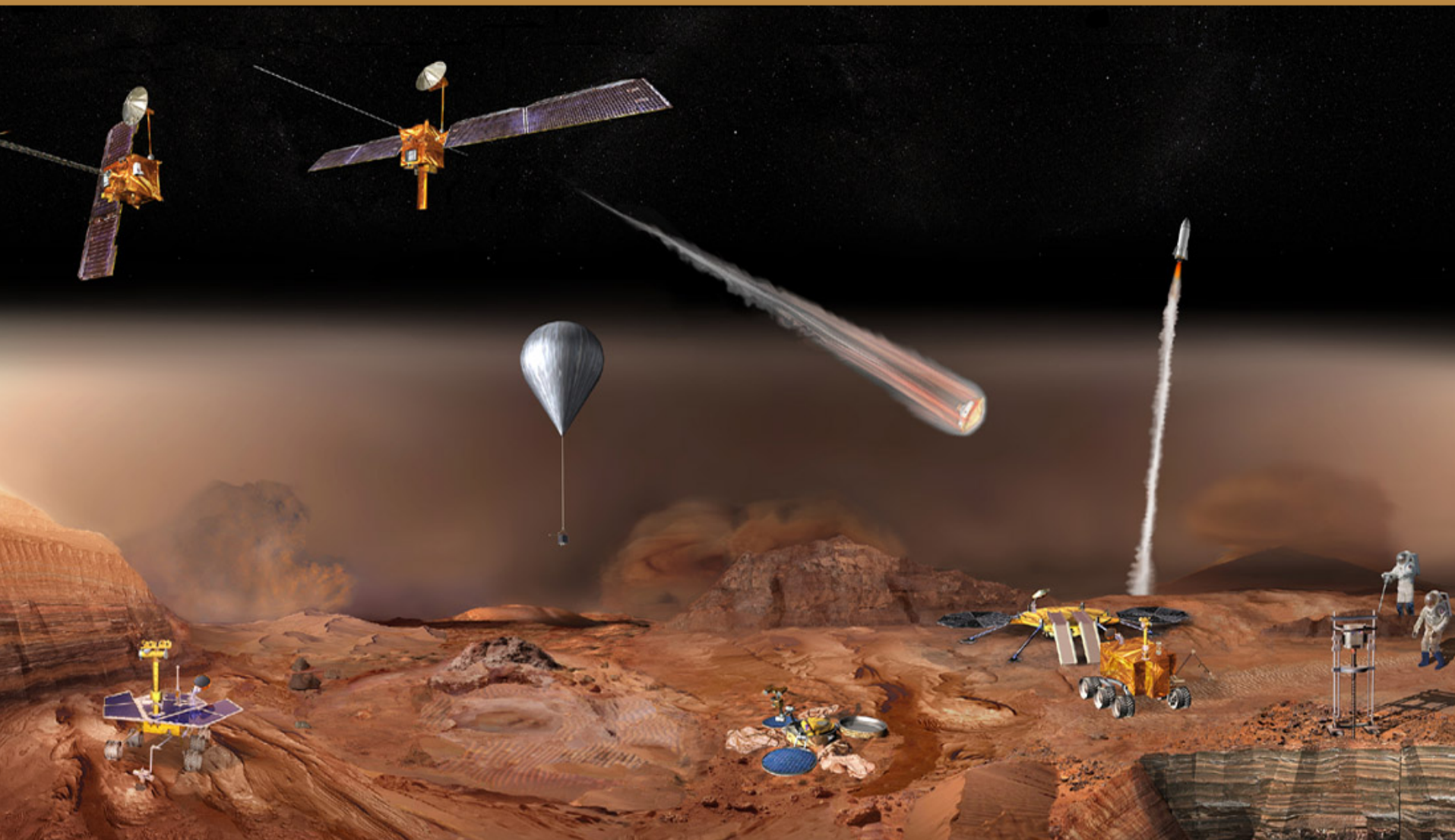
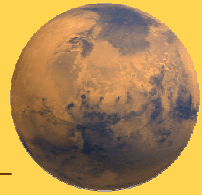
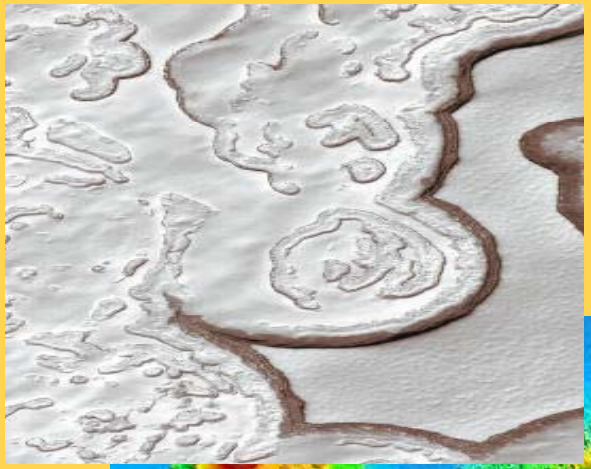
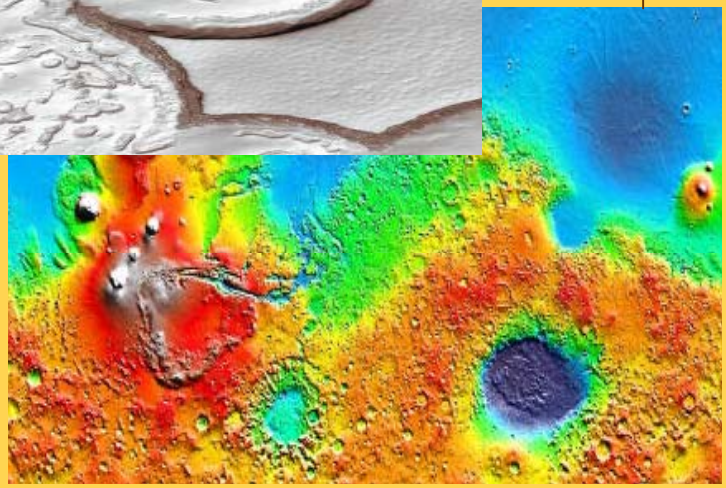
Mars Exploration Program This Decade



Mars Global Surveyor





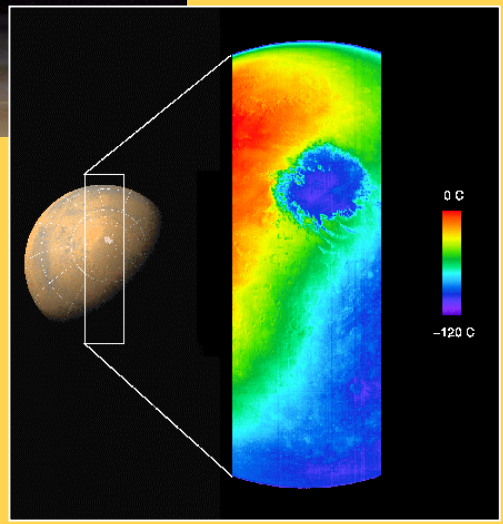


- Extended mission thru 2004
  - Inter-annual seasonal comparison
  - Helping other missions……
    - MER landing sites reconnaissance
    - Odyssey aerobraking atmospheric monitoring
    - MER EDL Relay support
    - MER Rover science relay

<u>Rewriting the textbooks</u>

- More data returned than all previous Mars missions combined
  - 1000 days of mapping completed
  - 100,000th image taken
  - Complete topographical map of Mars with resolution as good as 1m.
- Breakthrough of the year – *Science magazine*
  - Mars atmospheric pressure increase (Malin & Edgett)
- Ninth most productive NASA mission of the past 28 years – *Science News*

Mars Odyssey



Primary science mission ~ 900 days

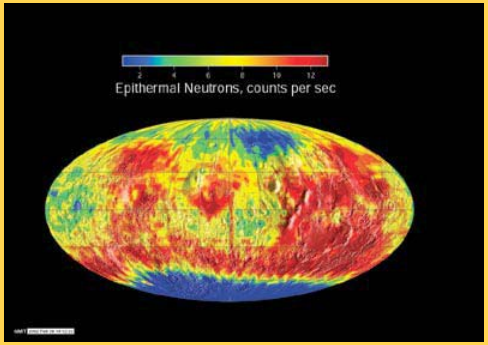
THEMIS: (Phil Christensen, ASU PI) mineral map, thermal map, visible map

GRS: (Bill Boynton, U of A PI) neutron map, gamma ray spectrometry map.

MARIE: (Gutman Badgwar, JSC PI) radiation environment

Relay mission for MER, BEAGLE

Discovered evidence for significant water deposits (frozen) below the Martian surface



Getting it There……

MOI – after traveling 470 million km, it hit the bull's eye – 750 m arrival accuracy!!

Aerobraking – Flawless. Shorter than planned with less usage of propellant

MER Twins

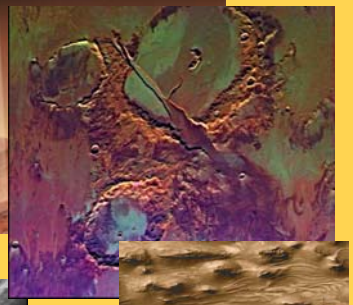
- Mars Exploration Rovers
  - Robot geologists
- Steve Squyers, Cornell U. PI
- Determine aqueous, climatic and geological history of a promising site on Mars – 4 sites still in the running
- Instruments
  - Remote sensing payload elements
    - Panoramic imager
    - Panoramic mid-IR spectrometer
  - In-situ payload elements
    - Mossbauer spectrometer
    - Alpha-proton-X-ray spectrometer
    - Microscopic Imager
    - Rock abrasion tool

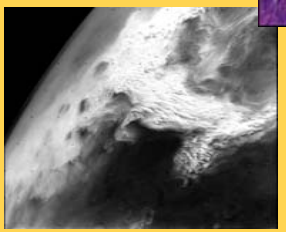
- 10 months to launch
- It is a tight fit
  - Mass, Volume, Schedule, Cost
- Scarcity of data on near surface wind is a challenge
  - Horizontal wind velocity vs airbag capability

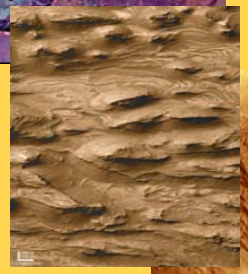
Mars Reconnaissance Orbiter

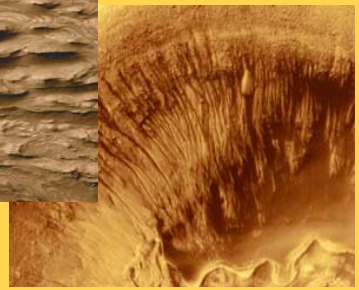
Science Objectives

- Map Water & Dust in the Present Climate
- Identify Sites with Aqueous Minerals/Sediments
- Resolve Detailed Surface Stratigraphy
- Explore the Solid Planet (radar & gravity)
- Identify Sites for Future Landed Missions



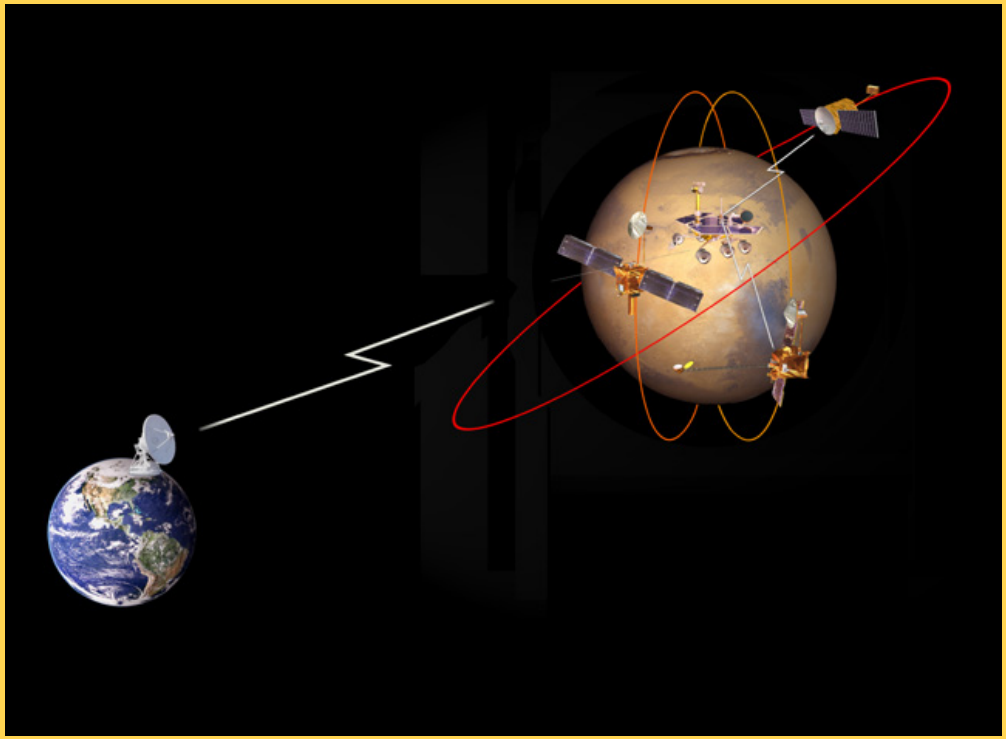






- Launch August 2005
- Science Mission: 1 Mars year
- Capable of an additional year
- Telecom Relay: 2 Mars year

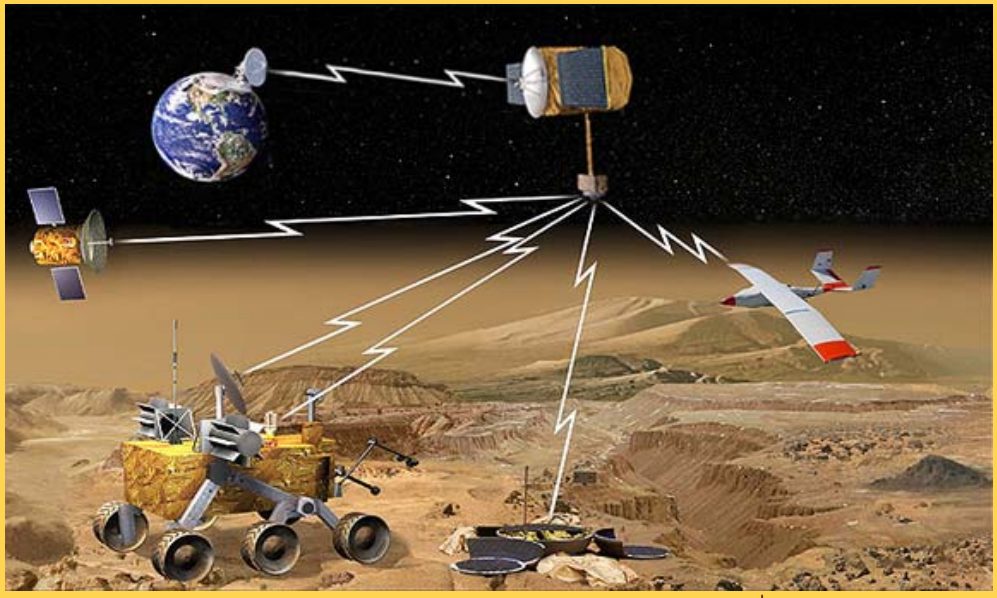
- Competed Spacecraft: LMA
- Competed Launch Vehicle
- Competed Payload
  - MRO AO: HiRISE, CRISM
    - A. McEwen, S. Murchie
  - MCO: MARCI, MCS
    - M. Malin, D. McCleese
- Facility Payload
  - CTX, SHARAD
    - M. Malin, R. Seu



Building Up to a Mars Telecom Network

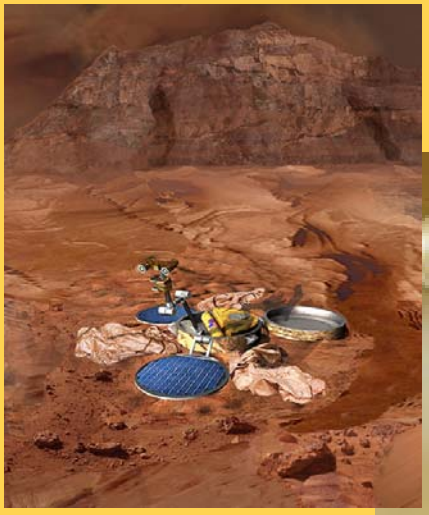
- A dedicated communications orbiter in a high inclined orbit …….plus
- Standard Electra payload for proximity links on every science orbiter
  - Software re-configurable radio

G. Marconi Mars Telecom Orbiter



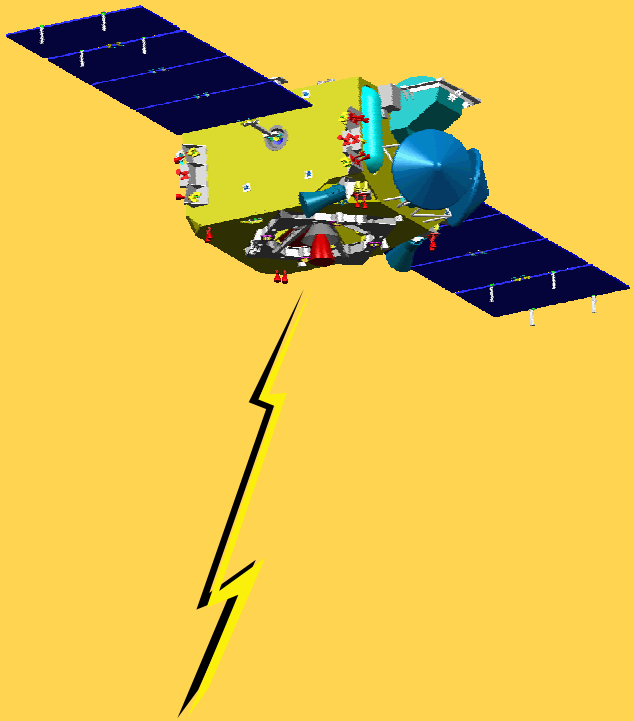
- Launch: August 2007
- Cooperation with ASI
- High 4500 km orbit
- 10-year in-orbit lifetime
- Communication relay for landers / orbiters
  - Critical event coverage
- Navigation for spacecraft approaching Mars

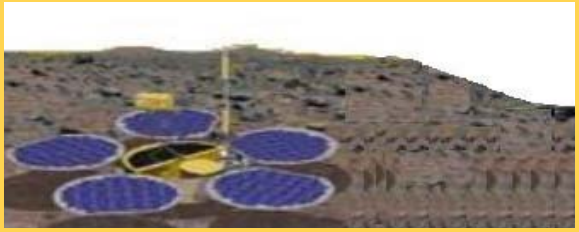
Mars Scout Concepts



- PI-led – “Discovery Program like”
- Announcement of Opportunity (AO) release occurred early April
- Up to four concepts selected for Step 1
  - Approx. six months/approx. $500K/ea
- Down select to final mission ~ summer 2003
- Mission cost cap $325M (2003 dollars)
- Launch Sept 2007

CNES Mars ’07 Orbiter Mission





- **Science**
- Network science – four netlanders
  - US contributes parts of three instruments
- Orbital Science – US may participate through provision of an instrument selected as part of the Scout AO

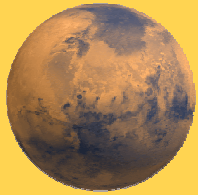
Technology

- Orbital sample finder/rendezvous “Lite” demo
- Aerocapture Demo – dropped

Other US Support

- Electra communications package
- Mission design, navigation, system engineering support
- RHUs for the Netlander

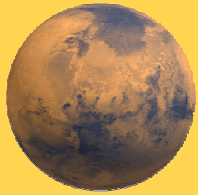
A Smart Mobile Science Laboratory in ‘09



- NASA’s Mars Exploration Program is a scientifically-derived, technologically-enabled program
  - Scientific discoveries/outcomes from each mission help frame future missions
  - Investments in various enabling technologies and phased introduction of them into missions allows the Program to follow up on the scientific discoveries

- A Mars lander is being developed for launch in 2009 to follow up on scientific discoveries from orbit (MGS, Odyssey, MRO) and on the surface (MER)
  - Mars Program needs to develop capabilities that will allow it to go to the sites dictated by discoveries
- Mars topographic maps generated from orbit on MGS point to a diversity of terrains on Mars
  - For future landers some areas are easy to get to – some are not
  - Some geological phenomenon cover a large region, some are confined to a small area

A Smart Mobile Science Laboratory in ‘09



- To allow increased access to a variety of terrains, NASA is developing the following technologies for incorporation into the Mars ’09 lander:
  - Precision landing
    - Optical navigation for precision approach
    - Guided entry to reduce landing site uncertainty from the current ~100km to ~ 5km
  - Hazard detection and avoidance during terminal descent
  - Robust landing – tolerant to 1m rocks and 30 degree slops
  - Increase mobility range on the surface from the current <1km to > 5km
    - Necessitates rover autonomy

- To most effectively use these smart landers of the future, NASA is also developing:
  - Provision for longer surface life from currently ~ 90 days to >2-3 years
    - Invest in nuclear power sources (a la Viking – but more advanced)
  - Sophisticated multi-disciplinary small laboratories
    - Biological/geological instruments
    - In-situ investigation prior to committing to a more elaborate sample return mission