NASA’s Robotic Exploration of Mars

HEND Workshop 2006

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Mars Exploration: Approach

SEEK

HUMAN EXPEDITIONS

Exploration Perspectives

IN-SITU

SAMPLE
Mars Exploration Program
1996 - 2009

A Chain of Missions Coupled Scientifically, Technologically and Operationally

 CURRENTLY OPERATING

NASA Mars: Global Surveyor

NASA Mars: Odyssey

European Mars Express

NASA Mars Reconnaissance Orbiter

NASA Phoenix Scout

NASA Mars Science Laboratory

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Mars Reconnaissance Orbiter
**MRO Mission Overview**

**Launched**
August 12, 2005

**Interplanetary Cruise**
Aug 2005 - Mar 2006

**Approach and Orbit Insertion**
March 10, 2006

- Capture Orbit ---
  - Period: 35 hrs
  - Asc Node: 8:30 pm LMST

**Aerobraking**
Mar-Sep 2006

**Primary Science/Relay**
Nov 2006 - Dec 2010

- Science Data Acquisition/Return
  - Primary Science/Relay Orbit ---
    - Period: 112 min
    - Hp: 255 km, Ha: 320 km, Frozen
    - Ascending Node: 3:00 pm LMST (Sun-Sync)

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**Launch**

- Atlas V-401
- LC-41

**Orbit Insertion**

- Earth at Arrival: 3/10/2006
- Mars at Arrival: 3/10/2006

**Earth at Departure**
8/10/2005

**Mars at Departure**
8/10/2005

**Mar-Sep 2006**

**Aug 2005 - Mar 2006**

**Nov 2006 - Dec 2010**
MRO Science Goals

Understand the Processes of Climate Change, Past and Present

Characterize the Nature and History of Different Terrain Types

Find Sites Showing Evidence of Aqueous and/or Hydrothermal Activity

Characterize the Present Climate; Understand Seasonal & Year-to-Year Variability

Identify Subsurface Structure and Potential Reservoirs of Water Ice

Identify Landing Site for future missions
Relation to Other Mars Missions for Imaging

Surface Spatial Scale

Visible

Visible - Near Infrared

Thermal

Wavelength

MGS MOC-WA

MGS-TES

MEX-OMEGA

ODY-THEMIS

MEX HRSC

ODY THEMIS VIS

MEX MOC-NA

MEX HSRC

Wavelength Relation to Other Mars Missions for Imaging

Phenomena

Sea beds?

Channels

Polar Layering

Paleolakes?

Salt Flats?

Layering

Vents/ Springs?

Gullies

Debris Fans

Fine Layering

Rocks

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Relation to Other Mars Missions for Imaging

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New Discoveries

MRO

Phenomena

MGS-MOC-WA

MARCI

MEX-OMEGA

CRISM-Survey

ODY-THEMIS

MGS-TES

MGS-MOC-NA

MEX-HRSC

CRISM

CTX

HiRISE

ODY-THEMIS VIS

THEMIS

THEMIS

MOC-NA

MARCI
Phoenix Scout Mission
Phoenix Investigation
Overview

- Study the Martian hydrological cycle
  - Land where Odyssey has found water ice in the subsurface
  - How is water stored and released from the polar region?
  - Determine the diffusion of water vapor through the regolith
- Determine the recent history of the subsurface ice
  - Has liquid water altered the mineralogy of the soil?
  - What is the aqueous chemistry of the soil? In other words, if the ice melts, what is the chemical environment?
- Study the polar region processes
  - How does the climate change with season?
  - Study the boundary layer processes
  - What are the processes that shape the geology?
- Determine the habitability of the ice-soil boundary
  - Are organic molecules able to survive intact in this environment?
  - Do environmental factors support the presence of life?
  - Are there environmental hazards?
Rationale:
• No large craters in center area
• Benign slopes, with low rock abundance
• Lowest elevations
• Reasonable amount of soil over ice
**Salient Features**

Mobile Science Laboratory  
One Mars Year surface operational lifetime (669 sols/687 days)  
Discovery Responsive over wide range of latitudes and altitudes  
Controlled Propulsive Landing  
Precision Landing via Guided Entry

**Science**

Mission science will focus on Mars habitability  
Highly capable analytical laboratory science investigations  
Next Generation remote sensing/contact investigations  
Suite of Environmental Monitoring Instruments
**MSL Payload**

**Remote Sensing (Mast)**
- **ChemCam** (PI: Wiens, LANL/CNES) – Mineralogy
- **MastCam** (PI: Malin, MSSS) - Color Stereo Imager

**Contact Instruments (Arm)**
- **MAHLI** (PI: Edgett, MSSS) - Microscopic Imager
- **APXS** (PI: Gellert, UofGuelph) - Elemental Composition

**Analytical Laboratory (Front Chassis)**
- **SAM** (PI: Mahaffy, GSFC/CNES) - Sample Comp/ Organics
- **CheMin** (PI: Blake, ARC) - Definitive Mineralogy

**Environmental Characterization (Body-mount)**
- **MARDI** (PI: Malin, MSSS) - Descent Imager/Geomorphology
- **REMS** (PI: Vasquez, CAB) - Meteorological monitoring
- **RAD** (PI: Hassler, SWRI) - Surface Radiation Flux Monitor
- **DAN** (PI Mitrofanov, IKI) - Subsurface hydrogen detection

* - Foreign Instrument
** - Foreign Contribution
*** - ESMD Contribution
Mission Concepts Evaluated

Mars Science Orbiter and Telecom

Midrovers

Astrobiology Field Laboratory

Planetary Evolution and Meteorology Network

Mars Sample Return

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Mars Exploration Program
Next Decade Plan

2007
Discovered persistent surface water

2009
MSL (Phase B)
Search for habitable zones and biosignatures

2011
Planetary Evolution

2013
MSTO
Identify biologic or geologic source of methane, characterize evolution of atmosphere

2016
Look for past or present life
Explore geologic diversity

Or
AFL
Mid Rovers

Scout: Focused Science
Phoenix (Phase C/D)
Search for organics in modern habitat

Scout

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Mars Exploration Program
Next Decade Plan

2018?

Planetary Evolution

Scout: Focused Science

? ?

2020?

Network Landers

Understand structure, state and processes of interior; characterize meteorology

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**Mars Science Orbiter and Telecom**

**Objectives:**
- Determine interaction of solar wind with Mars
- Determine diurnal and seasonal variations of upper atmosphere and ionosphere.
- Determine influence of crustal magnetic field on ionospheric process
- Measure thermal and non-thermal escape rates of atmospheric constituents and estimate evolution of Martian atmosphere

**Issues**
- Science requires orbit to dip into atmosphere (>130 km)
- Planetary protection for low altitude orbiter
- Trades between science and telecom on orbits and phasing of mission objectives

**S/C heritage**
- Odyssey
- MRO

**Instrument heritage**
- Nozomi
- Earth and planetary inst’s

**Telecom heritage**
- Electra
**MSTO**

**Candidate Science Questions**

- **Atmospheric Escape**
  - Could the present atmospheric escape processes account for climatologically significant amounts of loss of atmosphere in the early history of Mars?
    - Was liquid water present during that time?
    - Do present-day values for the nitrogen and argon isotopes in the upper atmosphere suggest a loss of atmosphere consistent with the CO2 and H2O escape?

- **Trace Gas**
  - What is the present day inventory of molecular species in the lower atmosphere?
    - Are the relative abundances of these species consistent with models?
  - What are the dynamic processes (winds)?
  - Are CH4 and its close derivatives present in the boundary layer atmosphere?
    - If so, can MSTO provide unambiguous discrimination between geological and biological sources?
  - Is there a clear correlation between the spatial variability of trace species and identifiable surface or subsurface features?