Team Rocket's Manned-Mission to Mars

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TEAM ROCKET
Mission To Mars

Abstract

Human exploration of Mars has been a subject of interest in the aerospace engineering industry for many years, as Mars is believed to have an evolutionary history similar to Earth. However, before human exploration of the Red Planet takes place, a thorough examination of the engineering challenges associated with interplanetary travel is required to ensure that the mission is completed in a safe and efficient manner. The work herein outlines a manned-mission to Mars in which the orbital trajectories, design of the human landing system, and mission logistics are presented and studied intricately.

Mission Objectives

1) Safe transportation of payload and crew to and from Mars.
2) Provide a benchmark for human survivability in the Martian environment for an extended period.
3) Increase understanding of the geographical history of Mars.
4) Build a foundational habitat to function as research and living quarters for the crew and remain operational for all systems and equipment to function for the current and future missions.

Payload Subsystem

- Payload 1: Martian Landing Module (MLM), for landing and recovery. The MLM will include water, food, oxygen, inflatable heat shield, and commanding interface.
- Payload 2: Martian Foundational Surface Habitat (MFSH), for research and development on Mars. Applications on-board the MFSH will include soil water extraction, water and oxygen recycling, and equipment storage for surface experimentation.

Mechanical & Structural Subsystem

- The two payload modules reside in a stacked configuration for the majority of flight time, MLM on bottom for powered descent, MFSH on top for parachute descent; separation mid descent.
- Propulsion components, tanks, and engines are housed in the MLM
- Large ablative heat shield for increased drag in descent
- Engines housed in sidepods with pushrod TVC mounts (discussed further in ADCS)

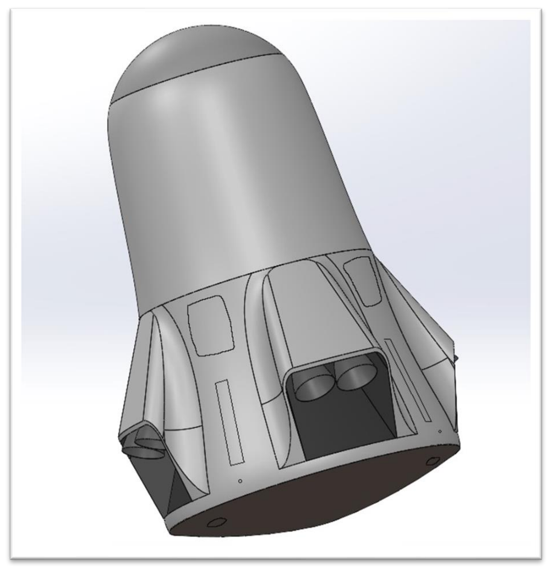


Fig. 1 Payload Full Stack Configuration

Orbital Mechanics

- Two Starship Fuel Tankers will be used to refuel Clifford I – each one during its Earth and Mars parking orbits.
- Launch will begin from the John F. Kennedy Space Center in Cape Canaveral, Florida, to utilize Earth's rotational velocity near the equator to minimize fuel consumption.

Table 1: Transfer Orbit to Mars

Orbital Characteristics	Values
Eccentricity	0.093
Semi-Major Axis (AU)	1.524
Inclination	1.85°
Time (Days)	98
ΔV1 (km/s)	4.48
ΔV2 Reentry (km/s)	3.18

Table 2: Transfer Orbit to Earth

Orbital Characteristics	Values
Eccentricity	0.045
Time (Days)	144
ΔV1 (km/s)	1.16
ΔV2 Reentry (km/s)	14.1

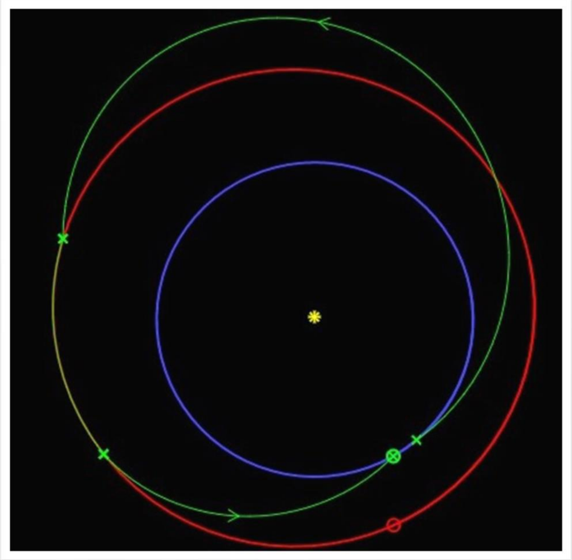


Fig. 2 Flight Trajectory for Clifford I

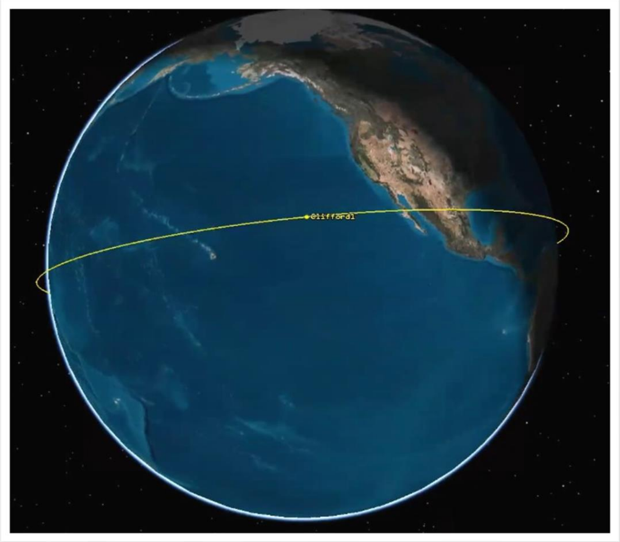


Fig. 3 Circular Parking Orbit Around Earth

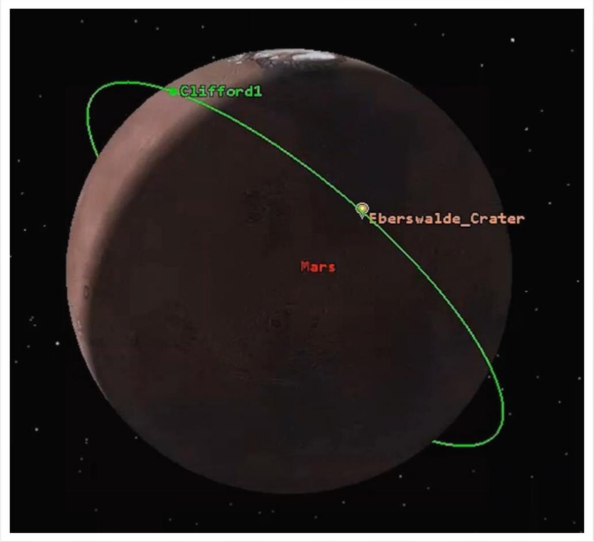
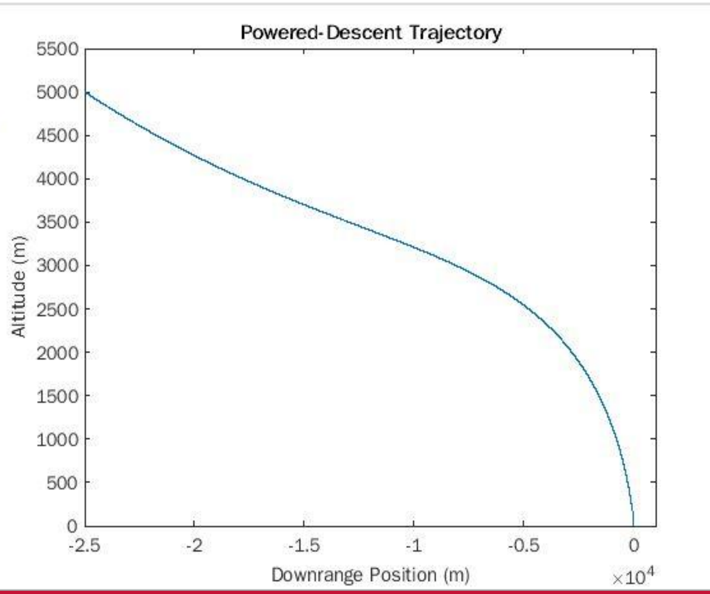
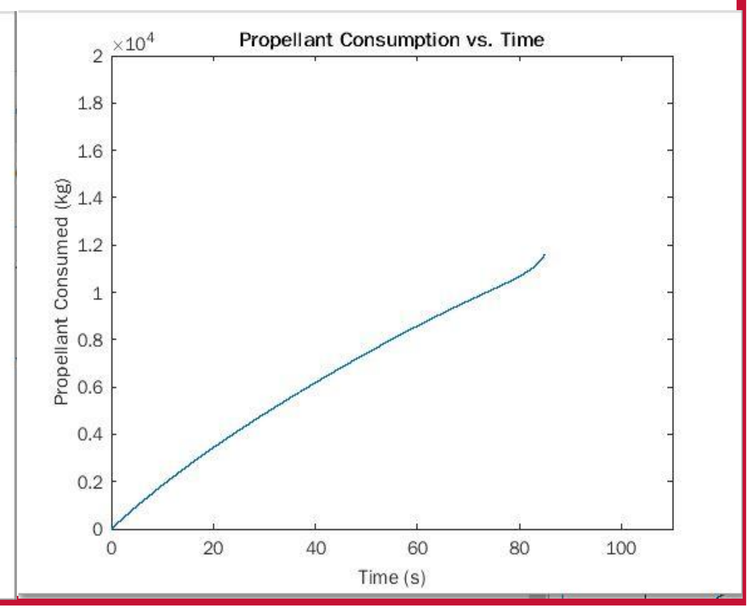


Fig. 4 Circular Parking Orbit Around Mars

ADCS Subsystem

For an effective entry, descent, and landing phase of the human landing system, a robust attitude determination and control system (ADCS) is necessary. The ADCS subsystem will be comprised of a Motus IMU Sensor by Advanced Navigation, a re-purposed AN/APY-9 radar system by Lockheed Martin, a custom 70 ft. diameter Technora Nylon parachute by NASA JPL, and 8 thrust-vectored SuperDraco engines by SpaceX to comply with the stated mission requirements. On entry to Mars' atmosphere, the Technora Nylon parachute will be deployed to decelerate the vehicle until it is 5 km above and 25 km downrange of the landing site. At this point, the lander will use energy optimal powered-descent guidance to retro-propulsively descend to the landing site and make a soft touchdown. A simulation was done in MATLAB to validate the guidance law and landing trajectory; the results are shown below.





Mission Schedule & Budget

Table 3: MLM Budget

Budget (MLM)			
Object	Number of Object(s)	Cost of Object	Total Cost of Objects
General Dynamics SDST	1	$ 10,400,000.00	$ 10,400,000.00
Food	4	$ 75,000,000.00	$ 300,000,000.00
MOXIE Module	20	$ 50,000,000.00	$ 1,000,000,000.00
APXS	1	$ 17,800,000.00	$ 17,800,000.00
PIXL	1	$ 130,000,000.00	$ 130,000,000.00
SAM	1	$ 200,000,000.00	$ 200,000,000.00
RAD	1	$ 165,000,000.00	$ 165,000,000.00
DAN	1	$ 75,000,000.00	$ 75,000,000.00
Mastcam-Z	1	$ 12,000,000.00	$ 12,000,000.00
Reconnaissance Drone	4	$ 80,000,000.00	$ 320,000,000.00
Oxygen	4	$ 8,000.00	$ 32,000.00
Manufacturing Materials	1	$ 500,000,000.00	$ 500,000,000.00
Production Process and Testing	1	$ 1,000,000,000.00	$ 1,000,000,000.00
TOTAL			$ 3,730,232,000.00

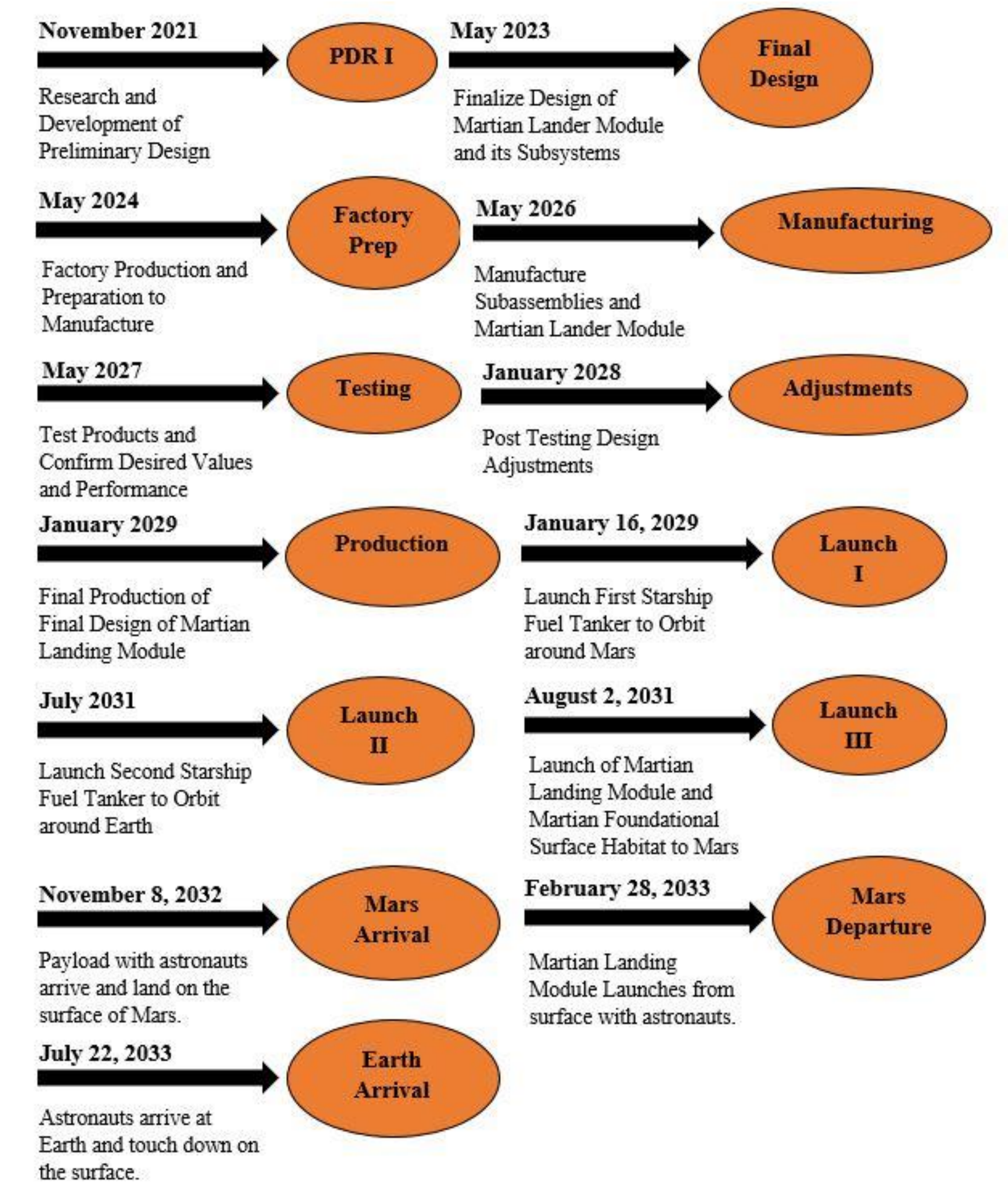


Fig. 5 Mission Schedule

Acknowledgements

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