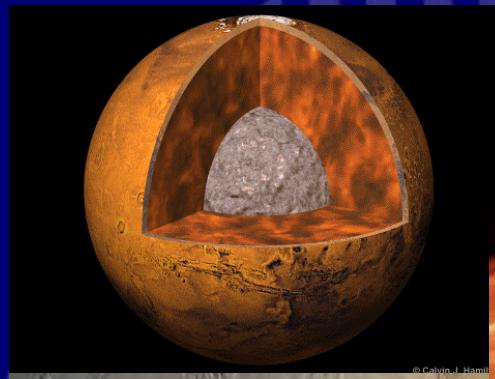
THE MARS EXPRESS MISSION AND ITS SCIENTIFIC OBJECTIVES

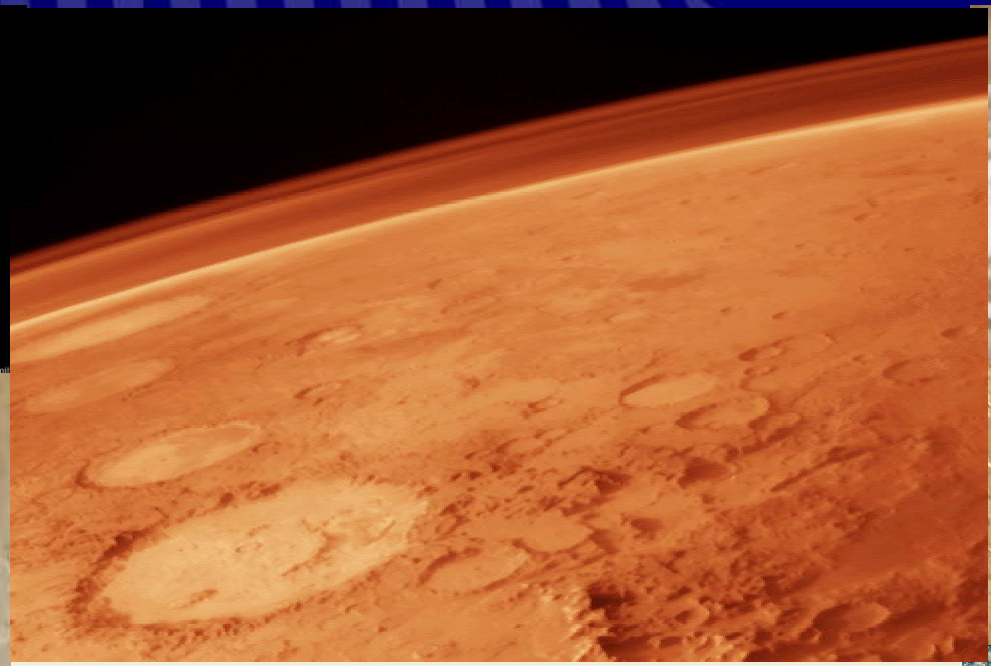
Agustín F. Chicarro
European Space Agency
Mars Express Project Scientist

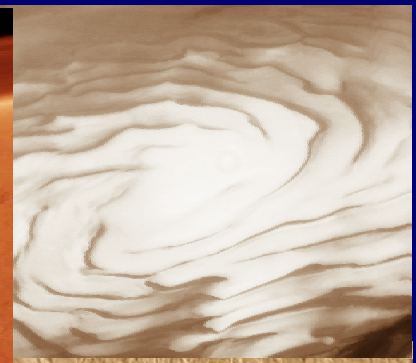
MEX Science Conf.
ESTEC, 21/25-02-05

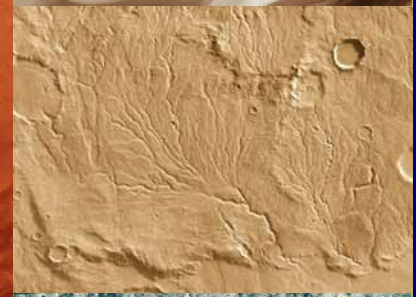
Introduction

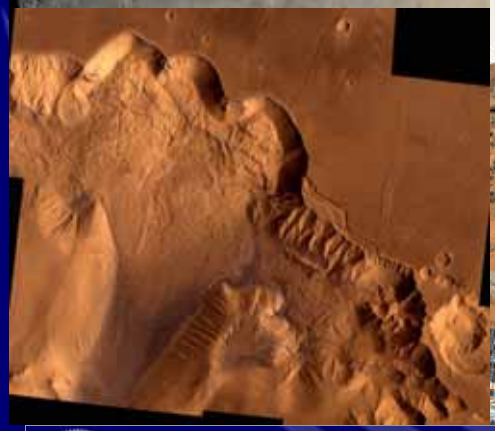
MARS – A Fascinating Planet

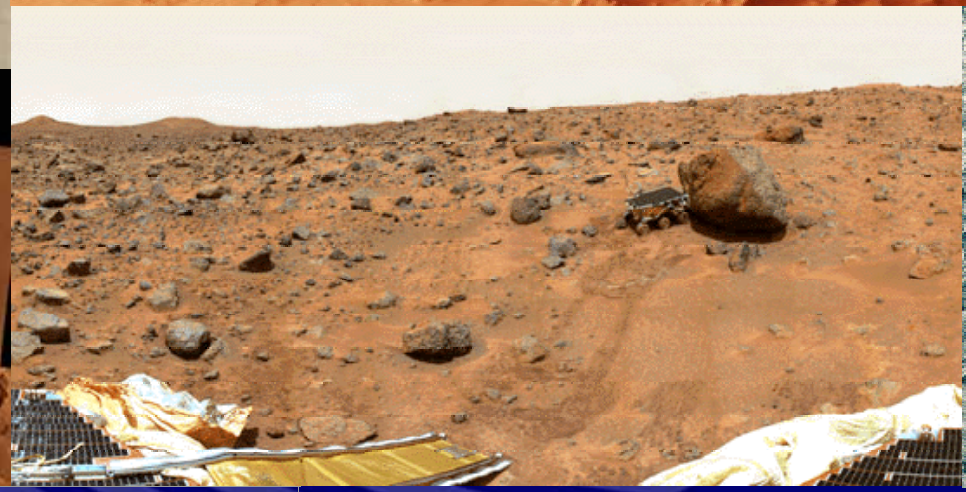


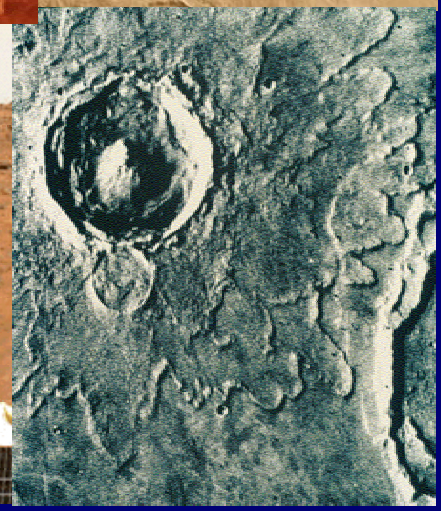






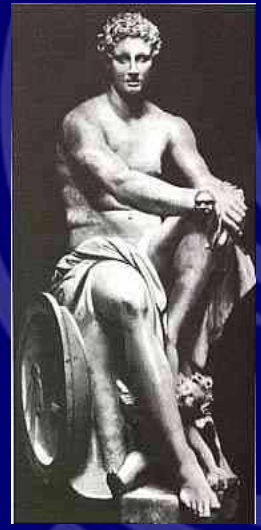


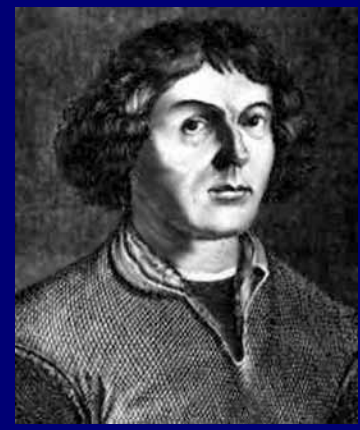




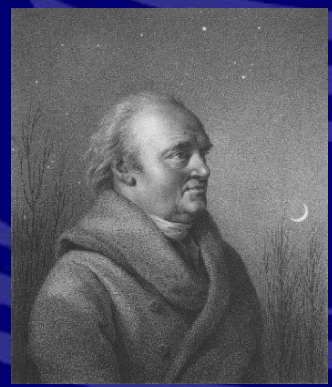
Discovery

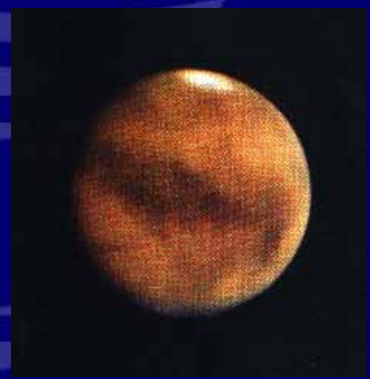
火星





- Gods:
  - Nergal (3000 BC, Mesopotamia)
  - Ares/Mars (Greece/Rome)
- Astronomers:
  - Claudius Ptolemy, 85-165 (Gr/Eg)
  - Nicolaus Copernicus, 1473-1543 (Pl)
  - Tycho Brahe, 1546-1601 (Dk)
  - Johannes Kepler, 1561-1630 (D)
  - Christiaan Huygens, 1629-1695 (Nl)
  - William Herschel, 1738-1822 (D/UK)
  - Asaph Hall, 1829-1907 (US)
- Accomplishments:
  - Period, polar caps, rotation axis
  - Light and dark patterns, maps
  - Deimos and Phobos satellites

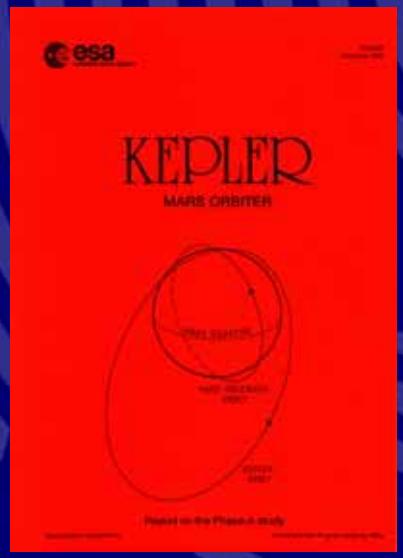


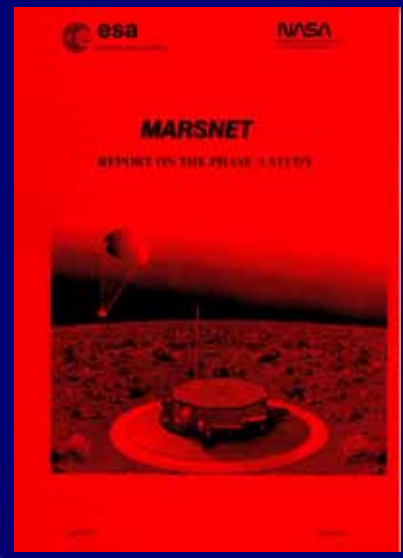


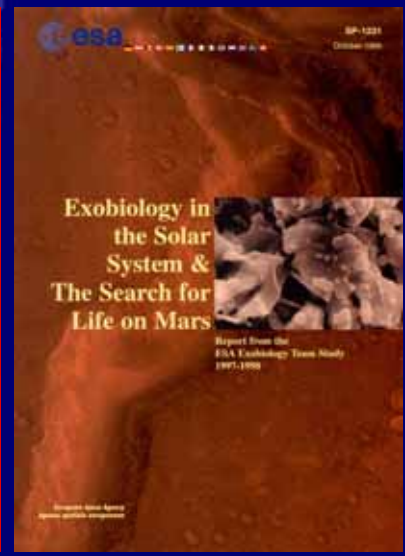
Asaph Hall

Previous studies

- **Beginnings:**
  - **Kepler study (82; 85)**
  - **Mission to Mars (89)**
- **Mars Network:**
  - **Marsnet (93)**
  - **Intermarsnet (96)**
- **Other Studies:**
  - **Mission to the Moon (92)**
  - **Exobiology (99)**
- **Technology Research:**
  - **Small rover, nanokhod**
  - **Robotic sampling arm**
  - **Micro technologies**
  - **Global circulation model**
  - **Balloon, aerobot**







ESA Solar System Missions

2011 ☑ BEPI COLOMBO — Mercury

2005 ☑ VENUS EXPRESS — Atmosphere & Surface

2004 ☑ ROSETTA — Comet Orbiter & Lander

2003 ☑ SMART-1 — Moon & Technology

2003 ☑ MARS EXPRESS — Planetology & Exobiology

1997 ☑ CASSINI-HUYGENS — Titan Probe

1986 ☑ GIOTTO — Halley's Comet Fly-by

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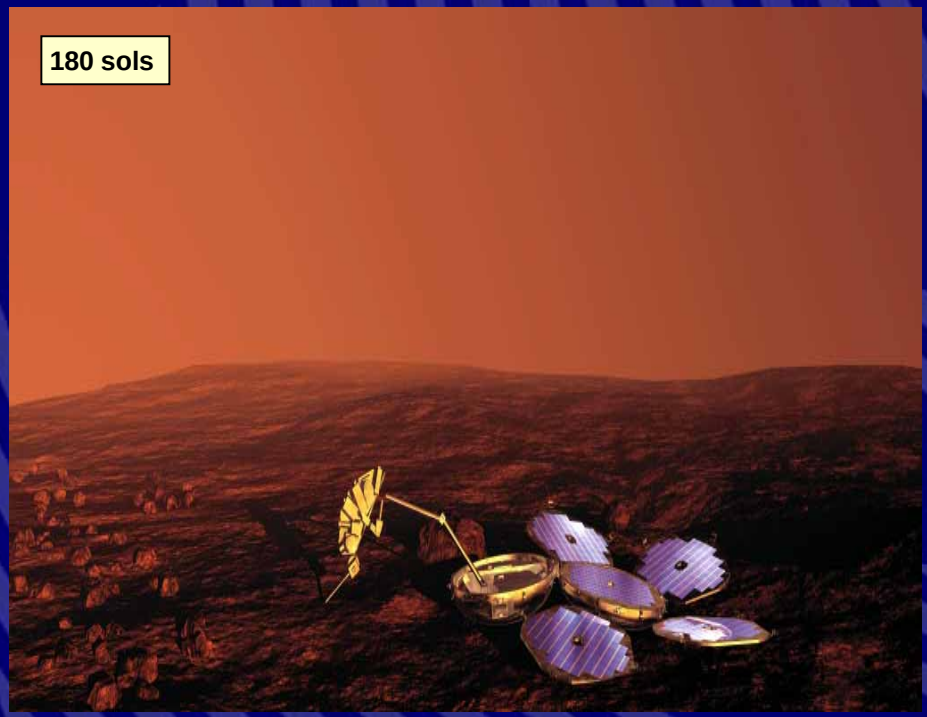
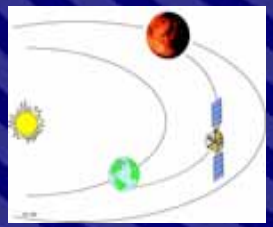
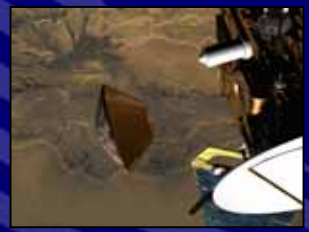
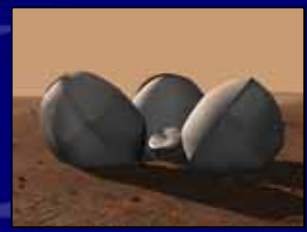
The Mars Express Mission

1 martian year = 687 days









6/7 month cruise

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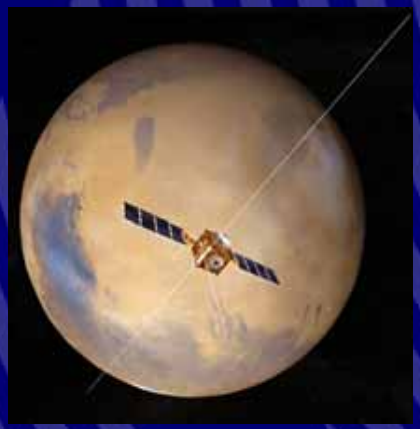
Mars Express Scientific Objectives

ORBITER



- Global high-resolution photogeology
- Super-resolution imaging of selected areas
- Global mineralogical mapping at 100 m resolution
- Global atmospheric circulation and composition
- Subsurface structure a few km down to permafrost
- Surface-atmosphere interactions
- Interaction of upper atmosphere with solar wind
- Gravity anomalies, surface roughness

LANDER

- Geology and mineralogy of landing site
- Organic and mineral geochemistry
- Exobiology (i.e. search for life signatures)
- Meteorology and climatology

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Mars Express Instruments

HRSC: High Resolution Stereo Camera

G. Neukum, FUB/DLR Berlin (DE)

OMEGA: Visible and Infrared Mineralogical Mapping Spectrometer

J-P. Bibring, IAS Orsay (FR)

MARSIS : Sub-surface Sounding Radar Altimeter

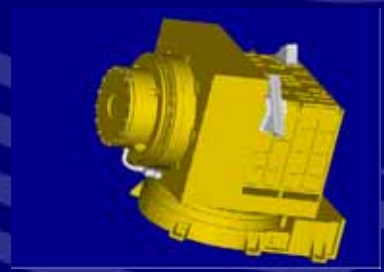
G. Picardi, Univ. Rome (IT)

PFS: Planetary Fourier Spectrometer

V. Formisano, CNR Rome (IT)

SPICAM: Ultraviolet and Infrared Atmospheric Spectrometer

J-L.Bertaux, CNRS Verrières (FR)

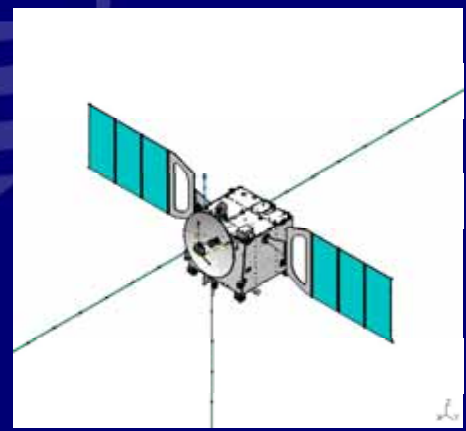


ASPERA: Energetic Neutral Atoms Analyser

R. Lundin, IRF Kiruna (SE)

BEAGLE- 2 Lander

C. Pillinger, Open Univ. (UK)

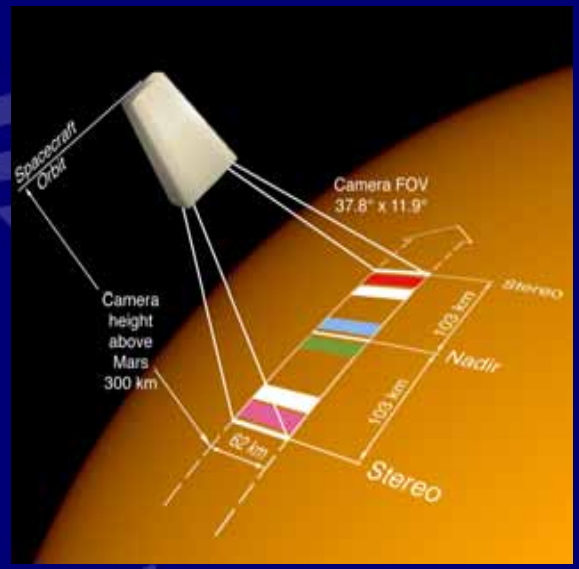


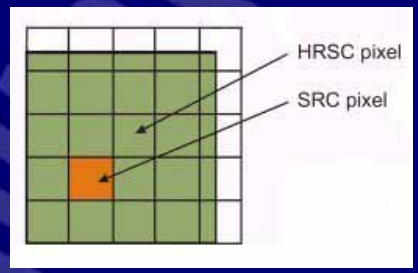
MaRS: Mars Radio Science Experiment

M. Pätzold, Univ. Köln (DE)

Mars Express Science Payload

HRSC – High Resolution Stereo Camera



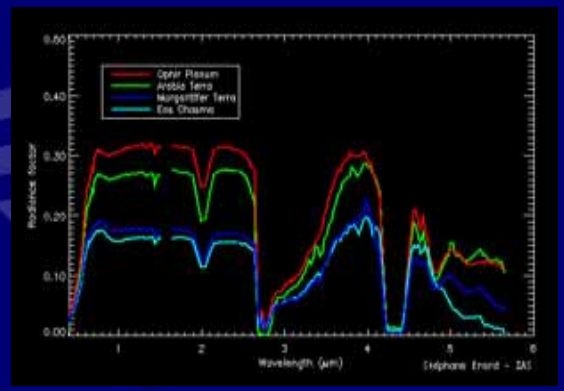


Full Colour 3D imaging of Mars

- Global coverage at high spatial / spectral resolution
- Embedded super-res. Images (2m/pixel)
- Detailed geological mapping
- Altimetry, photogrammetry
- Estimates of relative ages

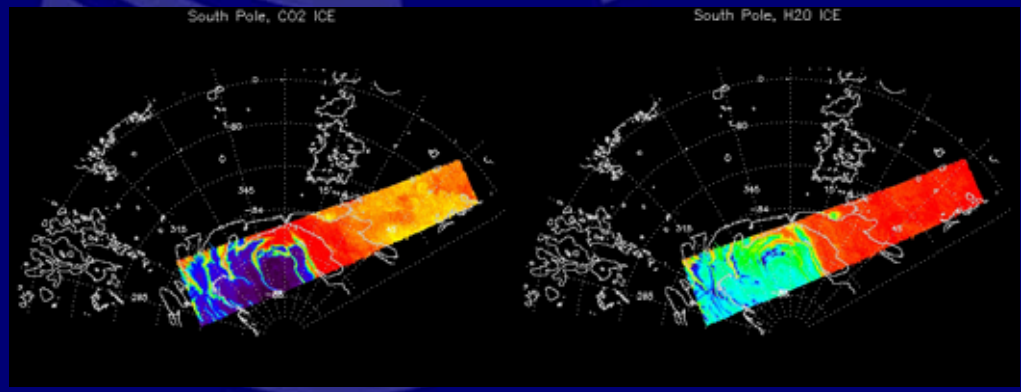
Mars Express Science Payload

OMEGA



Mapping of mineralogical composition of surface (and atmosphere) in visible and infrared

- Global coverage at 2–5 km res.
- Mapping of Selected areas at < 400 m res.
- Space/time distribution minerals/aerosols
- Contribution to H_2O and CO_2 cycles

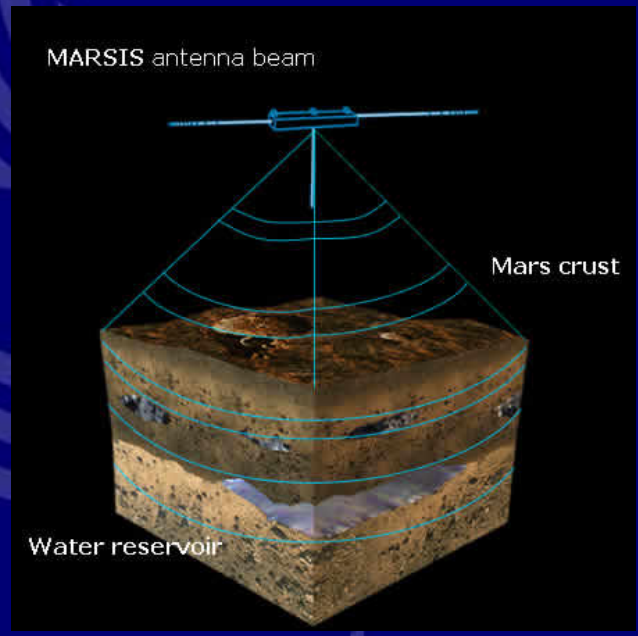


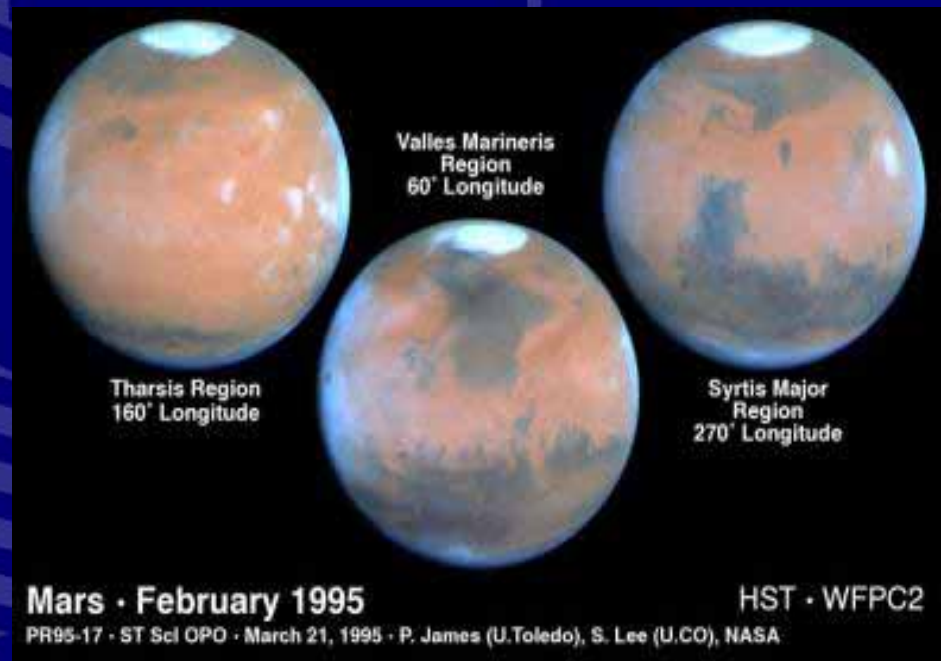
Mars Express Science Payload

MARSIS

Mapping the subsurface structure with micro waves

- Current/past inventory of water
- Study water transport, storage
- Evolution: geology, climate, life ?
- Surface roughness, topography
- Ionospheric sounding: e^- density to H_2O and CO_2 cycles



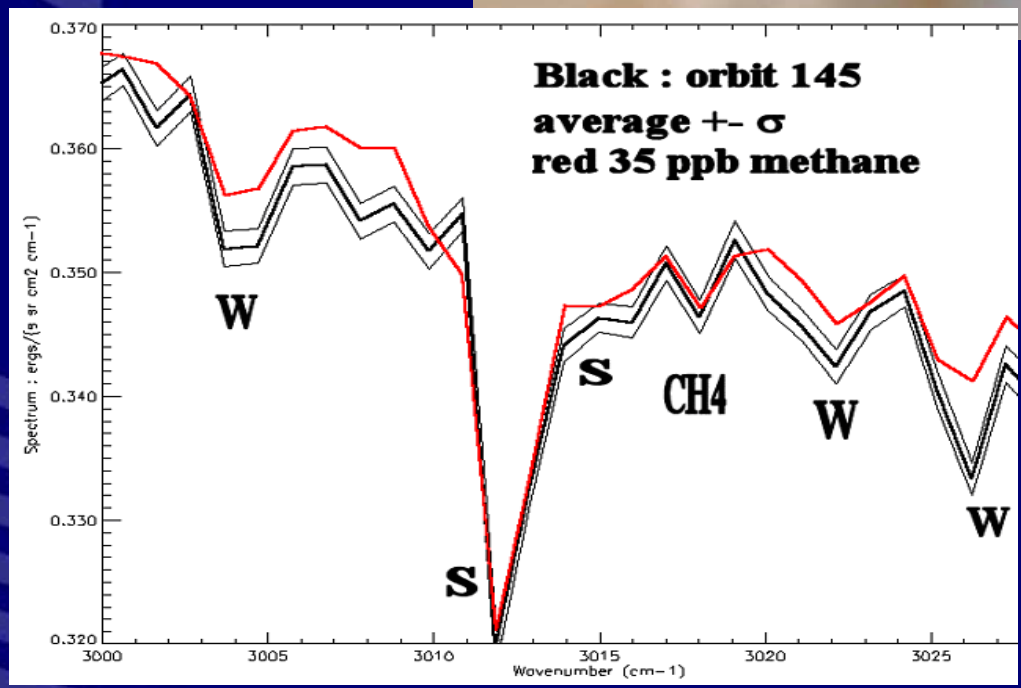


Mars Express Science Payload

PFS – Planetary Fourier Spectrometer

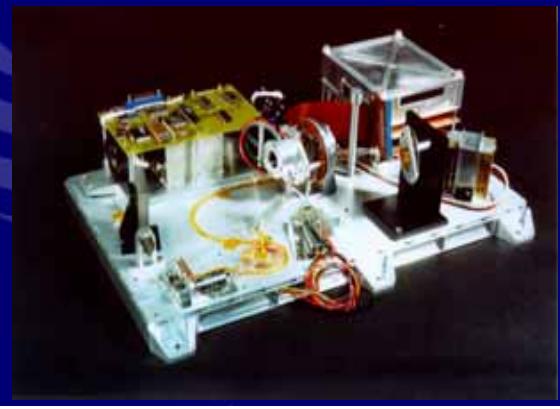
Determine the composition of the atmosphere and surface-atmosphere interactions

- Global 3D temperature field of lower atmosphere and surface
- Minor constituents, D/H ratio, minerals
- Aerosols (size distribution, chemistry)
- Global atmospheric circulation, surface thermal inertia
- Surface-atmosphere exchanges, seasonal variations



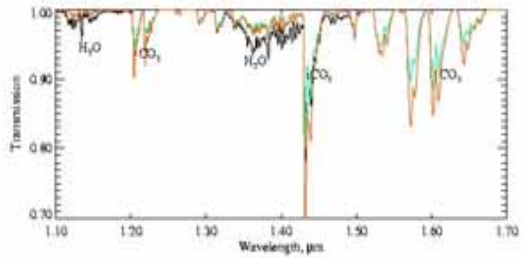
Mars Express Science Payload

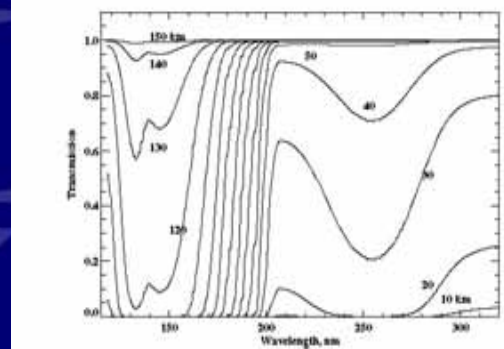
SPICAM



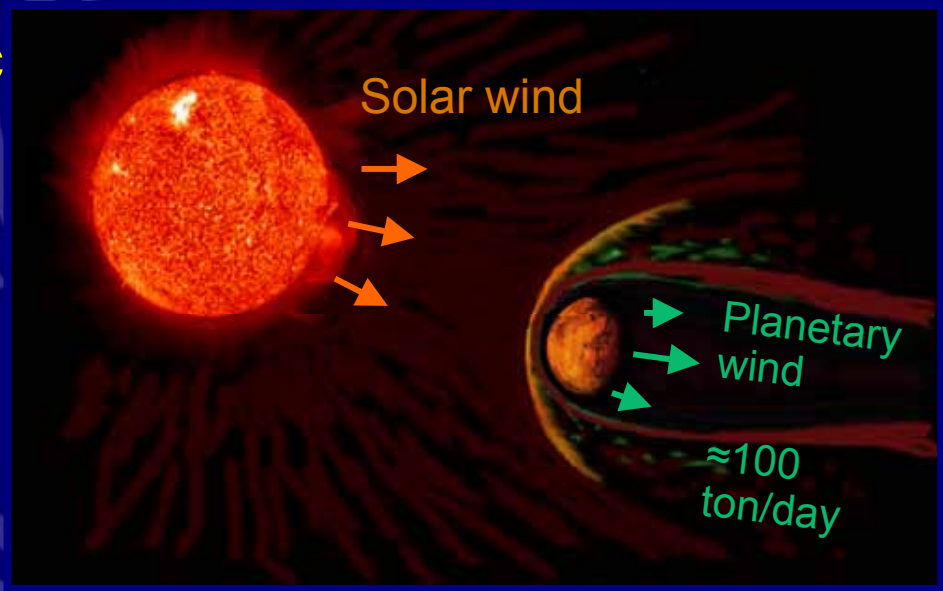
Determine the composition of the atmosphere

- Atmospheric vertical temperature profiles
- Simultaneous O_3 and H_2O: oxidation ?
- H_2O abundances, clouds, surface-atmosphere interactions
- Aerosols and dust particles: D/H ratio
- Structure and dynamics of atmosphere (20–40 km)
- Ionospheric daylight emissions: escape, solar wind





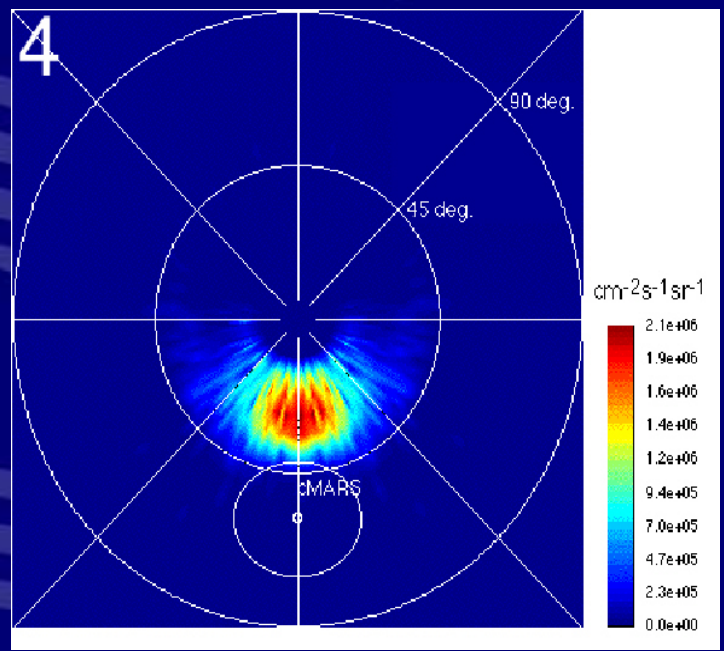
Mars Express Scienc



ASPERA

Search for oxygen and hydrogen atoms in the outer atmosphere

- Energetic neutral atom imaging
- In-situ ion and electron measurements
- Local characteristics of main plasma regions
- Plasma-induced atmospheric escape
- Energy deposition from solar wind to ionosphere
- Solar wind–Phobos interactions



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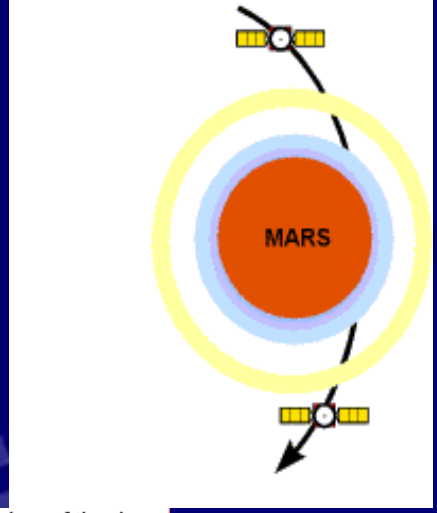
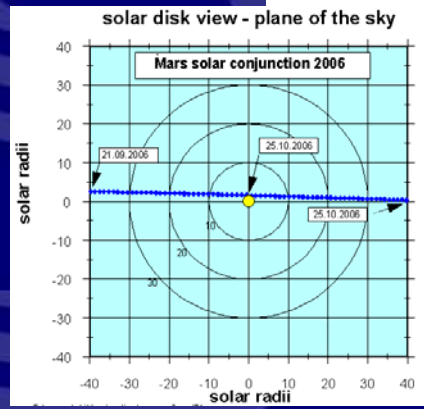
Mars Express Science Payload

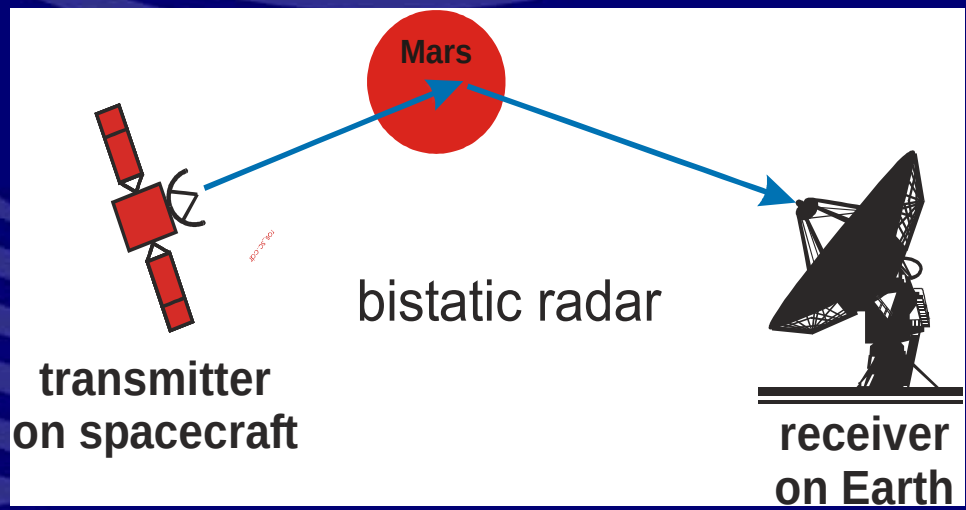


MaRS – Radio Science

Using radio signals to probe the planet ionosphere, atmosphere, surface and interior

- Neutral atmosphere: density, pressure, temperature profiles
- Ionosphere: e^- density profiles and diurnal and seasonal variations
- Surface roughness
- Gravity anomalies: crust evolution
- Sounding of solar corona





Beagle-2 Lander

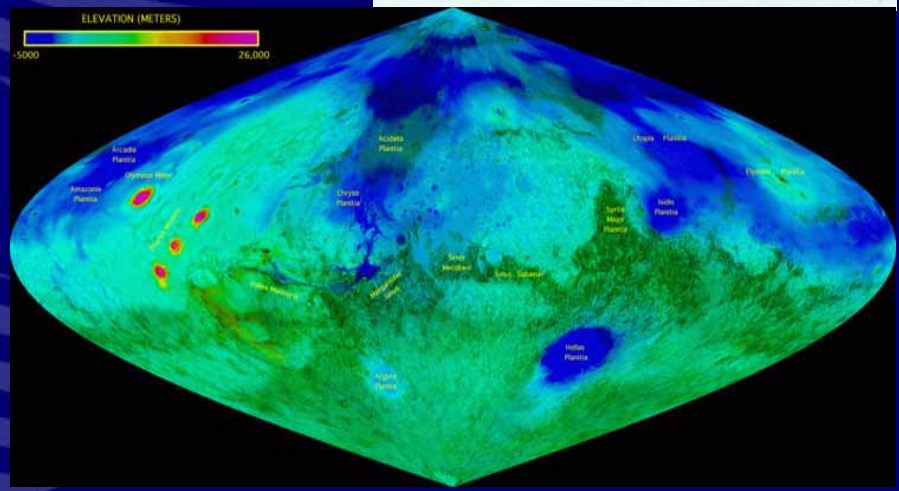
Small European Lander

Integrated suite of instruments

Looking for signs of past or present life

Step by step approach to exobiology

Landing site in Isidis Planitia



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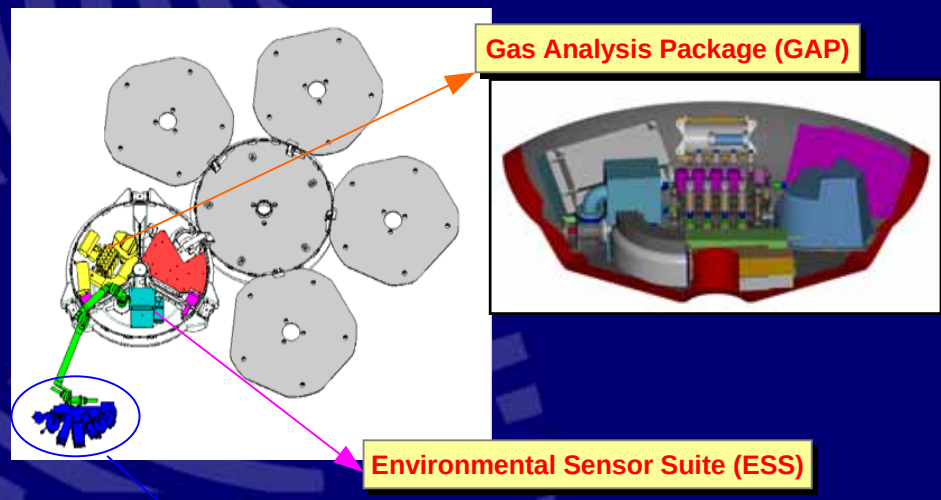
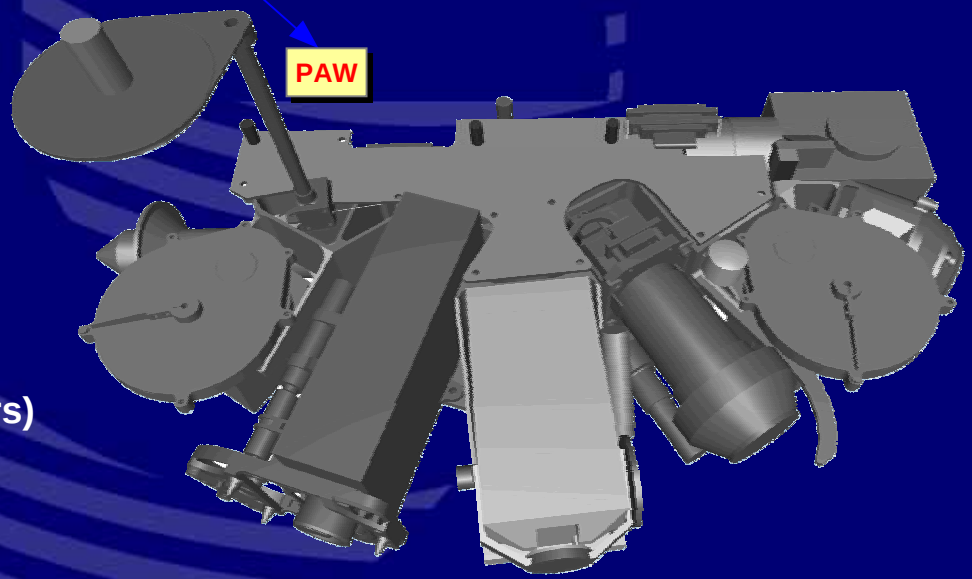
Beagle-2 Instruments

- Gas Analysis Package (GAP)
- Environmental Sensor Suite (ESS)
- Payload Adjustable Workbench (PAW)

  including:
  - a pair of stereo cameras
  - a microscope
  - X-ray spectrometer
  - Mössbauer spectrometer
  - the mole and the corer/grinder (soil & rock sample collectors)
  - a torch for night imaging
  - a wide-angle mirror





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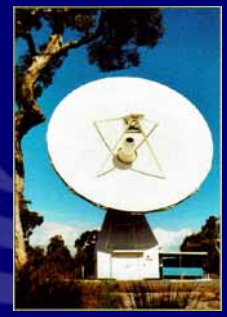
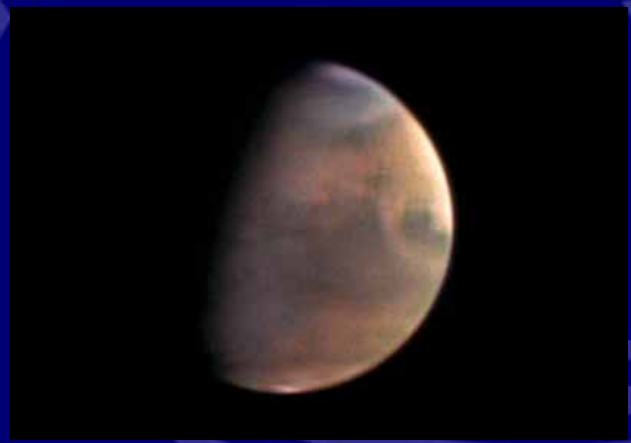
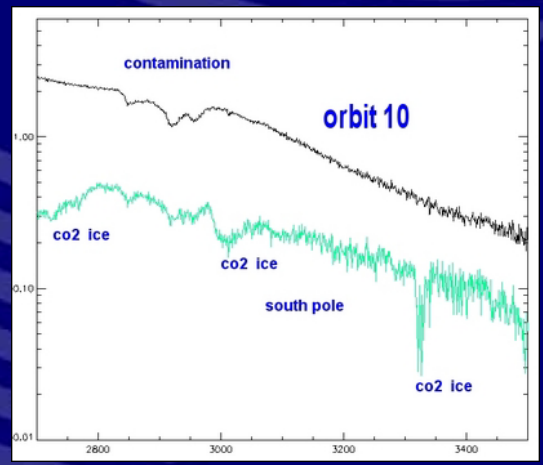
Commissioning Activities

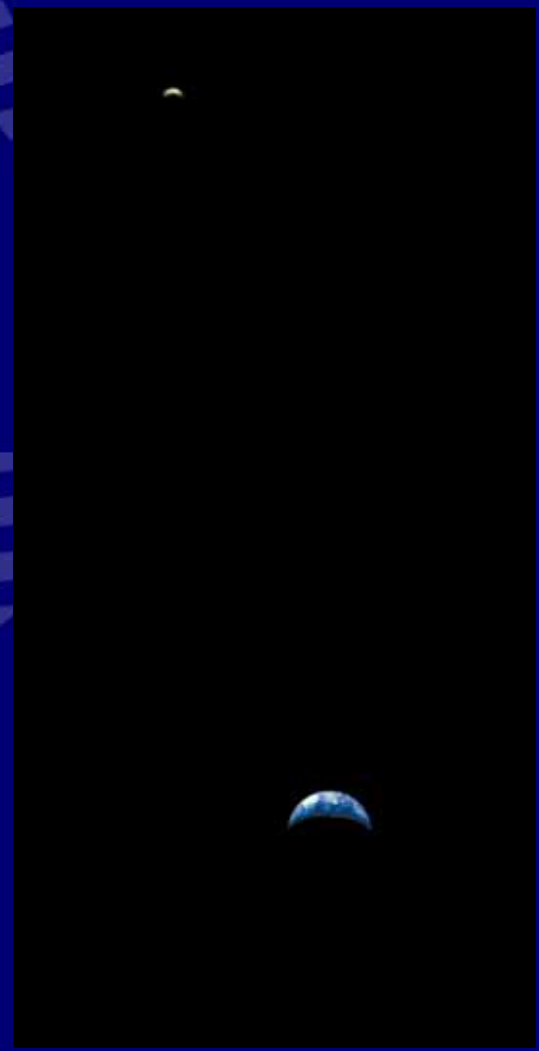


Early Science Results

- **Near-Earth verification**
  - HRSC, MARSIS, OMEGA, PFS, SPICAM, ASPERA healthy
  - VMC imaging, MELACOM
  - PFS, ASPERA to follow
  - Beagle-2 tested successfully
  - NNO/DSN for Radio Science
  - SRC imaging of Earth-Moon
- **Interplanetary cruise**
  - No baseline operations
  - Beagle-2 release: 5 d before MOI
- **In orbit around Mars**
  - Mid-January 04: instruments
  - Early science operations
  - MARSIS boom deployment
  - Resume routine operations



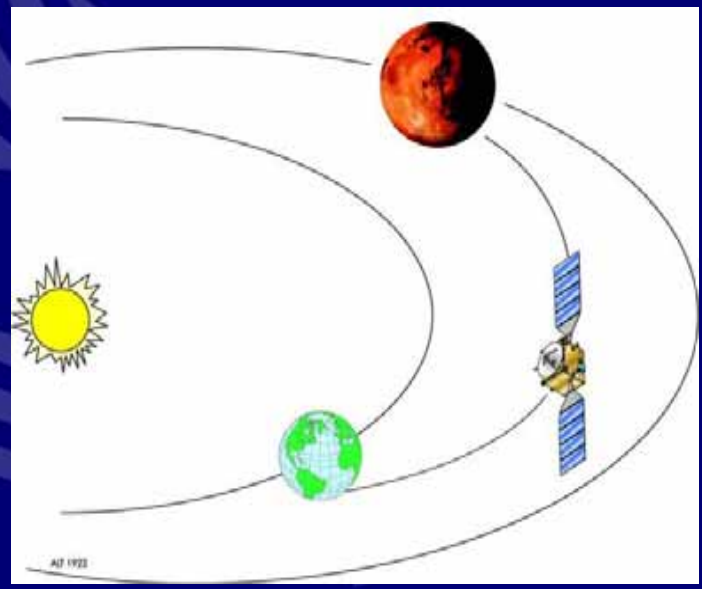


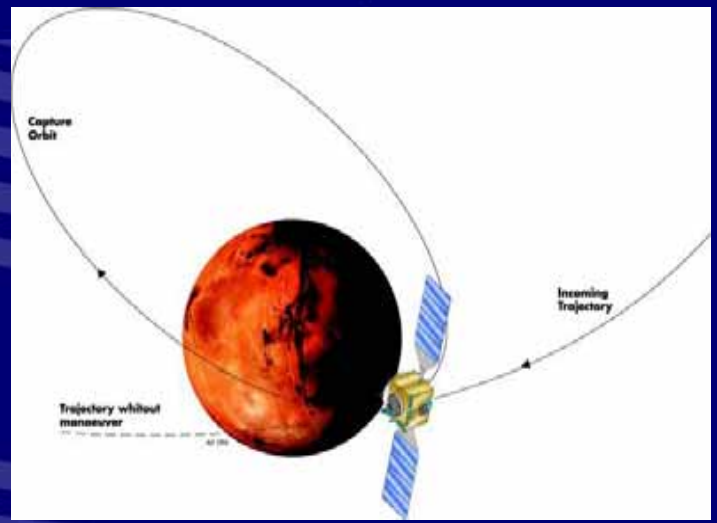


Mars Express Mission Overview

Cruise and capture

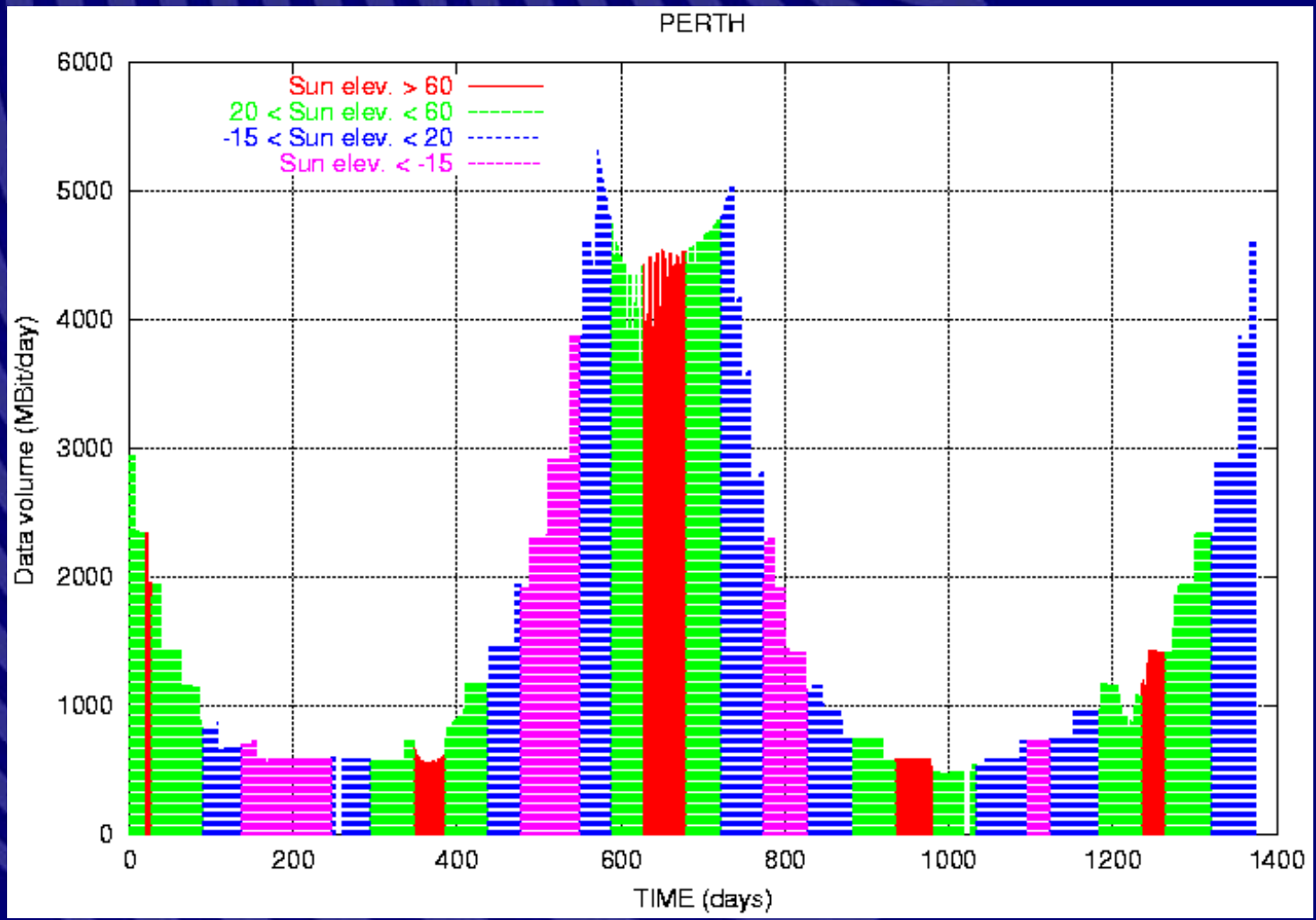
- **Interplanetary cruise**
  - About 6 months (launch–Mars Orbit Insertion)
  - Spacecraft on lander delivery trajectory
  - Release of lander 5 days before MOI
  - Arrival hyperbolic trajectory (250-300 km)
- **Mars orbit insertion (MOI)**
  - Minimum altitude: 200 km
  - Apocentre of capture orbit: > 147500 km
  - Apocentre reduction manoeuvres
- **Orbit**
  - Periapsis: 250 km; apoapsis: 10142 km
  - Inclination: 86.35°; period: 6.75 h
- **2003 Opportunity:** best in terms of launch mass and journey duration





Mars Express Science Operations

Science Data Downlink



Mars Express Mission Management

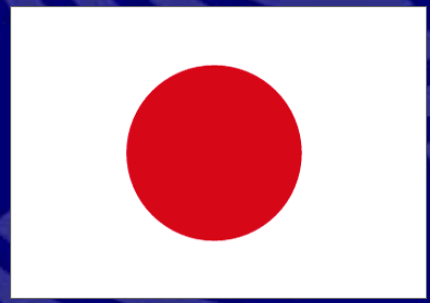
Flexible People

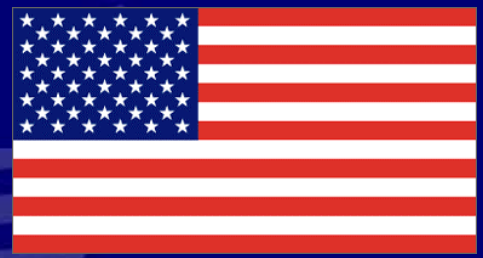
- ESA Project Team (ESTEC)
  - Project Manager, Engineers
- ESA Science Team (ESTEC)
  - Project Scientist, Operations, Archiving
- ESA Ground Segment (ESOC)
  - Ground, Operations, Analysis
- Industrial Consortium
  - Astrium, Sub-contractors
- Science Working Team
  - PIs, Co-I Teams, IDS, RCL
- International Collaboration
  - ESA Coordination (HQ)
  - Japan, USA, Russia

Mars Express Mission Overview

International Cooperation

- **Japan**
  - Joint Mars exploration: polar & equatorial orbits
  - Simultaneous observations
  - Exchange of Co-Investigators, students
  - Long-term partnership
  - Many common interests
- **United States**
  - MARSIS radar
  - Co-Is in most instruments
  - Deep Space Network support
  - Access to US missions
- **Russia**
  - Co-Is in most instruments
  - Helped EU instrument teams





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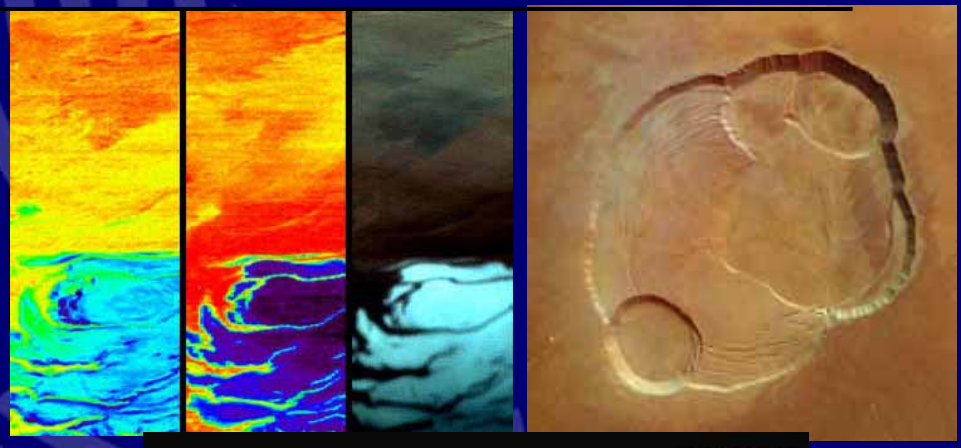
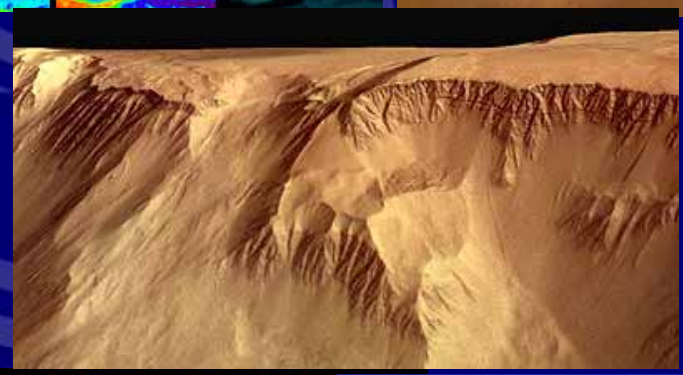
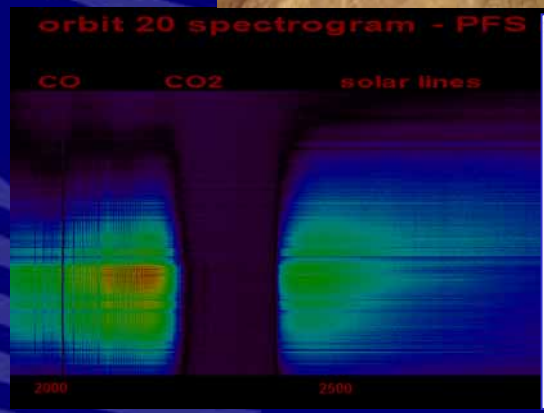
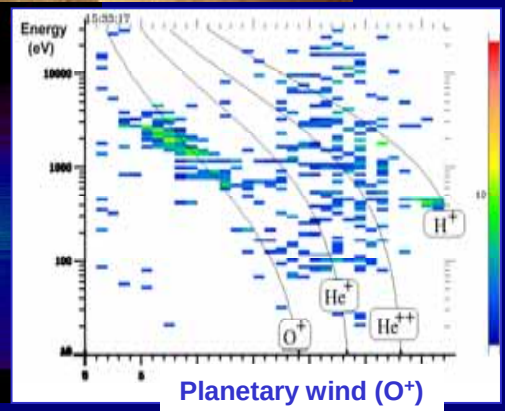
Scientific Highlights of Mars Express

- Scientific breakthroughs
  - Water-ice mapped at South pole
  - No hydrated minerals from alteration
  - “Very young” volcanic processes
  - “Very young” glacial processes
  - Methane in atmosphere (implications for life, volcanism)
- Scientific firsts
  - CO_2 depletion over volcanoes
  - Stellar occultations to probe atmosphere
  - Complete density & temperature profile of CO_2 between 10-110 km
  - Distribution of water vapour and ozone measured simultaneously
  - Confirmation of planetary wind (O^+)
  - Bi-static radar experiment & results
  - Erosion by liquid water seepage
  - 10% of surface imaged at high-resolution (15-20 m/pixel), in stereo and in colour; a few super-resolution (2 m/pixel) images









Planetary wind (O^+)