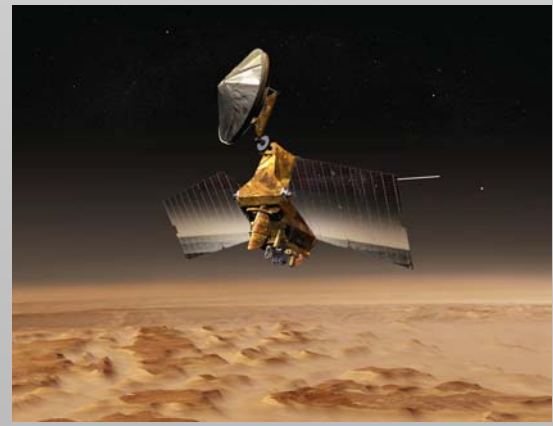
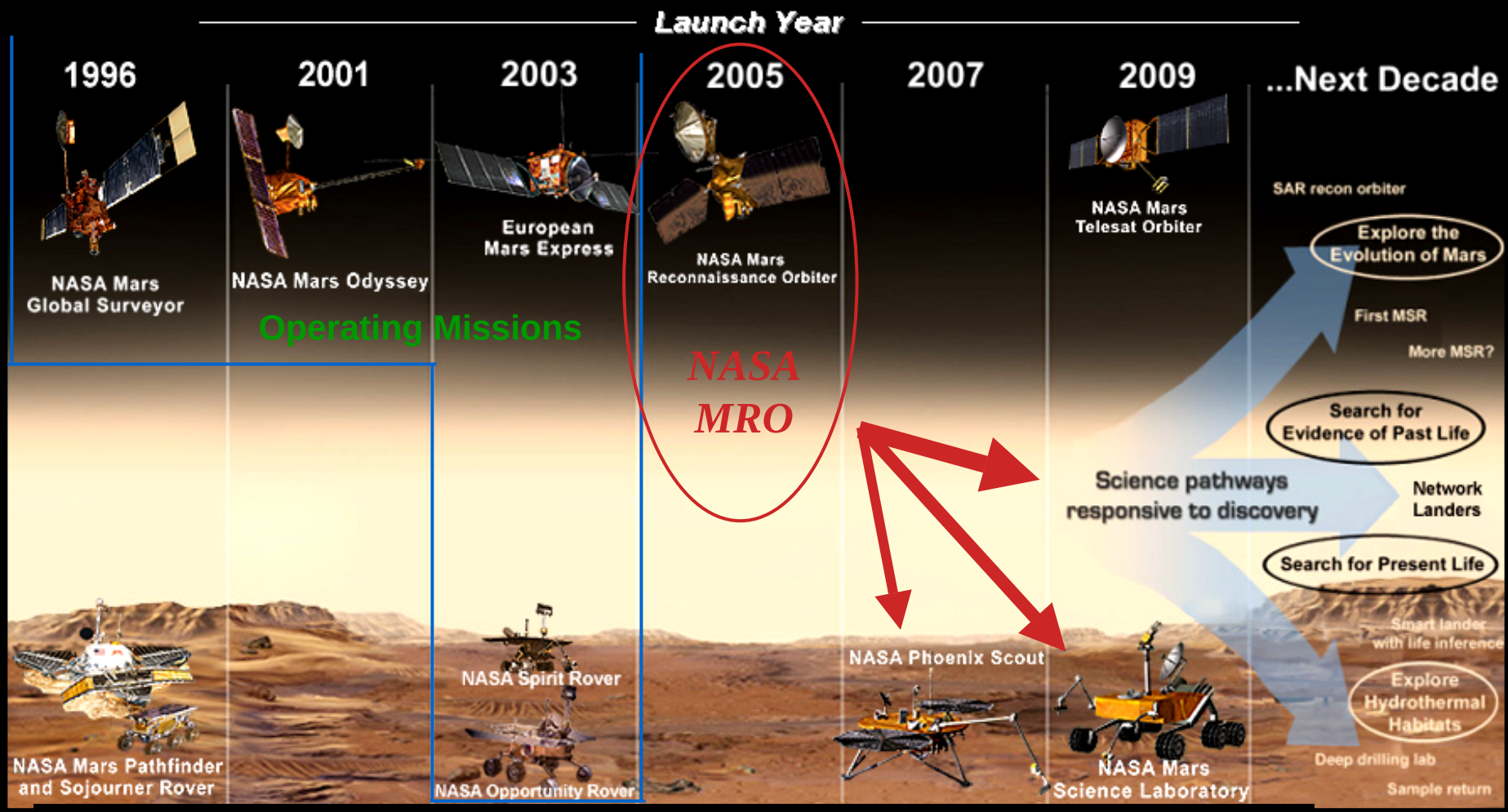
Mars Reconnaissance Orbiter (MRO)

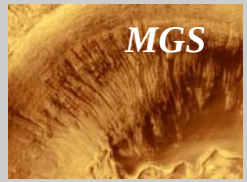


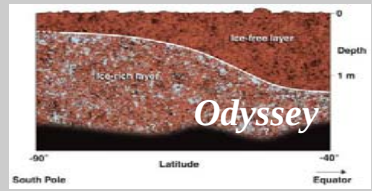
Robotic Mars Exploration



Mars Reconnaissance Orbiter (MRO)

Salient Features



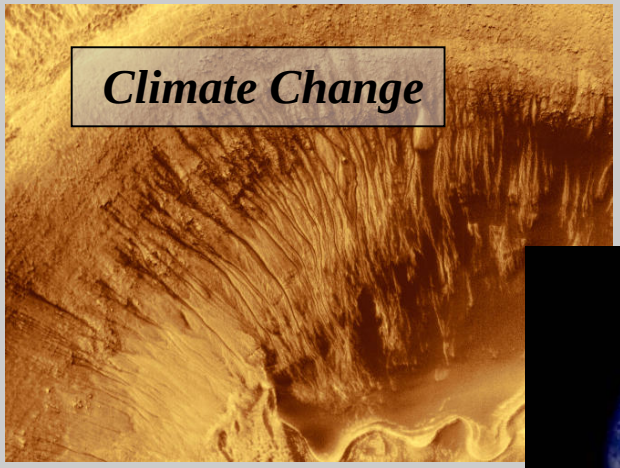


- **4 Earth years in Mars orbit (near polar, 3 p.m., 255 x 320 km)**
  - **2 years science observations plus relay support**
  - **2 years relay mode with capability to extend science operations**
- **International Science Payload:**
  - **Meter- scale (30 cm/pixel) and context (6 m/pixel) imaging**
  - **Hyperspectral (~20 m/pixel, 10 wn) compositional mapping m/pixel)**
  - **Atmospheric profiling and weather monitoring**
  - **Radar probing of the near-subsurface; gravity science**
- **Relay Telecom Payload + Optical Navigation & Ka-Band Experiments**
- **Launch: August 2005; Arrive: March '06; Aerobrake: Mar.- Oct '06; Mission End: Dec., 2010**

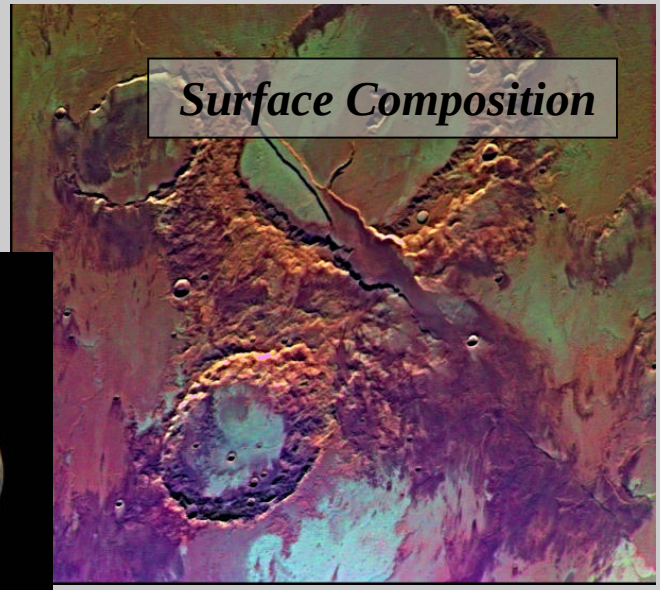
Science

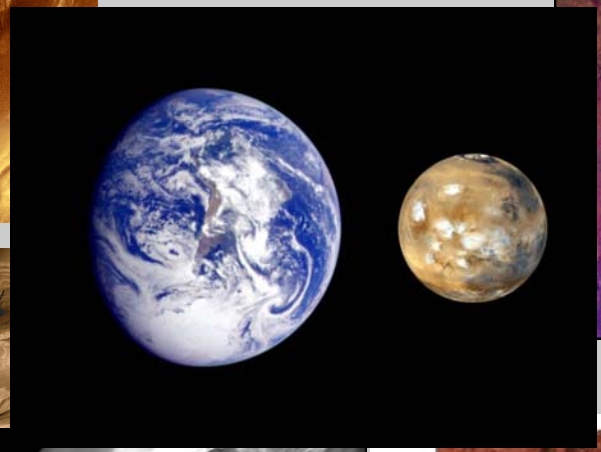
- **Characterize Mars' seasonal cycles and daily variations of water, dust & carbon dioxide.**
- **Characterize Mars' global atmospheric structure, transport and surface changes.**
- **Search sites for evidence of aqueous and/or hydrothermal activity.**
- **Characterize in detail the stratigraphy, geology & composition of Mars surface features.**
- **Characterize the Martian ice caps and the polar layered terrains.**
- **Profile the upper crust while probing for subsurface water and ground ice.**
- **Characterize the Martian gravity field and upper atmosphere in greater detail.**
- **Identify and characterize many sites for future landed missions.**

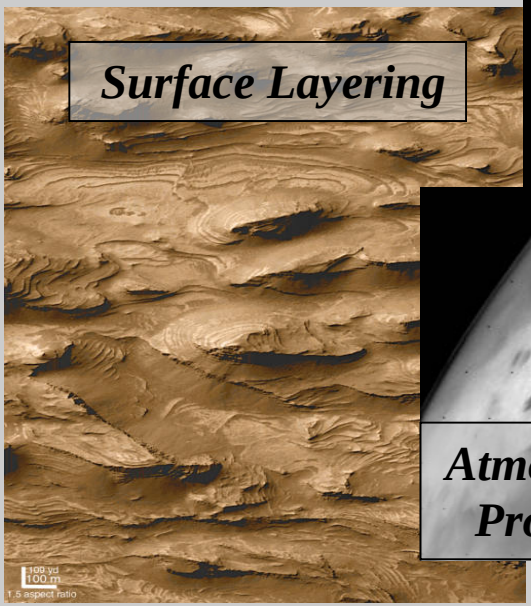
Mars: A Complex Planet

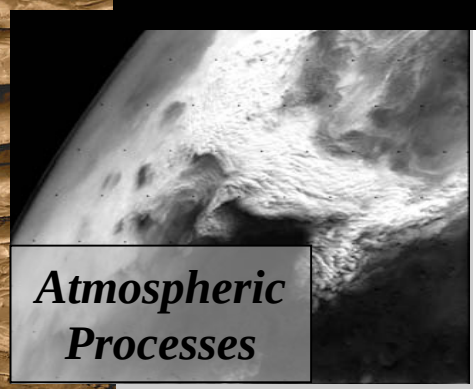


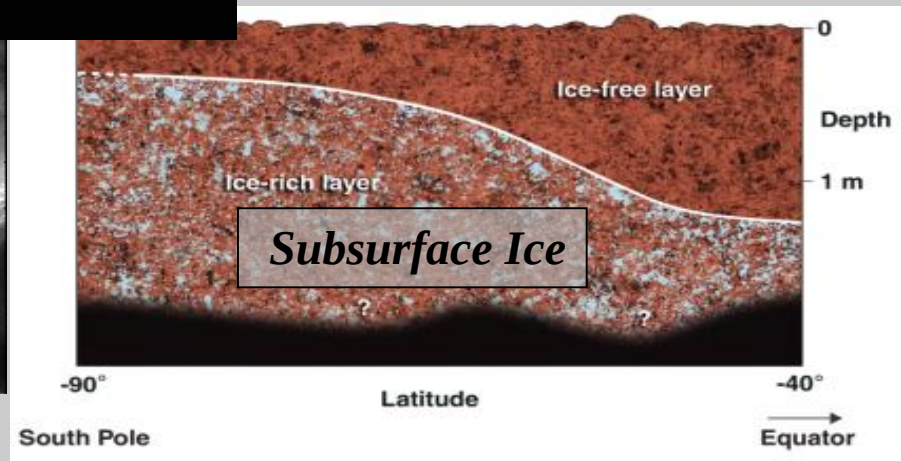
Comparative Planetology











Science Mission Implementation

Observe at Many Wavelengths

Observe at much Higher Spatial Resolution

Payload Selection

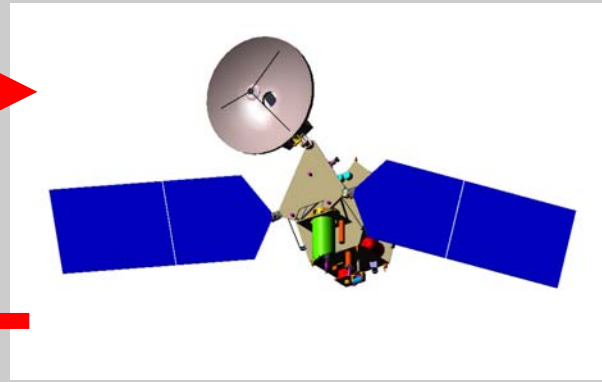
MARCI: UV - VIS imaging
MCS: Thermal IR Profiling, VIS
CTX, HiRISE: Visible imaging
CRISM: VIS - Near IR (544 channels)
SHARAD: Shallow Sounding Radar (15 m wavelength [free-space])

HiRISE: 0.3 m/pixel visible imaging
CTX: 6 m/pixel visible context imaging
CRISM: 20 m/pixel spectral imaging
MCS: 6 km vertical profiling of atmosphere
MARCI: Daily global weather monitoring
SHARAD: ~ 10-m vert. resoln. to 0.5 km depth

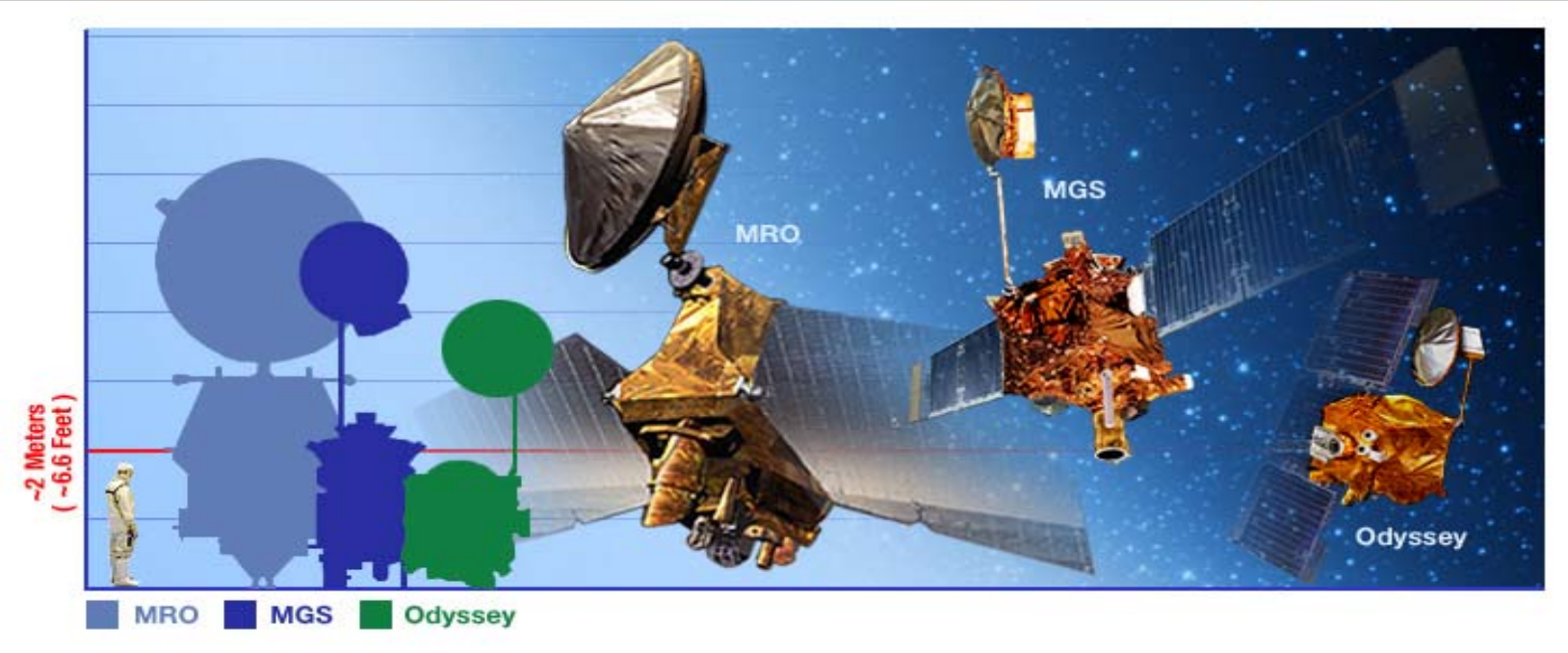
Mission Design

Orbiter Design

- *Must Return Large Data Volume (>26 Tbits)*
- *Investigate Multiple Scientific Disciplines*
  - Climate, Geology, Meteorology, Geoscience
  - Atmosphere, Surface, Polar Caps, Subsurface
- *Conduct Diverse Observation Modes:*
  - Global Monitoring for 1 Mars Year
  - Regional Survey
  - Site Targeting with Precision

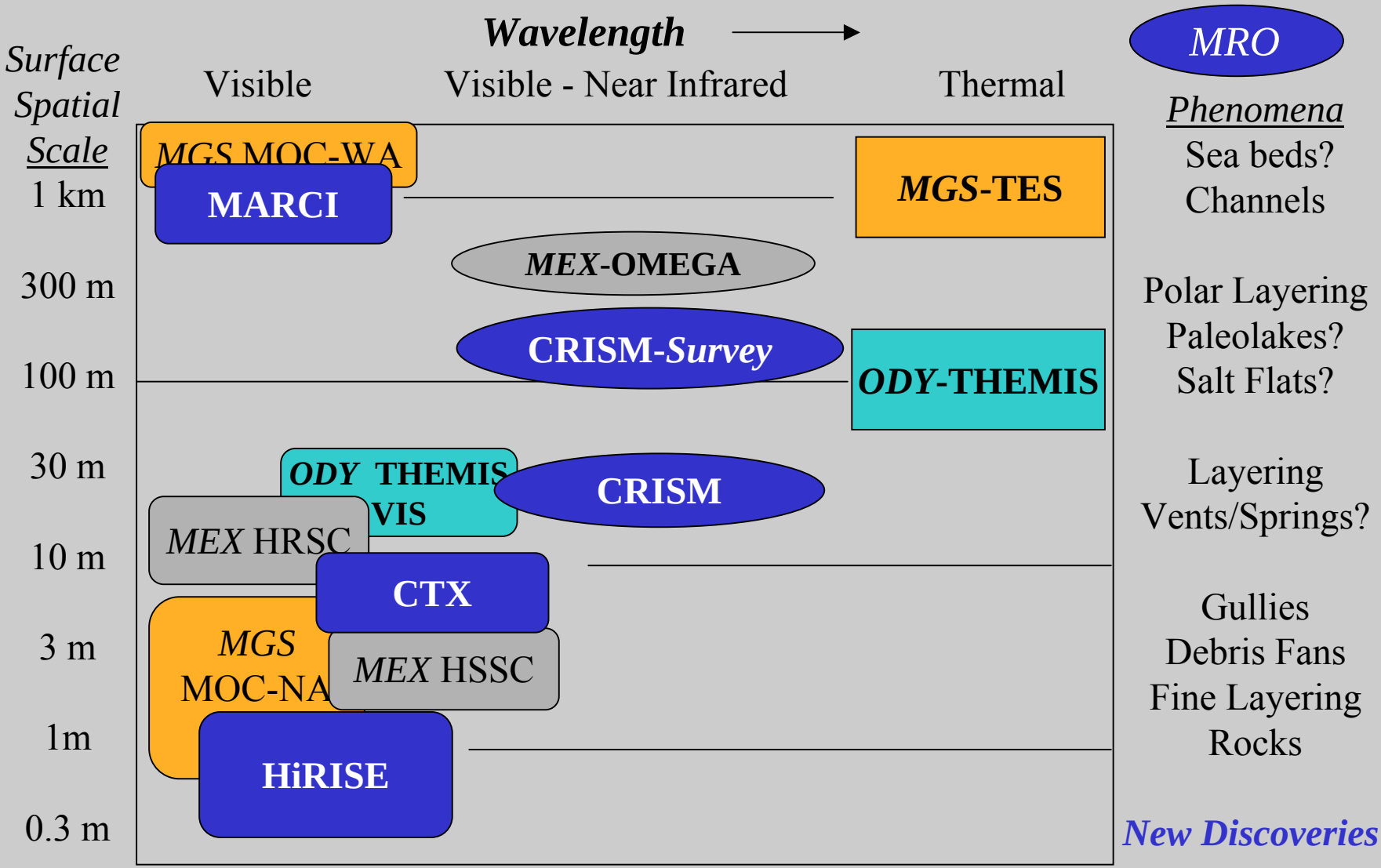


Mars Spacecraft Comparison

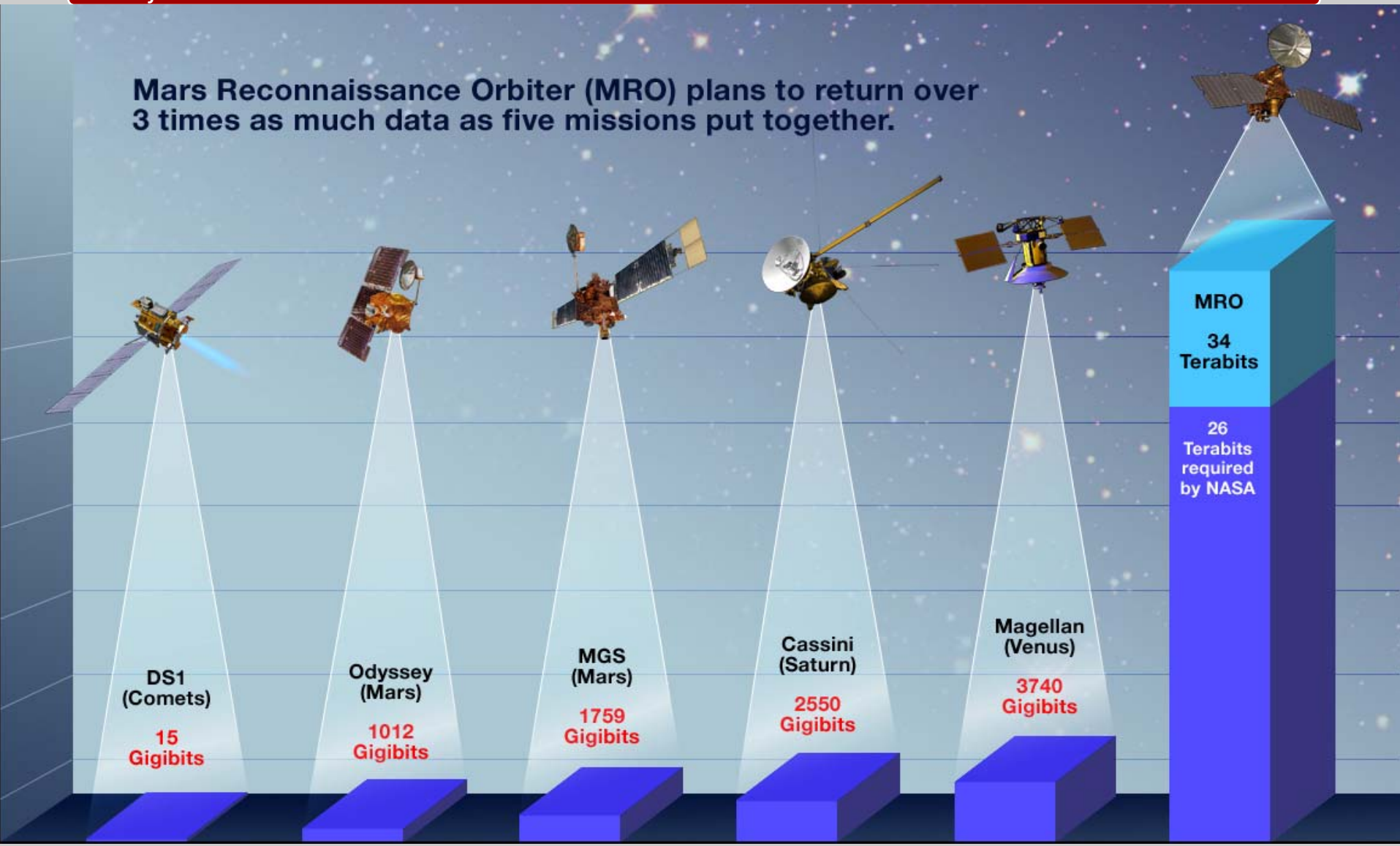


Item	MRO	MGS	Odyssey
Launch Year	2005	1996	2001
S/C Wet Mass (kg)	2180	1055	733
Science Orbit (km)	255X320	400	400
Ground Sampling (m)	0.3	1.5	18
Data volume (Gb/sol)	20-90 *	0.7	1

Relation to Other Mars Missions for Imaging



Data Return Comparison



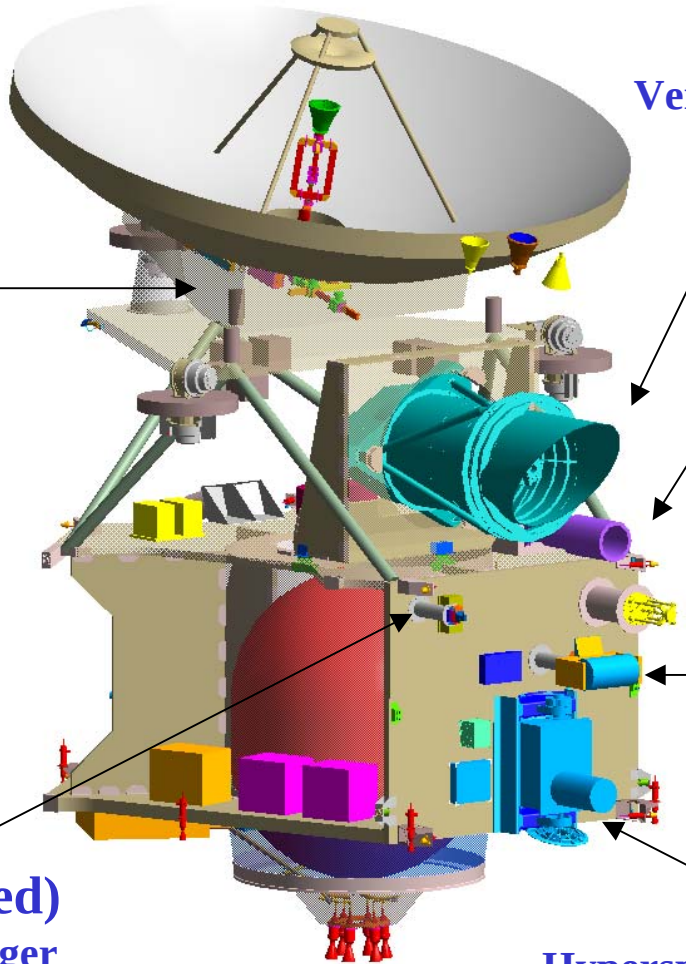
MRO Science Investigations (1 of 2)

Instrument	Type	PI/TL, Institution	Science Goals	Attributes
CRISM	Compact Reconnaissance Imaging Spectrometer for Mars	*Scott Murchie. PI* Johns Hopkins University Applied Physics Lab *Selected thru MRO -2005 AO*	Regional & Local Surface Composition; Atmospheric Properties	**High Spectral & Spatial Resolution** Targeted & Regional Survey **Very High Data Rate**
CTX	Context Imager	*Michael Malin, TL* Malin Space Science Systems (MSSS) *Facility Instrument* *Replaces MCO MARCI-MAC*	Regional Stratigraphy and Morphology	**High Resolution with Coverage** Targeted & Regional Survey **High Data Rate**
HiRISE	High-Resolution Imaging Science Experiment	*Alfred McEwen, PI* University of Arizona *Selected thru MRO-2005 AO*	Stratigraphy, Processes, Site Morphology	**Very High Resolution** Targeted Imaging **Very High Data Rate**
SHARAD	Shallow Subsurface RADAR	*Roberto Seu, TL/PI* University of Rome *Roger Phillips, DTL* *NASA-ASI Selection*	Regional Near-Surface Ground Structure	**Shallow Radar Sounding** Regional Profiling **High Data Rate**

MRO Science Investigations (2 of 2)

Instrument	Type	PI/TL Institution	Science Goals	Attributes
MARCI	Mars Color Imager	*Michael Malin, PI* **Malin Space Science Systems** ***Recover MCO MARCI-WAC***	Global Weather and Surface Change	**Daily Global Coverage** Daily,Global Mapping **Moderate Data Rate**
MCS	Mars Climate Sounder	*Daniel J. McCleese, PI* **Jet Propulsion Laboratory** **California Institute of Technology** ***Recover MCO PMIRR Science***	Atmospheric Fields, Transport & Polar Processes	**Global Atmospheric Limb Sounding** Daily,Global Limb & On-Planet Mapping; **Low-Data Rate**
Gravity Science	Facility Science Team Investigation	*Maria Zuber, TL* **MIT / GSFC** ***Selected thru MRO-2005 AO***	Improved Gravity Field Model; transient Mass Change	**Data from DSN tracking using Spacecraft X & Ka Band Telecom**
Atmospheric Structure (ACCEL)	Facility Science Team Investigation	*Gerald Keating, TL* **GWU / LaRC** ***Selected thru MRO-2005 AO***	Upper Atmospheric Structure & Variability; A/B Support	**Data from Spacecraft Accelerometers during Aerobraking**
Future	*Participating Scientists & Guest Observers may be selected and funded as part of a future Announcement of Opportunity or Research Announcement*			

Payloads (1 of 2)



X-Band & Ka-Band Telecom

Gravity Science
TL: M. Zuber
MIT/GSFC

HiRISE 63 kg
Very High Resolution Camera
PI: A. McEwen
U. Arizona
Ball Aersospace

CTX 3 kg
Context Imager
TL: M. Malin
MSSS

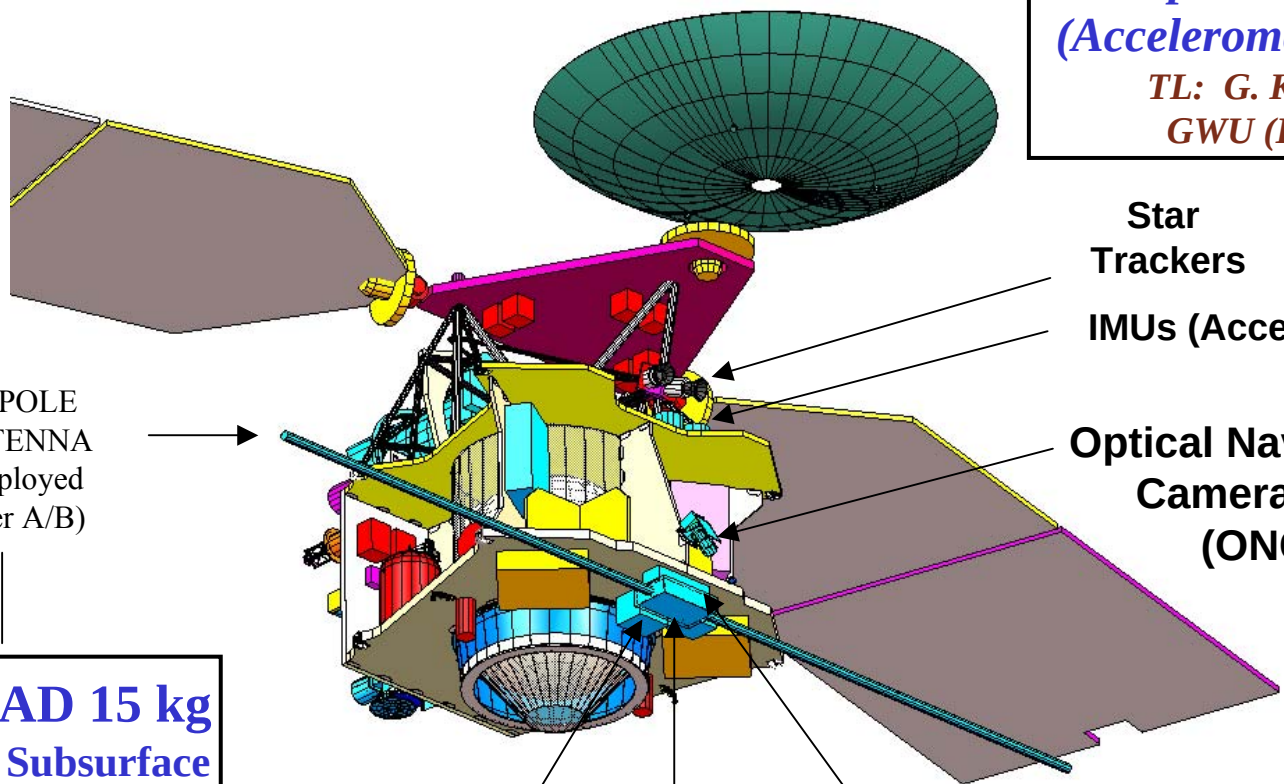
Electra 15 kg
UHF Relay Antenna (moved)

MCS 10 kg
Atmospheric profiler
PI: D. McCleese
JPL
(PMIRR)

MARCI 2 kg (moved)
Daily Global Color Imager
PI: M. Malin
MSSS

CRISM 27 kg
Hyperspectral Imaging Spectrometer
PI: S. Murchie
JHU/APL

Payloads (2 of 2)



Atmospheric Structure (Accelerometer Data)
TL: G. Keating
GWU (LaRC)

Star Trackers

IMUs (Accelerometers)

BI-POLE ANTENNA (Deployed After A/B)

Optical Navigation Camera 3 kg (ONC)

SHARAD 15 kg
Shallow Subsurface Radar Profiler
TL/PI: R. Seu
U. Roma
ASI/Alenia
R. Phillips DTL
Wash. U. (USA)

SHARAD RF & Digital System (RDS)

SHARAD Transmitter & Front End (TFE)

SHARAD ANTENNA BOX

Current Status

- **Finished Vibration Tests**
- **Preparing for System Thermal/ Vacuum Testing in February**
- **EM Compatibility Test in March**
- **Now onboard:**
  - **MARCI, MCS, CTX, HiRISE**
  - **SHARAD Electronics & Antenna**
  - **Opt-Nav Camera not visible in this view**
  - **Electra with UHF Antenna**
  - **CRISM re-delivered & integrated after this picture was taken**

Near-Term Schedule (2005)

Orbiter (s/c + instruments) have finished vibration & shock tests

Key Dates of Coming Attractions

• System Thermal/Vacuum Test (STV)	Feb 10 - 24
• EMI Compatibility Tests	March 4
• Pre-Ship Review:	March 30
• Ship to Cape:	April 26
• Launch Window:	August 10 - 31
• MARCI Calibration	L+3 (August)
• TCM-1	L+14 (Aug-Sept)
• HiRISE & CTX Lunar Calibration	Sept. 28

February 2, 2005: ***~ 6 months (190 days) to Launch Window***

~ 13 months to MOI & start of aerobraking

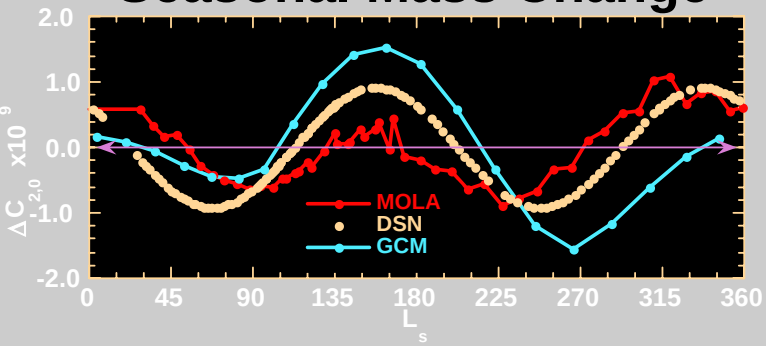
Payload Status

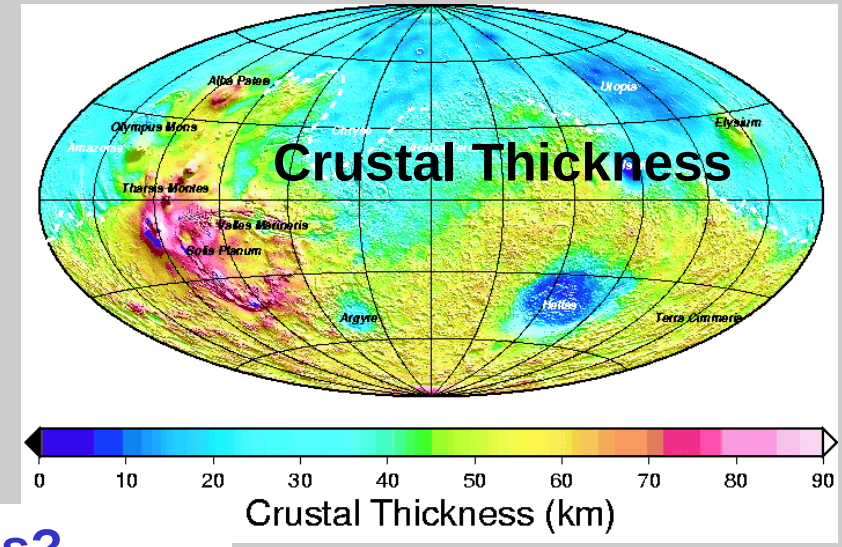
All instruments are on the spacecraft!

- **All instruments meeting their individual science requirements in terms of spatial resolution, signal-to-noise, spectral resolution, wavelength range, etc.**
  - Known "features" are judged acceptable, although they will require additional effort (e.g., in calibration) to produce data products ≥ Level 1
- **Issues being worked:**
  - HiRISE will reload its Focal Plane Electronics Software to improve timing margins and stability of imaging performance (this week)
  - Looking to characterize and reduce Electromagnetic Interference (EMI) between payload elements (MCS, CTX, CRISM) and Electra (UHF relay)
    - Conduct EM compatability test after STV (late Feb.)
  - Looking to characterize and reduce jitter between MCS and other payload elements and to verify compliance by spacecraft subsystems (e.g., gimbals)
    - Jitter test has been run & data are being analyzed
    - Potential MCS jitter mitigations being evaluated
  - Will remove SHARAD Antenna to fix small cracks on root hinge

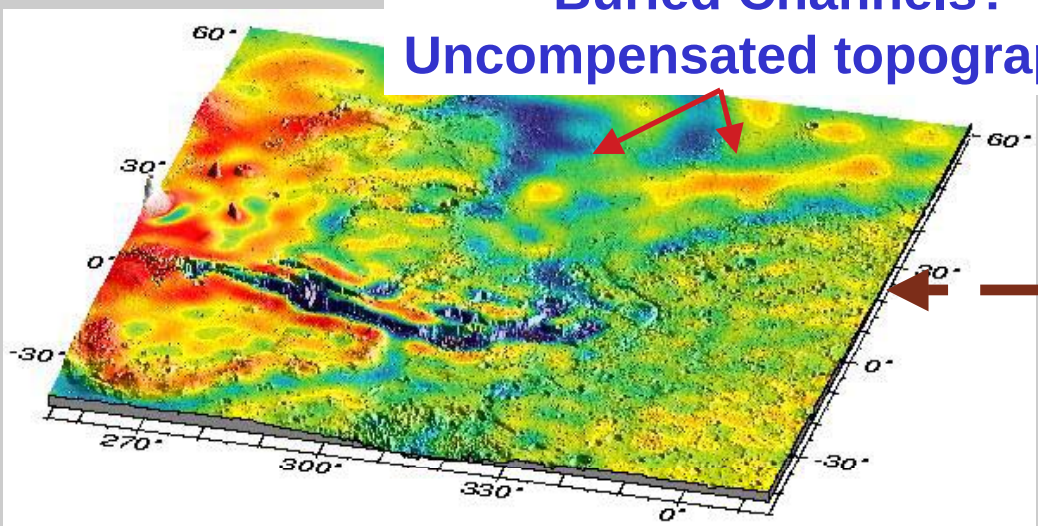
Gravity Science

Seasonal Mass Change

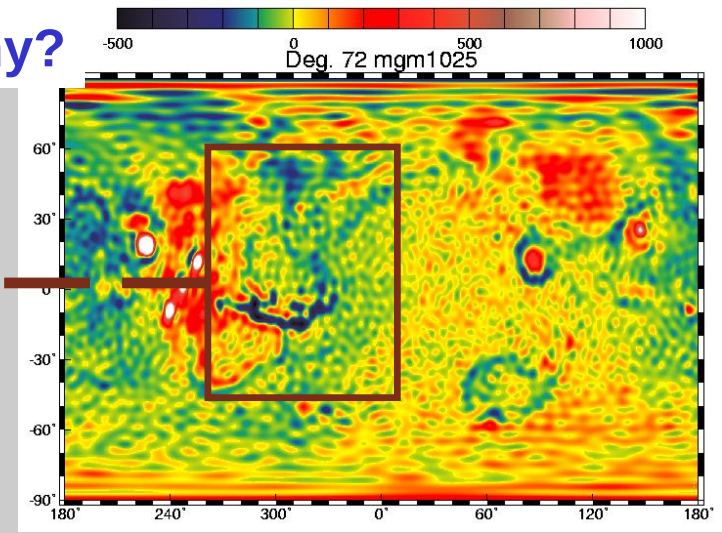




Buried Channels?
Uncompensated topography?



Regional Gravity



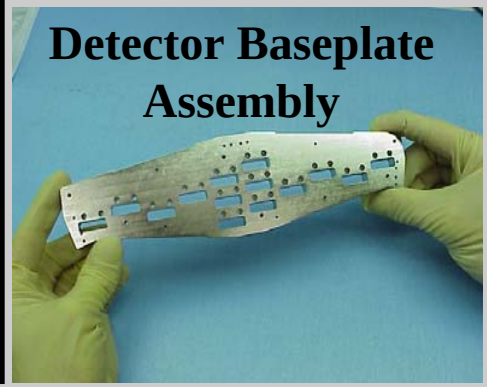
Global Gravity Field

HiRISE Flight Telescope

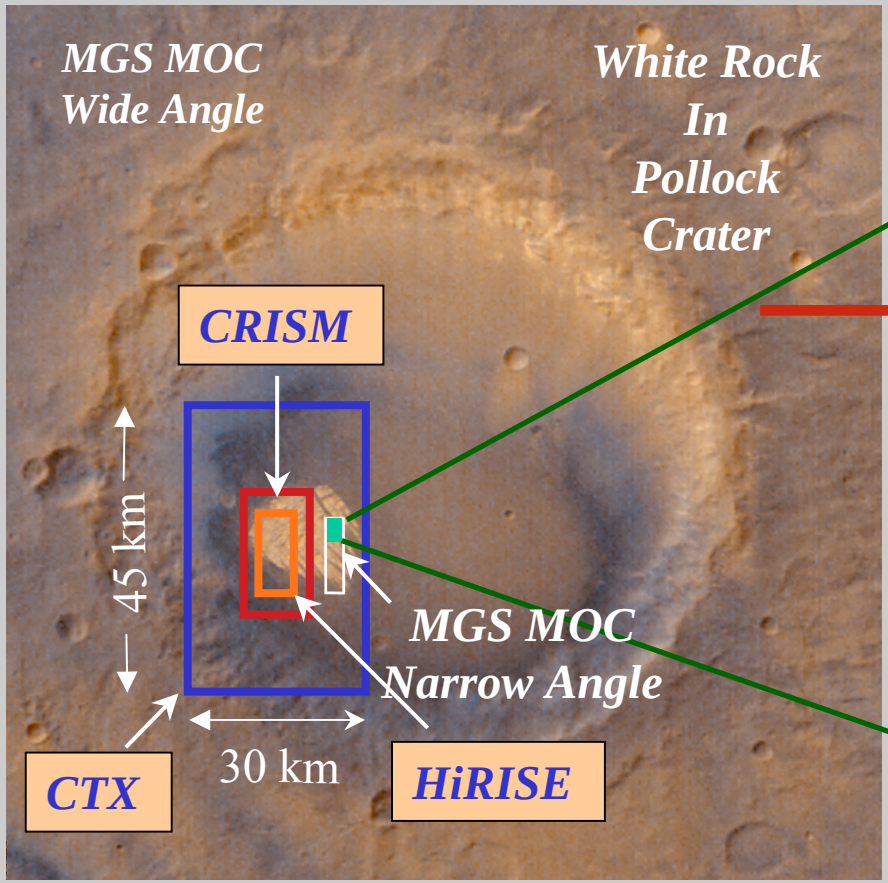
Overall Length ~ 1.5 m

Overall Diameter ~ 0.75 m

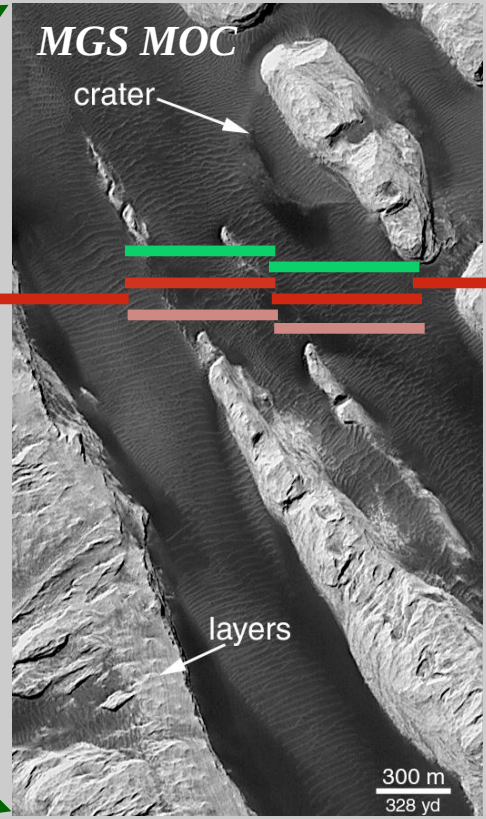
Primary Mirror 0.5 m



MRO Coordinated Observations



1.8 km



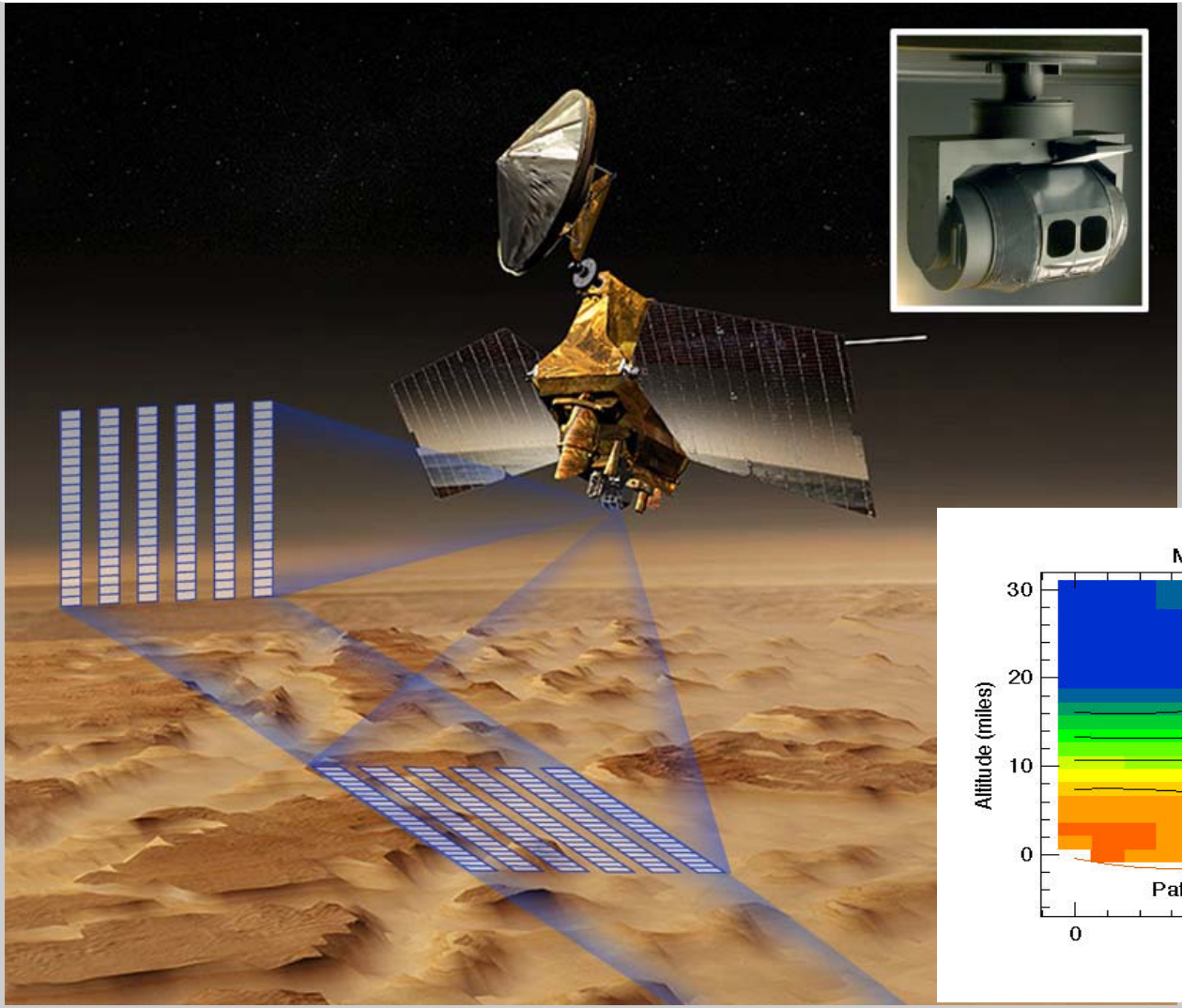
HiRISE:
14 CCDs
(10 red,
2 green, 2 NIR)

Nested Coverage Provides Context

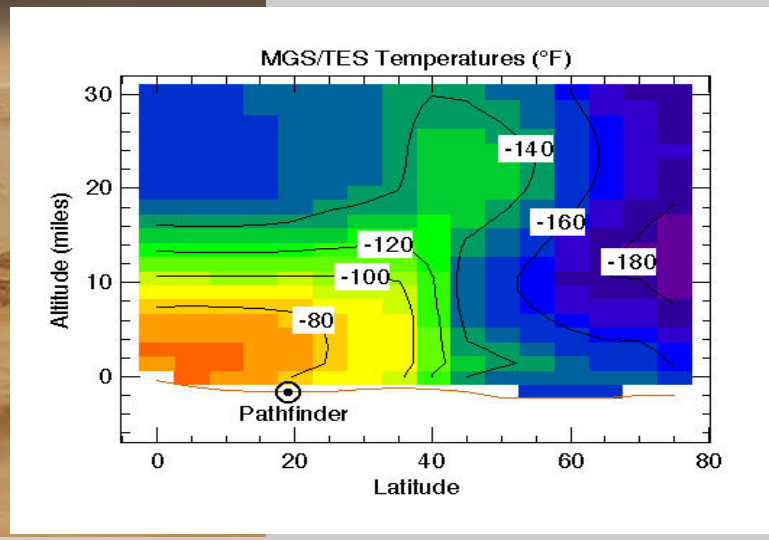
High Resolution Provides Detail

IMAGES from NASA/JPL/MSSS

Limb Staring Geometry for MCS

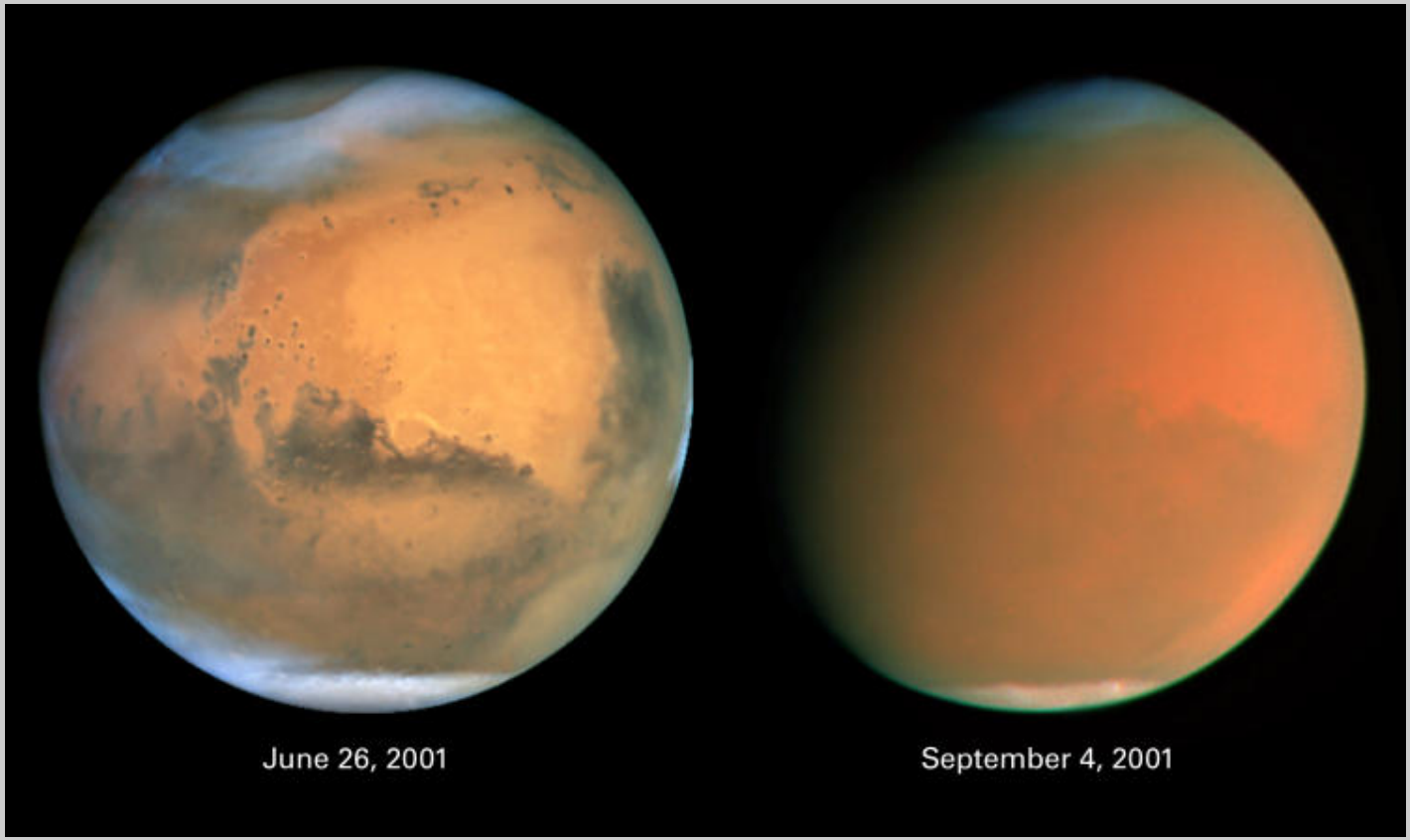


The Mars Climate Sounder (MCS) is an advanced version of the PMIRR limb sounder lost on Mars Climate Orbiter



Which Mars Will MRO Encounter?

MARCI will extend global coverage in time

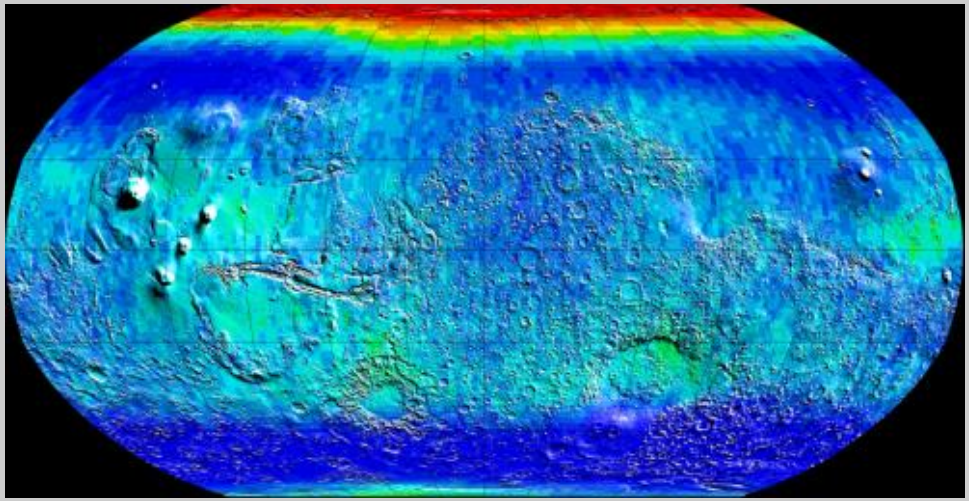


CREDIT: NASA / STScI / AURA / J. Bell & M. Wolff

Phoenix and MRO

- Need site observations as early in the MRO Primary Science Phase (PSP) as possible to capture seasonal environment and to provide maximum time for PHX to analyze MRO data
  - Will consider earlier atmospheric observations to test EDL simulations once aerobraking is completed
  - *Burden of analyzing MRO data falls on PHX*
- Support PHX critical EDL and initial surface ops events
  - Atmospheric monitoring during PHX approach
  - Relay during critical events
    - Change phasing in orbital plane, but not inclination (& LMST)
- Continue MRO observations during the PSP
  - Minimize EMI interferences so MRO can meet its twin Level 1 requirements of science mission success and relay
- Coordinate MRO & PHX science campaigns

SHARAD: Probing the Subsurface



Hydrogen (Ice) Map
2001 Mars Odyssey
GRS-Neutron
Spectrometer
& HEND

NASA / JPL / University of Arizona
& Los Alamos National Laboratory

How Deep is this Layer?
Is it in Equilibrium with
Today's Climate?
Is it the Top of the Ancient
Water Reservoir?