Mars Ascent Vehicle

In-Space Propulsion Technology Program

A joint Mars exploration program between NASA and the European Space Agency (ESA) has set a long term focus on the return of samples from Mars. The current proposed campaign, shown in figure 1, calls for a set of three missions potentially starting in 2018 to 1) Collect a cache of samples, 2) Land, retrieve and launch the samples into Mars orbit, and 3) Rendezvous with the orbiting sample container and return them to Earth for study.

The proposed Mars Sample Return lander mission would use the “Sky Crane” for entry, descent, and landing (EDL), carry a “fetch” rover to retrieve the cached samples, and use a rocket referred to as the Mars Ascent Vehicle (MAV) to launch and release the sample into orbit. A proposed lander configuration is shown in figure 2.

Top-level Requirements

The MAV will be the first vehicle to launch from another planetary body. The MAV is physically constrained by both the lander and EDL system for both mass and volume as illustrated in figure 3. Approximately 300 kg and a cylinder volume of 0.6 meter in diameter and 3 meters in length have been allocated for the MAV. The MAV must deliver an orbiting sample container approximately 16 cm in diameter with a mass of 5 kg into a low Mars orbit. The desire is a circular orbit at 520 km altitude with dispersions less than 60 km.

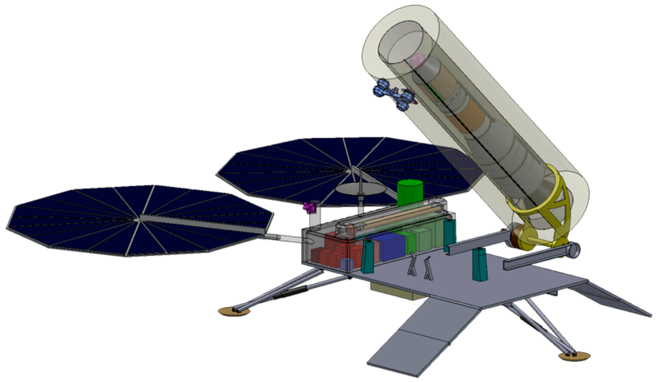

Figure 2: Notional MSR lander configuration.

The MAV must also be robust against single point failure modes and transmit telemetry to an orbiter during flight.

Support Systems

One of the biggest challenges of the MAV is the environments the vehicle must survive. The MAV will experience vibration and shock loads during Earth launch and Mars EDL; in some cases exceeding a sustained deceleration greater than 15-g’s while stowed. Once landed, the MAV must survive and operate in the cold temperatures that will be experienced on Mars. The worse case cold temperatures on the surface of Mars may approach -100°C. The vehicle itself has requirements to be kept above -40°C due to the

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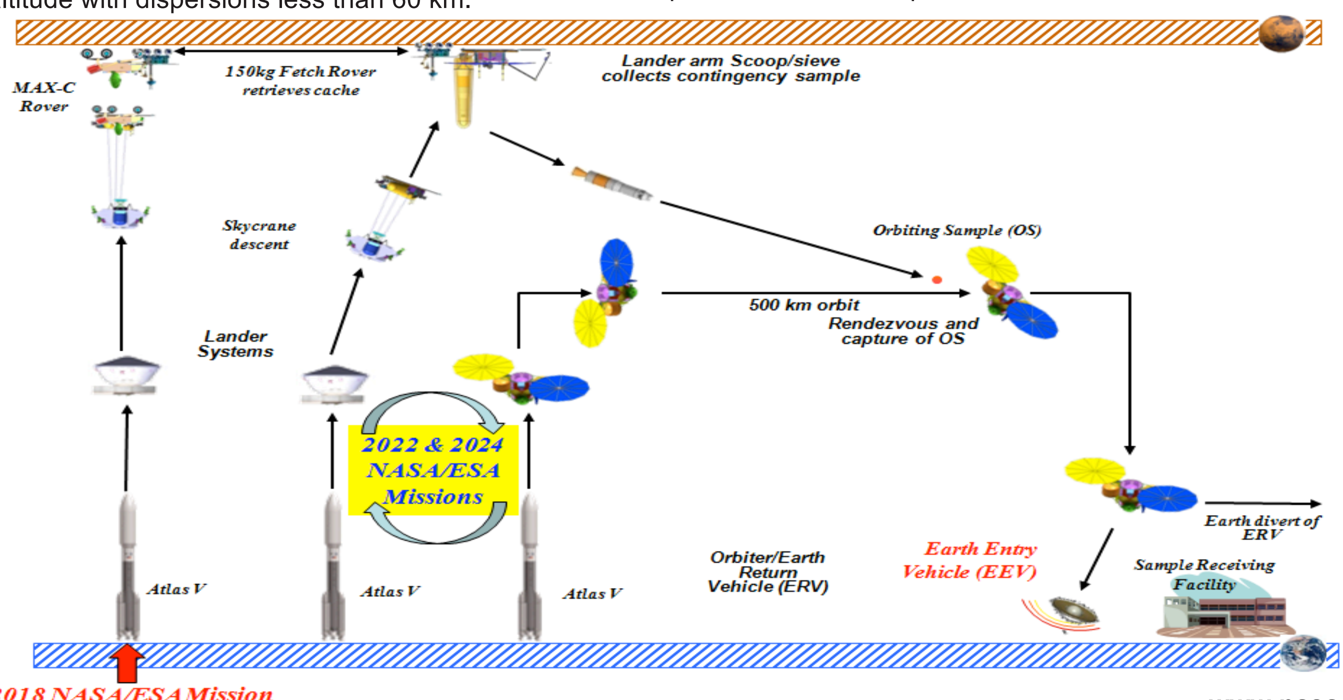

Figure 1: Notional MSR mission campaign

limitations of the vehicle hardware and propulsion system limits.

The MAV must be stowed in a horizontal position relative to the lander during Earth launch, transit and Mars entry due to the physical envelope allowed between the Sky Crane and the entry shell. Prior to launch, the MAV must be raised to an acceptable launch elevation angle. This erection system must also transfer launch loads to the lander for a stable lift-off.

While on the surface, the MAV will also be stored within a thermal enclosure referred to as the "igloo". The igloo will protect the MAV from the outside environment through the use of insulation, heaters, and potentially require radioisotope heat units (RHUs). The igloo itself is also very constrained with limited volume for insulation expansion during the stowed configuration and potential need to remove heat during the Earth launch and interplanetary transit.

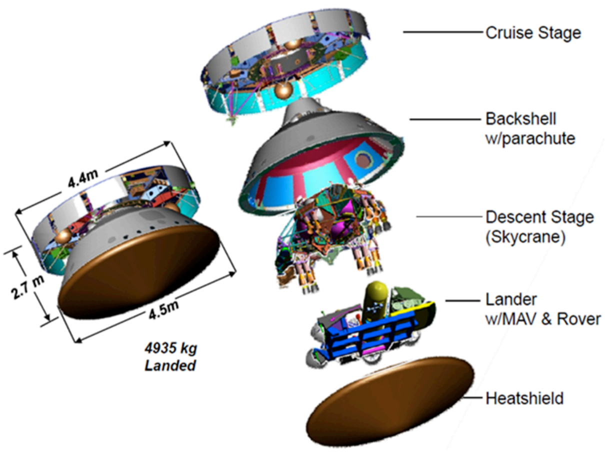

Figure 3: Spacecraft configuration for MSR Lander

Terrestrial Flight Validation

Another challenge associated with the MAV development is how to test the vehicle on Earth. Launch vehicles have historically demonstrated a high failure rate, greater than 20 percent, during the first few flights of a new or evolved vehicle. A 20 percent failure rate would be unacceptable for a mission of this class; so the full vehicle must first demonstrate the ability to survive the environments and meet the performance requirements of the mission terrestrially.

The Mars flight environment is difficult to replicate on Earth. The Mars gravity is 38 percent that of Earth, but more importantly, the Mars atmosphere is only one percent that of Earth, and the MAV will be at vacuum before performing its circularization maneuver. On Earth, the initial atmospheric conditions to demonstrate the aerodynamic loads can be closely replicated with a launch from an altitude of 27.5 km. On Earth, however; the circularization maneuver would still be within the Earth's atmosphere and could achieve orbit.

A potential option is to perform high altitude flight tests launched from a balloon platform. NASA's Balloon Program evaluated the potential to complete the MAV tests at high altitude and found that the balloons provide a feasible option, but may pose a risk due to the potential range of the MAV. The first flight of the vehicle must have a safe range of approximately 1500 km in radius. This range is so large that there are few places on Earth that can accommodate the MAV balloon launch. The potential launch sites are shown in figure 4. Additional test options are still being evaluated for practical performance validation to ensure a low-risk mission for the MAV.

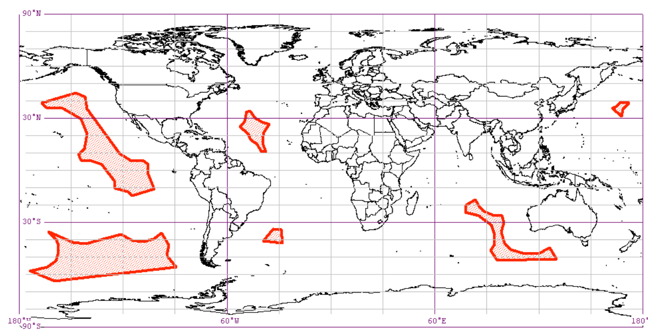

Figure 4: Potential balloon launch locations.

Additional Information

NASA's MAV technology development team includes NASA's Jet Propulsion Laboratory, Marshall Space Flight Center, and NASA Glenn Research Center.

The Mars Ascent Vehicle is being matured by the In-Space Propulsion Technology Program, which is managed by NASA's Science Mission Directorate and implemented by the In-Space Propulsion Technology Office at the Glenn Research Center. The program objective is to develop technologies that can enable or benefit near and mid-term NASA space science missions by significantly reducing risk, cost, mass and travel times.

For more information about the Mars Exploration Program, visit:

http://marsprogram.jpl.nasa.gov/

For more information about NASA's In-Space Propulsion Technology program and MAV activities, visit:

http://spaceflightsystems.grc.nasa.gov/SSPO/ISPTProg/

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