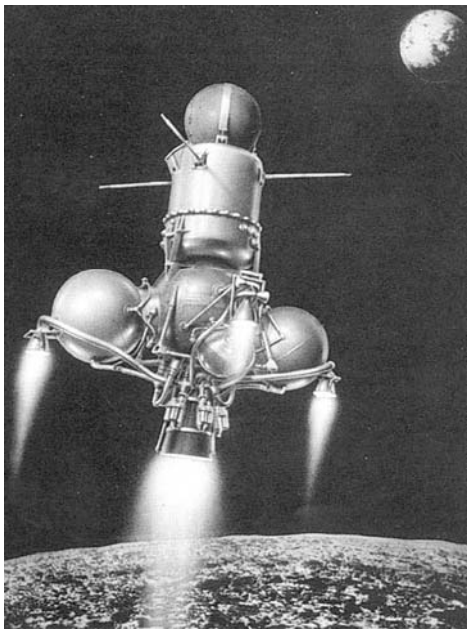
The Soviet Robotic Lunar & Planetary Exploration Program

Emphasis on the early years 1960 - 1975

Wesley T. Huntress, Jr. and Mikhail Ya. Marov

The Soviet Robotic Lunar & Planetary Exploration Program

Born as part of the Cold War and nearly died with it
Provided a sinister and mysterious stimulus to American efforts

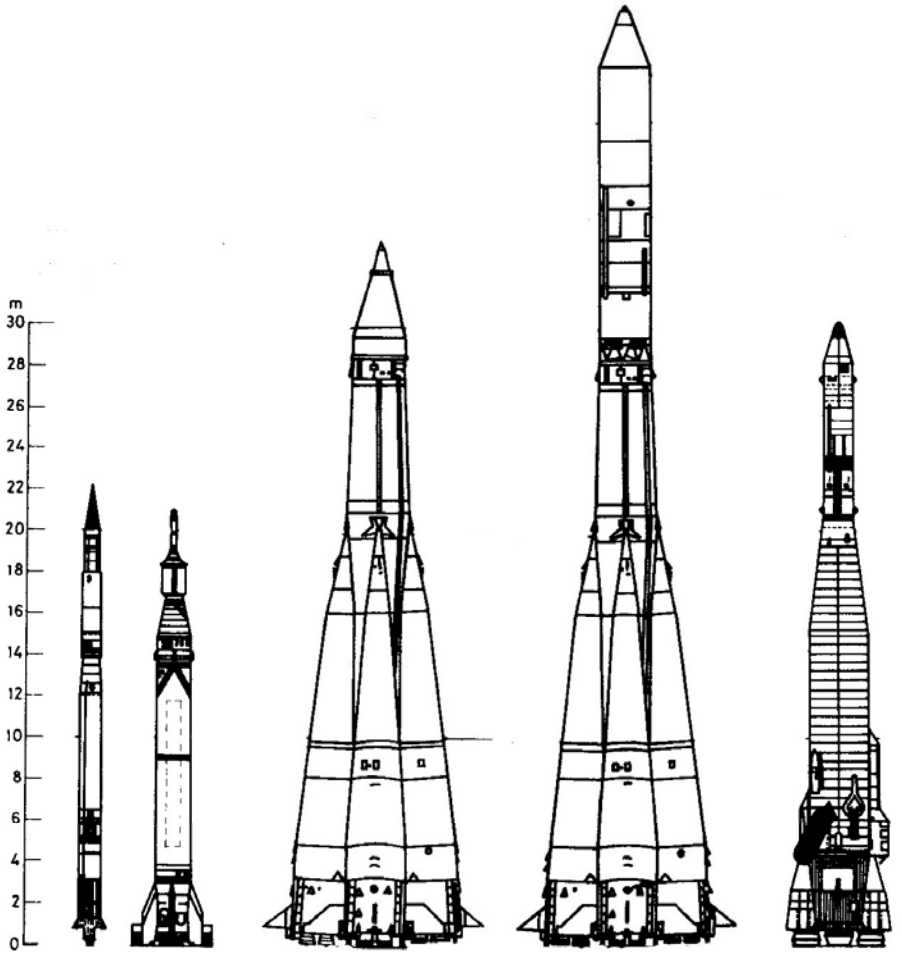


A tale of adventure, excitement, suspense and tragedy
A tale of courage and patience to overcome obstacles and failure
A tale of fantastic accomplishment, and debilitating loss
Most events virtually unknown outside the closed circle of Soviet secrecy

Sergei Korolev

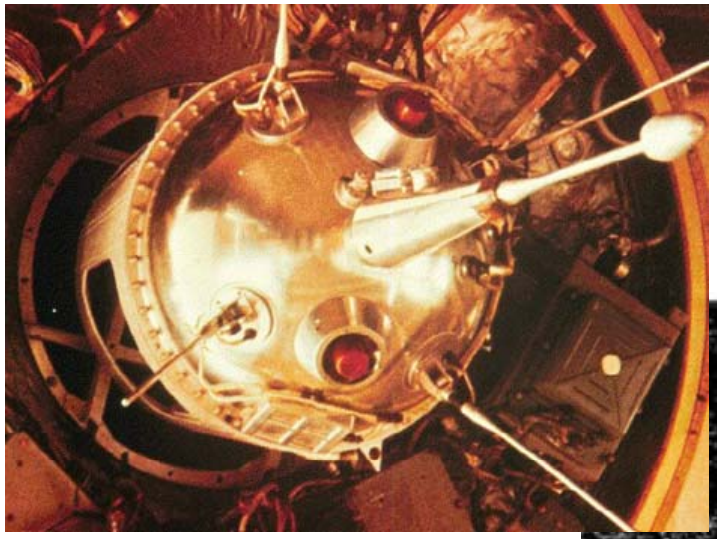
Mstislav Keldsh

1960 - Early Soviet and American Exploration Rockets

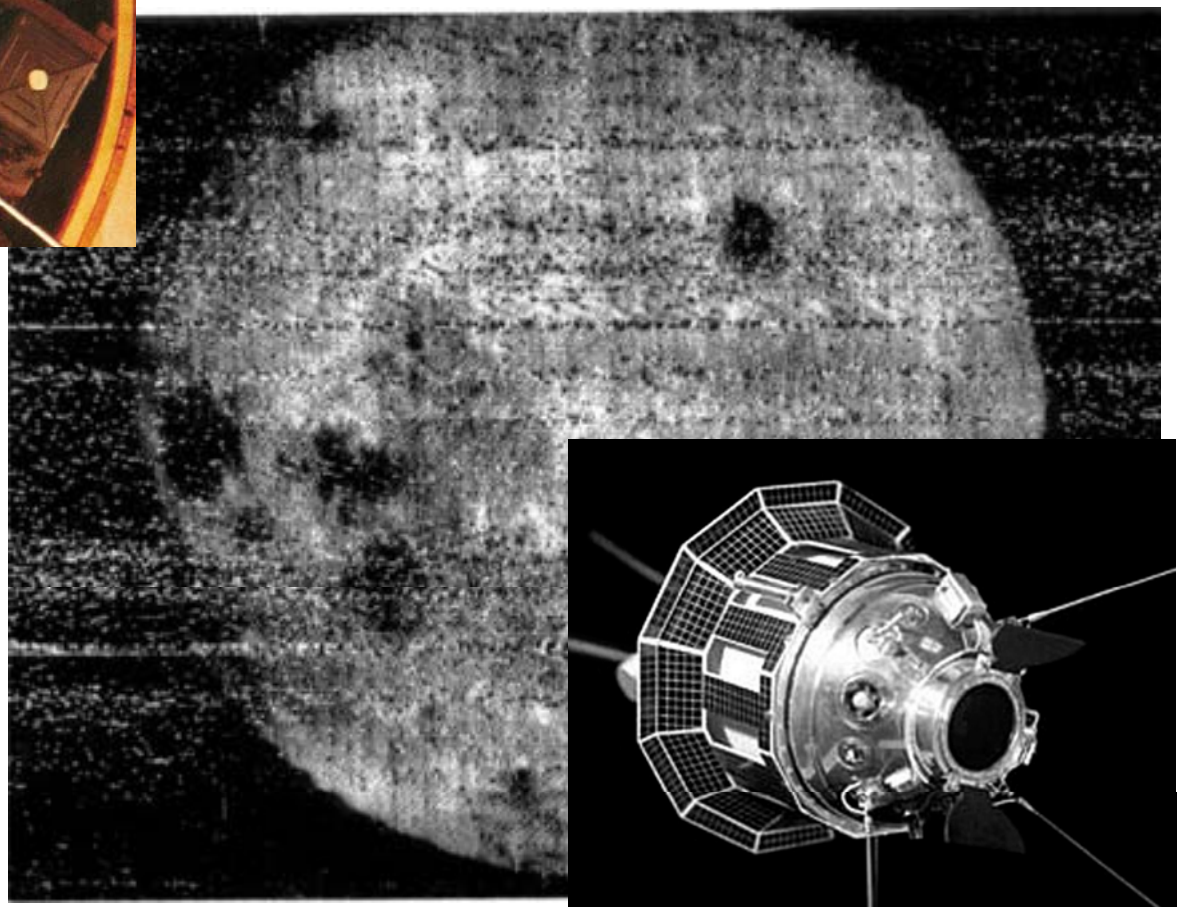


Vanguard Jupiter-C Luna Molniya Atlas-Agena

1958 - 1959 The Age of Robotic Lunar Exploration Opens



1958 - 3 failed impactor launches
1959 - 1 failed impactor launches
- 3 successful (Lunas 1, 2, 3)
1960 - 2 failed circumlunar launches



Luna 1 January 2, 1959
1st s/c to leave Earth
missed lunar impact
1st lunar flyby Jan 4, 1959

Luna 2 1st lunar impactor
Sept 14, 1959

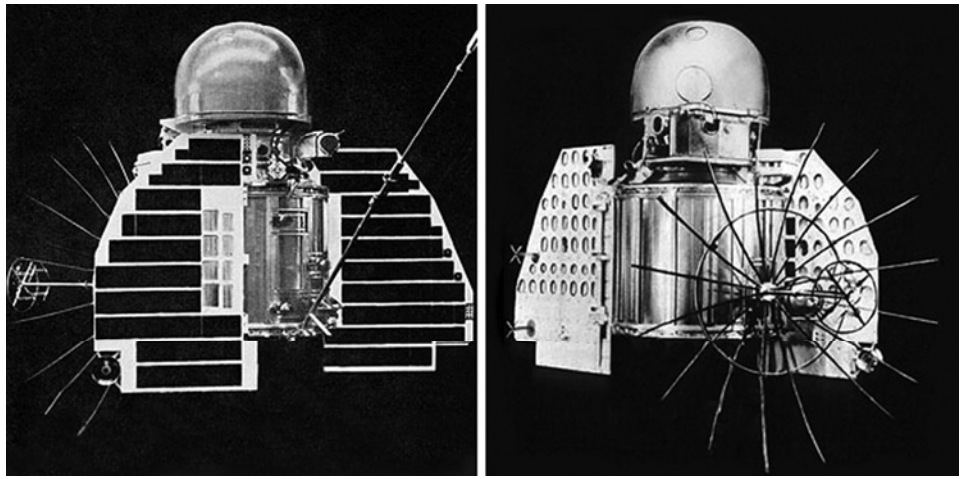
Luna 3 circumlunar flyby
1st farside picture
Oct 7, 1959

1960 - 1961 The Age of Robotic Planetary Exploration Opens

The first launches to Mars and Venus

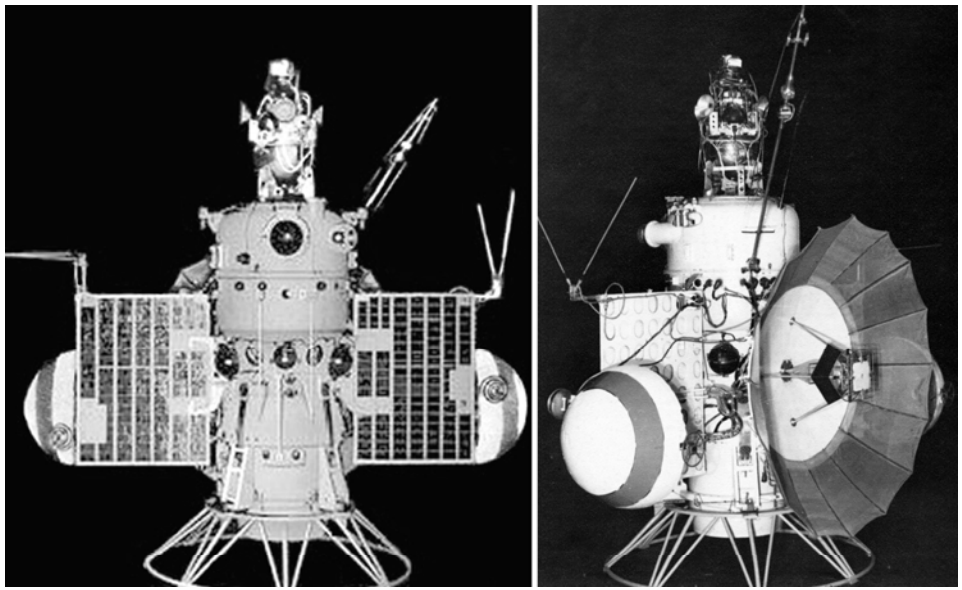
October 10 & 14 1960
2 Mars flyby launch failures
Maiden flight of the Molniya

February 1961
2 Venus impactor launches
1 success on Feb 12, 1961,
but **Venera 1** fails 5 days later



1962 The New 2MV Planetary Spacecraft

Modular design for both Venus & Mars and for both flyby and probe missions



Mars 1 Flyby Spacecraft

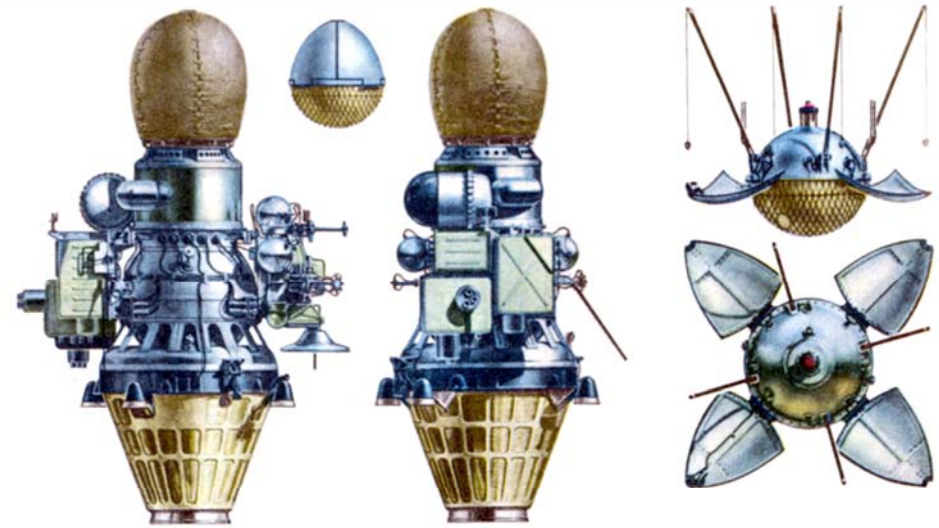
Five of six victimized by the launch vehicle
- 2 Venus probes, 1 Venus flyby
- 1 Mars probe, 1 Mars flyby

Mars 1 flyby vehicle successfully launched
- ACS problems, fails after 5 months
- while the US Mariner 2 succeeds at Venus

Mars 1 launched Nov 21, 1962
Lost inflight March 21, 1963

1963 - 1965 Three More Years of Frustration

A new 1500 kg spacecraft for lunar soft landing transport module plus landing capsule



Eleven failed missions in 1963 – 1965!

Six due to launch vehicle failures

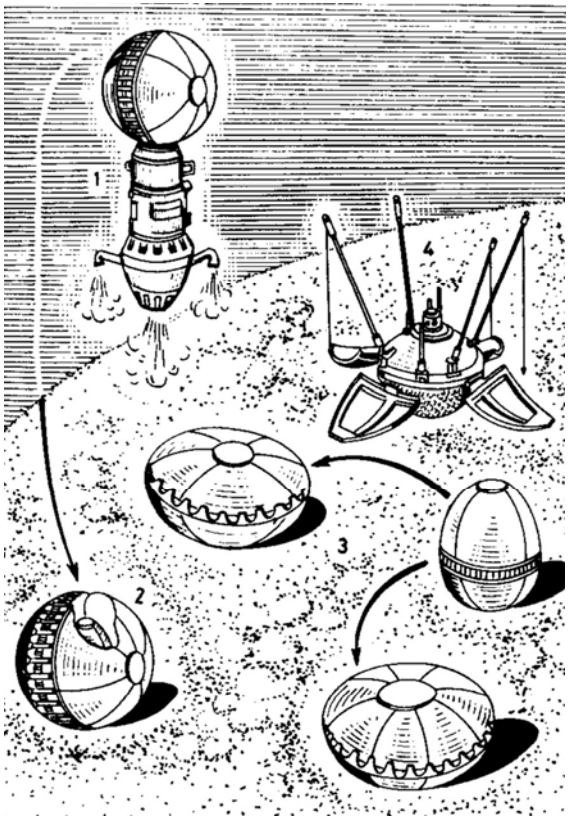
Luna 4 - navigation failed, missed the Moon

Luna 5 – guidance failed, crashed

Luna 6 – mid-course failed, missed the Moon

Luna 7 – attitude control & retro failed, crashed

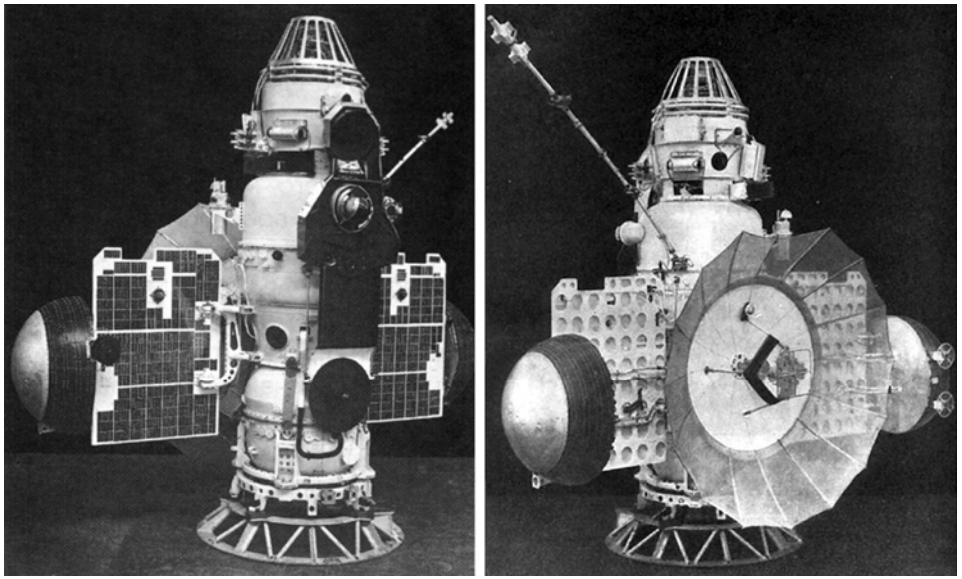
Luna 8 – air bag puncture & retro failed, crashed



Air-bag landing scheme

1963 - 1965 Three More Years of Frustration

Back to Mars and Venus with a new planetary spacecraft - the 3MV

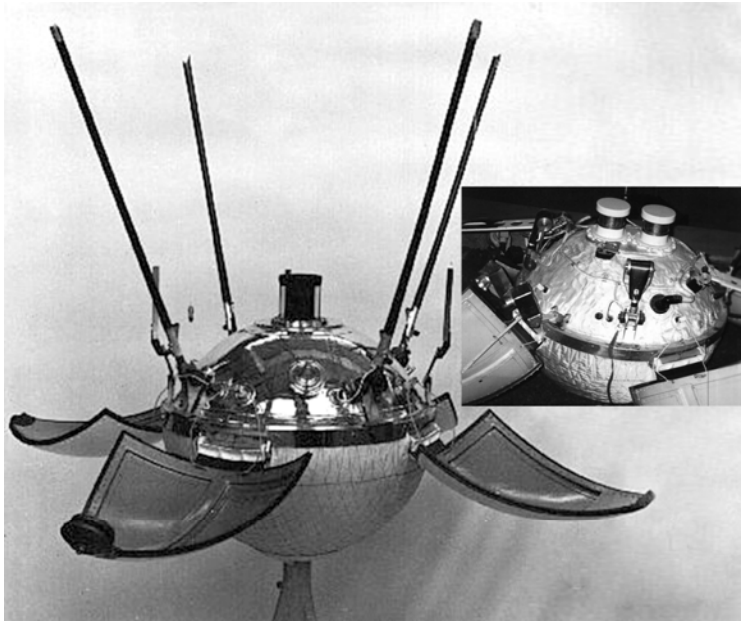


Zond 3 Mars s/c & lunar farside picture

Nov 11, 1963 – Test flight launch to Mars distance fails
Feb 19, 1964 – Test flight launch to Venus distance fails
Mar 27, 1964 – Venus probe launch fails
April 2, 1964 – **Zond 1** Venus probe, lost May 25, 1964 due to slow leak
Nov 30, 1964 – **Zond 2** Mars flyby, lost May 5, 1965 after multiple problems
July 18, 1965 – **Zond 3** Mars test succeeds at the Moon, survives for 8 mo., 150M km
Nov 12, 1965 – **Venera 2** Venus flyby, thermal problems, failed to return flyby data
Nov 16, 1965 – **Venera 3** Venus probe, thermal problems, lost 17 days before arrival
Nov 23, 1965 – Venera flyby launch fails

1966 - 1969 Success at the Moon and Venus, but Mars eludes

Luna 9 *- The first lunar soft lander, Feb 3, 1966*



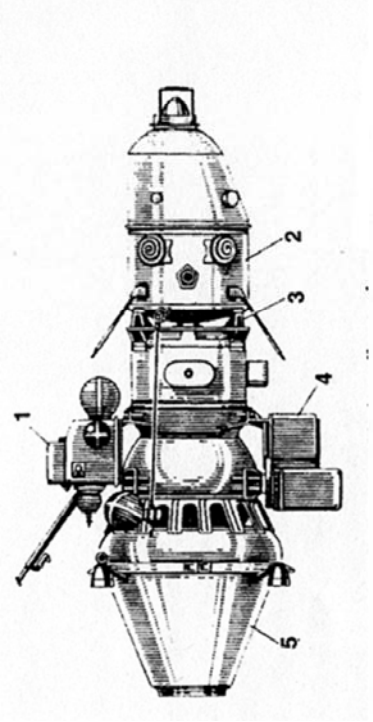
Luna 13 *– Dec 24, 1966*

1966 - 1969 Success at the Moon and Venus, but Mars eludes

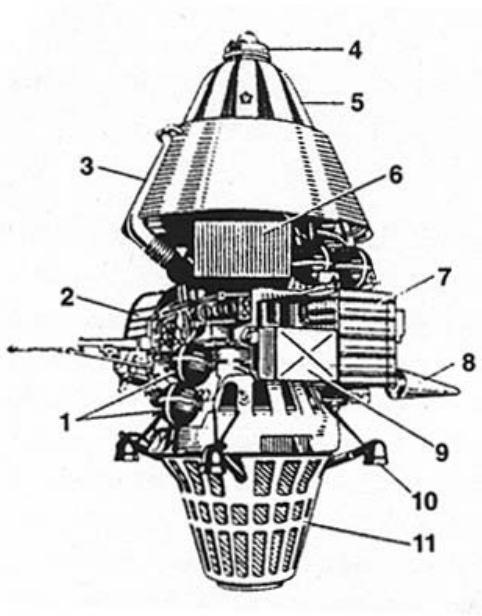
First Soviet Lunar Orbiters - 1966

Rushed together from Luna 9/13 vehicle
Replaced lander module with orbiter module
4 of 7 succeed March 1966 – April 1968
Luna 10 1st lunar orbiter – April 3, 1966

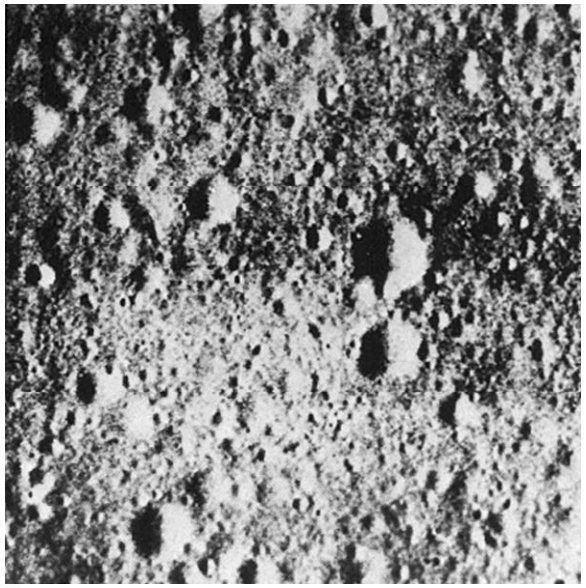
Lunar gravity mapping – mascons!
Radiation and magnetic field mapping
Cosmonaut landing site imagery
Technology tests for piloted program



Luna 10



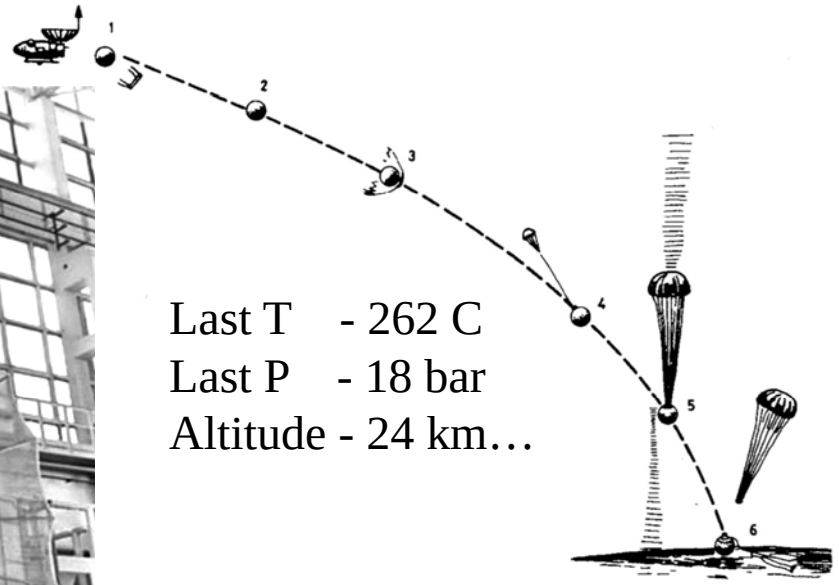
Luna 11, 12, 14



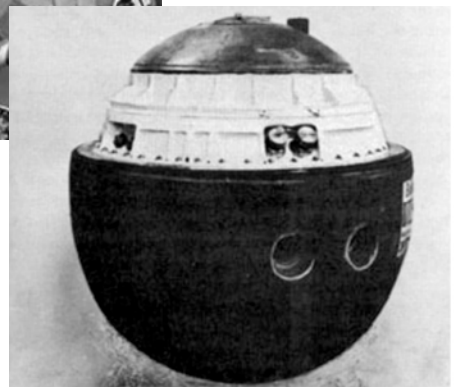
Luna 12 Image

1966 - 1969 Success at the Moon and Venus, but Mars eludes

Venera 4 *- Inside the Venusian Atmosphere Oct 18, 1967*



Last T - 262 C
Last P - 18 bar
Altitude - 24 km…

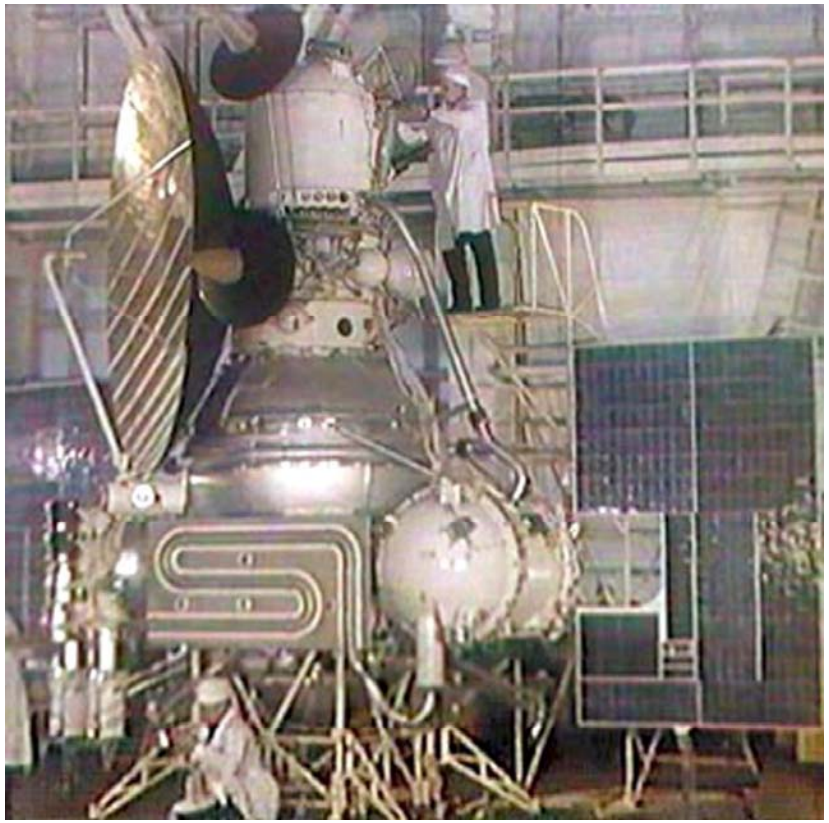


CO2	>90%	Derived @ surface:
N2	< 2.5%	442 C
O2	0.4-1.6%	90 bar
H2O	0.05-0.70 %	

Venera 5 and 6 *follow up in May 1969 – both cease at 27 bar, 18 km*

1966 - 1969 Success at the Moon and Venus, but Mars eludes

A bold new program for Mars goes bust



Mars 69 under test at Lavochkin
Final launch mass 4850 kg

New & demanding goal - soft landing
Comprehensive science objectives defined
1969 campaign to get atm & ephemeris data
Upstage Mariner 69 flybys and 71 orbiters

New heavy design for Proton launch
3yr new development challenge
Diverted by rush to succeed at Venus in ‘67
Lunar spacecraft based design fails
13 month for redesign…
3574 kg Orbiter with 280 kg Probe
Probe to be deployed from orbit
Probe deleted late: mass & test problems
Replaced with orbital module

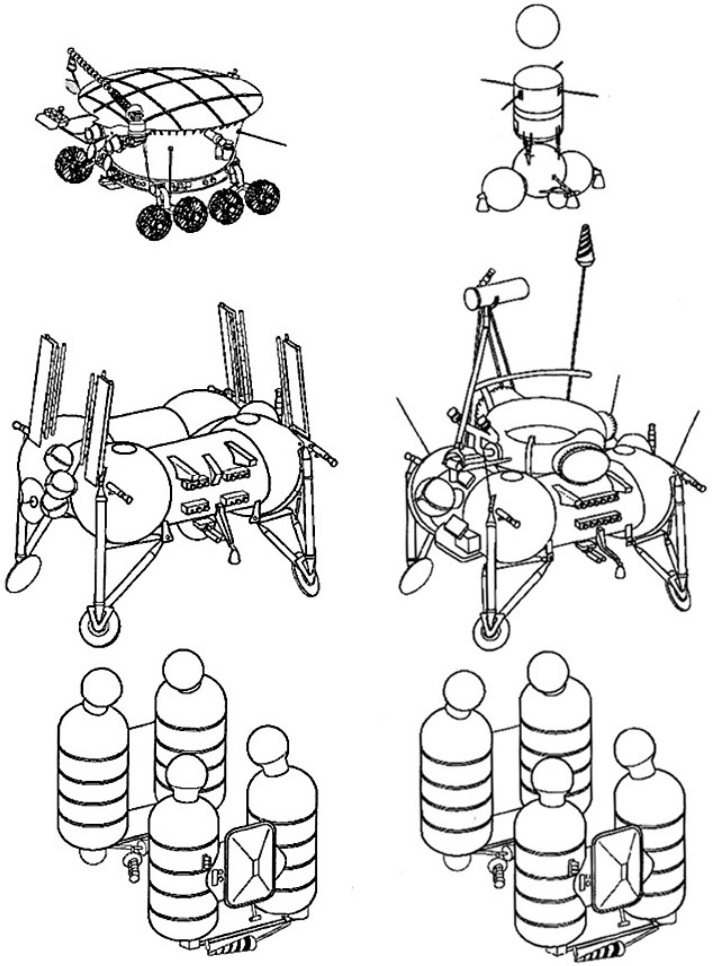
Both Protons exploded
Third stage on March 27, 1969
Booster on April 2, 1969
Missions virtually unknown in West…

1969 - 1976 Robotic Achievements in the Shadow of Apollo

New 5800kg Robotic Lunar Rovers and Sample Return Spacecraft

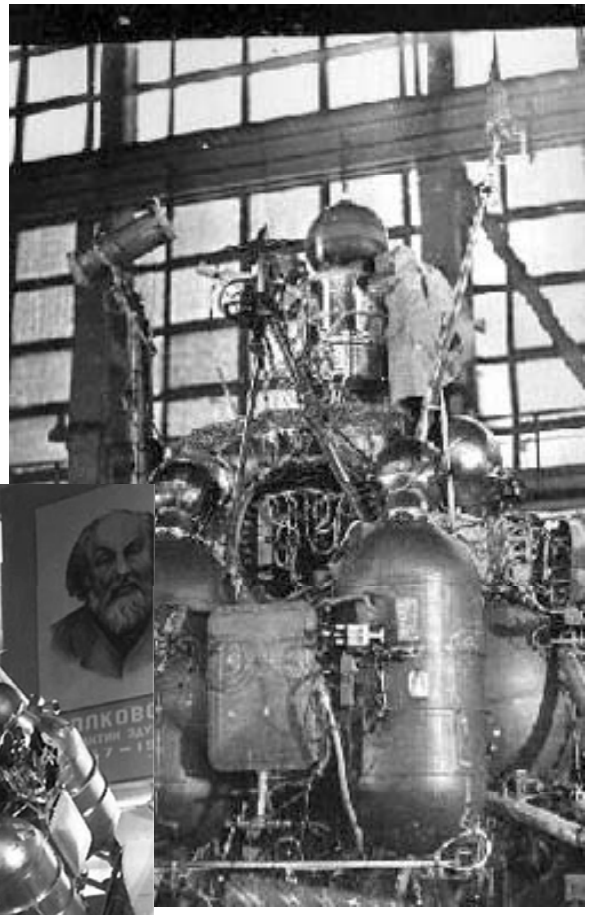
Rover

Sample Return



Used new Proton-K launcher

Luna 16



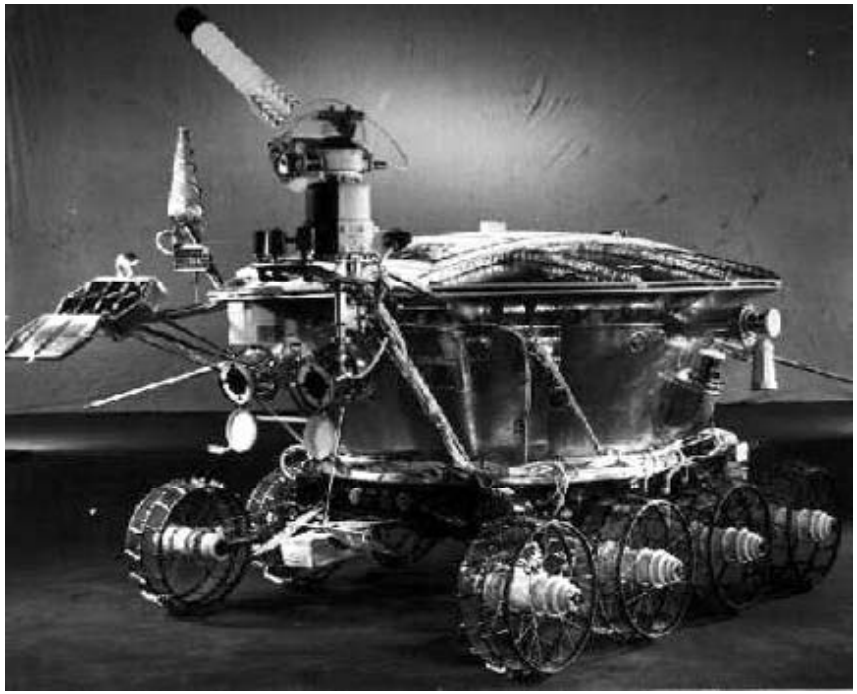
Luna 17

1969 - 1976 Robotic Achievements in the Shadow of Apollo

Robotic Lunar Rovers and Sample Return

Rover Launch History

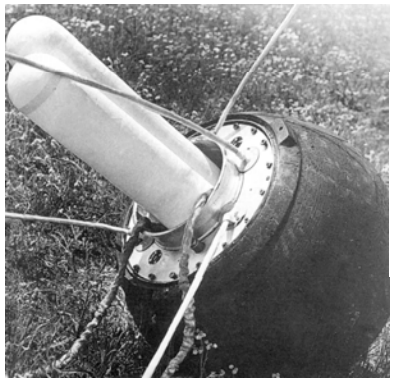
1969, Feb 19 Launch failure
1970, Nov 10 **Luna 17**/Lunokhod 1
1973, Jan 8 **Luna 21**/Lunokhod 2



First Robotic Lunar Rover - Lunokhod 1

Sample Return Launch History

1969, Jun 14 Launch failure
1969, Jul 13 **Luna 15**, crashed
1969, Sep 23 Launch failure
1969, Oct 22 Launch failure
1969, Feb 6 Launch failure
1970, Sep 12 **Luna 16**, success
1971, Sep 2 **Luna 18**, failed at landing
1972, Feb 14 **Luna 20**, success
1974 Nov 2 **Luna 23**, damaged on landing
1975, Oct 16 Launch failure
1976, Aug 9 **Luna 24**, success



First Lunar Sample Return – Luna 16

1969 - 1976 Robotic Achievements in the Shadow of Apollo

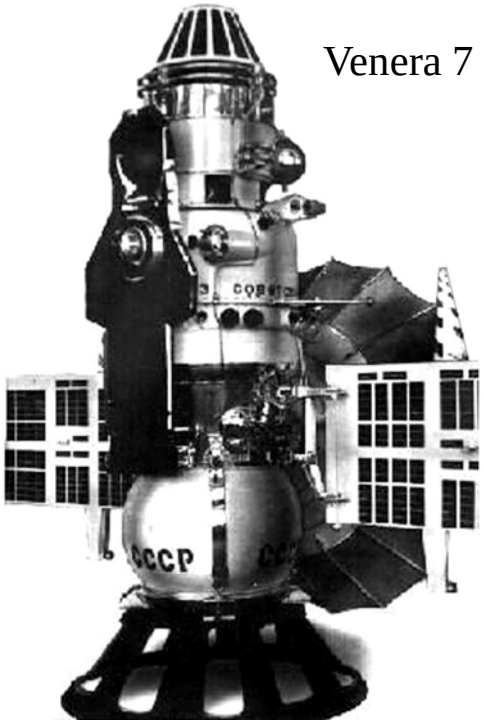
__Luna 19__ (1971) & __22__ (1974) Orbiters

Obtain data for human landing site selection

Surface imaging at high resolution – 100m x 400m
Altimetry measurements of lunar topography
Remote surface composition and dielectric properties
Accurate mapping of lunar gravity field
Radiation, plasma, micrometeorites in lunar orbit

1970 - 1972 Landing on Venus and Mars

First landing on Venus Dec 15, 1970, Venera 7



Venera 7 s/c

Venera 7 capsule

1970

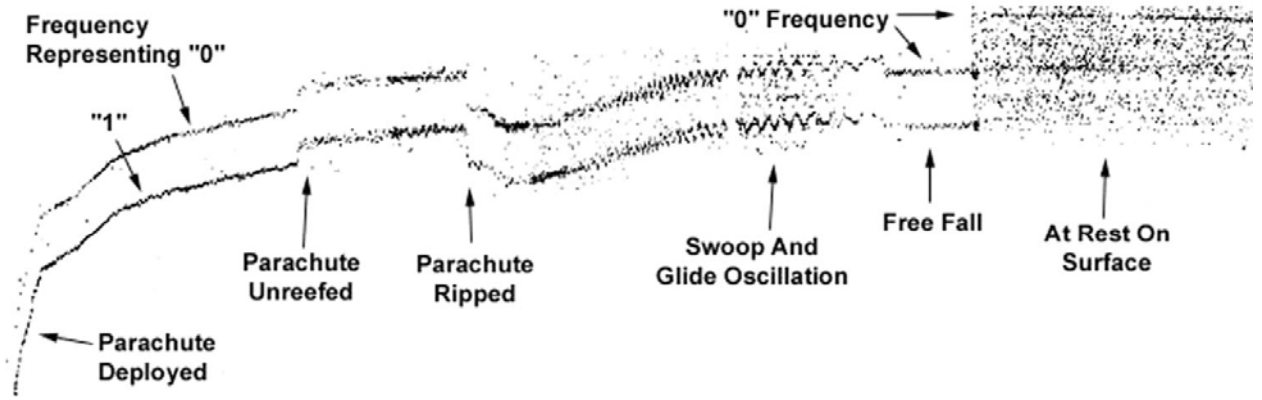
Venera 7 launch Aug 17, 1970
2nd launch fails Aug 22, 1970

Venera 7 lands Dec 15, 1970

1972

Venera 8 launch Mar 27, 1972
2nd launch fails Mar 31, 1972

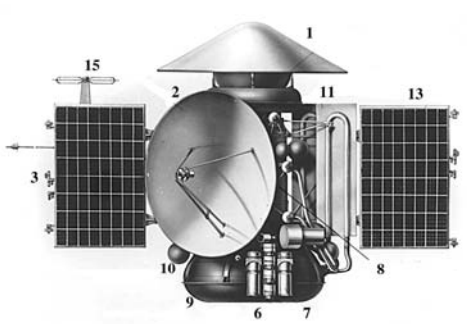
Venera 8 lands Jul 22, 1972

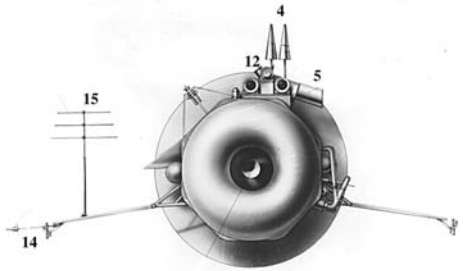


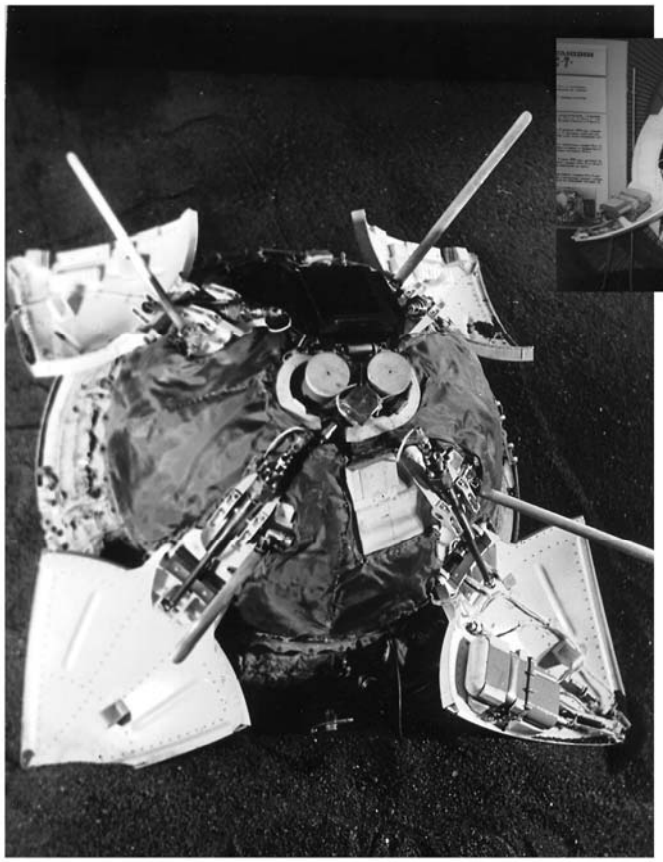
1970 - 1972 Landing on Venus and Mars

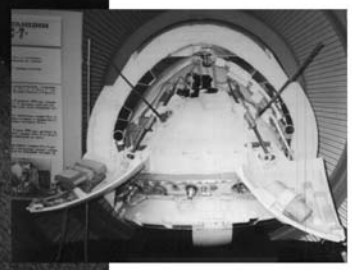
Three spacecraft for Mars landings in 1971

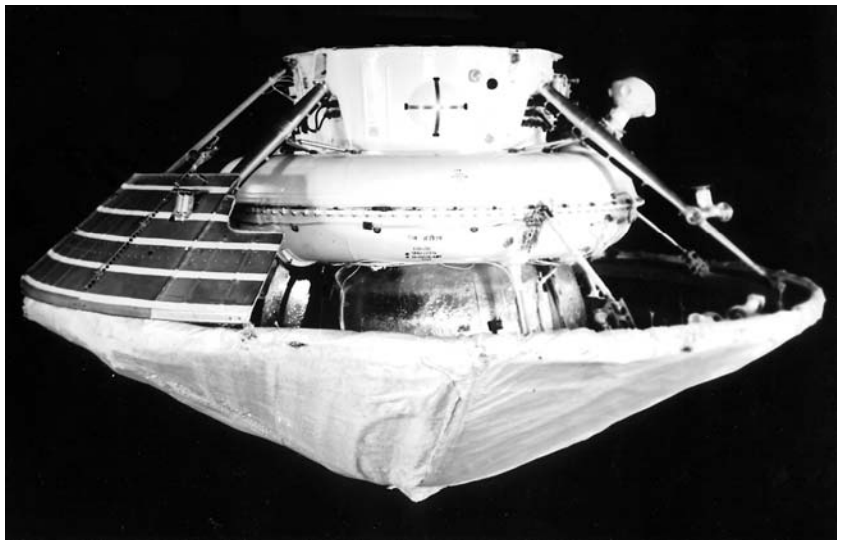
New 5-ton spacecraft design for Proton launch
US refuses to provide Mars ephemeris
Fast ‘pathfinder’ orbiter launch fails
Mars 2,3 orbiter/landers use auto optical nav







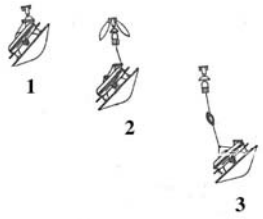


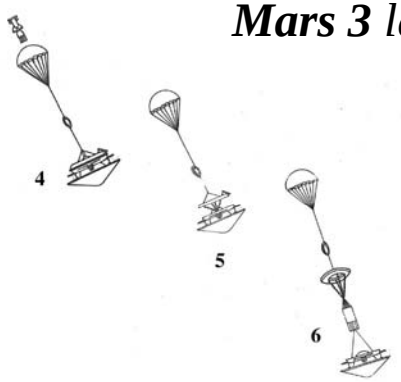


First landing on Mars Dec 2, 1971, Mars 3

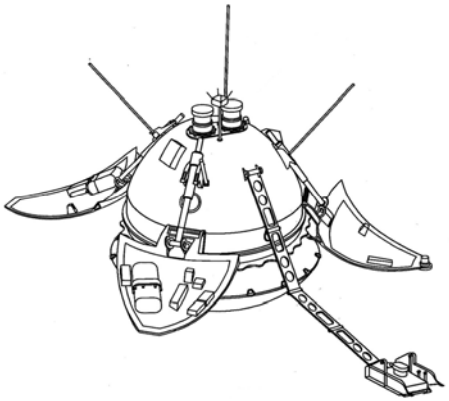
Mars 2 *crashed*

Mars 3 *lander fails 2 min after landing*

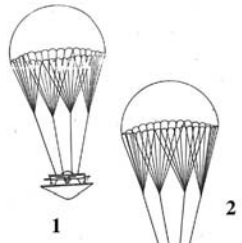


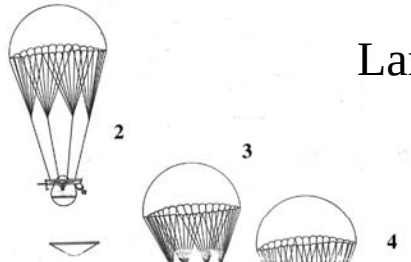


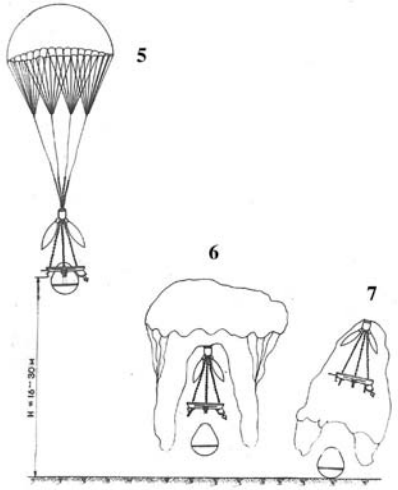
Descent Sequence



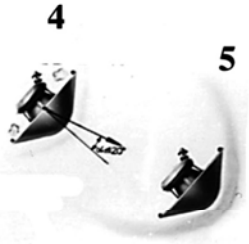
Lander Deployed







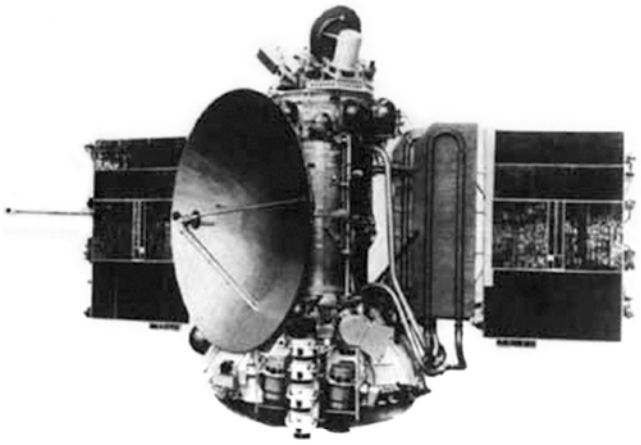
Entry System Deployment



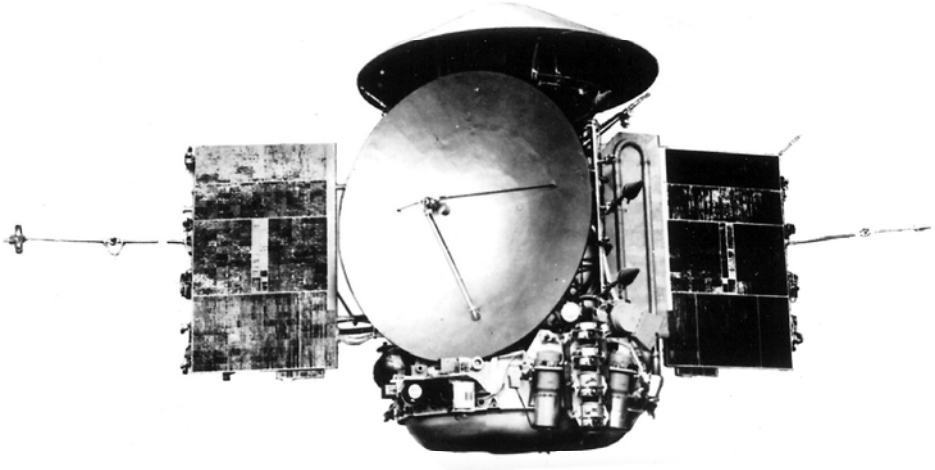
1973 - 1974 The Doomed Mars Fleet

Four spacecraft launched in 1973

Recover 1971 failures, beat Viking to the surface
Could not combine orbiters and landers in 1973
Launched two orbiters and two flyby/landers
Virtual copies of the Mars 71 spacecraft
Except for a crucial substitution of a transistor
All spacecraft plagued with onboard failures



Mars 4,5

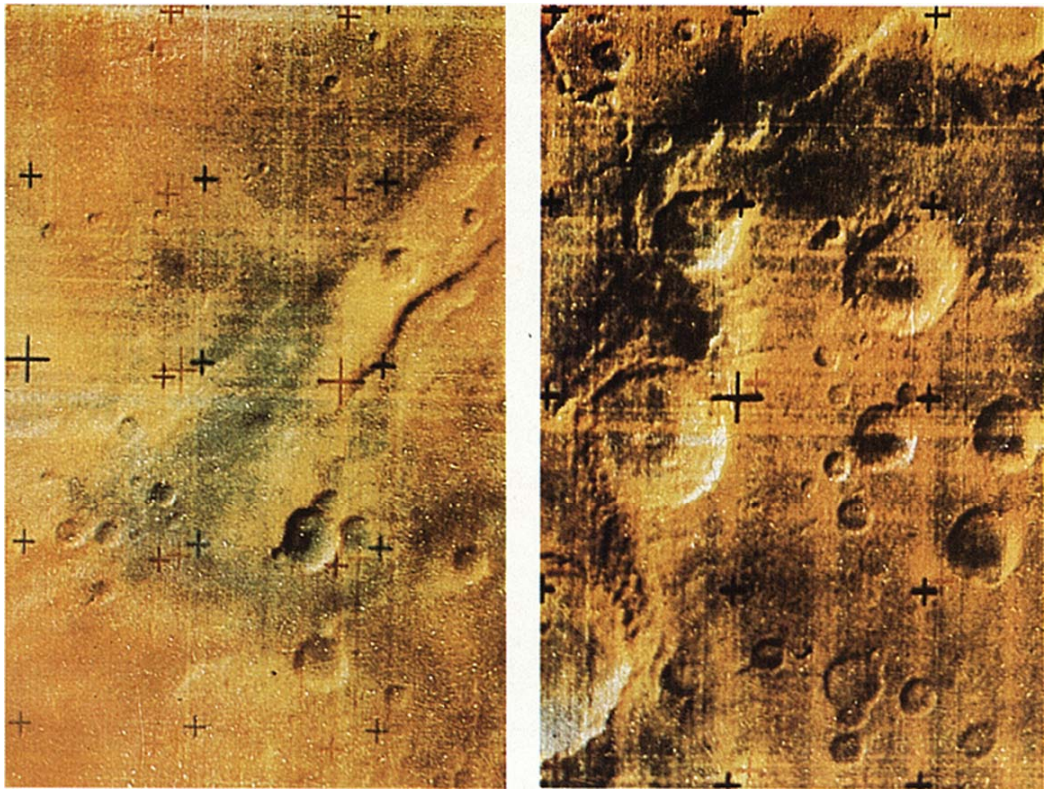


Mars 6,7

1973 - 1974 The Doomed Mars Fleet

Little result for a massive investment

Mars 4 orbiter flew past planet
Mars 5 orbiter short lived
Mars 6 gets T, P, wind data on descent, lost on landing
Mars 7 lander flew past planet



Mars 5 orbiter color images

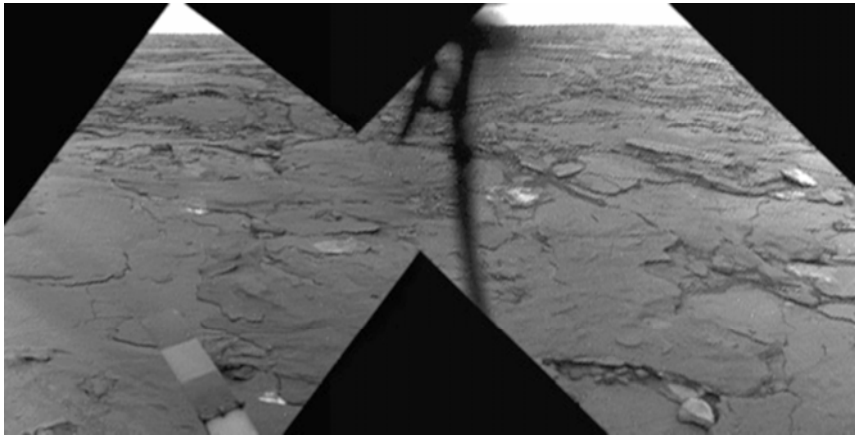
Mars 4 flyby image

Mars 5 orbiter image

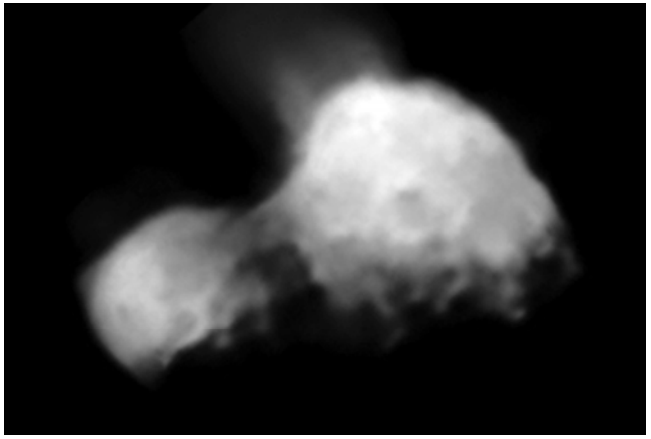
The later years 1975 - 1996

Major successes at Venus and Halley 1975 - 1986

1975-1983: successful sophisticated landers/orbiters at Venus, Veneras 9-16
1984-1986: comprehensive international missions Vegas 1-2 at Venus & Halley



Venera 14



Vega 2

Failure again at Mars 1988 - 1996

1988: heavy, complex, international Phobos 1-2 missions fail at Mars & Phobos:
Phobos 1 lost en route, Phobos 2 gets some data on Mars & Phobos from Mars orbit but fails at Phobos approach
1996: massive, international Mars 96 mission lost at launch

Soviet exploration of the Solar System ends in 1996

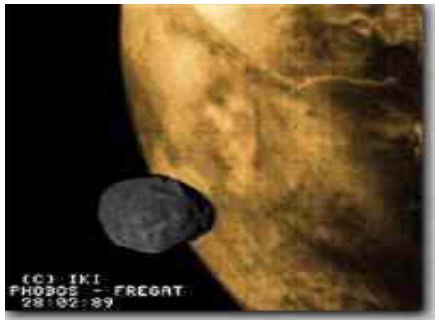
A tragic loss of vision, enterprise and expertise

- courage and enthusiasm to try the previously impossible
- superb expertise in engineering design and development
- innovation in using technology available to accomplish the task
- masters of materials development and engineering
- masters of propulsion system engineering
- excellence in celestial mechanics, navigation and guidance
- excellence in automation and software, that later unraveled
- produced a stable of very powerful and readily available rockets

- poor reliability of launch vehicles until mid-1970s
- handicapped by poor electronics technology
- poor system engineering management
- insufficient ground systems testing
- complex, entangled, heavy-handed national system of control & supply

Russian exploration of the Solar System after 1996

"Rumors on my death are too exaggerated" ***Mark Twain***



- **Disintegration of the former Soviet Union followed social-economical turmoil dramatically impacted on the Russian space program, specifically the Solar exploration**

- **Space budget was shrank down many folds, the lion share going for MIR orbital station operations support, MIR-Shuttles docking, and then ISS**

- **Space facilities were partially destroyed, cooperative links broken, many skilled personnel in space science and technology lost**

- **Mars 96 failure significantly worsened the situation, the planned missions and blue print for the planetary explorations have been abandoned**

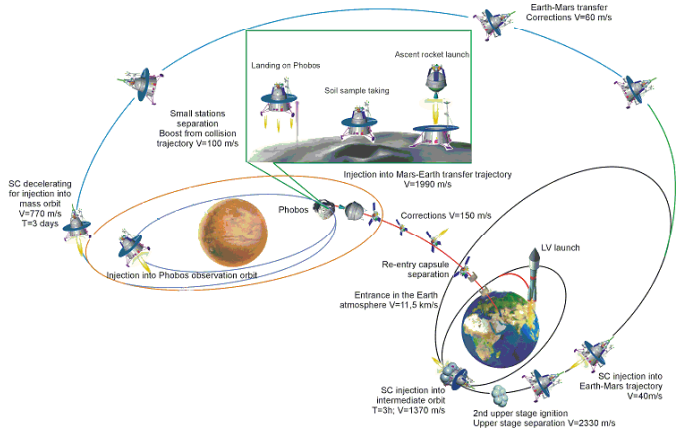
Russian exploration of the Solar System after 1996 (cont)

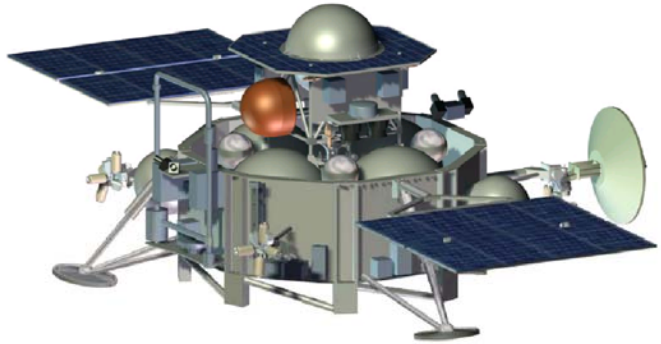
- **The concept of basic spacecraft of new generation for Solar system study was developed (*starting by a small enthusiastic team of scientists and engineers*) during 1996 – 2000**

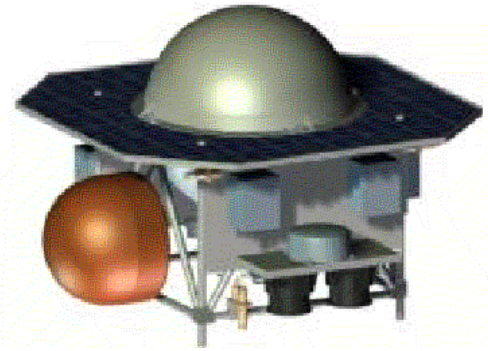
- **It underlined PHOBOS-SOIL mission with good scientific objectives, modern technology and robust engineering**

- **Because of limited budget the mission was three times postponed and finally failed in 2011 launch not leaving LEO**

- **Basically, the failure was caused by the factors rooted in the destroying 1990s which sequels have not been yet overcome though lessons were learned**

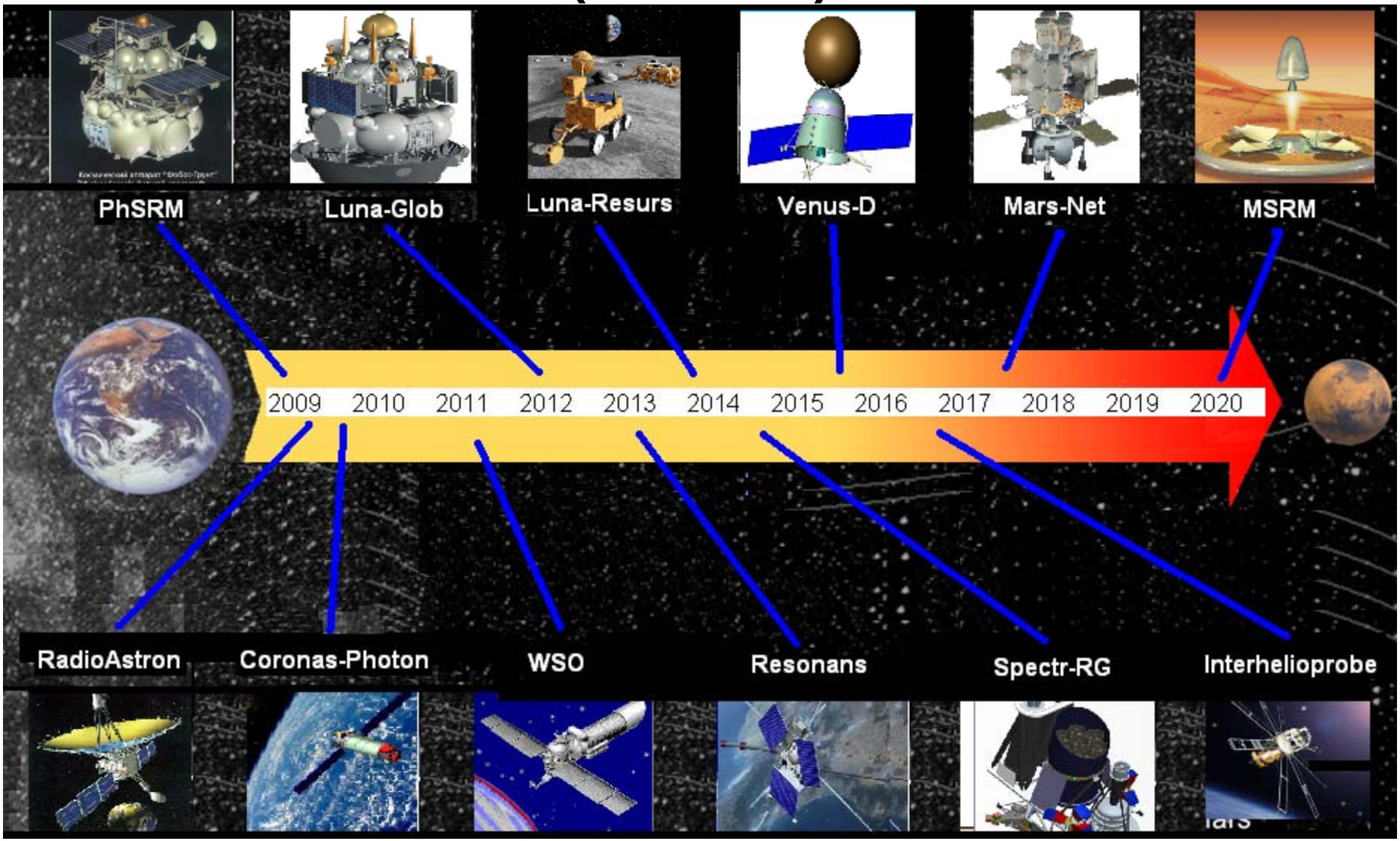






RUSSIAN SPACE PROGRAM on SCIENCE

(as of 2011)



source: http://www.esa.int

Lessons Learned: A Perspective

"With the recent failure of the Phobos-Grunt probe the Russian planetary exploration program is once again in the news and its leaders are on the hot seat in Russia. Perhaps it would be wise before voicing criticism of this failure to read this history. It will demonstrate that planetary scientists and engineers in the Soviet Union/Russia have been working with minimal resources, poor political support, and less than optimal technologies for many years. Despite that reality, they have enhanced understanding of the solar system in fundamental ways. Phobos-Grunt must be viewed as part of a long train of missions over the years. I hope it is not the last such mission undertaken."

David M Harland: **Note on an Important Book:**

Soviet Robots in the Solar System: Mission Technologies and Discoveries