University of Arizona Mars Orbiter (UA-MO)
SIE 552-Fall 2011
System Requirement Document (SRD)

1.0 Program Overview

University of Arizona Lunar and Planetary Laboratory (UA-LPL) is proposing a mission to Mars as part of the next NASA Discovery Class proposal bid. Scientists from LPL are coming with a set of science goals and objectives that must be satisfied by the proposed mission. This document set the stage for the spacecraft system requirements. The developing time is 5 years (including pre-proposal stage) and the PI cost-cap is $450M (FY16$, launch vehicle cost excluded)

2.0 Science Objectives

UA-MO shall be designed to satisfy the following science objectives

1. Search for evidence of hydrothermal and aqueous activities
2. Map and characterize in details the stratigraphy, structure and composition of Mars surface features
3. Provide high resolution imagery to support future landing sites
4. Detect on Mars the presence of liquid water and determine the distribution of ground ice in the upper surface

3.0 Payload

UA-MO spacecraft shall be designed to accommodate the following set of scientific instruments:

1. Mars Orbiter High Resolution Camera (MOHiResC) Suite
2. Mars Orbiter Thermal Emission Imaging Spectrometer (MOTIES)
3. Mars Orbiter High Energy Neutron Detector (MOHEND)
4. Mars Orbiter Laser Altimeter (MOLA)

Instrument characteristics are described in the Instrument Payload Document (IPD). The payload is supplied and managed by the instrument team. Mass and power requirement as described later must be assumed as upper limits.

4.0 Mission Design

The mission for this study shall be a Type-I trajectory to Mars with orbit insertion scheduled for 2022. The orbiter shall establish a sun-synchronous polar circular orbit around Mars at an altitude of 400 km

5.0 Launch Vehicle

Two possible options are set as a choice of launch vehicle, i.e. ATLAS V 401 or ATLAS V 551. Details and characteristics of such rockets can be found in the ATLAS V user guide (2010) provided by United Launch Alliance (ULA, see supporting pdf on the D2L website). It is shown that using an ATLAS V 401 with $C_3 = 18.54\ km^2/sec^2$ yields a total upper limit for the launch mass of 2335 Kg. If an ATLAS V 551 had to be used with the same C_3, a total 4465 kg will be the launch mass upper limit. The spacecraft launch mass includes all propellants and gasses as well as the spacecraft-Launch Vehicle Adapter (LVA). Clearly, the designer shall strive to provide a spacecraft designer that fits the smaller LV, i.e. ATLAS V 401. The ATLAS V 551 shall be used only if the proposed design is shown to be beyond the ATLAS V 401 mass capabilities (including mass margin). LV configuration, fairing dimensions, physical interface with the spacecraft, flight profile and loads are reported in the ATLAS user guide.

6.0 Mission Life

The spacecraft shall be designed for a three-year nominal mission (orbit around Mars). The design shall include redundancy such that no single, non-structural, malfunction can cause loss of the mission. The system shall be designed to provide options for an additional three-year extended mission.

7.0 Propulsion

The spacecraft shall be capable of providing a Mars orbit insertion velocity change, Thrust Correction Maneuvers (TCM), Deep Space Maneuvers, and Mars Orbit Maintenance. An initial estimate shows that 2.0 km/sec is sufficient to satisfy the propulsion requirements.

NOTE: this is just an initial guess. When the mission trajectory analysis and design is complete, you should have a better estimate of the required delta-V that you need to provide to satisfy the requirements. Also, additional aerobraking maneuvers shall be considered in the design space to reduce the delta-V requirements.

8.0 Attitude Control

The spacecraft shall be nadir pointed and the attitude control system shall provide the pointing accuracy required by the science instruments. It must be possible to make a 180 degree rotational maneuver about any axis in 30 second. The solar arrays shall be pointed to the Sun within 5 degrees maximum array pointing error.

9.0 Power

The power system shall be direct energy transfer type with two rigid fold-out solar panels with 2x4 cm GaAs cells. The panels shall have one or two degrees of freedom. The system shall use NiH2 batteries and shall be capable of conducting the mission with one battery out. The nominal bus voltage shall be 27.5 V.

10.0 Thermal Control

The thermal control system shall maintain the spacecraft bus equipment temperatures 5 degrees higher thant the lower temperature limits in Table 1 and 5 degrees below the upper temperature limit listed in Table 1 (5 deg thermal margin).

Table 1: Temperature Limits

Components	Lower Temperature Limits, Celsius	Upper Temperature Limits, Celsius
Electronics	0	40
Batteries NiCd	5	20
Batteries NiH2	-10	20
Solar Arrays	-100	100
Propellant, Hydrazine	7	35
Structures	-45	65

11.0 Command and Data Handling

Commands data rate shall be 62.5 bps maximum, The C&DH subsystem shall provide for an engineering data rate of 1200 bps. The science and engineering data shall be Reed Solomon (255,223) coded. Commands shall be BCH (63,56) coded (CCSDS standard)> Overhead on science and engineering data shall not exceed 10%. The science data will be recorded 24 Hrs a day, 22 hours at minimum rate and 2 hours at maximum rate. Engineering data shall be recorded 24 hours/day. See supporting documents for instrument data rates. Redundant data storage shall be provided.

12.0 Telecommunications

The assigned frequencies are the following:

Downlink: 8.4177 GHz

Uplink: 7.1646 GHz

The Earth-Mars range is the following:

Maximum: 375 millions of kilometers

Minimum: 20 millions of kilometers

For science and engineering data, the maximum bit error rate is 10^{-3}, the minimum Eb/N0 = 4.5 dB. For commands, the maximum bit error rate is 10^{-5} and the minimum Eb/N0 = 5.5 dB. The ground stations will be DSN 34m HEF, with characteristics reported in the tables below . DSN time is limited to 12 hours/day during the normal operations.

Receiving Parameters	
Nominal Frequency	8.4177 GHz
Antenna Gain	68.1 dBi
System Noise Temperature	30 K, degrees

Transmitting Parameters	
Nominal Frequency	8.4177 GHz
Transmitting power	0.2 to 20 kW
Antenna Gain	67 dBi