides high-resolution topographical information about the moons
- RIMFAX (RADAR System)
    - Ground-penetrating radar to image ground densities, structural layers, buried rocks, meteorites, and detect underground water at 10 m (33 ft) depth

Trajectory Analysis

- EEV Interplanetary Cruise: August 22nd, 2037 - March 30, 2038. Travel time: 220 days
- Insertion into 5-sol Mars orbit, awaits DST arrival.
- Docks with DST January 1st, 2040 to begin primary mission
- Maximizes scientific return and minimizes ΔV by visiting Phobos, ascending to Deimos, and then returning to DST.
- Utilize "distant" retrograde orbits around moons.
- Duration of landing for each moon: ~1 week.
- Total crewed mission duration: 23 days.

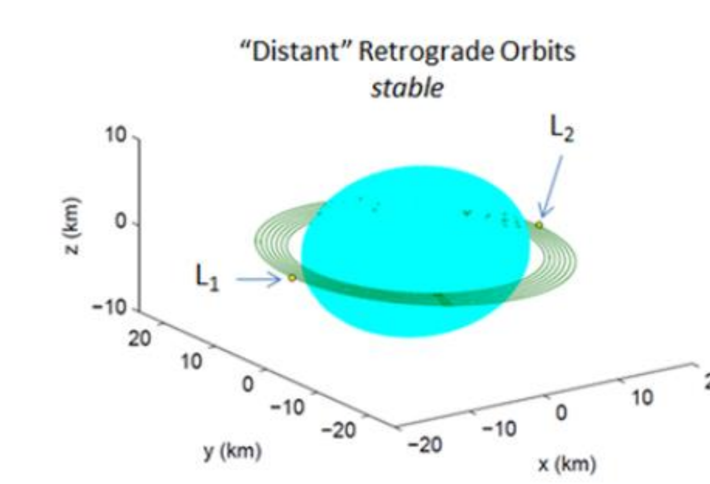

Figure 3.0 Orbit around Phobos

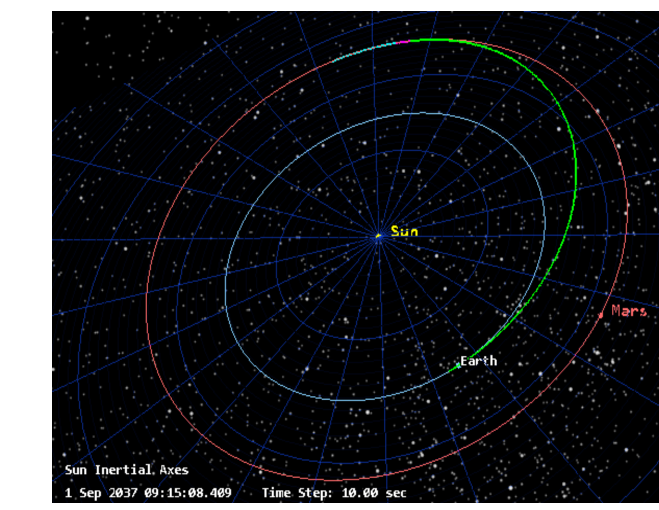

Figure 4.0 Trajectory to Mars

Crew Life Support

- The VIKA Oxygen Generator is the main source of oxygen for the two crew members
- Consists of 84 canisters of lithium perchlorate, which produce oxygen for the crew and lithium chloride as solid waste
- Four 20-gallon water tanks and 150kg of food storage
- The Carbon Dioxide Removal Assembly will be used to remove C02 in the cabin from crew exhalation. The waste management system of the EEV consist of a bathroom

Power System

- Two 2kW solar arrays are used alongside a 6 kWh battery to provide power to the spacecraft
- Peak loads of 6 kW are expected, with an average load of 2.5 kW
- Life support, thermal control, and telecommunications systems use most of the spacecraft power

Telecommunication System

- A laser-based communication system using infrared lasers for data transmission rates of at least 10,000 kbps
- Traditional radio frequency communications with a high/low gain antenna as a backup safety feature to the laser system