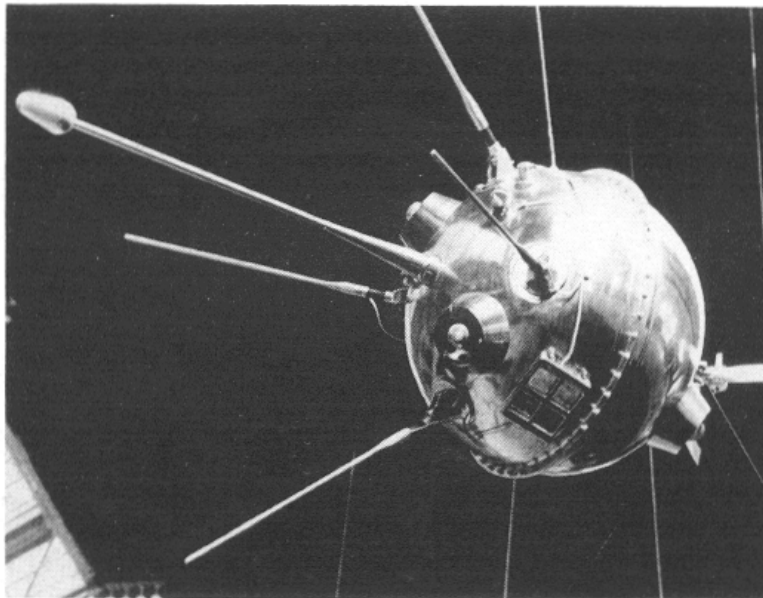


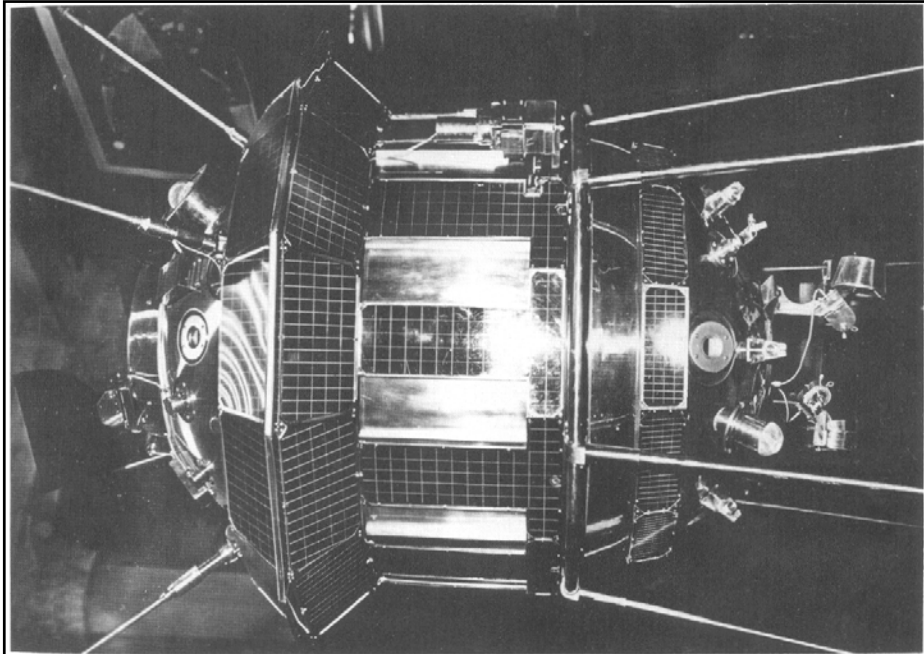
The Greatest Engineering Race:  
Russia vs USA in  
The Race to Space  
Part 2: The Moon & Space Stations  
By Glenn Chapman



*Luna 2.*

Russian Luna 1: Jan 2 1959: First to escape velocity

Luna 2 hits Moon Sept 12, 1959 387 Kg



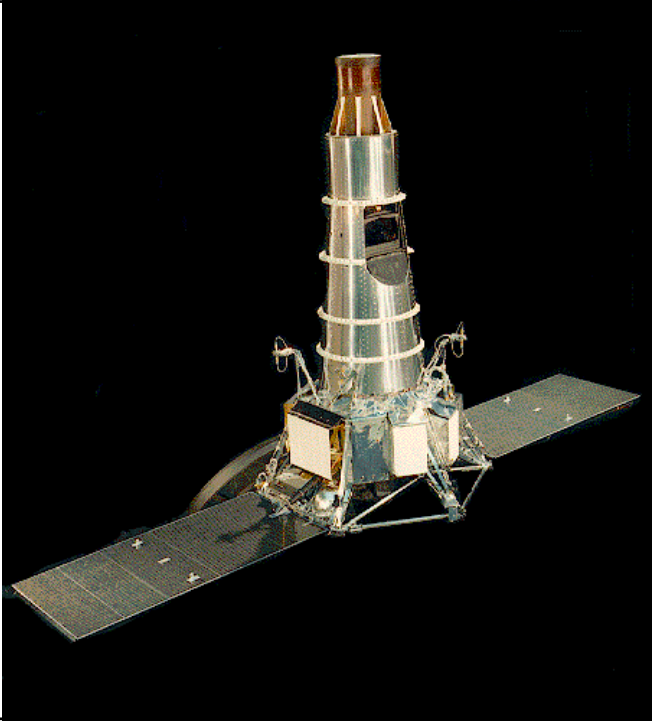
**Luna 3 Oct 4, 1959 orbit moon**  
**279 Kg**

*Soviet drawing of Luna 3. Key: 1 Camera system (thermal doors closed) 2 gas-jet nozzles 3 solar sensor 4 solar cells 5 thermal shutters 6 thermal protection 7 antennae 8 scientific instruments*

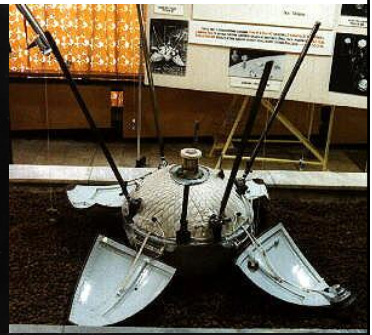
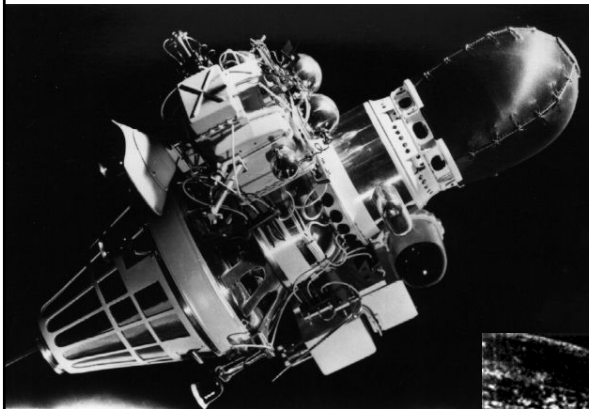
**Luna 3 Backside of Moon**



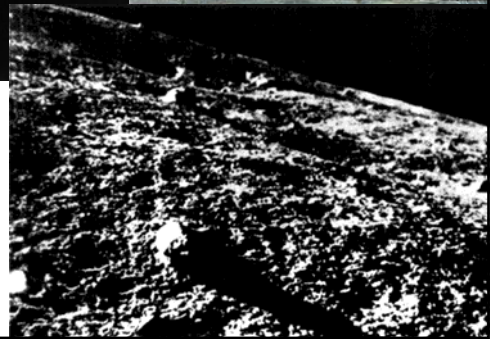
**Ranger 7**  
**1st US Moon Success**  
**Hits Moon July 31 1964**  
**4,308 Photos**  
**Ranger program starts**  
**1961**  
**Rangers 1-6 fail**



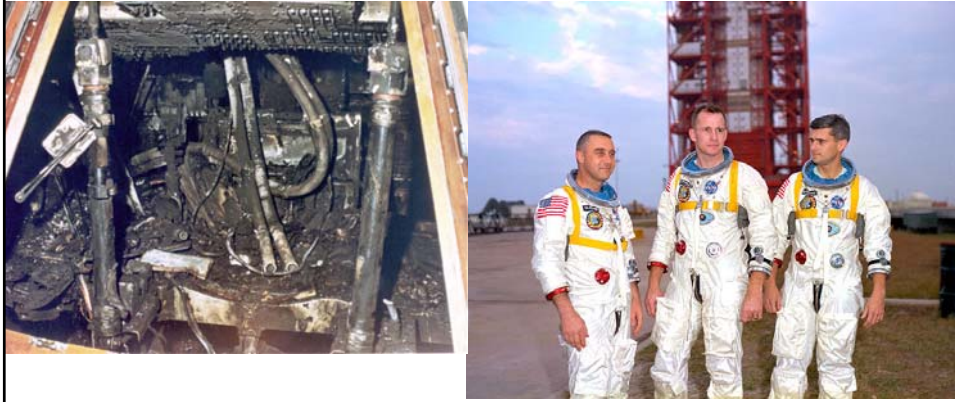
**Russian Luna 9 Soft lands Feb 3 1966**



**1500 Kg main probe**  
**99 Kg lander**  
**Lasted 6 days on surface**



**Apollo 1 Fire Jan 27, 1967:  
US program stops for 2 years**

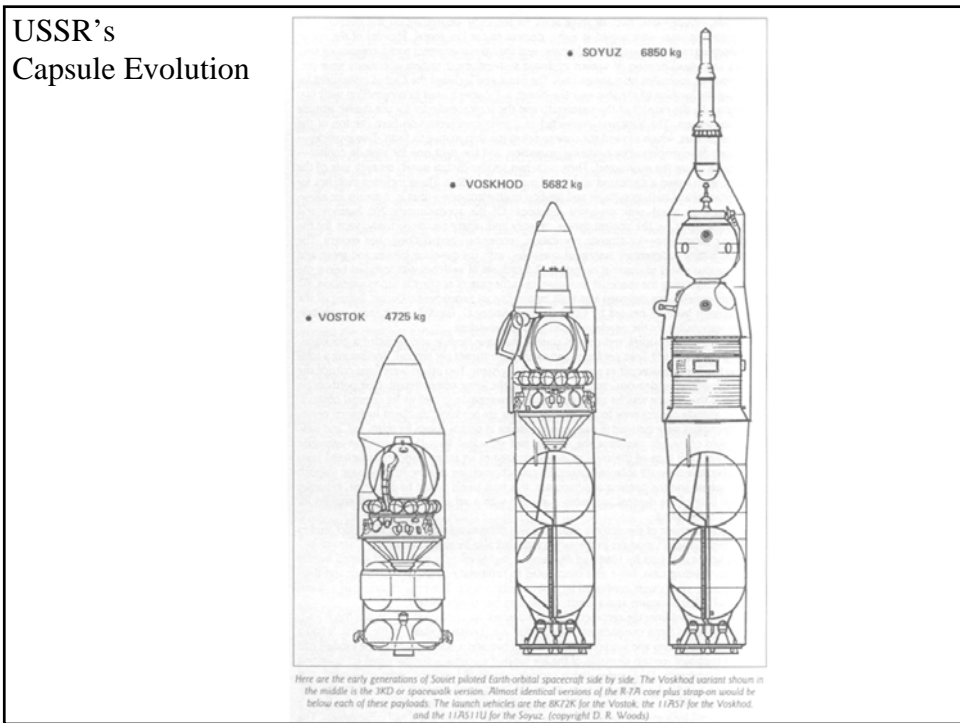
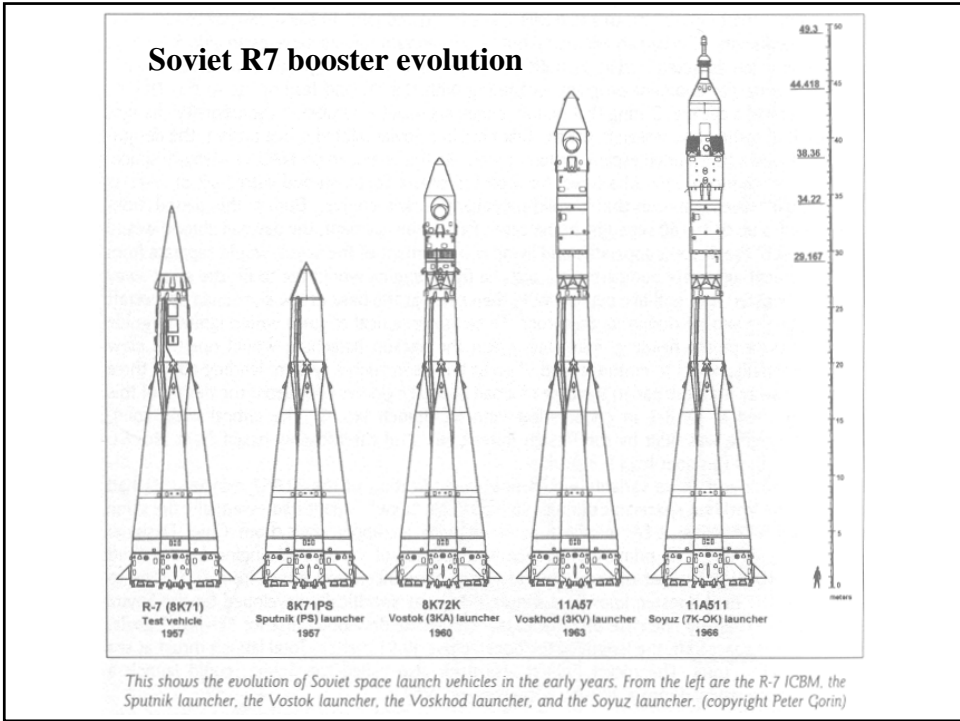


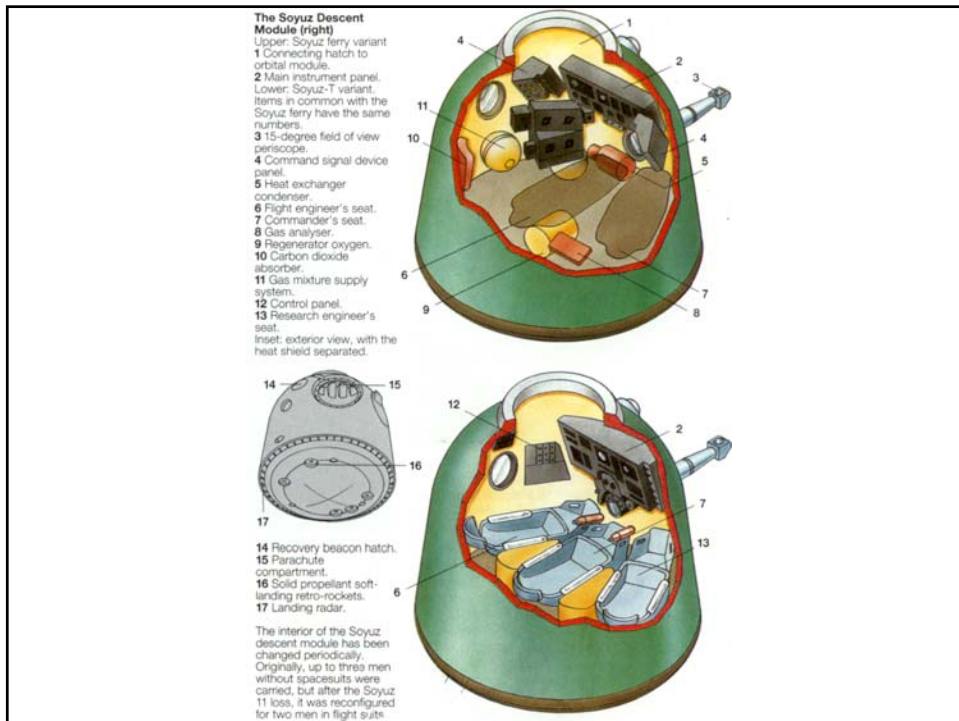
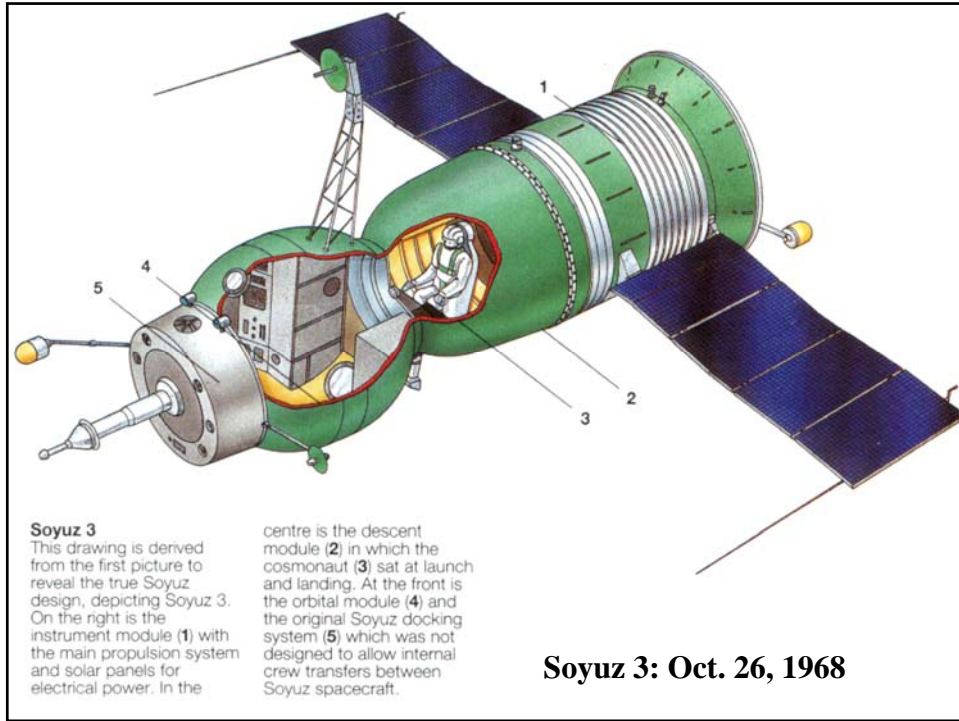
**Gus Grissom, Ed White, Roger Chaffee**

**Soyuz 1 Apr. 23 1967: Komarov dies**



**Vassily Mishin in charge**





**Soyuz Landing  
Rocket assisted**



*Above: The landing of a Soyuz descent module. The dust is not caused by the impact, but by the solid propellant retro-rockets firing.*

**USA Saturn program**



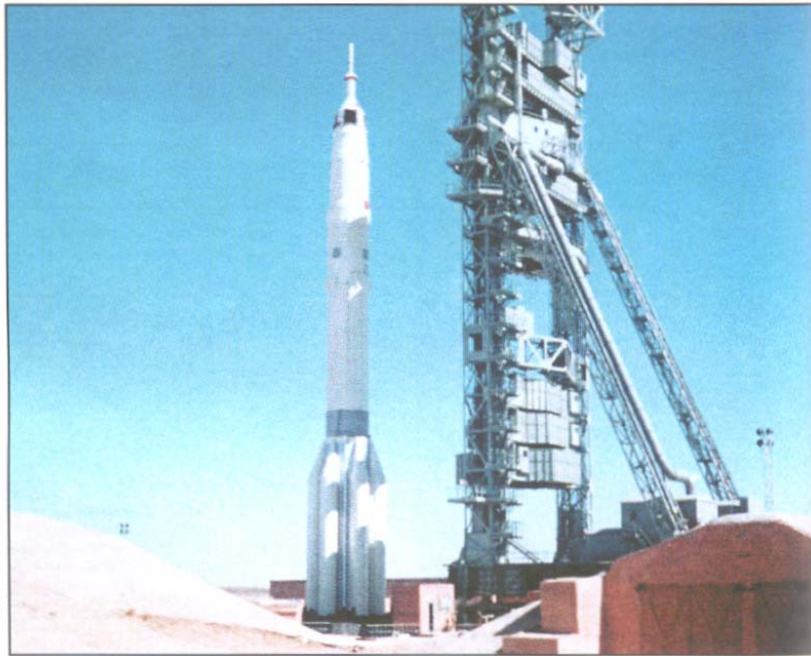
**Saturn I: 670 Tonne thrust  
Program starts July 1958  
1<sup>st</sup> orbital launch Jan 29, 1964  
Target 15Tonne to orbit**

**Saturn V Moon Rocket  
design starts July 1961**

**USSR**  
**Proton Booster**  
**July 1965**

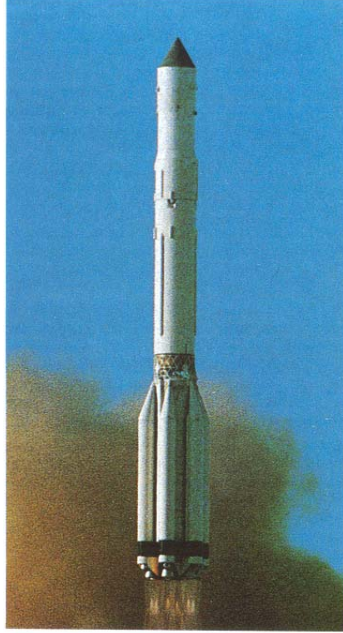


The Proton launch vehicle with the LI complex on the launch pad.





**USSR  
Proton Booster**



*Above: The four stage variant of Proton.  
For Salyut missions the station replaces  
the fourth stage and payload.*

**Apollo 7 Oct 11, 1968 orbital test**



**Eisele, Schirra, Cunningham**

**Saturn 1B: 15 T to orbit**

**Time Cover  
Race to the Moon  
Dec. 1968**



**Saturn V  
first success  
Nov 11, 1967**

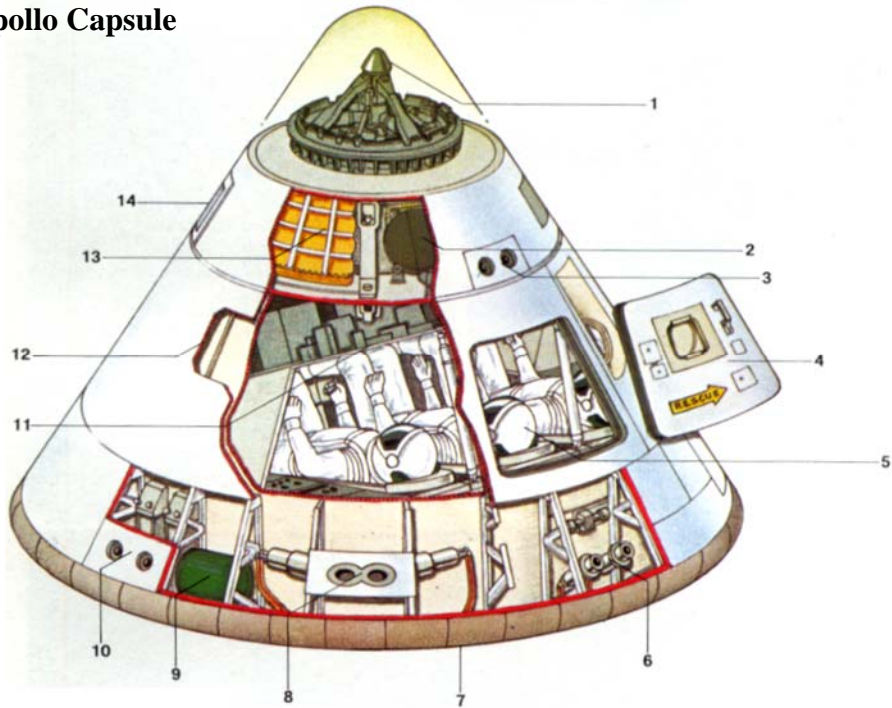


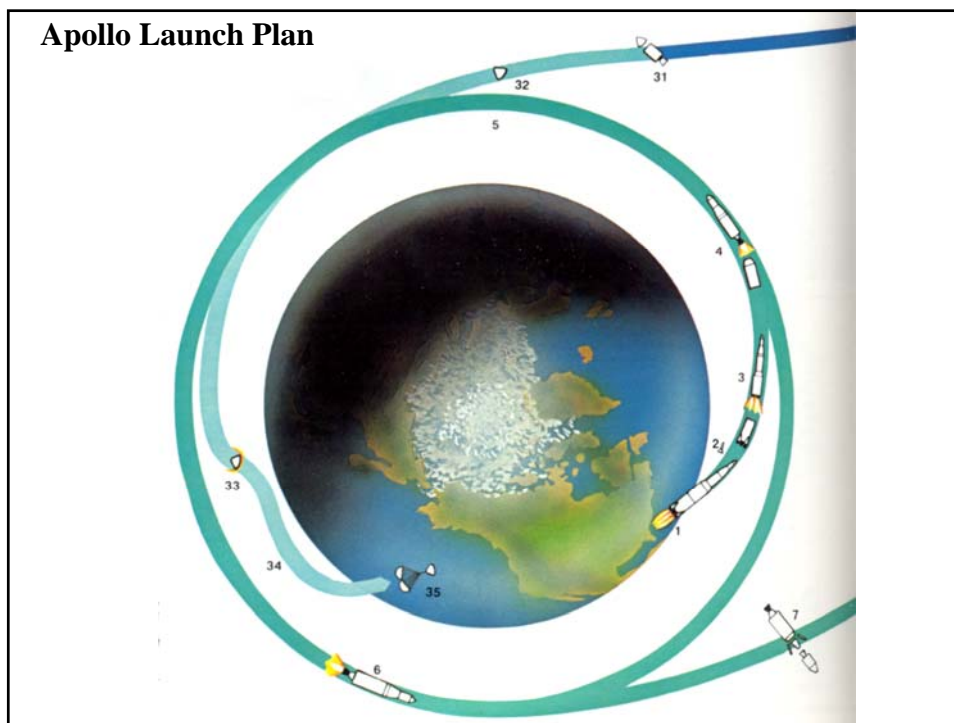
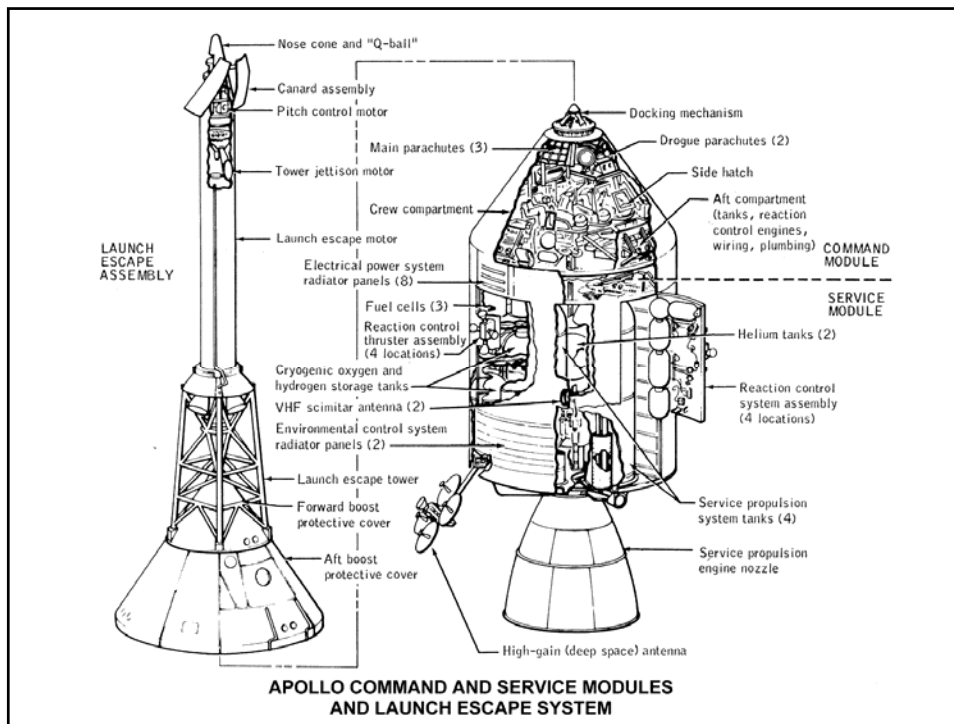
**Apollo 8**  
**Dec. 21 1968**

**Lovell, Anders, Borman**



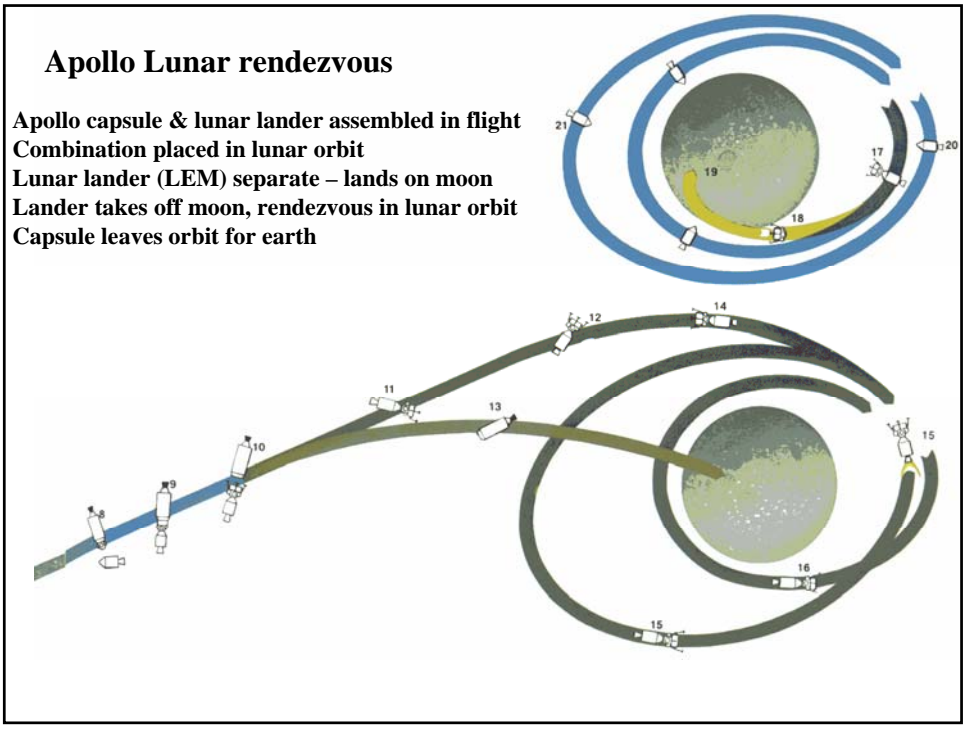
**Apollo Capsule**





## Apollo Lunar rendezvous

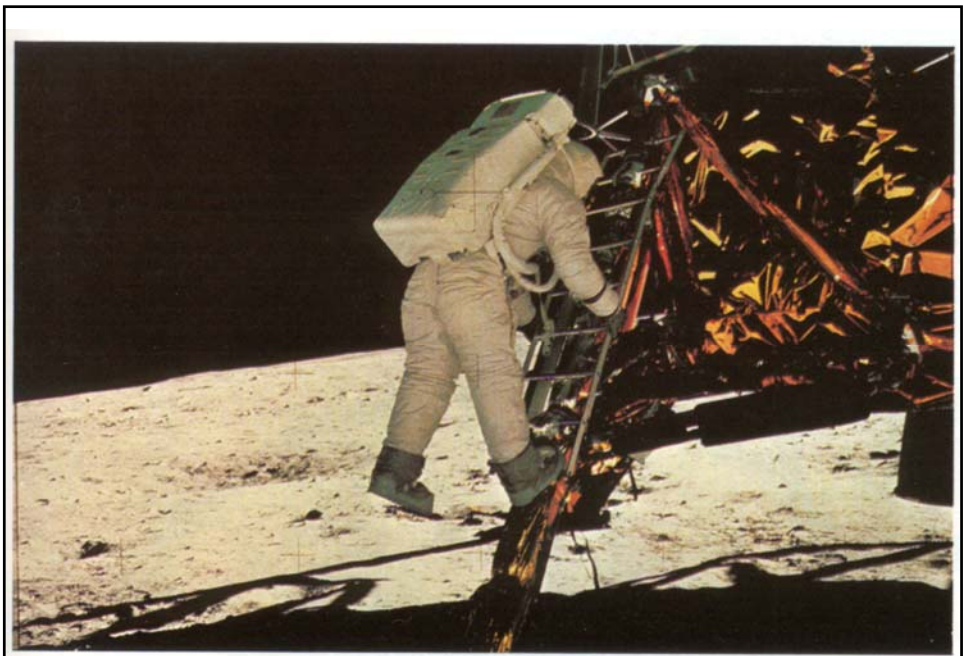
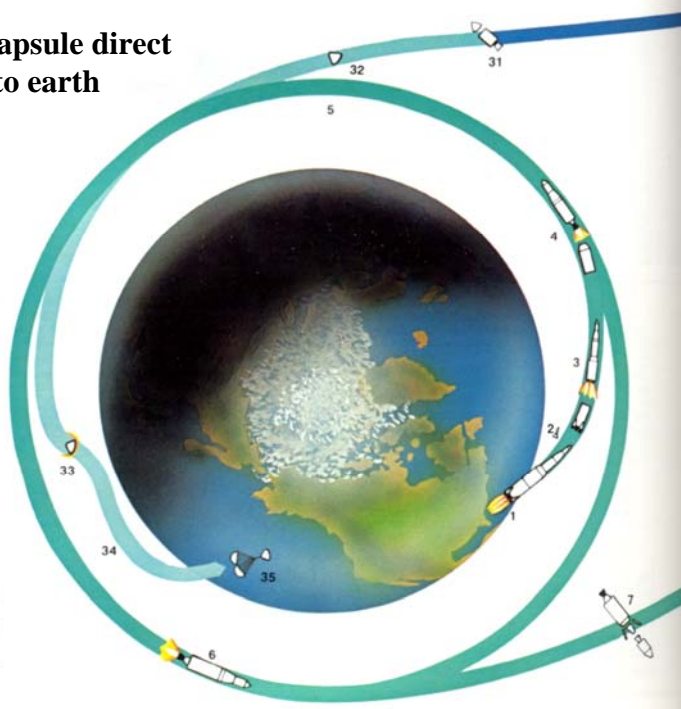
Apollo capsule & lunar lander assembled in flight  
Combination placed in lunar orbit  
Lunar lander (LEM) separate – lands on moon  
Lander takes off moon, rendezvous in lunar orbit  
Capsule leaves orbit for earth



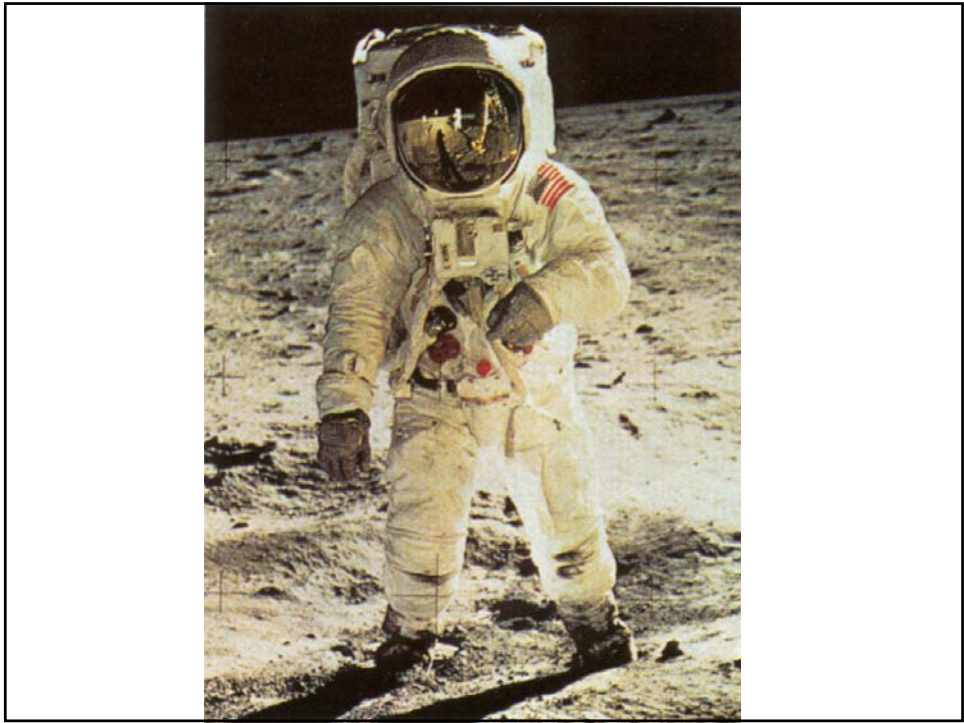
## Lunar Excursion Module



**Apollo capsule direct reentry to earth**

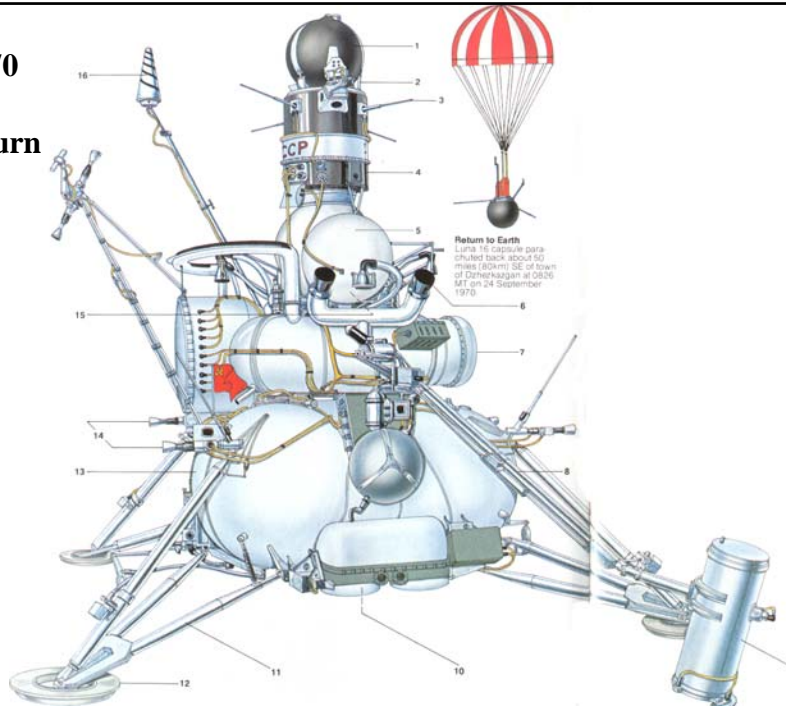


**Apollo 11 July 20, 1969**



**Last Mission: Apollo 17, Dec. 1972**

**Luna 16**  
**Sep. 12 1970**  
**First robot**  
**sample return**

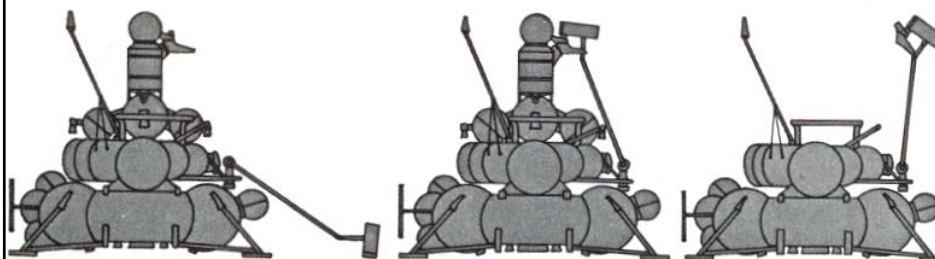


**Luna 15, 16, 20 Sample return operation**

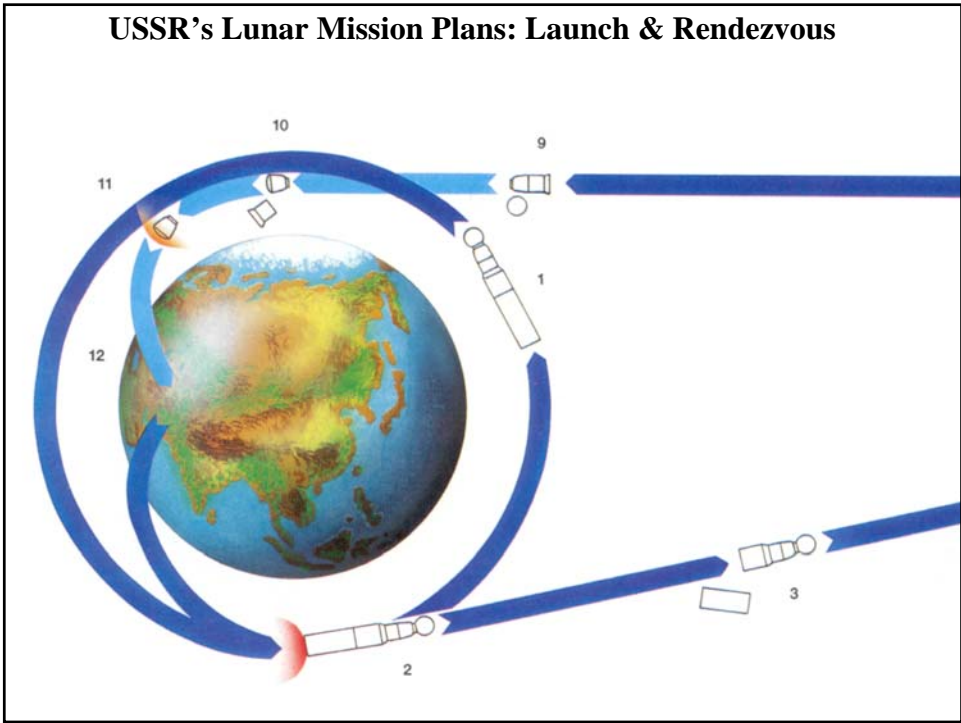
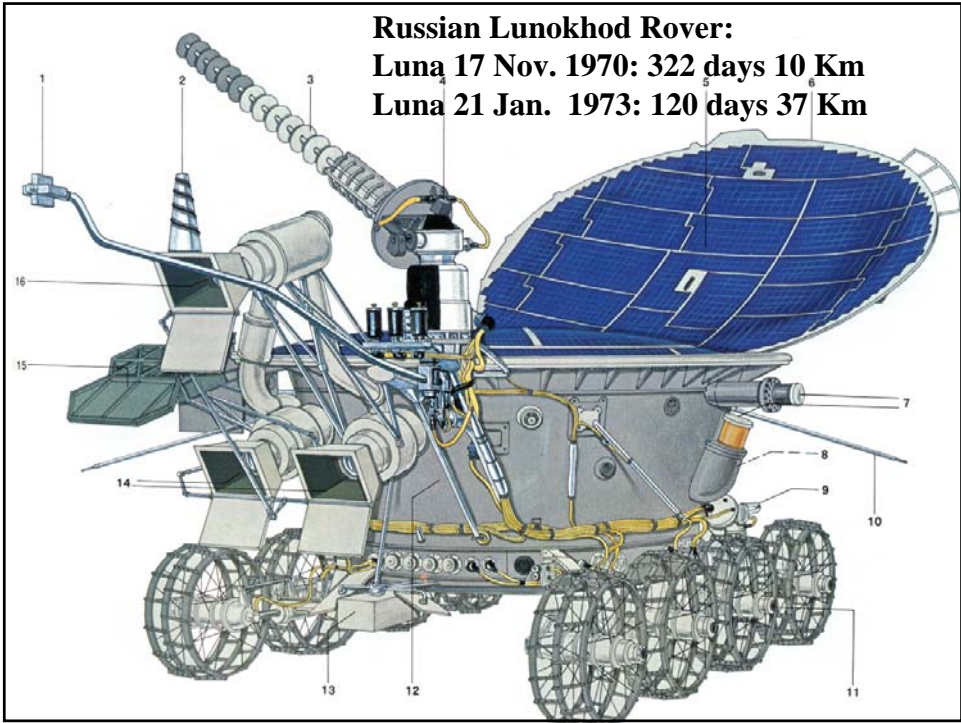
**Lunar Operations**  
 After Luna 16 had been manoeuvred in lunar orbit, an Earth command put it into a descent trajectory by firing the main descent engine. When the craft was within 65.6ft (20m) of the surface, this was switched off and two vernier engines com-

pleted the touchdown. Ground controllers sent the command which lowered the drilling rig to the surface. After drilling had been completed, the rig was raised and the hollow drill containing the sample deposited in the spherical capsule at the top of the descent stage.

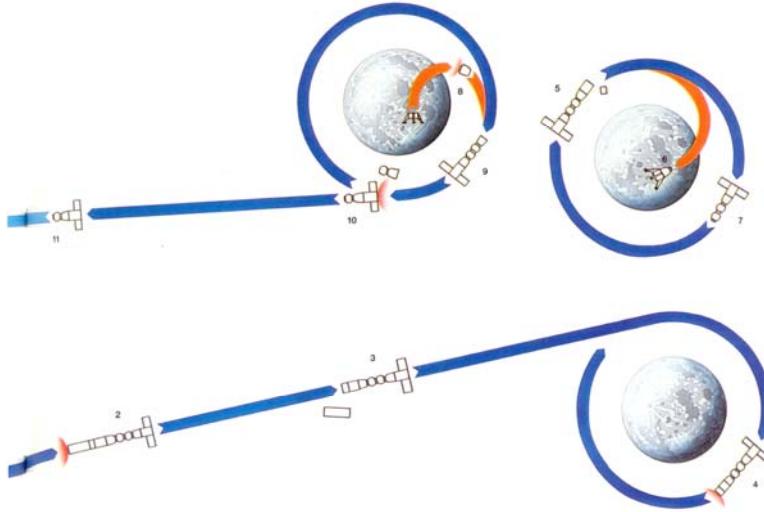
After 26hr 30min on the Moon, the ascent stage was launched back to Earth without any correction to its trajectory. Instruments in the descent stage, which remained on the Moon, telemetered radiation and temperature data and transmitted them back to Earth.



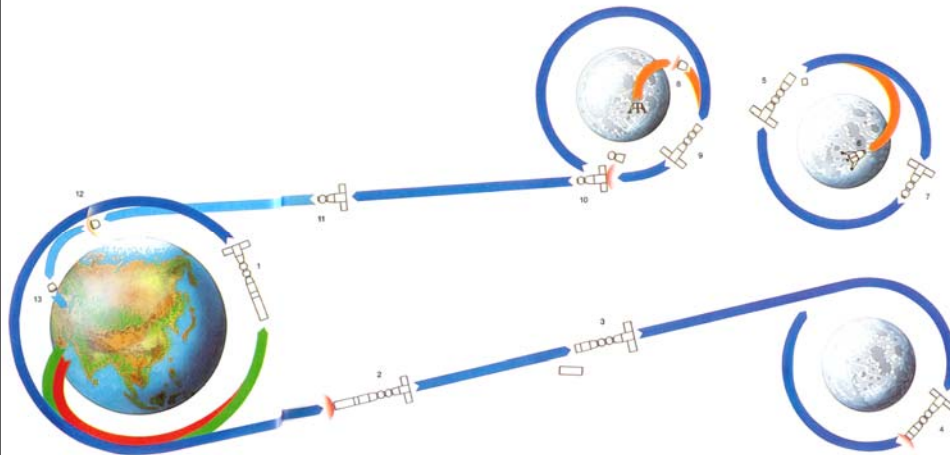




### USSR's Lunar Orbiting and Landing



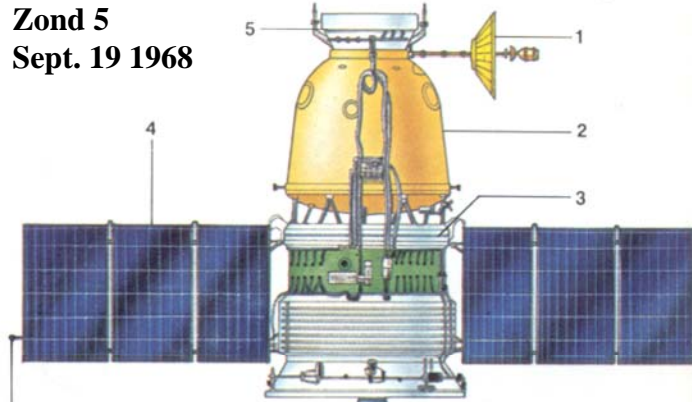
### USSR's Lunar Return and Landing



**Zond Circumlunar Spacecraft**

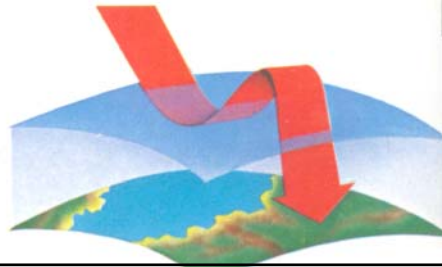
- 1 High gain antenna
- 2 Re-entry module similar to that of Soyuz spacecraft
- 3 Service module with manoeuvre engine and attitude control system
- 4 Extensible solar panels
- 5 Instrument package

**Zond 5  
Sept. 19 1968**

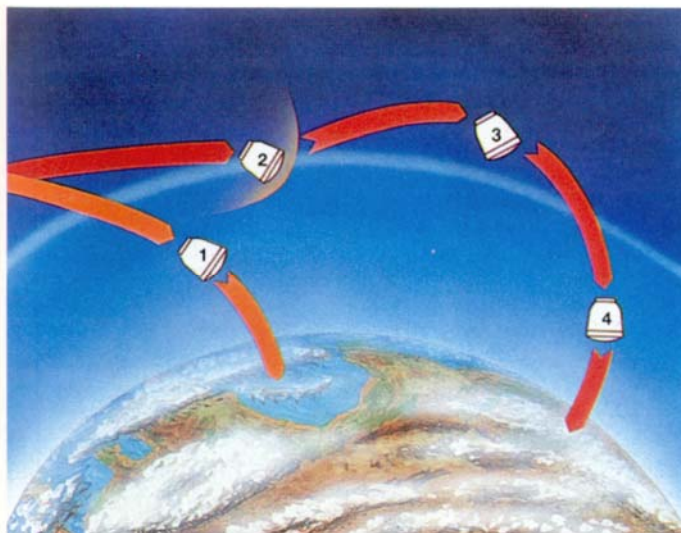


**Skip Re-Entry**

The re-entry capsule had to enter a precise corridor in the Earth's atmosphere only 6.2 miles (10km) wide, 28 miles (45km) above the ground. Then the heat shield end of the capsule was pitched at an angle to create aerodynamic lift making the capsule skip back into space and dropping it back in the



**Zond Skip Reentry**



**Zond Re-Entry Profiles**

The two different Zond re-entry techniques after their circumlunar missions are shown here. Zond 5 (1) made a single high-velocity entry into the Earth's atmosphere, this involving decelerations which were higher than could comfortably be used on a manned mission. Zond 6 made an entry into the upper part of the atmosphere (2) and after losing some of its velocity "skipped" out again (3). A second entry was made (4) at a lower velocity, leading to recovery. This approach had lower decelerations, and could have been used on manned flights. It was thought that a manned Zond mission might have followed Zond 6, but in retrospect it seems that a manned flight was never considered.

## Zond 5 on Landing

*Below: A rare photograph of the Zond 5 descent module bobbing in the Indian Ocean after the first Soviet splashdown on 21 September 1968; it appears to be almost identical with the Soyuz descent module. The open hatch reveals the empty parachute compartment.*



## USSR's N1 Moon Booster

**Started concept 1959**  
**Conflict between Korelev & Glushko**  
**Final design started in 1962**

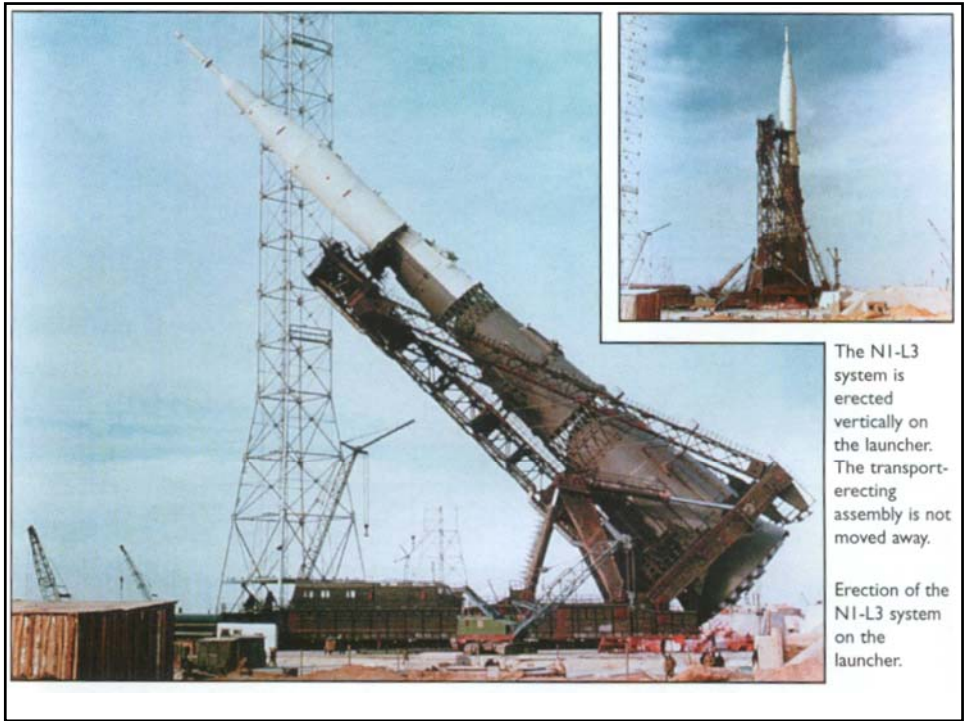


The N1-L3 system on the way to the launching complex.

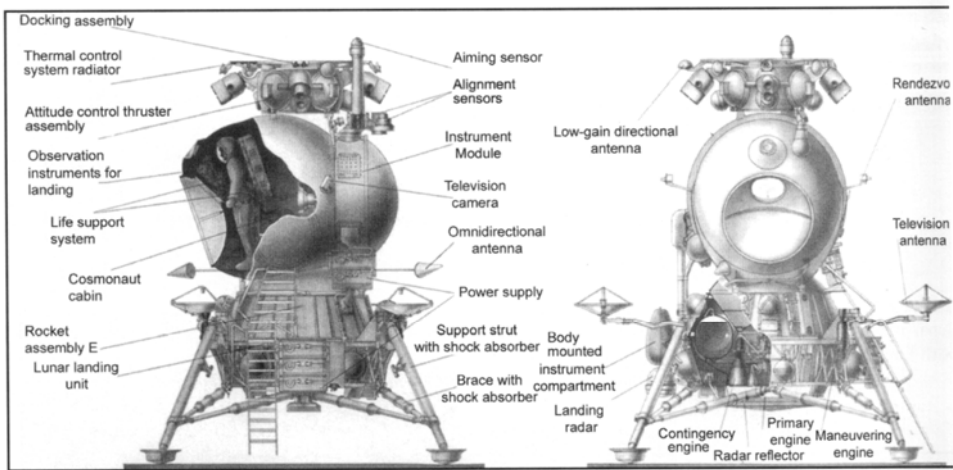
The N1-L3 system near the launch pad.



The N1-L3 space system on the transport-erecting assembly in the assembly building, ready for roll-out to the launch area.

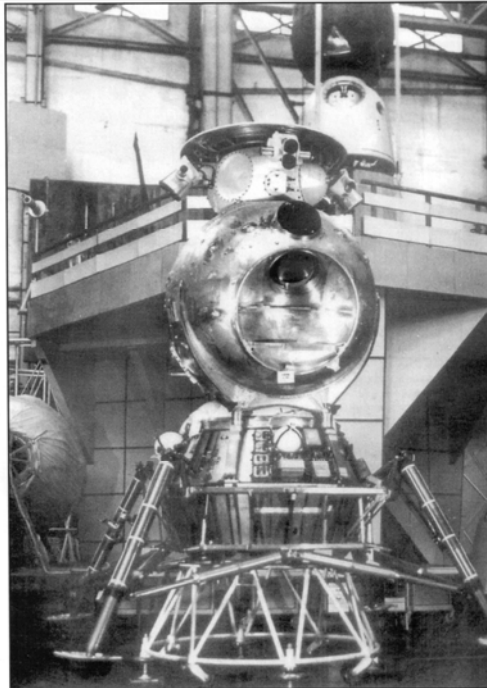


## USSR's Lunar Lander



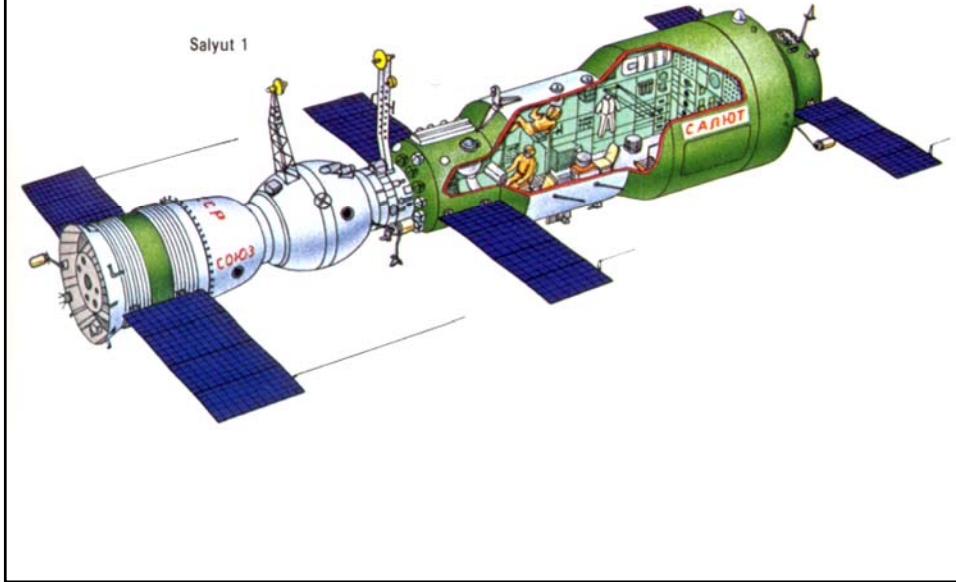
The lunar vehicle consisting of the lunar descent assembly, the cosmonaut's cabin with various systems, and the E rocket unit with main and stand-by engines.

## USSR's Lunar Lander



The lunar vehicle in the shop.

**Salyut 1 Space Station Apr. 1971**  
**Salyut 3 July –Dec 1973**



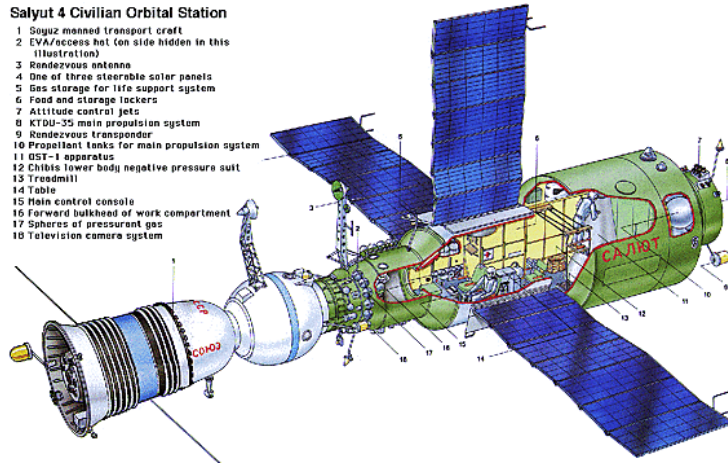
**USA Skylab**  
**May 1973**



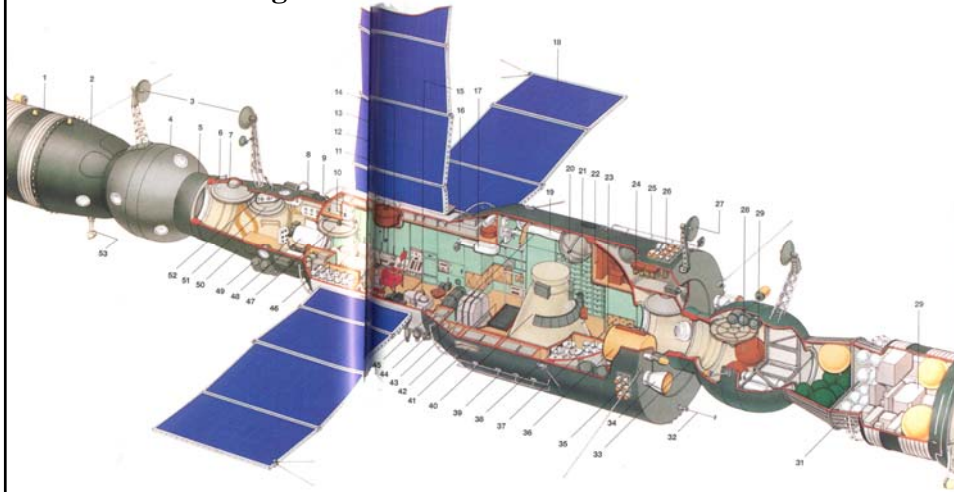
**Soviet Mid program Salyut Space stations**  
**Salyut 4 Dec. 1974-dec 1975**  
**Salyut 5 June 1975-Mar. 1977**

**Salyut 4 Civilian Orbital Station**

- 1 Soyuz manned transport craft
- 2 EVA/access hot (on side hidden in this illustration)
- 3 Rendezvous antenna
- 4 One of three steerable solar panels
- 5 Gas storage for life support system
- 6 Food and storage lockers
- 7 Altitude control jets
- 8 KTDU-35 main propulsion system
- 9 Rendezvous transponder
- 10 Propellant tanks for main propulsion system
- 11 OST-1 apparatus
- 12 Chibis lower body negative pressure suit
- 13 Treadmill
- 14 Table
- 15 Main control console
- 16 Forward bulkhead of work compartment
- 17 Spheres of pressurant gas
- 18 Television camera system



**Salyut 6 Oct. 1977-Jun 1981: 2 ports**  
**16 Soyuz crew, 37 Cosmonauts**  
**11 Progress Tankers**





## Progress Tanker

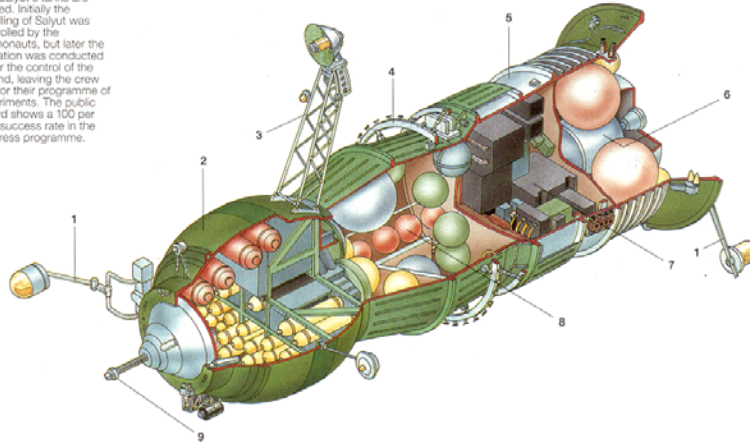
### Progress

The outaway of the Progress re-supply craft clearly shows its Soyuz derivation.

- 1 Short range radar transponder.
- 2 Modified Soyuz orbital module with cargo for the Salyut crew.
- 3 Long range radar transponder.
- 4 Antenna.
- 5 Soyuz instrument module.
- 6 Soyuz KTDU-35 propulsion system.
- 7 Equipment for the automatic control of Progress.
- 8 Tanks for the propellant to be transferred to Salyut and nitrogen pressurant gas.
- 9 Docking probe.

Operations with Progress have been automated as much as possible. When a docking is taking place with a Salyut, the cosmonauts on the station need take no part in the operation – ground controllers do all the work. Dockings are always at the rear of the station, where the propellant lines connecting

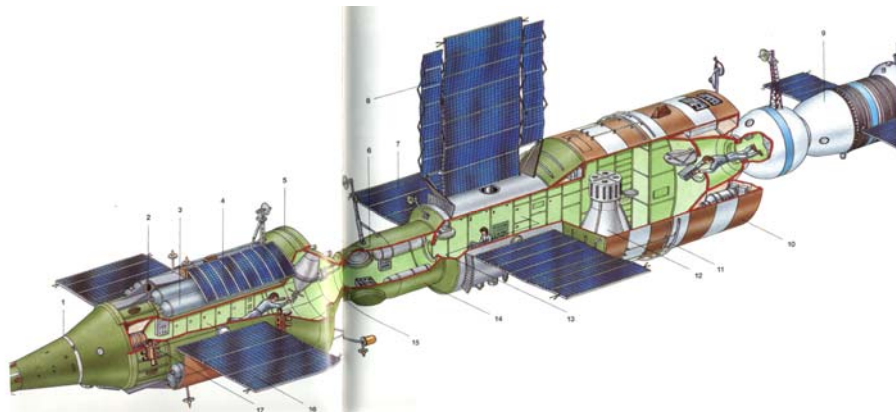
with Salyut's tanks are located. Initially the refueling of Salyut was controlled by the cosmonauts, but later the operation was conducted under the control of the ground, leaving the crew free for their programme of experiments. The public record shows a 100 per cent success rate in the Progress programme.



## Salyut 7 1982-1986

### 2 Docking ports

### Added expansion modules



**Salyut 7 in orbit**

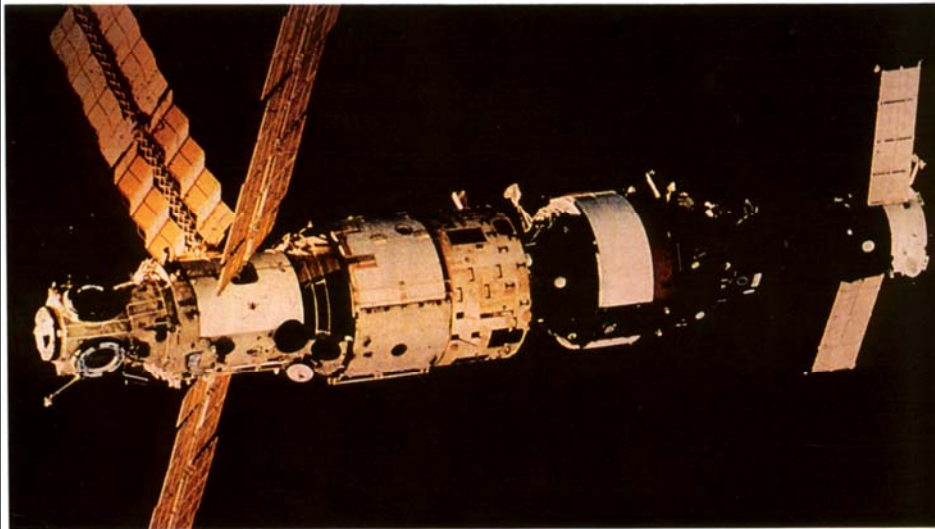
**10 Soyuz visits, 26 Cosmonauts**

**14 progress or modules**



**Mir Space Station Feb 1986**

*Below: A spectacular view of Mir in orbit, with the Kvant module docked at the rear of Mir, and Soyuz-TM 3 docked at the rear of Kvant. The picture was taken from the returning Soyuz-TM 2.*





**The Greatest Engineering Race: Part 3  
Cheap Access to Space  
The New Race to Space &  
The Key to our Future in Space**

