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Mars Surveyor '98 Project

Mission Plan and Databook

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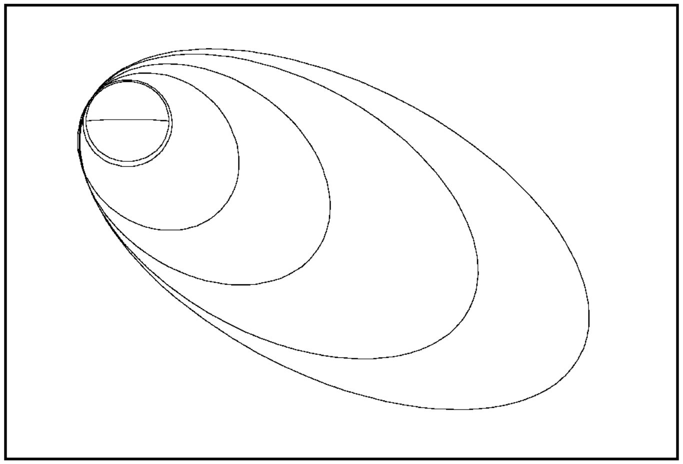
August 8, 1997

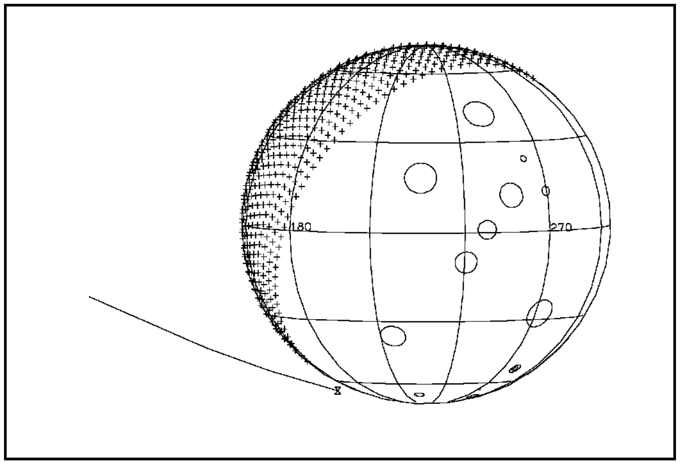
JPL
Jet Propulsion Laboratory
California Institute of Technology

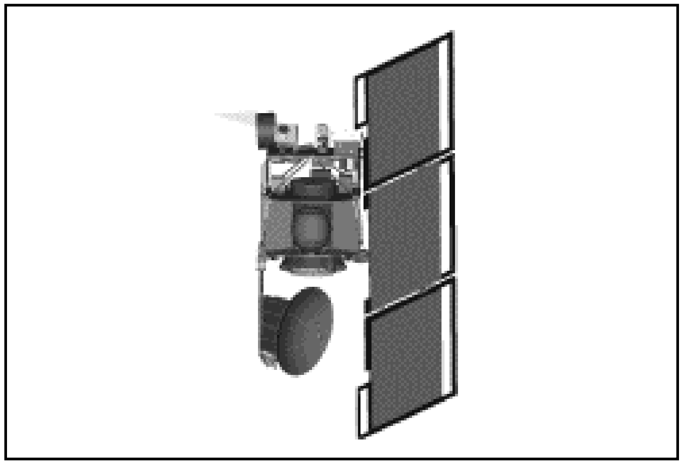
MARS SURVEYOR '98 PROJECT

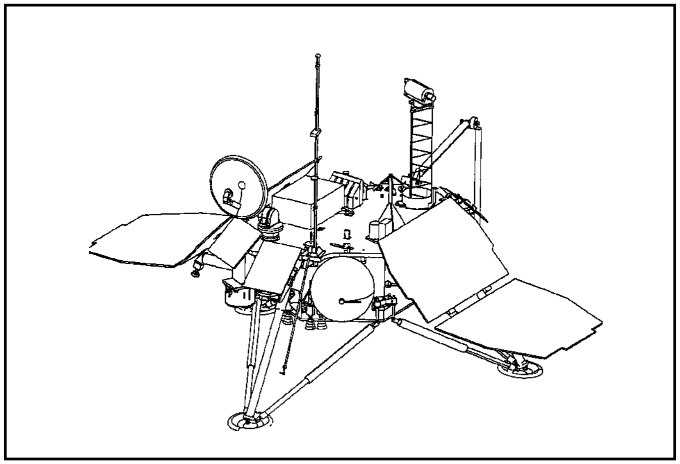
MISSION PLAN and DATABOOK

M98-1-2001









August 8, 1997

MARS SURVEYOR '98 PROJECT

MISSION PLAN and DATABOOK

M98-1-2001

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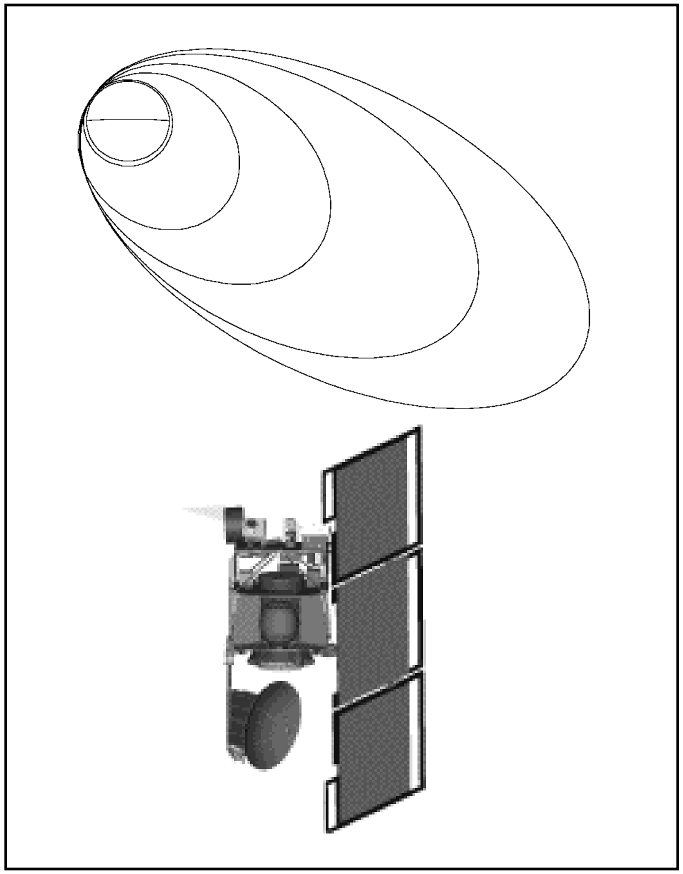
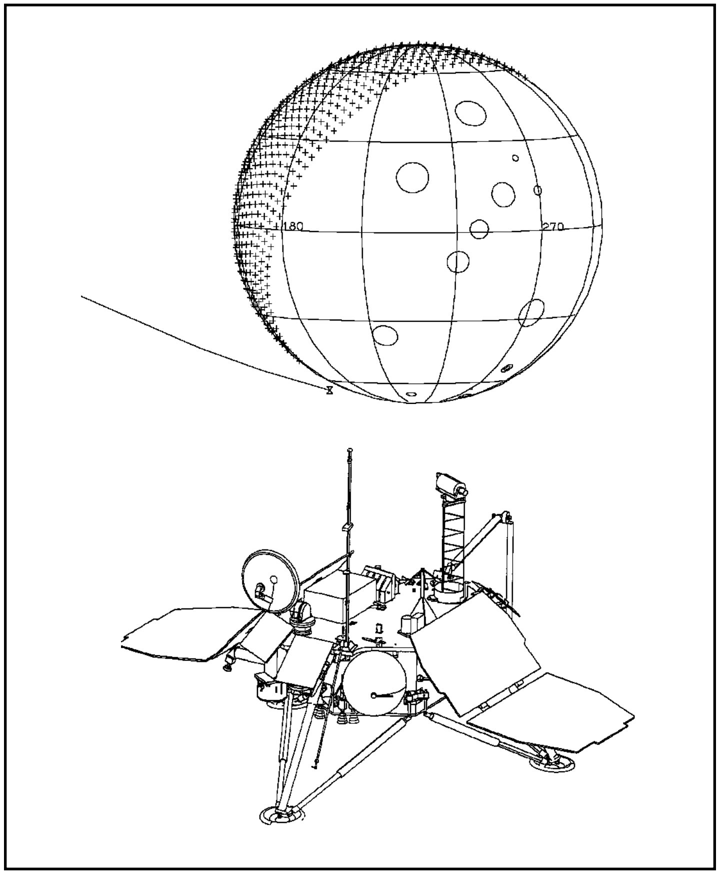
MARS SURVEYOR '98 PROJECT

MISSION PLAN and DATABOOK - Introduction





August 8, 1997

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 PURPOSE, SCOPE, AND RELATION TO OTHER DOCUMENTS

The Mars Surveyor 98 Orbiter and Lander Mission Plan and Databook combines the functionality of a high-level mission summary for the Orbiter and Lander, a databook containing mission data, including those usually found in trajectory characteristics documents, and a navigation plan. It defines the baseline mission and provides the basis for development of detailed mission event sequences. This document does not levy new mission and system requirements, but is intended to show how previously defined requirements, constraints, or capabilities are combined to define the mission concept. This document includes change-controlled sections containing baseline data or processes requiring review prior to alteration. It reflects a current understanding of evolving mission capabilities; these capabilities may, in certain cases, differ from contractual or other requirements.

This document is consistent with and responsive to high level project policies, constraints, and capabilities, as described in the following documents:

Mars Surveyor '98 Project Plan [1-1001]
Mars Surveyor '98 Project Policies, Requirements, and Capabilities Document [1-1002]
Payload Interface Control Documents

It is also consistent with capabilities and constraints of the project systems as described in the following documents:

Planetary Protection Plan [3-2001]
Launch Vehicle Specifications [3-4001]

The portions of this document under change control are described in the following section.

Go to TOC

DOCUMENT PURPOSE, SCOPE, AND RELATION TO OTHER DOCUMENTS

- **CONTENTS:**
  - High-level summary of mission events for the Orbiter and Lander
  - Mission data, including trajectory characteristics
  - Navigation Plan

- **PURPOSE:**
  - Defines the baseline mission
  - Provides the basis for development of detailed mission event sequences
  - Demonstrates how current requirements, constraints, or capabilities combine to define the mission concept
  - It does <u>not</u> levy new mission and system requirements
  - Includes change-controlled sections containing baseline data or processes requiring review prior to alteration.
  - Reflects current mission capabilities [may differ from contractual or other requirements]
  - Documents design reference missions used to assess performance vs. resources

- **The Mission Plan and Databook is responsive to:**
  - **Mars Surveyor '98 Project Plan [1-1001]**
  - **Mars Surveyor '98 Project Policies, Requirements, and Capabilities Document [1-1002]**
  - **Payload Interface Control Documents**

- **The Mission Plan and Databook is consistent with:**
  - **Planetary Protection Plan** [3-2001]
  - **Launch Vehicle Specifications** [3-4001]

1.2 SECTIONS UNDER CHANGE CONTROL

The following table lists those sections of the Mission Plan and Databook which are under change control as part of the Project Documentation Tree. Changes are subject to review by the Project Manager and Project Change Board.

Go to TOC

SECTIONS UNDER CHANGE CONTROL

- Indicated sections are under change control as part of the Project Documentation Tree, and are subject to review by the Project Manager and Project Change Board.

- **INTRODUCTION:**

Section	Description of Controlled Items
1.3	Planetary Constants
3.1	Launch Vehicle wet mass capabilities

- **ORBITER MISSION PLAN and DATABOOK:**

Section	Description of Controlled Items
4.2.3	Orbiter Launch/Arrival Period
4.2.4	Orbiter Launch Period Strategy
4.2.5	Summary of Mission Events and DSN Tracking Requirements
4.2.6	Orbiter ΔV and Propellant Mass Summary
4.4.1	Orbiter Cruise Navigation
4.4.2	TCM's
4.6.3.1	TMO Maneuvers
4.7.1	Overview [Lander Support Phase]
4.8.1	Mapping Orbit
4.10	Orbiter Design Reference Missions
A.13	Orbiter Approach Targeting Data

- **LANDER MISSION PLAN and DATABOOK:**

Section	Description of Controlled Items
5.2.3	Lander Launch/Arrival Period
5.2.4	Summary of Mission Events and DSN Tracking Requirements
5.2.5	Lander ΔV and Propellant Mass Summary
5.4.1	Lander Cruise Navigation
5.4.2	TCM's
5.6.2	Sol 0,1 Design Reference Mission
5.6.3	TEGA Day 1 Design Reference Mission
B.11	Lander Approach Targeting Data

1.3 TBD LIST

The following table lists TBD [to be determined] items. These include items for which no value is yet available, or for which a representative value is proposed in the Mission Plan and Databook. These items may be revised pending further review or analysis. TBD items appearing in change-controlled sections are indicated.

Go to TOC

TBD LIST

- **ORBITER MISSION PLAN and DATABOOK:**

Section	Description of TBD Item	In a Change Controlled Section?
4.2.5	**Use of BWG antenna**	**yes**
4.2.6	**Inclination trim during and after aerobraking**	**yes**
4.4.5.1	Use of PMIRR, MARCI during HGA transmission [undeployed]	
4.4.5.1	MARCI pictures taken during Earth-Moon Calibration	
4.4.5.1	Requirement to keep sun off PMIRR scan mirror during checkout	
4.5.1.1	Confidence level for 150 km altitude limit at MOI	
4.5.1.1	Accelerometer cutoff value during MOI-1 [current estimate 65-75%]	
4.5.1.2	Time before MOI to disable Safe Mode	
4.6.1	Updating walk-in maneuver post-MOI	
4.6.2.2	When to go to reduced tracking pass duration during power end-game	
4.6.2.2	Feasibility of measures to compensate for reduced periapse prediction capability	
4.6.3.1	**Time for transfer to mapping orbit [current allocation = 24 hrs]**	**yes**
4.6.3.1	**Maximum feasible maneuver after HGA deployment**	**yes**
4.6.3.2	Need for HGA calibration after deployment	
4.7.1	**Days after Lander Landing to initialize PMIRR and MARCI**	**yes**
4.7.1	**Orbiter science operations during Lander Support Phase [EMI interference]**	**yes**
4.7.2.1	Maximum size of lander command load	
4.8.1	**Acceptable range of mapping orbit inclinations**	**yes**
4.8.3	Frequency of nav predicts during mapping	

- **LANDER MISSION PLAN and DATABOOK:**

Section	Description of TBD Item	In a Change Controlled Section?
5.1.2	Operation of Lander under dust-storm conditions	
5.2.3	**Confidence level for achieving ±0.25° entry angle control**	**yes**
5.4.1	**Near-simultaneous tracking for entry control**	**yes**
5.4.4.1	2100 bps for Checkout/Calibration Campaigns using 70m station	
5.4.4.2	TEGA checkout interval, requirement for TEGA valve exercise	
5.4.4.3	D/L percentage allocation for Science during Checkout/Calibration Campaigns	
5.4.5	Schedule for updating entry state	
5.4.5	Time before Entry to disable Safe Mode	
B.5.7	Payload scenarios, transition to “nominal” Sol 1 activities.	

1.4 PLANETARY CONSTANTS

** This page under Change Control **

The following table summarizes the planetary constants to use for all mission calculations. Data are based on MGS and Pathfinder planetary constants. All other data not listed [e.g. data for Earth-relative calculations, definitions of coordinate systems, etc.] must conform to the Mars Pathfinder Project PLANETARY CONSTANTS AND MODELS (JPL D-12947), September, 1996 revision.

The "Reference Radius" of 3397.2 is used to define Mars-relative planetocentric altitudes, index altitudes, and entry interface points. Entry interface is defined to occur at a radial distance of 3397.2 + 125 = 3522.2 km.

Mars-relative planetographic altitudes are calculated using the MarsGRAM reference triaxial ellipsoid. Calculations requiring the use of an oblate spheroid use an equatorial radius equal to the mean of the two triaxial equatorial radii.

Go to TOC

PLANETARY CONSTANTS

- Values are based on MGS and Pathfinder Planetary Constants. Constants not listed below must conform to the Mars Pathfinder Project PLANETARY CONSTANTS AND MODELS (JPL D-12947), September, 1996 revision.

Description	Value	Units	Application	Reference
Mars Reference Radius	3397.2	km	Planetocentric altitudes, Index altitudes, and Entry Interface.	MO Planetary Constants 7/86, MGS Mission Plan 6/95
MarsGRAM Triaxial Ellipsoid [6.1 mb surface] • Rx • Ry • Rz	 3394.67 3393.21 3376.78	 km km km	Planetographic altitudes, elevations.	Pathfinder Planetary Constants & Models 9/96
MarsGRAM-based Oblate Spheroid • Equatorial Radius • Polar Radius • flattening = (Equatorial Radius - Polar radius)/ (Equatorial Radius)	 3393.94 3376.78 [0.00505607]	 km km	Planetographic altitude calculations requiring the use of an oblate spheroid.	Equatorial radius = average of the two triaxial equatorial radii.
GM of Mars	42828.3142580671	km^3/s^2		Pathfinder Planetary Constants & Models 9/96
Gravity Field of Mars	Mars 50c	-		Pathfinder Planetary Constants& Models 9/96

- **Entry Interface Definition**: radial distance of 3397.2 + 125 = 3522.2 km.

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1.5 LIST OF ACRONYMS - DEFINITION OF TERMS

Acronym or Term	Definition
AMM	Autonomous Momentum Management
bps	bits per second
C3	Launch Energy = outgoing $V\infty$^2
CE	Cincinnati Electronics protocol
CPU	Central Processing Unit
D/L	Downlink
desat	Abbreviation for momentum wheel desaturation, using the RCS thrusters
DOD	Battery depth of discharge
DRAM	Dynamic RAM
DRM	Design Reference Mission
DSN	Deep Space Network
DTE	Direct to Earth telecomm link on the Lander
EMI	Electromagnetic Interference
HGA	High Gain Antenna
ICD	Interface Control Document
LIDAR	lidar [light detection and ranging] experiment
LMST	Local Mean Solar Time
Ls	Longitude of the sun with respect to the vernal equinox of Mars
LTST	Local True Solar Time
MARCI	Mars Color Imager
MARDI	Mars Descent Imager
MET	Meteorological Package [MVACS instrument]
MGA	Medium Gain Antenna
MGS	Mars Global Surveyor
MOI	Mars Orbit Insertion
MSP	Mars Surveyor Program

MVACS	Mars Volatiles and Climate Surveyor
OTM	Orbit Trim Maneuver, specifically during aerobraking.
PCS	Probability of Commanded Shutdown for the 2nd stage of the launch vehicle
PMIRR	Pressure Modulator Infra-Red Radiometer
PMU	Pressure Modulator Unit
RA	Robotic Arm [MVACS]
RAC	Robotic Arm Camera [MVACS instrument]
RCS	Reaction Control System
RWA	Reaction Wheel Assembly
SSI	Surface Stereo Imager [MVACS instrument]
TCM	Trajectory Correction Maneuver
TEGA	Thermal and Evolved Gas Analyzer [MVACS instrument]
TPS	Thermal protection system
U/L	Uplink
V_∞	"V-infinity" - planet relative hyperbolic excess velocity on outgoing or incoming asymptote

Go to TOC

2.0 ORBITER AND LANDER MISSIONS OVERVIEW

2.1 ORBITER MISSION

The MSP98 Orbiter launches on a Delta II 7425 in December 1998, arriving at Mars in September 1999. After a propulsive capture, aerobraking is used to circularize the orbit. The mapping orbit is a near sun-synchronous, near circular frozen orbit with a descending node at approximately 4 PM. It is planned to have the Orbiter in place to support MSP98 Lander data relay and commanding prior to Lander arrival in December, 1999. The nadir-pointed instruments perform imaging and systematic daily global sounding of the Mars atmosphere for a minimum of one Mars year [687 Earth days]. The science payload consists of a Pressure Modulator Infrared Radiometer (PMIRR) identical to that flown on Mars Observer, and the Mars Color Imager (MARCI). The MSP98 Orbiter serves as a communications relay asset for landed vehicles for up to 5 years from insertion into the mapping orbit.

2.2 LANDER MISSION

The MSP98 Lander launches on a separate Delta II 7425 in January 1999 and arrives in December 1999, a period in late southern spring when the seasonal CO_2 polar cap has disappeared at the prime landing site [75 - 78S]. The Lander is slowed during entry by a Mars Pathfinder-heritage aeroshell and parachute, and effects a controlled propulsive landing. The first landed day's activities include solar panel and instrument deployments, spacecraft and payload functional checkouts, establishment of communication with the Orbiter and Earth, and time critical science activities. Science investigations continue for the remainder of the 2-3 month landed surface mission. The Lander has a UHF telecomm system which supports data relay via the MSP98 Orbiter and/or MGS, and commanding via the MSP98 Orbiter. A direct Earth link is also available for backup commanding and telemetry relay.

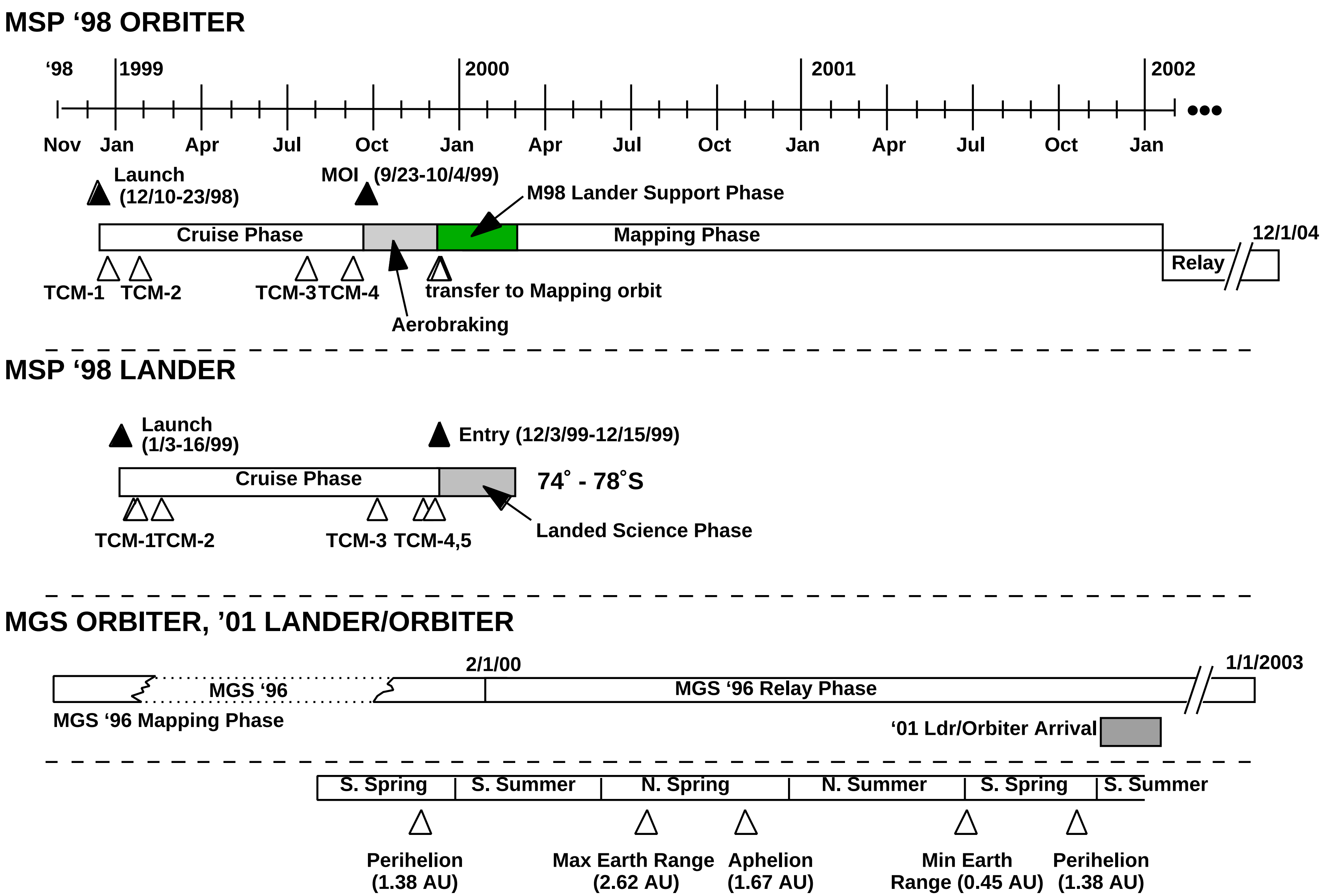
The Lander carries the Mars Volatiles and Climate Surveyor (MVACS) instrument suite, a LIDAR instrument supplied by the Russian Space Agency, and the Mars Descent Imager (MARDI). At the targeted landing site on the polar layered terrain, the lander's goals include a search for near-surface ice, analysis of possible surficial records of cyclic climate change, and characterization of physical processes key to understanding the seasonal cycles of water, carbon dioxide and dust on Mars.

2.3 MARS MISSIONS TIMELINES

The following timeline illustrates the primary activities of the MSP98 Orbiter, Lander, and the MGS spacecraft during their respective operational life cycles.

Go to TOC

MARS MISSIONS TIMELINES



3.0 LAUNCH VEHICLE

3.1 LAUNCH VEHICLE DESCRIPTION

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The Mars98 Orbiter and Lander are each separately launched on McDonnell Douglas Delta II 7425 launch vehicles, procured via the MedLight Launch Vehicle contract. Each launch vehicle is equipped with 4 thrust augmentation solids and use the 9.5 ft. fairing. The upper stage in each case consists of a spin stabilized Star 48 with a Nutation Control System and a yo-yo despin device. For both vehicles, a single, near instantaneous launch window is baselined for each day in the launch period, using a 95° flight azimuth and short coast ascent trajectories.

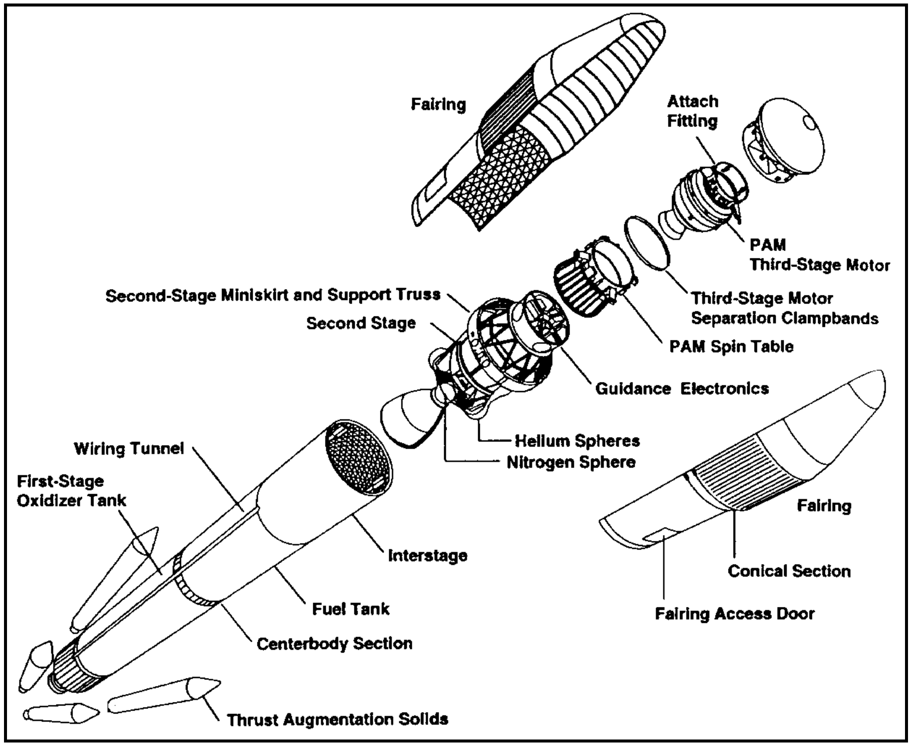
A minimum probability of second stage commanded shutdown [PCS] of 95% is required by the Project. The Delta II 7425 capability for the Orbiter is 643 kg wet mass at a C3 of 11.263 km^2/s^2 and 95% PCS. [The current estimated maximum C3 is 11.19 km^2/s^2 at the start of the launch period.] The Lander wet mass at launch must not exceed 615 kg, a figure dictated by the maximum mass allowed at atmospheric entry and landing, and the need to carry the New Millenium Microprobes. The performance of the Delta II 7425 accommodates this requirement with PCS greater than 99.7% across the entire launch period.

Launch vehicle operational constraints limit the time between Orbiter and Lander launch to be no less than 9 days, assuming the use of two launch pads. This has been accommodated by separating the end of the Orbiter launch period and the start of the Lander launch period by 9 days.

Go to TOC

LAUNCH VEHICLE DESCRIPTION

- **Orbiter and Lander each separately launched on McDonnell Douglas Delta II 7425.**
  - Procured via MedLite Launch VehIcle contract
  - 4 solid [GEM] version of Delta II
  - 9.5 ft fairing
  - Spin stabilized Star 48 upper stage
    - » Nutation Control System
    - » Yo-yo despin device



- **Daily Launch Opportunties across each launch period.**
  - 95˚ flight azimuth
  - Near instantaneous launch windows
  - Short coast ascent trajectories

- **Capability:**
  - **Project requires 2nd Stage probability of commanded shutdown [PCS] ≥ 95%**
    - » Orbiter: **643** kg wet mass capability.
    - » Lander maximum wet mass = **615** kg, dictated by maximum entry, landed masses, and need to carry New Millenium Microprobes.
      - Launch vehicle performance exceeds this requirement with PCS ≥ 99.7%

- **The Orbiter and Lander launches must occur at least 9 days apart.** Two pads are needed to support this requirement.

** This page under Change Control **