2021-2022 AIAA Foundation Undergraduate Space Mission Design Competition

Martian Moons Exploration Excursion Vehicle

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Abstract

As the private space race heats up with more and more compeition, all eyes are on Mars. As such, the National Aeronautics & Space Administration (NASA) is aiming to partner with a private entity to assist in its incremental exploration approach of crewed missions to the Red Planet. The biggest challenge with Mars surface missions is the deployment of large-scale Mars descent systems. This necessary technology stalls crewed exploration of Mars, so this mission offers the possibility of gaining more knowledge of Mars and its moons before the proper descent technology is developed. The Ares mission, accompanied with the Martian Moon Exploration Vehicle (EEV) presents a mission that would result in extensive scientific knowledge of Phobos and Deimos, as well as 50 kg of raw samples returned from each of the moons.

Trajectory

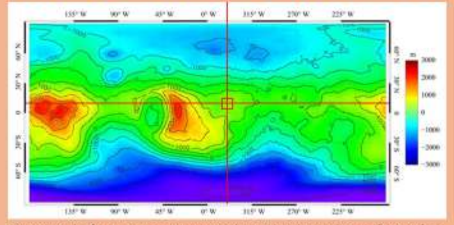
A 2035 launch window was selected for the Ares mission to allow for sufficient time for the EEV to reach Mars and enter the 5-sol parking orbit before the January 1, 2040 deadline, when the Deep Space Transport (DST) vehicle will arrive with crew. Initial launch and trans-Martian injection will be achieved by using a SpaceX Starship launch vehicle that will be re-fueled for trans-Martian injection in a low-Earth parking orbit.

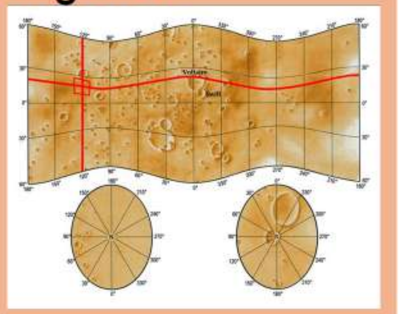
- Earth departure: June 20th, 2035
- Mars arrival: January 2nd, 2036
- Total DeltaV for trip to Mars: 4.371 km/s

Upon Mars arrival and docking with the DST, the crew will then use the thrusters aboard the EEV to manuever from the 5-sol parking orbit to Phobos, where they will spend XX days. The crew will then manuever from Phobos to Deimos, where they will spend XX days. Finally, the crew will manuever from Deimos to rendezvous with the DST in the original 5-sol parking orbit.

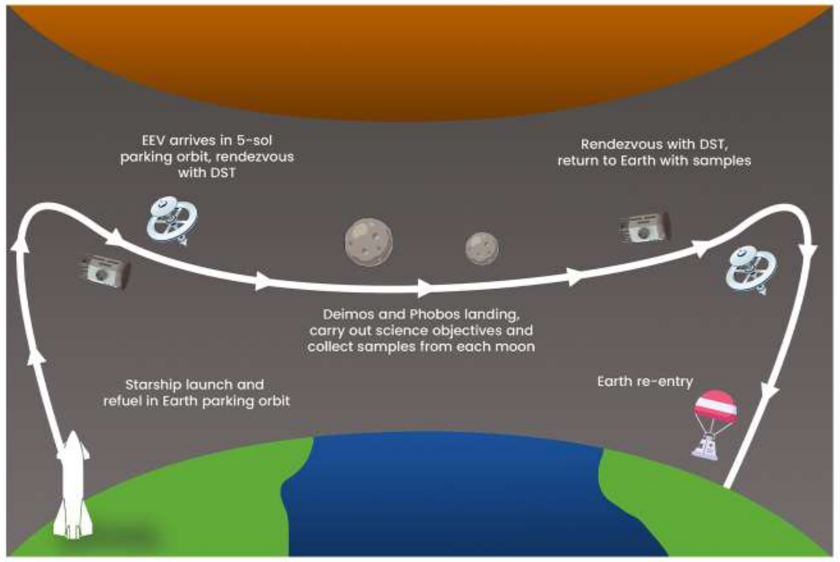
- Phobos arrival: January 6th, 2040
- Deimos arrival: January 7th, 2040
- Final docking with DST: January 10th, 2040
- Total DeltaV for intra-lunar maneuvers: 4.284 km/s

Phobos and Deimos Landing Sites





On the left, you can see the Phobos landing site, which was chosen for its flat terrain and to maximize the amount of sunlight recieved by solar panels on the EEV. The Phobos landing site is located in the Northern Hemisphere at 10° N and 335° W. On the right, you can see the Deimos landing site, which was also chosen for its flat profile and high amounts of sunlight exposure. The Deimos landing site is located in the Northern Hemisphere at 20° N and 120° W.



Exploration Excursion Vehicle (EEV)

The Exploration Excursion Vehicle (EEV) is an all-access pass for the crew to visit, explore, and understand the geology and topography of Phobos and Deimos. Equipped with 2 Aestus engineers with 29 kN of thrust each, the EEV is sure to get you where you need to be. The 7 meter diameter MegaFlex solar array provides our crew with all the power they need to carry out scientific experiments, communicate with Earth and the Deep Space Transport Vehical (DST), or even relax in their down-time. The solar power from the array is stored in a set of Saft VL51ES lithium-ion batteries, to make sure that there is never a moment without power. To keep the crew safe from radiation, a cutting-edge radiation shielding technique has been employed using a Gadolinium Oxide polymer, which absorbs 3x as much radiation and is nearly half the mass of conventional radiation shielding. Most importantly, activated charcoal air filters will be used to remove impurities from the air.

Mission Cost

Component		Total Cost (USD)
Launch Vehicle	$	2,000,000.00
Scienctific Objectives and Experimentation	$	486,200,000.00
Exploration Excursion Vehicle	$	20,314,785.00
Rover	$	1,500,000.00
Telecommunications Equipment	$	10,000,000.00
TOTAL	$	520,014,785.00

Sample Collection and Handling

The sample collection will be carried out by an independent rover detached from the EEV. The rover is a self-sufficient robot much like the Perseverance rover found on Mars. The samples are obtained through a robotic arm on the rover. The arm has a set of grippers used to grab the empty test tube and scoop up the regolith from the ground. The test tubes are adopted from the Perseverance mission. These test tubes are made from titanium for strength with a coating on the outside to protect the samples from the Sun and other contaminants. Each sample tube is 15.25 cm long with a diameter of 3.00 cm. Once the material is collected, the arm sets the sample tube in a specially made storage unit within the chassis of the rover. The arm is also equipped with a small scoop that uncovers deeper layers of regolith. 10 samples are obtained with 2 samples at each depth: surface, ¼ meter, ½ meter, ¾ meter, and 1 meter.

Scientific Objectives

Great value is placed on the scientific advancement that can be attained through the success of the Ares mission. A multitude of equipment, sensors, and recorders will accompany our crew on their journey to Phobos and Deimos, which will help them to accomplish the following scientific objectives:

Magnetic Field Measurement

Magnetic fields are vital to humankind and our materials since they provide protection from the sun. The crew will measure the flux and spectra of energetic particles surrounding each moon. In studying each moon's magnetic field (or lack thereof) this experiment aims to reveal the moons' ability to deflect solar wind.

Advanced Imaging

By utilizing a variety of cameras, this mission will be able to view both celestial bodies across different portions of the electromagnetic spectrum. IR, UV, gamma ray, and other telescopes will be used to capture close-proximity photos of both moons. These images will allow researchers to draw conclusions on the surface conditions present. Any unpredicted or otherwise visually imperceivable conditions can be captured.

Solar Wind Sampling

Solar wind has the capability to induce force on bodies of little acceleration. This energy can be absorbed, recycled, or transmitted. The amount of force exerted on a solar sail may provide a renewable source of mechanical energy on the moons. It is anticipated that there will be a significant amount of force due to the moons' expected lack of atmosphere and low gravity. This may prove to be useful for experiments or procedures in the future.

Exploration Excursion Vehicle Rover

The rover's primary mission and focus on this trip to the Martian moons will be to complete scientific objectives. The rover, controlled remotely by the astronauts on the EEV, will be lowered down from the EEV to the surface of the moons. Imaging equipment on the rover will be used by the astronauts to navigate the terrain. From there, using the sample storage containers, the rover can collect samples of regolith from varying depths/layers and any larger samples of rocks. The rover will leave the EEV with a full charge and also carry solar panels on board to continuously restore any lost power. In addition, the solar panels will function to collect data on the intensity of sunlight present on the moons. The rover will use robotic arms to manipulate scientific equipment and collect samples from the moon. Once the scientific objectives are complete on the moon, the rover will return to the EEV garage before the EEV departs the moon.