

PLYMOUTH ROCK: EARLY HUMAN MISSIONS TO ASTEROIDS

ACCESSIBLE ASTEROIDS

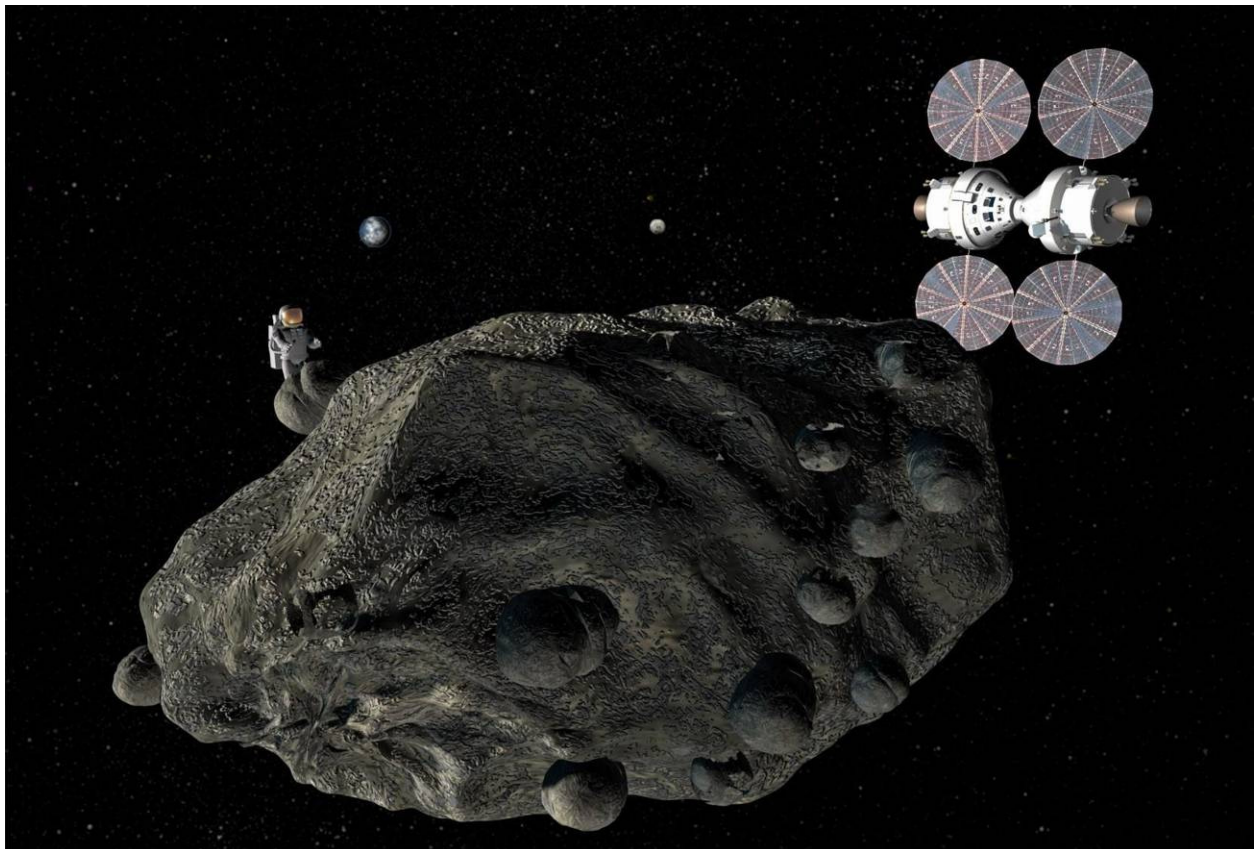
In the last decade, astronomers searching for hazardous asteroids which might impact Earth have discovered a few dozen very small asteroids whose orbits make round-trip missions easier than any previously known asteroid. For the past three years Lockheed Martin has been studying the feasibility of human missions to these asteroids and has developed a concept dubbed Plymouth Rock which uses two Orion spacecraft.

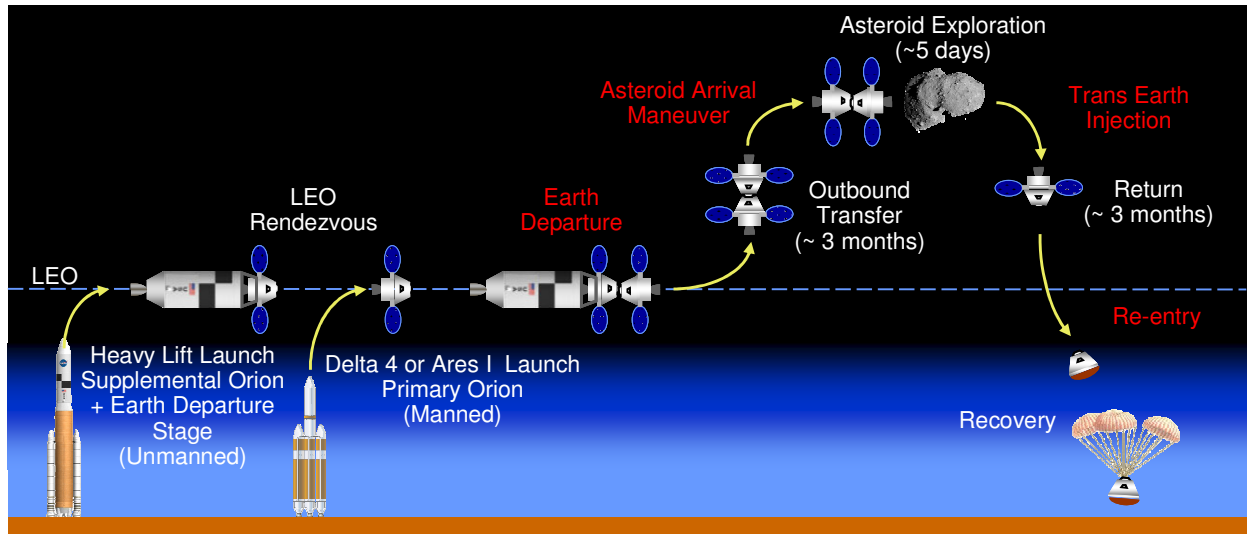
Exploring the Asteroids

The asteroids are the “leftovers” from the formation of the solar system – extra material which wasn’t absorbed into planets. More than half a million have been discovered. More are mountain-sized objects in a belt between Mars and Jupiter. A few thousand asteroids come closer to the Earth and are tracked to determine whether they could impact our planet. A few dozen of these are smaller asteroids which occasionally come close enough to Earth and pass by slowly enough to make them tantalizing targets for a round-trip visit. Sending astronauts to explore asteroids, characterize their structure, and select samples to bring back to labs on Earth will help us understand the primordial material the planets were made from. It will also en-

Key Messages

- **Astronomers have recently discovered very small asteroids in nearby orbits which could be reached by manned spacecraft like Orion.** These asteroids are 10-75 meters across - the size of buildings. The most favorable mission opportunities, in 2019 and 2028 are similar in difficulty to a lunar landing but only a few such opportunities occur each decade.
- **Astronauts exploring asteroids and returning samples to Earth would advance key scientific, planetary defense, and exploration goals.** We would learn about the structure and composition of asteroids, which would help us understand the birth of the solar system and how to deflect hazardous asteroids which may be discovered in the future. We would learn how to operate six-month missions far beyond the Moon as an easier precursor to Mars voyages.
- **An asteroid mission is feasible in 2019 using a pair of enhanced Orion spacecraft and a heavy lift launch vehicle.** More difficult missions such as the President’s proposed 2025 mission would require developing a larger and more advanced spacecraft but could still use Orion for the launch and Earth return phases.





able us to recognize which asteroids are big enough to be dangerous and learn how to deflect one if in the future we discover an asteroid on a collision course with Earth. Asteroid missions provide an intermediate step in difficulty between the Moon and Mars so that we can practice longer missions deeper into space before we are ready to perform a multi-year trip all the way to Mars.

Mission Plan

A mission to an asteroid will last about six months and take astronauts several million miles from Earth – many times farther than the Moon. This requires a very capable spacecraft with propulsion, living space, and life support supplies, as well as safety features to protect the crew in the event of a problem since they can not return to Earth quickly. Orion is designed with many of the capabilities needed for an asteroid mission because they are similar to the requirements for a lunar mission, such as radiation protection, deep-space communications, and the ability to reenter Earth's atmosphere at much higher speeds than a vehicle designed only to go to the International Space Station. However, a single Orion spacecraft is not large enough for an asteroid mission. Combining two Orions provides just enough propellant, supplies, and living space to reach the easiest asteroids. The twin spacecraft also provide redundancy in the event of a failure on one spacecraft. The spacecraft could be launched using a human-rated rocket plus a heavy lift vehicle slightly smaller than the proposed Ares V. Once the astronauts reach the asteroid, they would not land their spacecraft on it, since the asteroid's gravity is negligible. Instead, the astronauts would park their spacecraft nearby and float over to the asteroid using zero-g spacewalking techniques similar to those used in Earth orbit to collect samples and set up instruments. Humans can perform these complex tasks more effectively than robots. In the next twenty years, three known asteroids will come close enough to reach using this dual-Orion approach, in 2016, 2019, and 2028. Additional accessible asteroids will probably be discovered in the meantime.

Visiting more difficult asteroids, such as the President's proposed mission to asteroid 1999 AO₁₀ in 2025, will require a larger spacecraft with more advanced propulsion. We envision that this type of mission could use a single Orion for launching and returning the astronauts, but it would be attached to a larger spacecraft which the astronauts would live in while in space. Designing a dedicated spacecraft for asteroid missions like this provides greater exploration capability but is also more expensive, especially if only a few asteroid missions are planned. This approach will also require a larger launch vehicle.

Next Steps

Most near-Earth asteroids have not yet been discovered. Additional funding for asteroid detection would not only help discover the best asteroids for astronauts to visit, it would also support the Congressionally-mandated search for potentially hazardous Earth-impacting asteroids. Ground-based telescopes are an affordable approach. A small space-based telescope for asteroid surveys would cost more but be much more effective.

A robotic scout spacecraft should also be sent to asteroids similar to the ones being considered for human missions. Although spacecraft have visited a few asteroids before, these were all much larger than the ones being considered for human visits. It would be safer to characterize smaller asteroids before astronauts are sent to visit them.

Precursor human missions are also needed before we can safely send astronauts on a six-month mission into deep space. Missions like the proposed L2-Farside mission would be test the spacecraft and operations methods on shorter trips closer to Earth.