THE HISTORY OF MARS EXPLORATION



Mars Observers: The European Pioneers

• Nicolaus Copernicus: described the motion of the planets, including

Mars, around the Sun

• **Tycho Brahe:** first to map accurately the movement of Mars

across the sky

• **Johannes Kepler:** worked out the orbit of Mars

• Galileo Galilei: first to observe Mars through a telescope

• Christian Huygens: first to observe a feature on Mars, Syrtis Major

• Giovanni Cassini: first to observe the poles of Mars

• William Herschel: first to measure the diameter of Mars

• Giovanni Schiaparelli: described « cannali » misinterpreted as canals

on Mars

• Eugene Antoniadi: produced the most accurate map of Mars

before the space age

The Saga of Mars Exploration

- Began in 1960 with the first attempts by USSR to launch 2 s/c designed for Mars flybys.
- Since then, more than 30 space missions to Mars were undertaken by USSR, USA, Europe, and Japan.
- 50 per cent of these missions performed successfully.

Mars Exploration has its roots in the 1950s

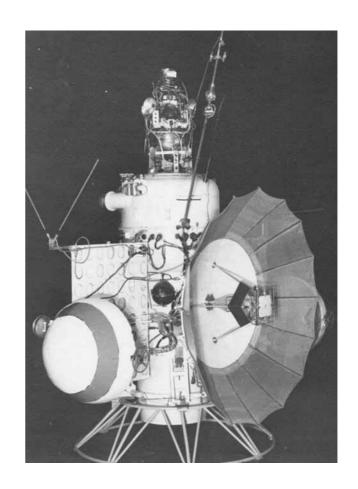
- The goal of many early rocket and space exploration pioneers
- The dream of von Braun in Germany/U.S. and Korolev in the USSR
- Enabled by the Cold War development of ICBMs
- Competition between the US and USSR

But it first got off the ground in 1960

- In 1959 Korelev had developed a 4-stage 'Molniya' planetary launch vehicle
 - derived from the 2-stage R-7 ICBM that had launched Sputnik in 1957
 - 3-stage 'Luna' version had been developed for lunar missions in 1958-60
- With success of Lunas 1-3, Korelev built a new planetary s/c for Mars and Venus.
- The first two were built for launch to Mars in Oct 1960
- New large 3rd stage failed on both launches

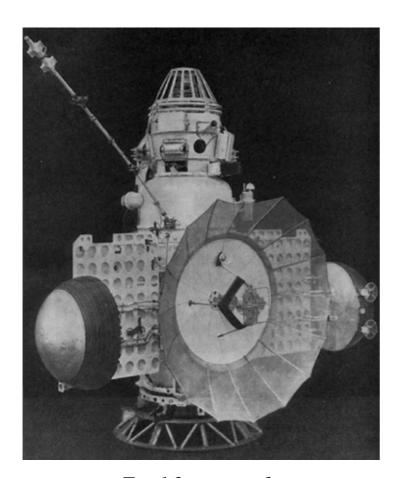
USSR tries again in 1962

- Much improved new multi-purpose modular s/c
 - improved avionics
 - mid-course correction motor
- First launch fails atm probe s/c
- Second launch succeeds Mars 1 flyby s/c launched on Nov.1, 1962
 - camera & most of payload removed
 - lost after 5 months due to attitude control
- Third launch fails flyby s/c



Mars 1 spacecraft

1963-5: USSR flies test missions



Zond 3 spacecraft

1963 - Test mission launch failure

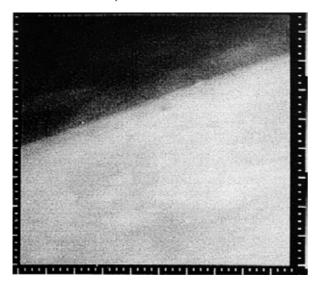
1964 - Zond 2 flyby lost after 2 months

1965 - Zond 3 success at Moon, fails to reach Mars orbit

1964: Americans succeed at Mars

Mariner 4

- First launch fails Mariner 3
- Second launch succeeds Nov 28,1964
- Successful flyby on July 15, 1965
 - → Craters, not canals!



First s/c image of Mars



The famous picture No.11



1969: Americans flyby Mars again



Mariner 6,7



Mariner 6 image

Both missions succeed - Mariners 6 & 7

More craters imaged by Mariner 6

Dry ice south pole imaged by Mariner 7

Mars is looking barren!

1969: USSR developed a new and bold plan using a new super rocket and a heavy soft landing s/c

New science goal - soft landing

1969- Orbiter/probes for Mars atmosphere & ephemeris data

1971- Soft landers

• New heavy design for Proton launch

3yr new development challenge

Diverted by rush to succeed at Venus in 1967

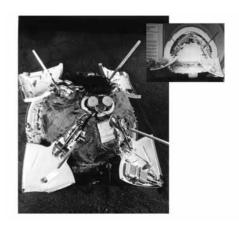
3574 kg Orbiter with 280 kg Probe

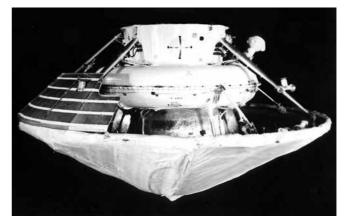
Probe to be deployed from orbit

Probe deleted late in development: mass & test problems

1971: USSR regroups with a new spacecraft design

- Required atmosphere & ephemeris data lost in 1969
- US refuses to provide ephemeris from Mariner 6,7
- Soviets devise a clever but risky 3 s/c plan:
 - launch orbiter first,
 - provides navigation for landers





Outcome of USSR Mars Campaign in 1971

First orbiter launch fails: key navigational pathfinder vehicle lost forces risky back-up autonomous optical navigational scheme by orbiter/landers

Mars 2 Orbiter: orbit successful, bad telemetry system, poor data

Mars 2 Lander: entry vehicle misdirected. Lander crashes

Mars 3 Orbiter: runs out of fuel on MOI, bad orbit

Mars 3 Lander: entry system works! Lander fails 20 sec after landing

Lander results: first successful landing on Mars, but no data returned!

Orbiter results: imagery foiled by dust storm, some data on upper atmosphere:

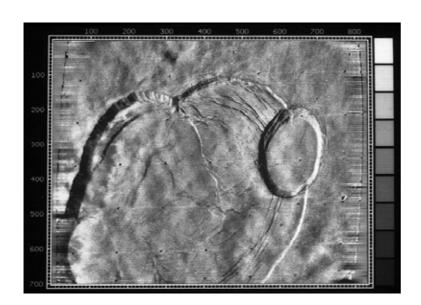
no magnetic field, surface T variations, CO2 column densities,

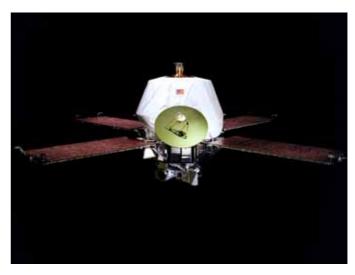
occultation T and density profiles.

Campaign is overshadowed by US Mariner 9 orbiter

1971: American Mariner 9 orbiter

- First Mars orbiter
- Mapped entire planet
- Discovered tectonic structures, giant volcanoes and valleys
- Mars begins to look more Earth-like!



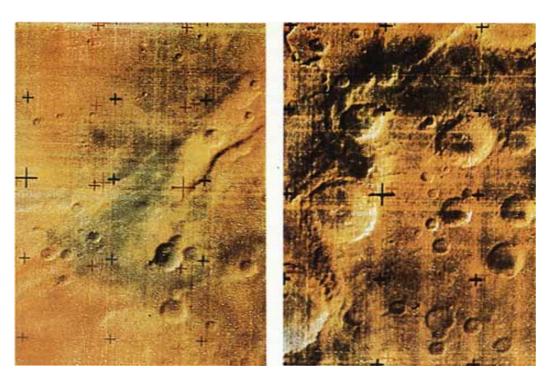


Mariner 9

Olympus Mons caldera

1973: USSR goes all out

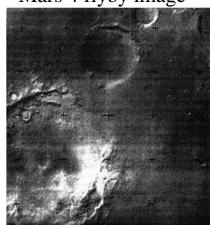
Can't fly orbiter/lander combination Knows about plans for Viking lander (first 73 then 75) Determined to beat US to land before Viking Four large s/c! Use 71 vehicle designs to save money



Mars 5 orbiter color images



Mars 4 flyby image



Mars 5 orbiter image

Outcome of the USSR Mars Campaign in 1973

Mars 4 Orbiter: Many subsystem problems, MOI fails.

Mars 5 Orbiter: Pressure leak at MOI, fails in Mars orbit after 15 days.

All possibility of data relay from the Mars 6,7 landers is lost.

Mars 7 Lander: Entry system misdirected and misses planet.

Mars 6 Lander: Lost uplink, no more commands possible, but...

all on its own: updates entry system parameters and release,

entry successful,

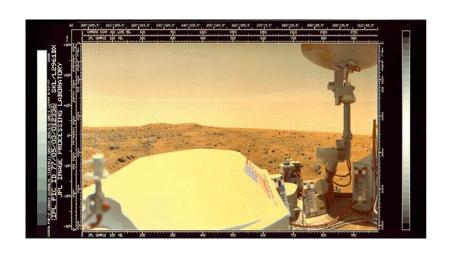
descent data received from backup telemetry system (poor),

lander dropped to surface according to plan, never heard from.

Orbiter results: some images from Mars 4 on flyby and from Mars 5 in orbit.

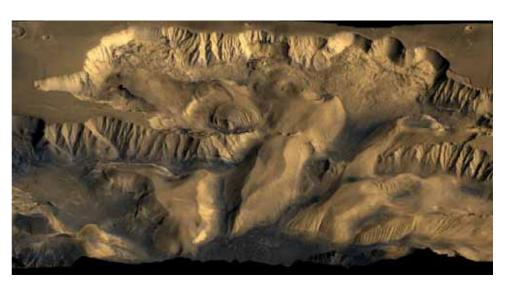
Lander results: some data on P, T during Mars 6 descent, mass spec failed.

1975: the American Viking Lander





- Two orbiters & landers at Mars
- Spectacular images from orbit and from the surface
- First successful landers, but unsuccessful (?) search for life
- Interest in Mars wanes after Viking



1988: USSR revives interest in Mars





Phobos lander

Very ambitious Mars/Phobos goals, international payload, bold Soviet payload Phobos 1 fails enroute after 2months - command error Phobos 2 lost in Mars orbit after 2months - failsafe software deleted

Soviets establish their lead in internationalization, but mission a disappointment

1992: Americans go back to Mars too, and also lose

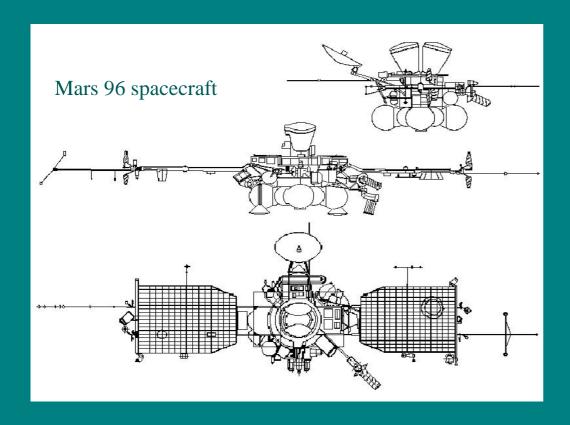


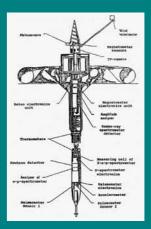
Mars Orbiter with comprehensive payload lost on approach to Mars

- first US planetary spacecraft to fail after launch
- forces re-examination of risk with single large, comprehensive s/c
- new approach to distribute risk with smaller spacecraft over multiple launches
- long-term Mars Surveyor program (now Mars Exploration Program) funded

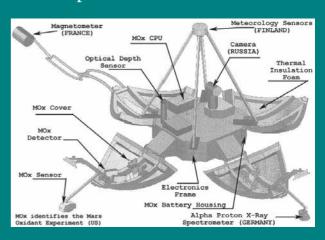
1996: Russia tries again

- Mars 96 an ambitious, comprehensive mission
 - large orbiter with 2 landers, 2 penetrators
 - rover and balloon abandoned in 1994
 - heavy international investment
 - launch fails in Nov 1996





Mars 96 penetrator



Mars 96 small lander

1996: Americans try out their new approach with two spacecraft - a lander and an orbiter

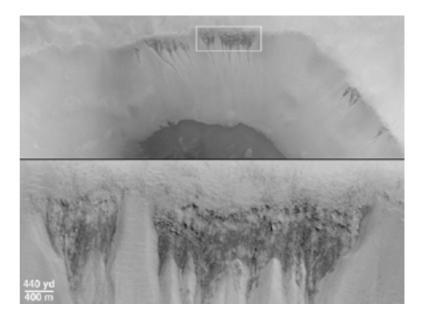
Mars Pathfinder lander succeeds

- about 5% the cost of Viking
- pathfinds new approach to low-cost s/c
- more technology test than science
- including first successful rover on Mars
- revives public interest in Mars

1996: Mars Global Surveyor orbiter



Succeeds and keeps on ticking today
First science mission in new US Mars program
Carries first third of lost Mars Observer payload
Continuous science and lander data relay activity



Finds layering and signs of water!

1998-9: The new American Mars program stumbles

A double blow - both spacecraft crash on Mars!

- limits to low-cost spacecraft development found by experiment
- US program in jeopardy but maintains government support
- cancels 2001 landers and restructures the program for success



Mars Climate Orbiter



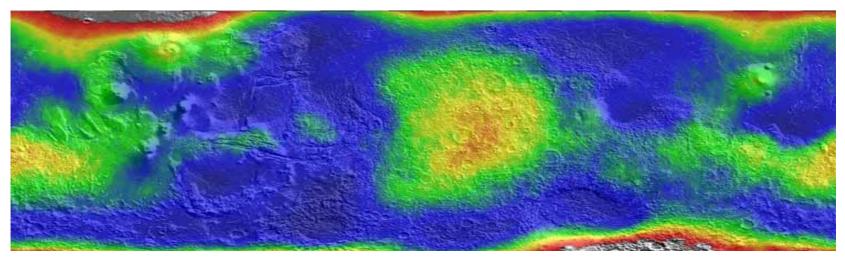
Mars Polar Lander

2001: the American program recovers

Successful single orbiter - Mars Odyssey

- carries last of lost Mars Observer payload
- plus new instruments including Russian neutron expt
- discovers subsurface ice around the planet
- continues with Vis and IR imaging, hydrogen maps and global elemental analysis.





2003: the Europeans have a great success the American program gets in full stride and Japan makes a bold effort

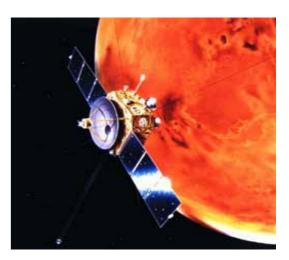


Mars Express



Mars Exploration Rovers

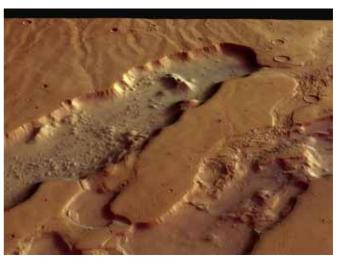
Mars is now the target of true international exploration!



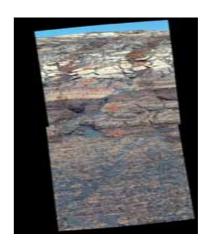
Nozomi

The Major Steps of Mars Exploration

- Mariner 9 (1971)
- Viking Orbiters & Landers (1975)
- Mars Pathfinder (1996)
- Mars Global Surveyor (1996)
- Mars Odyssey (2001)
- Mars Express (2003)
- Mars Exploration Rovers (2003)



Dao Vallis (HRSC MEX)



Endurance (MER)



What is next?

• NASA Mars Exploration Program:

- 2005: Mars Reconnaissance Orbiter

- 2007: Phoenix

- 2009: Mars Science Laboratory

- 2009: Mars Telecommunications Orbiter

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• ESA Aurora Programme

