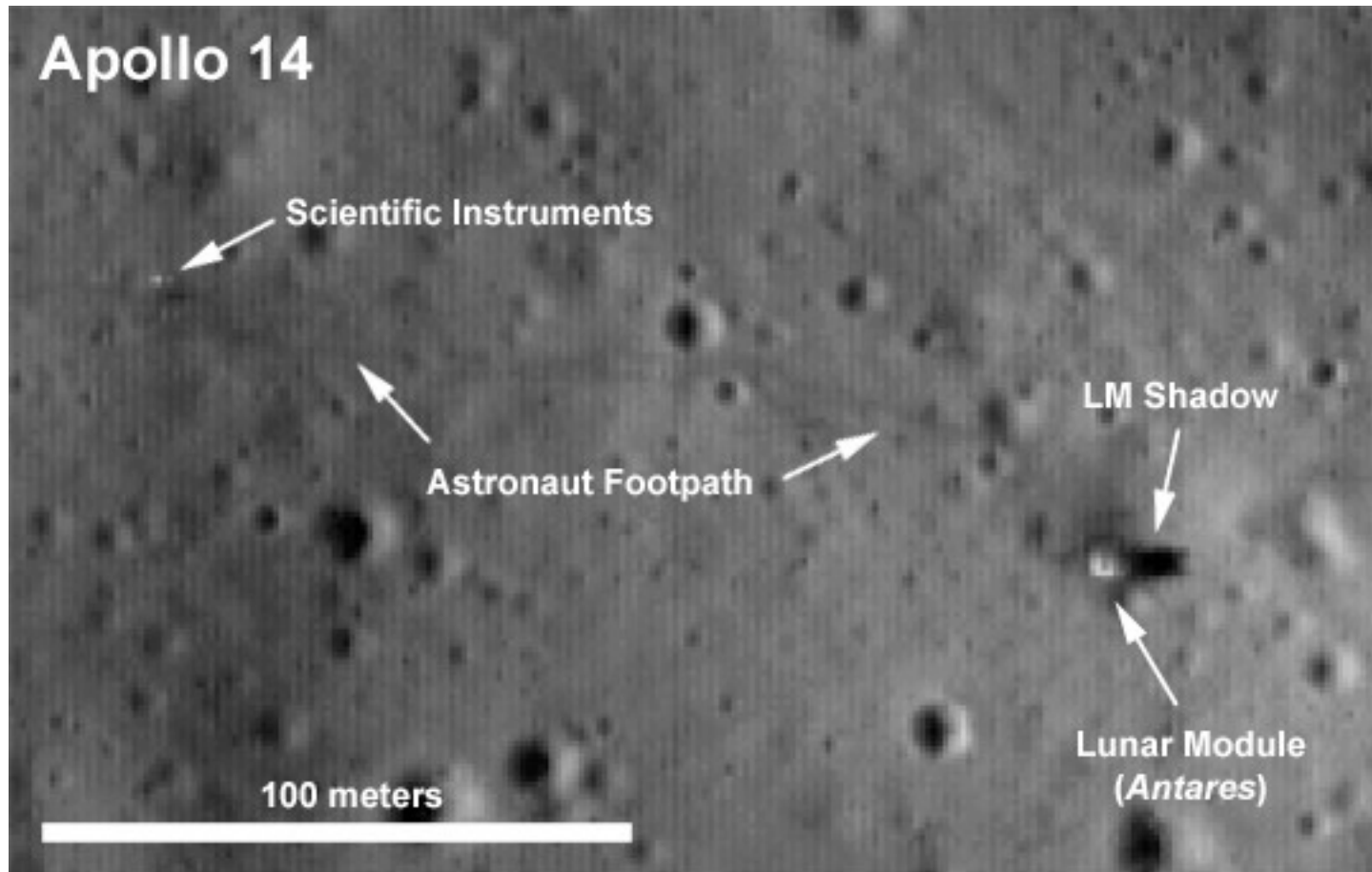


The Race to the Moon



Jonathan McDowell

© JAXA/NHK



Yes, we really did go there... July 2009 imagery of Fra Mauro base from Lunar Reconnaissance Orbiter.

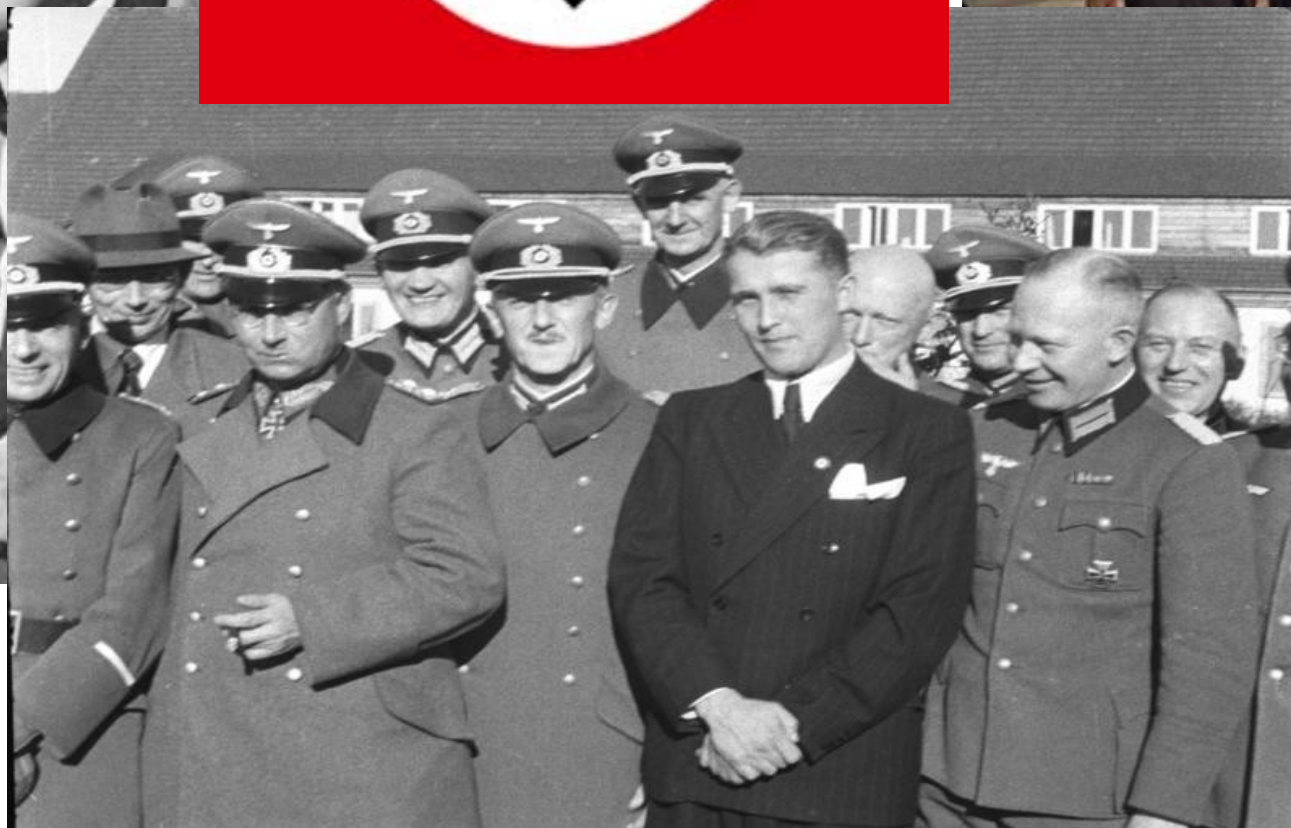
Sergey Korolev's Program



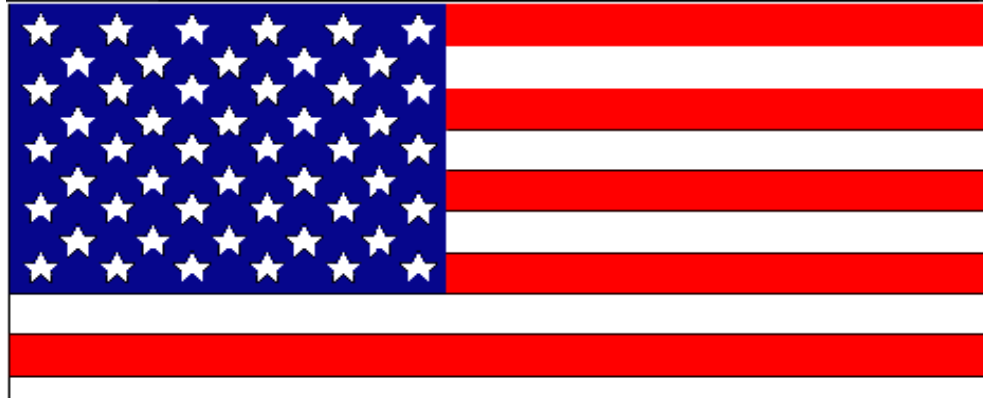
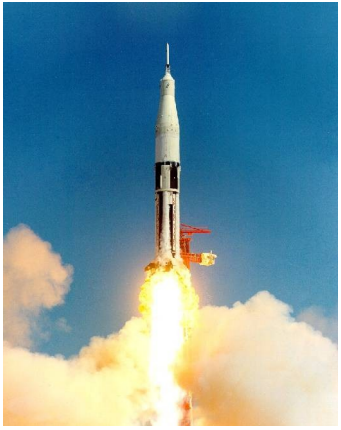
At Podlipki, in the Moscow suburbs, Korolev's factory churns out rockets and satellites

- Sputnik
- Luna moon probes
- Vostok spaceships
- Mars and Venus probes
- Spy satellites

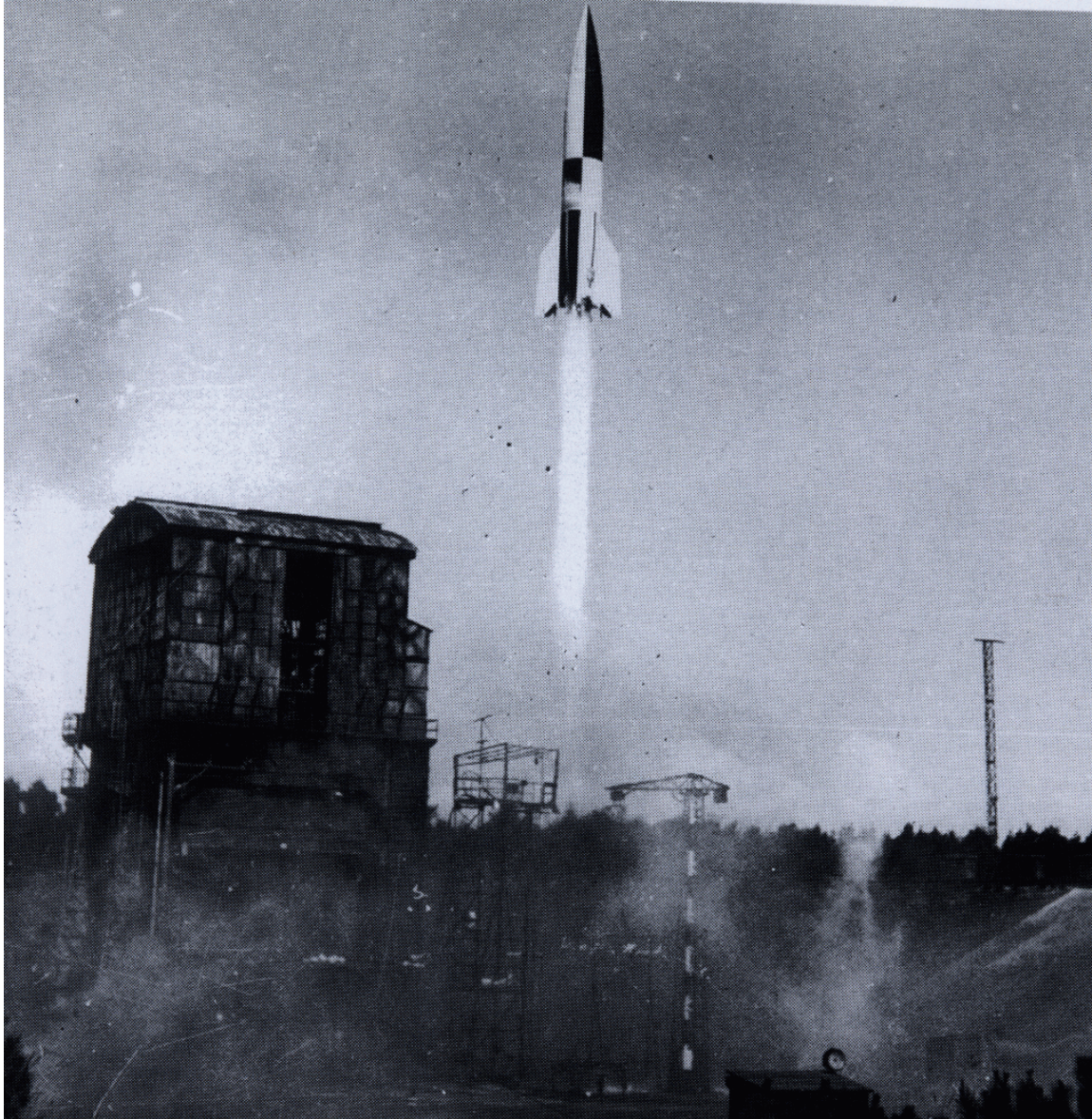
America's answer: the captured Nazi rocket team led by Dr. Wernher von Braun, based in Huntsville, Alabama



America's answer: naturalized US citizen Dr. Wernher von Braun, based in Huntsville, Alabama



October 1942: First into space



The A-4 (V-2) rocket reaches over 50 miles high – the first human artifact in space.

This German missile, ancestor of the Scud and the Shuttle, was designed to hit London and was later mass-produced by concentration camp labor – but the general in charge said at its first launch:

“Today the Space Age is born”.



First Earth Satellite: Sputnik Oct 1957



First Living Being in Orbit: Laika, Nov 1957



First Probe to Solar orbit: Luna-1 Jan 1959

First Probe to hit Moon: Luna-2 Sep 1959

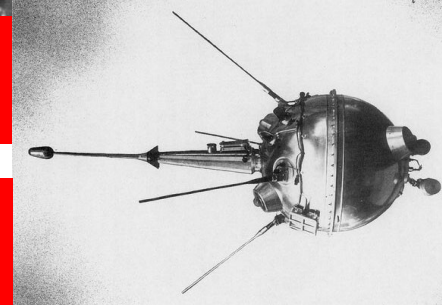
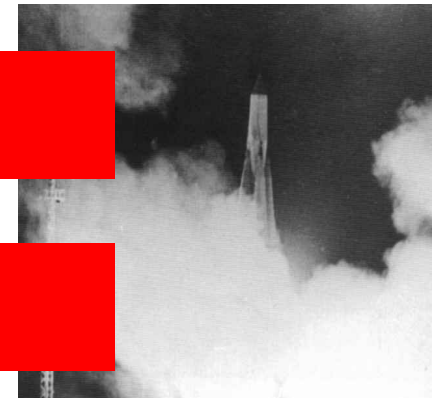


First intact return to Earth from orbit:
Discoverer 13 Aug 1960

First human in space:
Yuriy Gagarin in Vostok-1 Apr 1961



Is America losing the Space Race?
Time to up the stakes dramatically....



“In this decade...”



I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth.

John F Kennedy, address to Congress, May 25, 1961

1958-1961 MOON PROGRAM – USSR



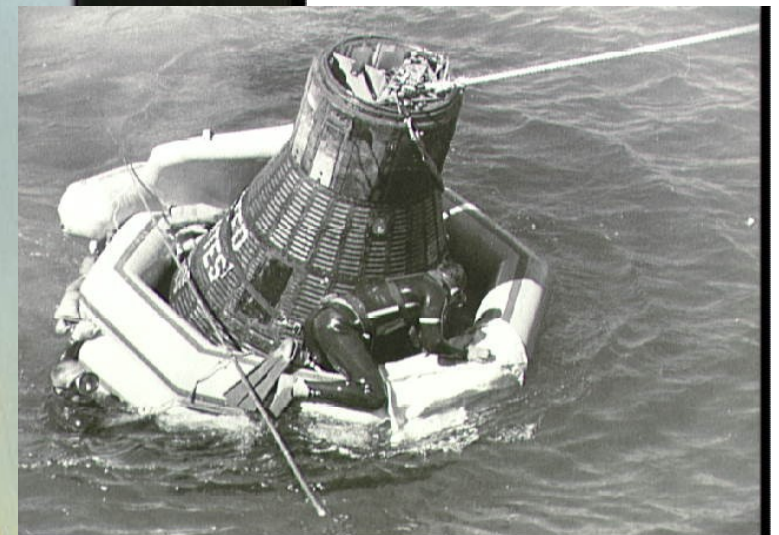
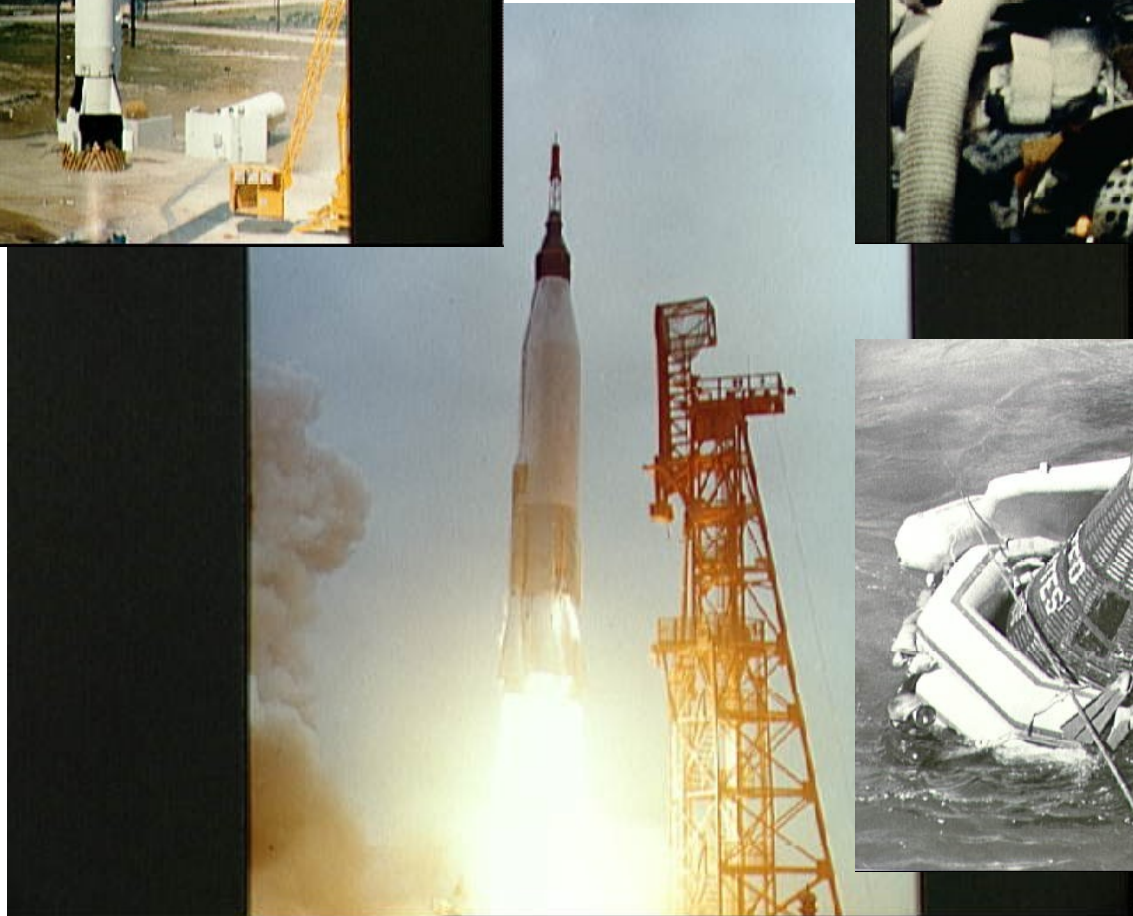
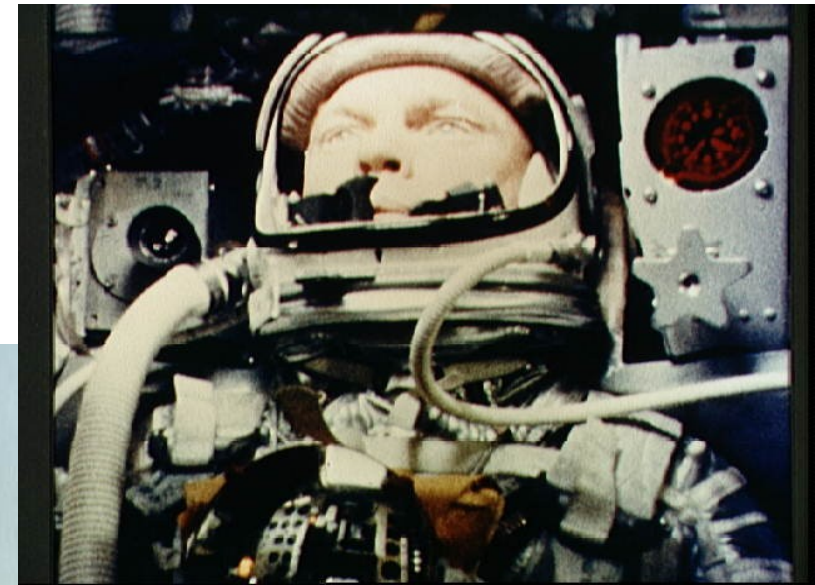
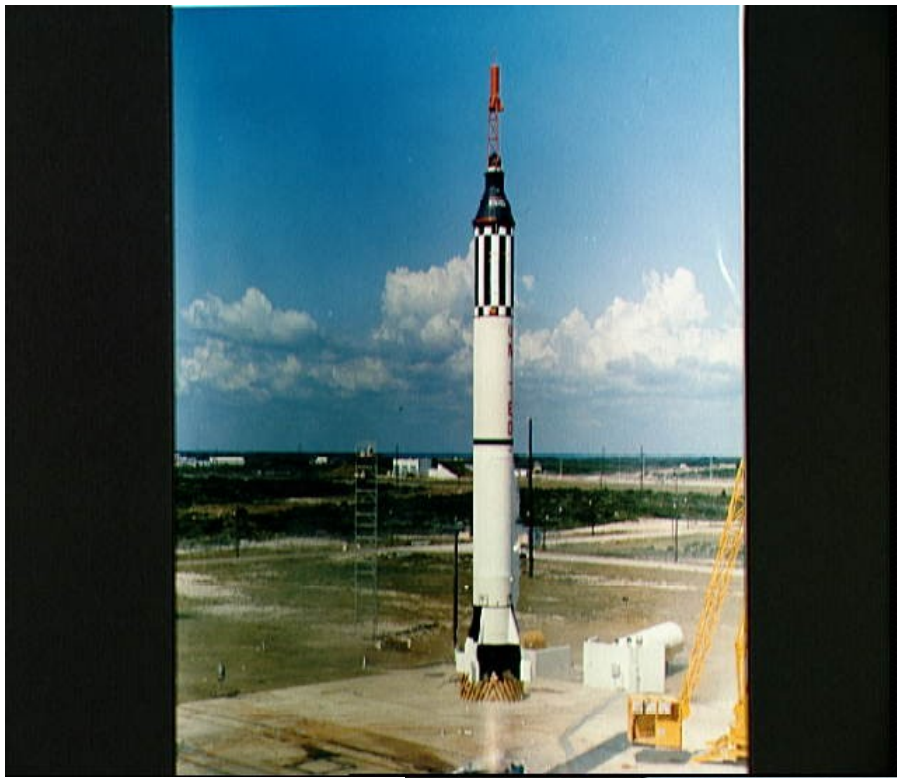
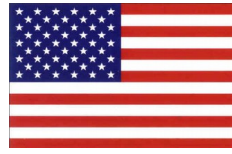
SEP 1958: E-1 No. 1, **LAUNCH FAILURE**
OCT 1958: E-1 No. 2, **LAUNCH FAILURE**
DEC 1958: E-1 No. 3, **LAUNCH FAILURE**
JAN 1959: E-1 No. 4, LUNA-1, **MISSED MOON**, **SOLAR ORBIT**
JUN 1959: E-1A No. 5, **LAUNCH FAILURE**
SEP 1959: E-1A No. 7, LUNA-2, **HIT MOON**
OCT 1959: E-2A No. 1, LUNA-3, **MAPPED LUNAR FAR SIDE**
APR 1960: E-3 No. 1, **ORBIT TOO LOW**
APR 1960: E-3 No. 2, **LAUNCH FAILURE**

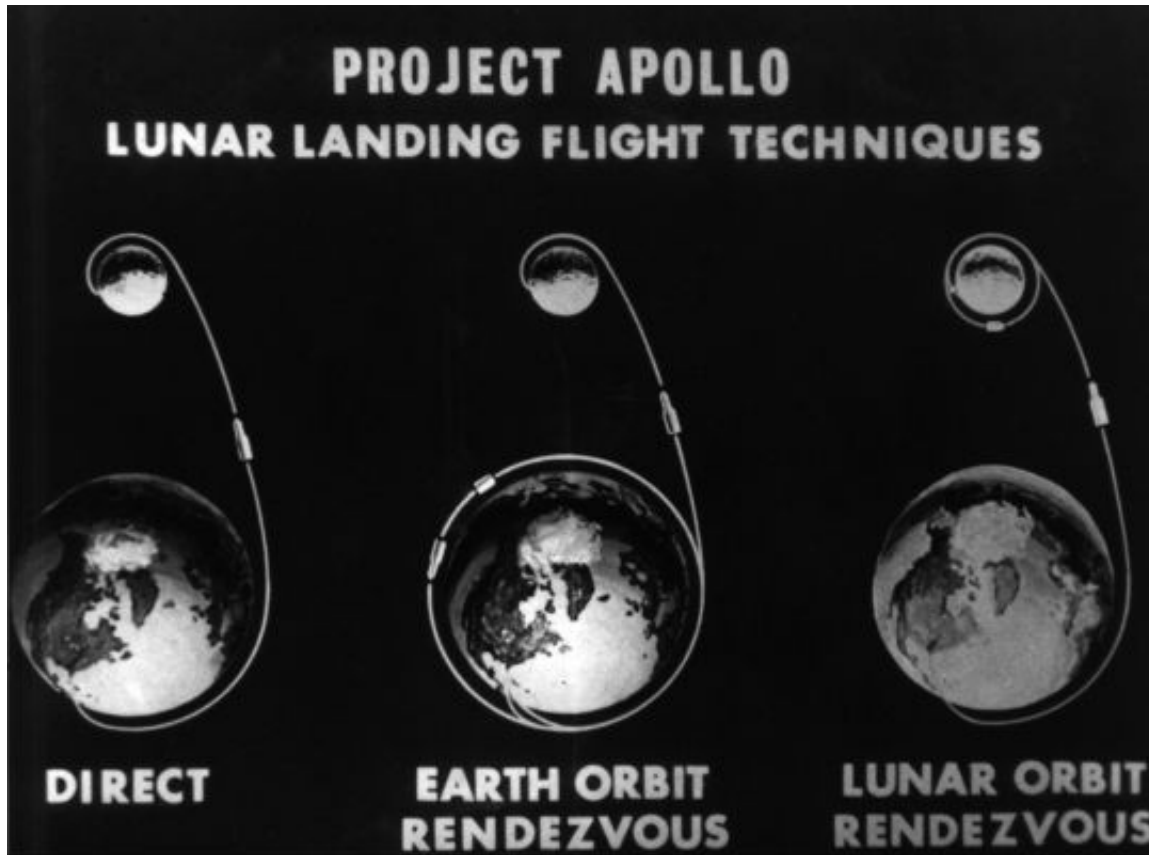
USA



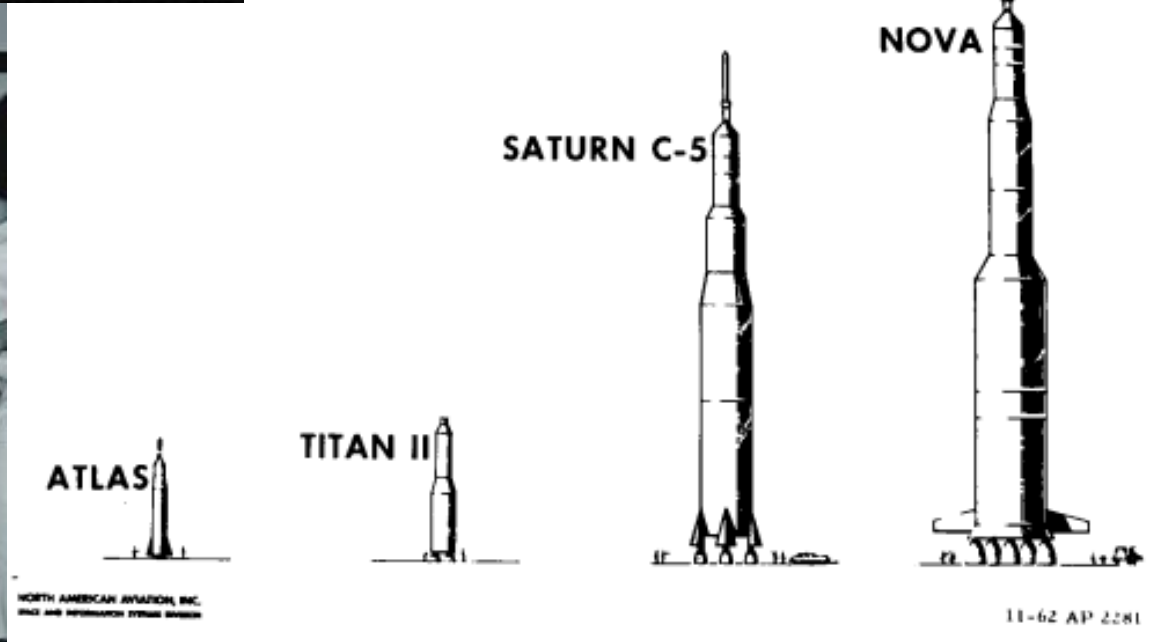
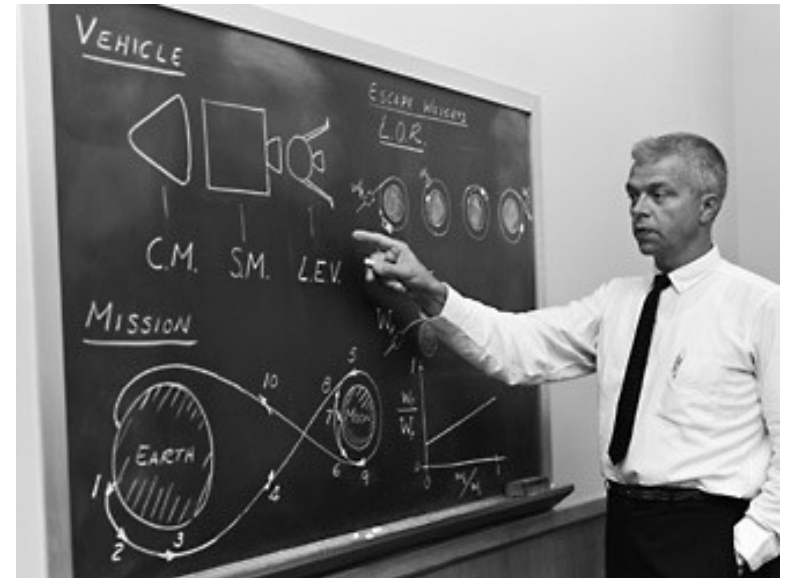
AUG 1958: ABLE I PIONEER, **LAUNCH FAILURE**
OCT 1958: ABLE I PIONEER, **ORBIT TOO LOW**
NOV 1958: ABLE I PIONEER (PIONEER 2), **LAUNCH FAILURE**
DEC 1958: PIONEER 3, **ORBIT TOO LOW**
MAR 1959: PIONEER 4, **MISSED MOON**, **SOLAR ORBIT**
SEP 1959: ABLE IVA, **BLEW UP ON PAD**
NOV 1959: ABLE IVB, **LAUNCH FAILURE**
SEP 1960: ABLE VA, **LAUNCH FAILURE**
DEC 1960: ABLE VB, **LAUNCH FAILURE**

MERCURY 1961-1963





JUNE 1962: Von Braun accepts John Houbolt's scheme for Lunar Orbit Rendezvous, so the enormous Nova rocket is not needed...

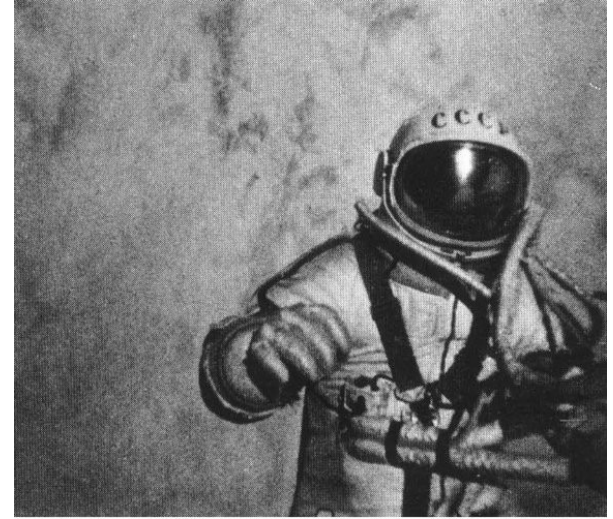




2006.

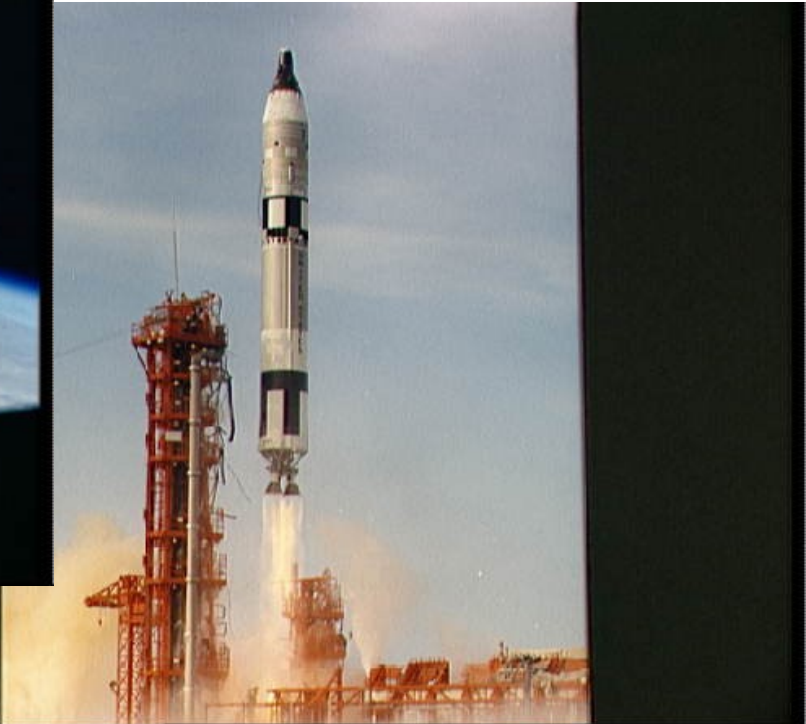
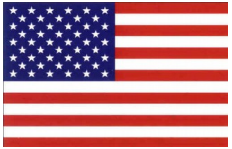


**Voskhod 2
First Space Walk
March 1965**

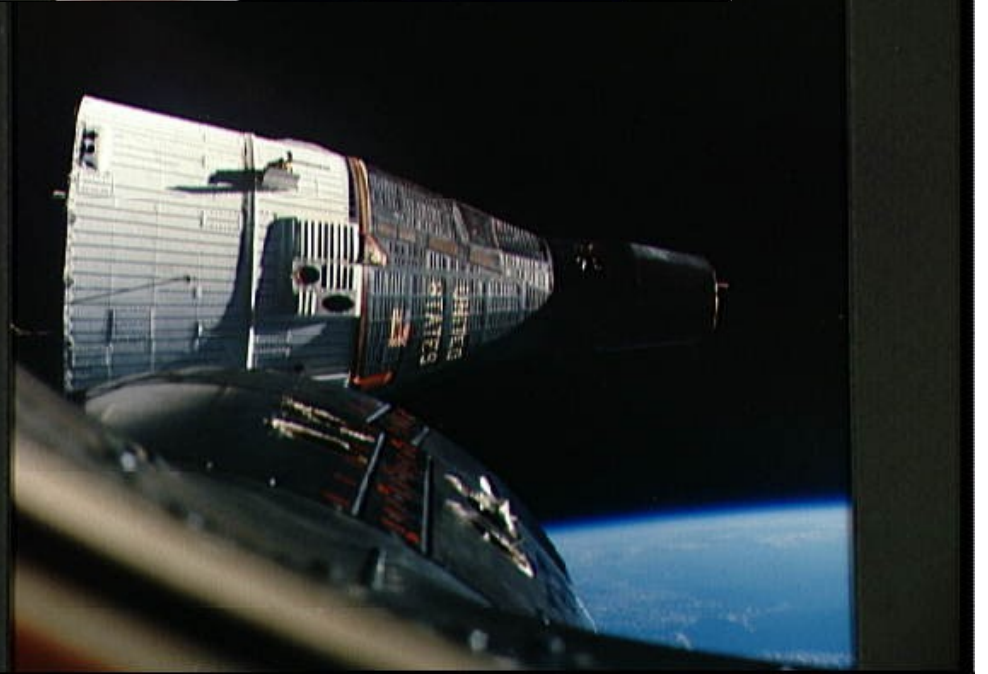
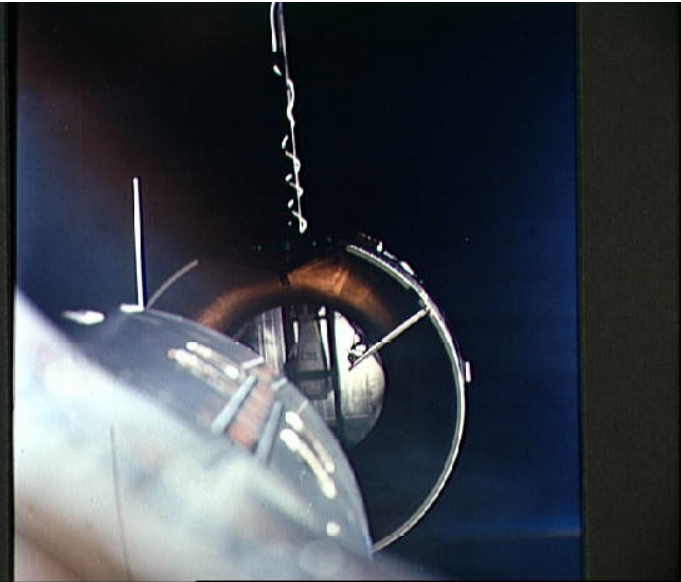
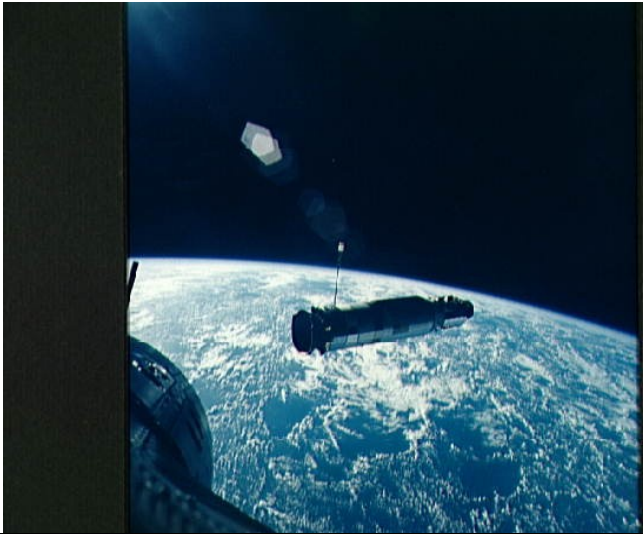


2006.09.22

GEMINI 1965-1966



1965-66: Gemini rendezvous and docking



1965-66: Gemini spacewalks

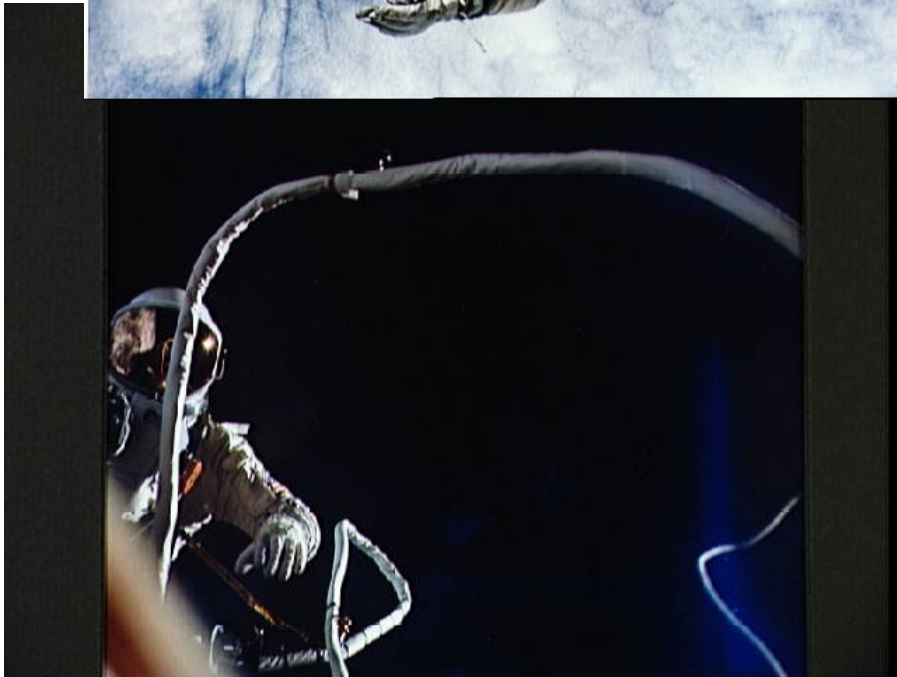
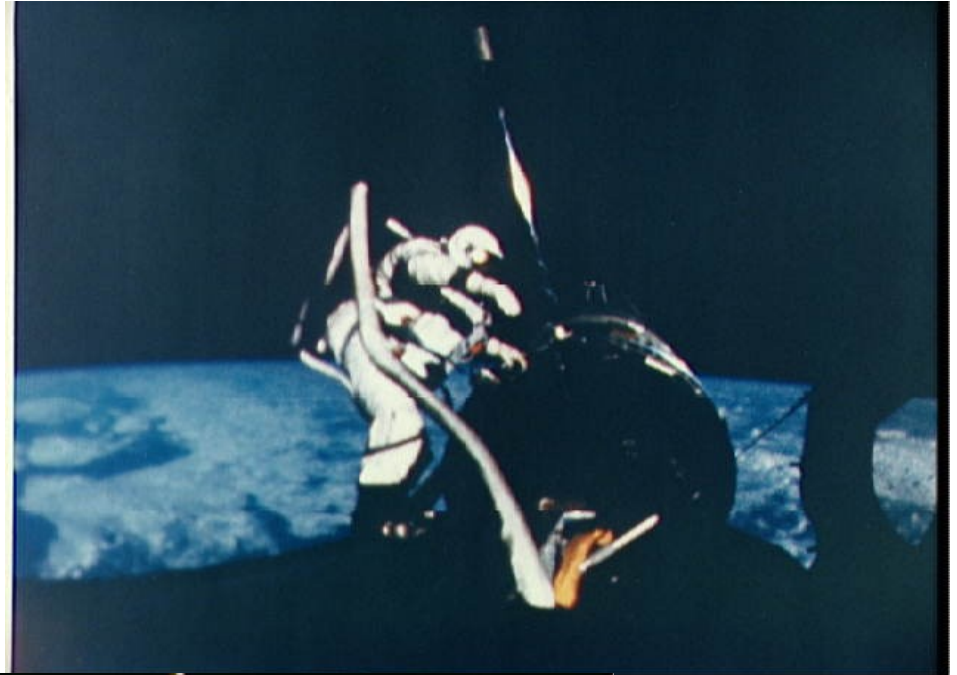
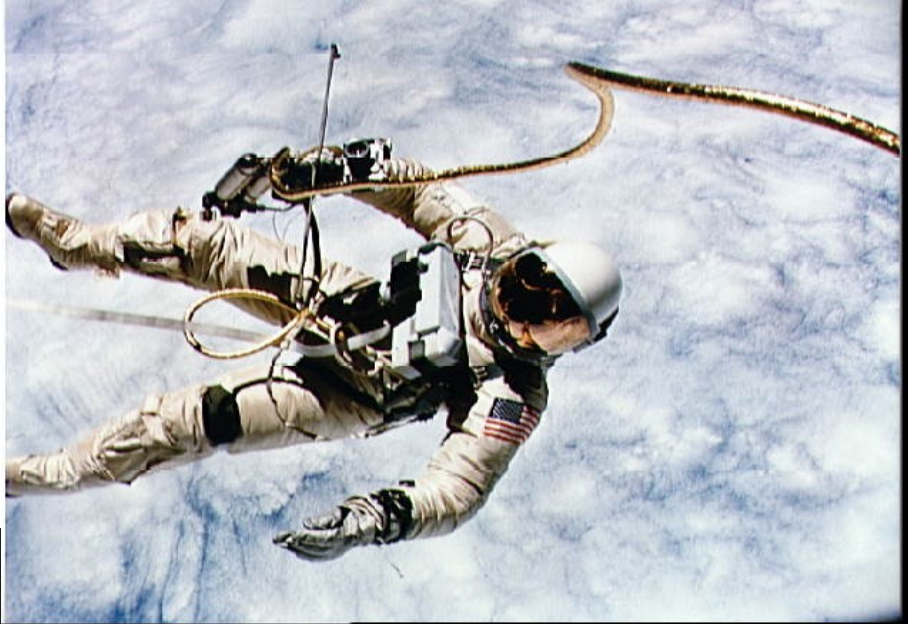
Gemini IV: Ed White

Gemini IX: Gene Cernan

Gemini X: Mike Collins

Gemini XI: Dick Gordon

Gemini XII: Buzz Aldrin



1961-1968

**Test launches of
the Saturn rocket:
Saturn I Block I
Saturn I Block II
Saturn IB
Saturn V**



1961-1966 MOON PROGRAM – USSR



JAN 1963: LUNA, **STUCK IN EARTH ORBIT**
FEB 1963: LUNA, **ROCKET FAILED, CRASHED IN PACIFIC**
APR 1963: LUNA-4, **MISSED MOON**
MAR 1964: LUNA, **ROCKET FAILED, CRASHED IN PACIFIC**
APR 1964: LUNA, **ROCKET FAILED, CRASHED IN PACIFIC**
MAR 1965: LUNA (K-60), **STUCK IN EARTH ORBIT**
APR 1965: LUNA, **FAILED TO REACH EARTH ORBIT**
MAY 1965: LUNA-5, **CRASHED ON MOON**
JUN 1965: LUNA 6, **MISSED MOON**
JUL 1965: PROTON **TEST FLIGHT, PROTON-1**
OCT 1965: LUNA 7, **CRASHED ON MOON**
NOV 1965, PROTON **TEST FLIGHT, PROTON-2**
DEC 1965, LUNA 8, **CRASHED ON MOON**
JAN 1966: LUNA-9, **LANDED ON MOON**
MAR 1966: LUNA-10, **ORBITED MOON**
MAR 1966: PROTON **TEST FLIGHT, FAILED**
JUL 1966: PROTON **TEST FLIGHT, PROTON-3**
AUG 1966: LUNA-11, **ORBITED MOON BUT CONTROL LOST**
OCT 1966: LUNA-12, **ORBITED MOON**
DEC 1966: LUNA-13, **LANDED ON MOON**

USA

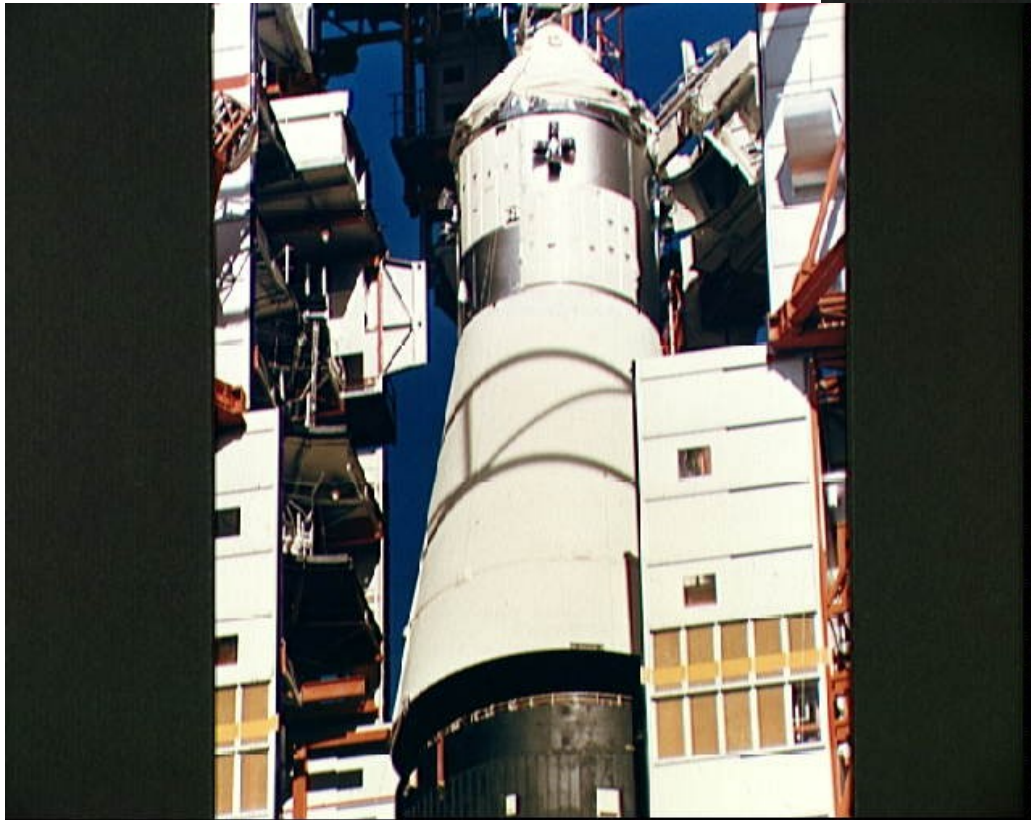
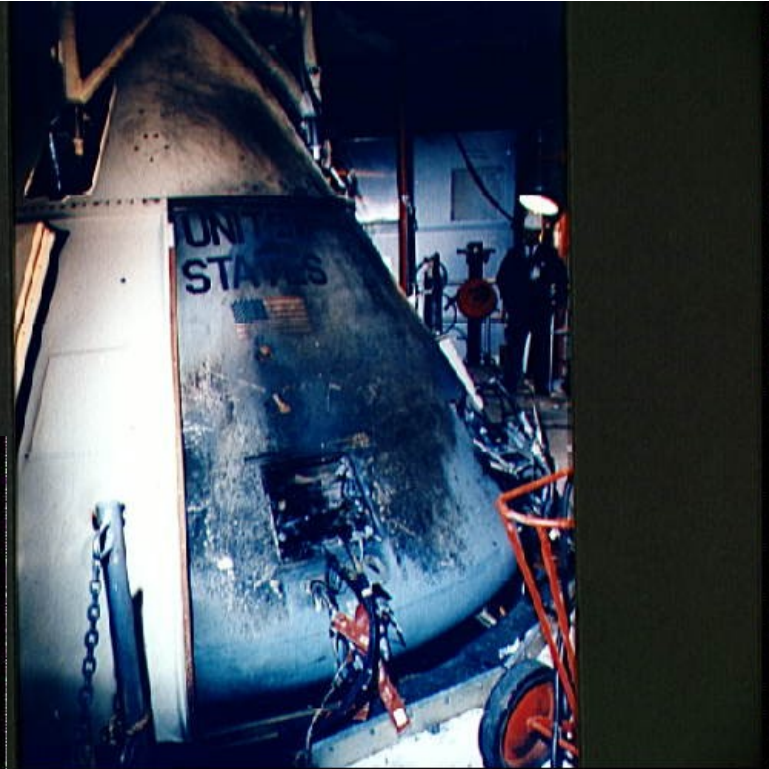


AUG 1961: RANGER 1, **FAILED**
OCT 1961: SATURN SA-1 **ROCKET TEST**
NOV 1961: RANGER 2, **FAILED**
JAN 1962: RANGER 3, **MISSED MOON**
APR 1962: RANGER 4, **HIT FAR SIDE**
APR 1962: SATURN SA-2 **ROCKET TEST**
OCT 1962: RANGER 5, **MISSED MOON**
NOV 1962: SATURN SA-3 **ROCKET TEST**
MAR 1963: SATURN SA-4 **ROCKET TEST**
JAN 1964: SATURN SA-5 **ROCKET TEST**
JAN 1964: RANGER 6: **HIT MOON, CAMERA FAILED**
APR 1964: FIRE 1, **REENTRY TEST**
MAY 1964: SATURN SA-6 **ROCKET TEST**
JUL 1964: RANGER 7: **LUNAR IMPACT IMAGING**
SEP 1964: SATURN SA-7 **ROCKET TEST**
DEC 1964: CENTAUR AC-4, **PARKING ORBIT TEST**
FEB 1965: SATURN SA-9 **ROCKET TEST**
FEB 1965: RANGER 8, **LUNAR IMPACT IMAGING**
MAR 1965: RANGER 9, **LUNAR IMPACT IMAGING**
MAY 1965: SATURN SA-8 **ROCKET TEST**
MAY 1965: FIRE 2, **REENTRY TEST**
JUL 1965: SATURN SA-10 **ROCKET TEST**
AUG 1965: CENTAUR AC-6, **ROCKET TEST**
FEB 1966: APOLLO-SATURN 201 **TEST FLIGHT**
APR 1966: CENTAUR AC-8, **PARKING ORBIT TEST**
MAY 1966: SURVEYOR 1, **LANDED ON MOON**
JUL 1966: EXPLORER 33, **SCIENCE PROBE MISSED MOON**
JUL 1966: APOLLO-SATURN 203 **TEST FLIGHT**
AUG 1966: LUNAR ORBITER 1, **MAPPED MOON**
AUG 1966: APOLLO-SATURN 202 **TEST FLIGHT**
SEP 1966: SURVEYOR 2, **CRASHED ON MOON**
OCT 1966: CENTAUR AC-9, **PARKING ORBIT TEST**
NOV 1966: LUNAR ORBITER 2, **MAPPED MOON**

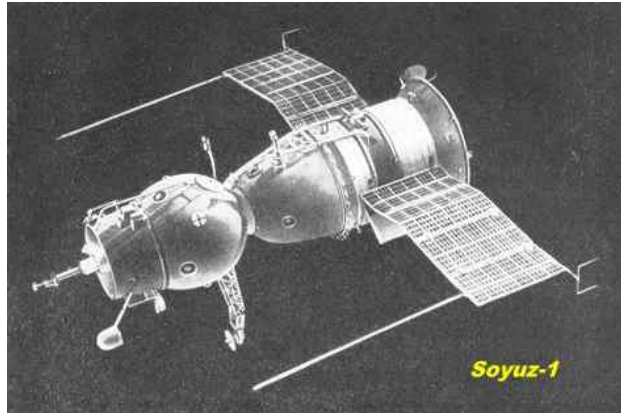
The Apollo AS-204 Fire (“Apollo 1”)

January 27, 1967

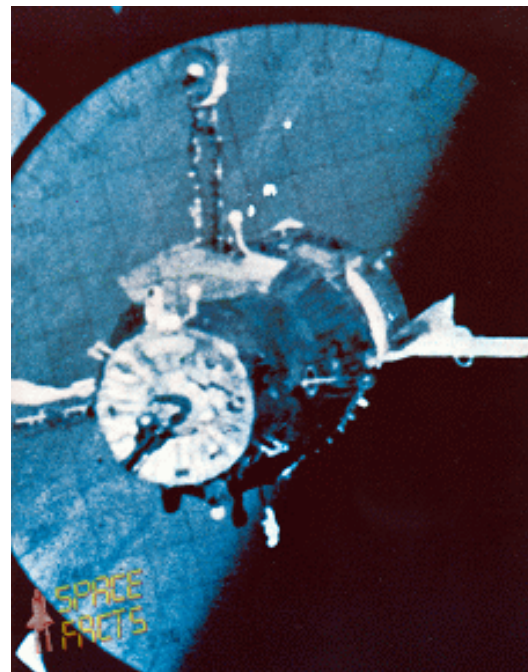
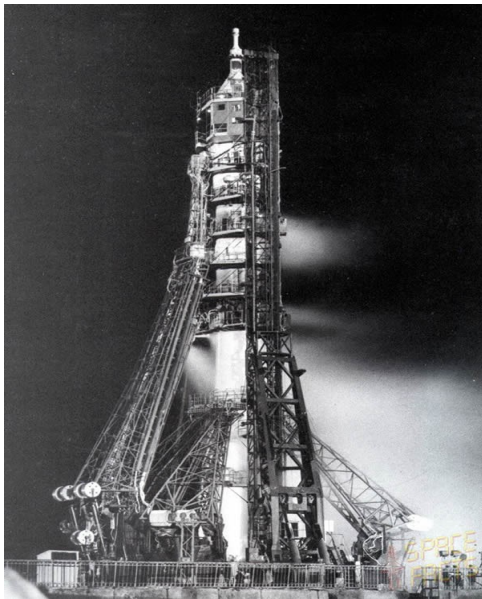
Gus Grissom, Ed White, Roger Chaffee



Soyuz-1
Apr 1967



New spaceship design
Designed for lunar flight
Earth orbit test by test pilot Vladimir Komarov
Solar panel failed to open, spacecraft tumbling
Emergency reentry and crash landing
First fatality during a space flight



1967 MOON PROGRAM – USSR



MARCH:

ZOND (KOSMOS-146): PROTON RESTART TEST, L-1 SPACESHIP REENTRY TEST

APRIL:

**ZOND (KOSMOS-154): RESTART AND REENTRY TEST, FAILED TO RESTART
SOYUZ-1 TEST FLIGHT: FAILED ON ORBIT,
PILOT KILLED ON LANDING**

MAY:

LUNA E-6 (KOSMOS-159), HIGH EARTH ORBIT COMMUNICATIONS TEST, ORBIT LOW BUT OPERATED OK?

SEPTEMBER:

ZOND (PROTON) BLEW UP ON ASCENT

OCTOBER:

**ROBOT DOCKING TEST, KOSMOS-186/188
FIRST AUTOMATIC RENDEZVOUS/DOCKING**

NOVEMBER:

ZOND (PROTON) BLEW UP ON ASCENT

USA



JANUARY:

**APOLLO 204 GROUND TRAINING TEST...
3 ASTRONAUTS DIE IN FIRE**

FEBRUARY:

LUNAR ORBITER 3, MAPPED MOON

APRIL:

SURVEYOR 3, LANDED ON MOON

MAY:

LUNAR ORBITER 4, MAPPED MOON

JULY:

**SURVEYOR 4 LUNAR PROBE, CRASHED
EXPLORER 35, LUNAR ORBIT SCIENCE PROBE -
OPERATED FOR 6 YEARS**

AUGUST

LUNAR ORBITER 5, MAPPED MOON

SEPTEMBER

SURVEYOR 5, LANDED ON MOON

OCTOBER:

**APOLLO 7 – FIRST EARTH ORBIT TEST OF
APOLLO CSM, FIRST ASTRONAUT
CREW ON APOLLO - SUCCESS**

NOVEMBER:

SURVEYOR 6, LANDED ON MOON

**APOLLO 4: FIRST SATURN V TEST FLIGHT,
APOLLO HIGH SPEED REENTRY - SUCCESS**

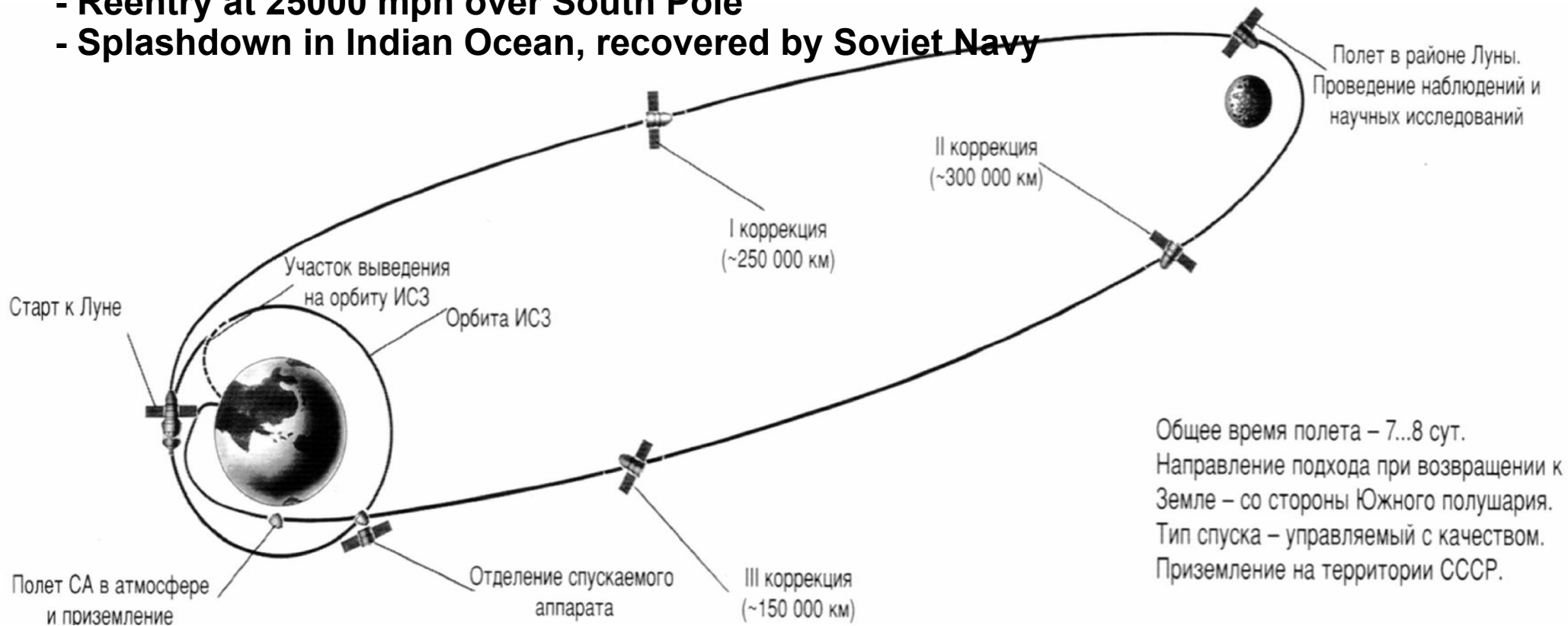
The Flight of Zond-5 Sep 14-21, 1968

First Return To Earth From Lunar Vicinity

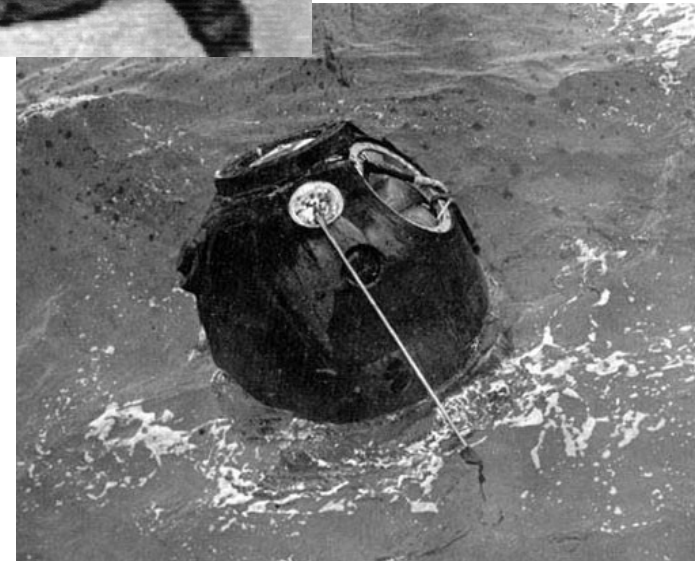
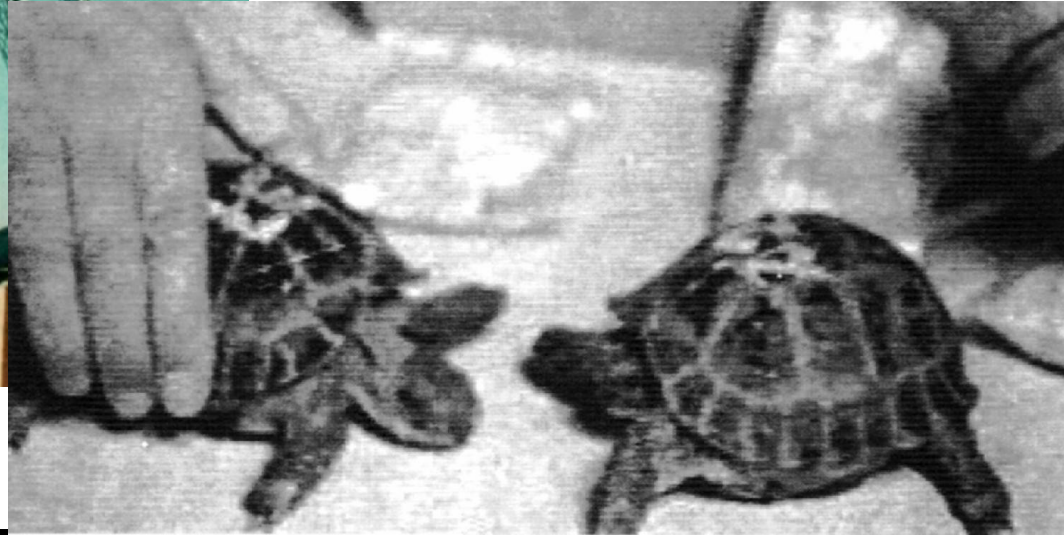
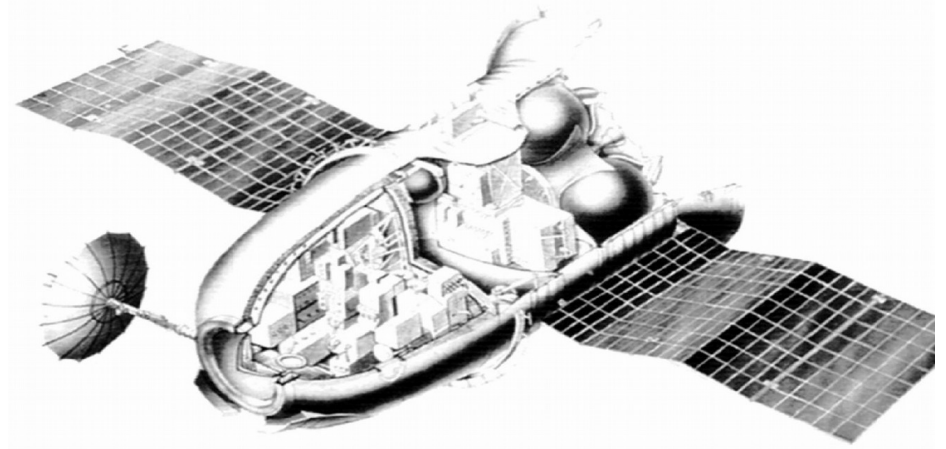
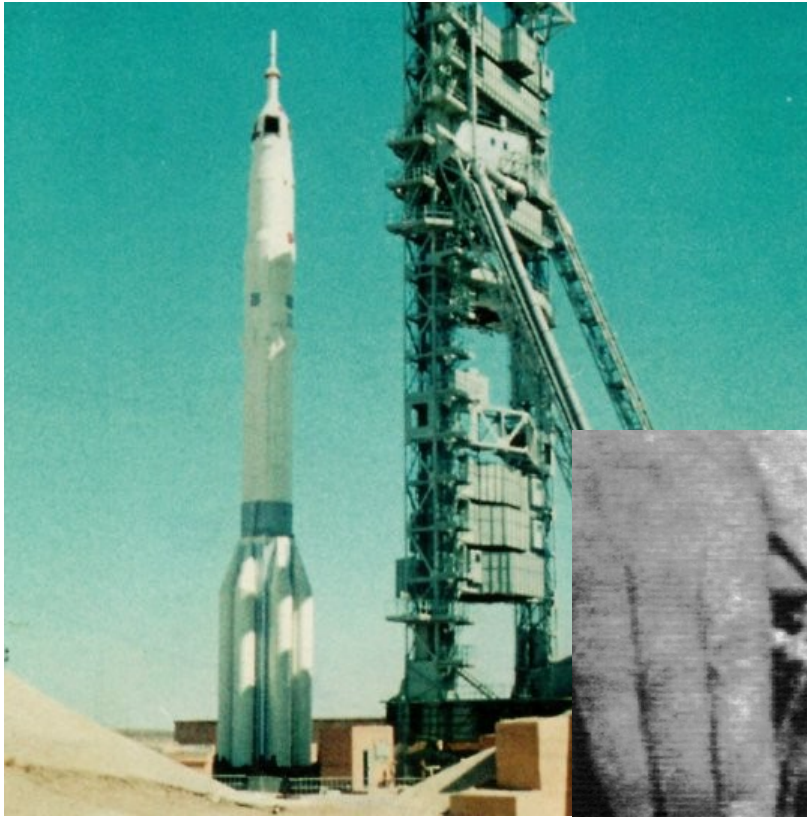
First Terrestrial Creatures in Interplanetary Flight



- Launch into Earth orbit
- TLI (Trans Lunar Injection) rocket burn towards the Moon
- Fly around lunar farside (but not into a closed lunar orbit)
- Pass 1200 mi (1950 km) from lunar surface
- Coast back down towards Earth
- Reentry at 25000 mph over South Pole
- Splashdown in Indian Ocean, recovered by Soviet Navy

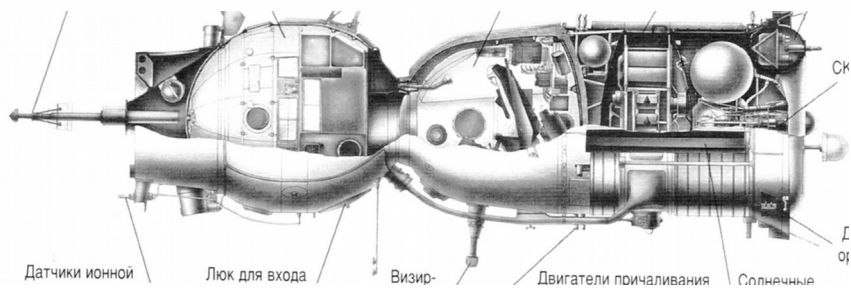
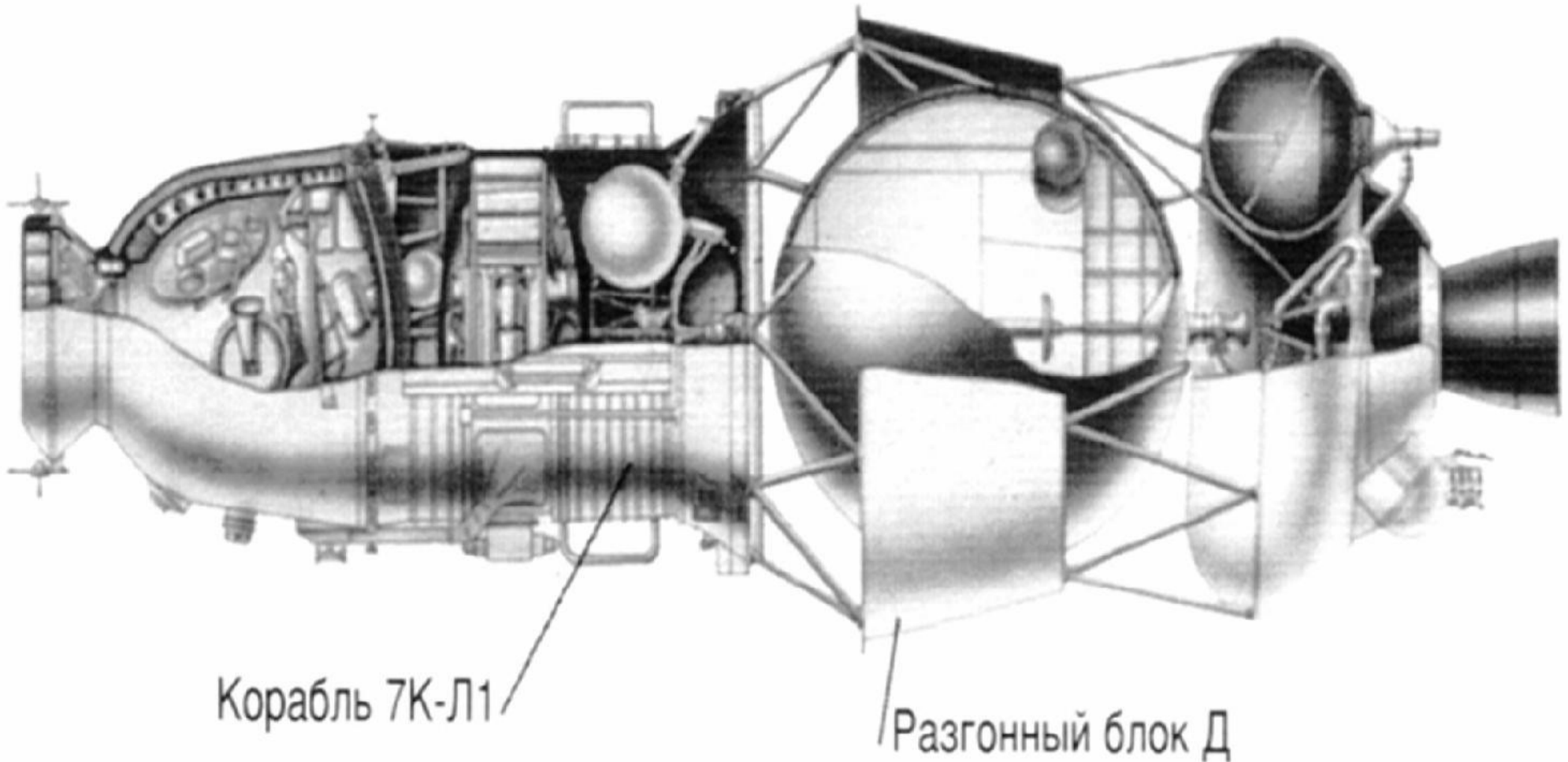


TORTOISES TO THE MOON! (AND BACK)



**Space Complex L-1
With Spaceship 7K-L1 (Zond) and Booster Stage "Block D"**

Космический комплекс Л1

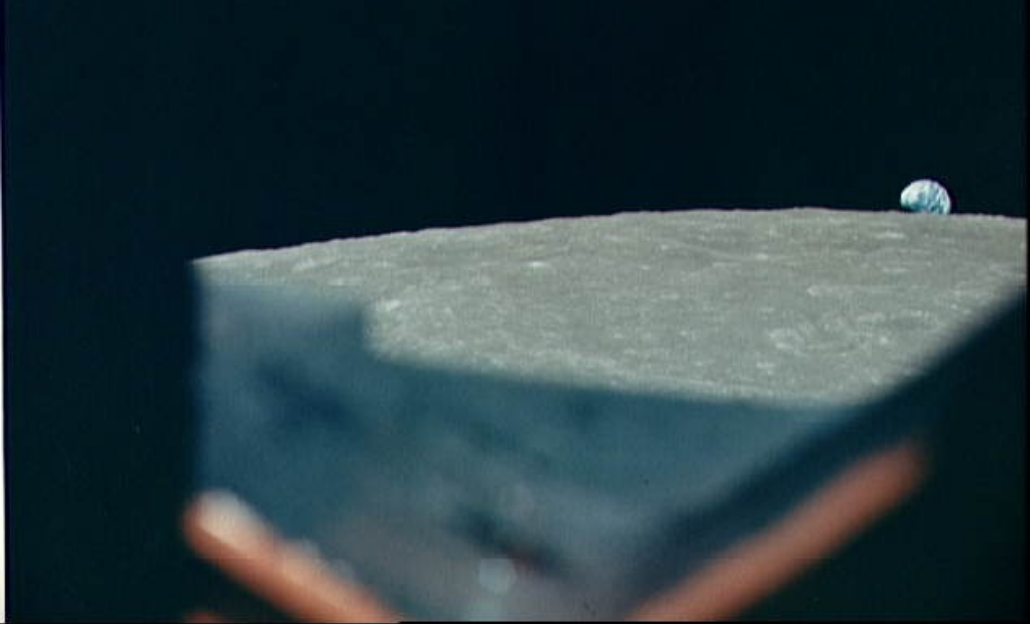


**Compare 7K-L1 (above)
with Soyuz (left)**



**Apollo 8, Dec 1968:
First humans to leave Earth's
gravitational sphere of influence**

First humans to orbit the Moon



1968 MOON PROGRAM – USSR



FEBRUARY

LUNA E-6LS ORBITER – **MOLNIYA ROCKET
FAILED TO REACH EARTH ORBIT**

MARCH

ZOND-4: REENTRY TEST FROM LUNAR DISTANCE:
REENTRY FAILED

APRIL

LUNA-14: LUNA E-6LS ORBITER

ZOND: **PROTON FAILED TO REACH ORBIT**

JULY

ZOND: **PROTON BLEW UP ON LAUNCH PAD**

SEPTEMBER

ZOND 5 – **SUCCESSFUL FLYBY/RETURN**

NOVEMBER

ZOND 6 – **SUCCESSFUL FLYBY, BUT
CRASHED ON LANDING**

USA



JANUARY:

SURVEYOR 7: **ROBOT LUNAR LANDING**

APOLLO 5, EARTH ORBITAL TEST OF LUNAR MODULE,
SUCCESS

APRIL:

APOLLO 6 – TEST LAUNCH OF SATURN V, REENTRY TEST OF
APOLLO -

VIBRATION AND RESTART PROBLEMS,
BUT SUCCESSFUL APOLLO ORBIT AND REENTRY

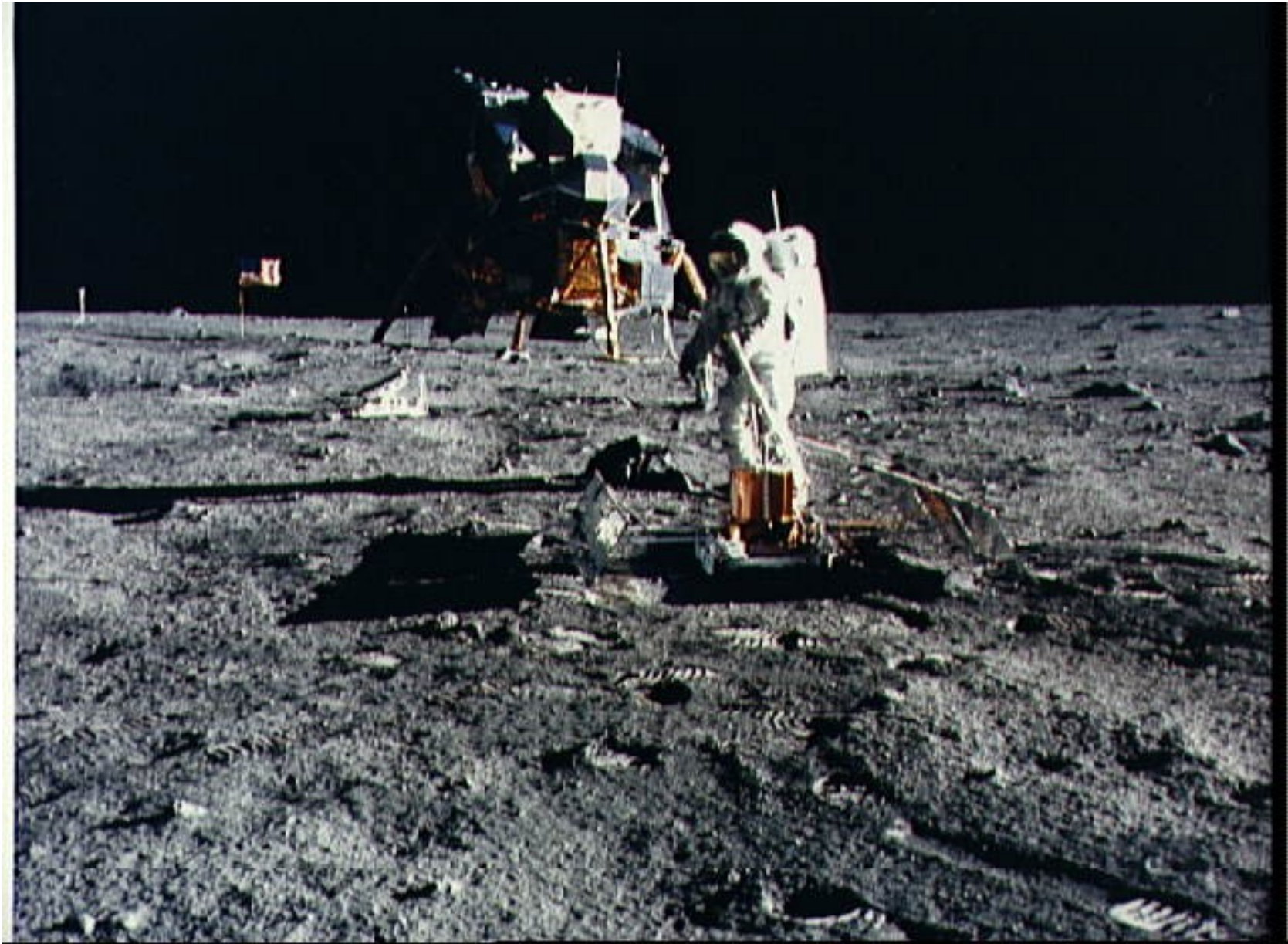
OCTOBER:

APOLLO 7 – FIRST EARTH ORBIT TEST OF APOLLO CSM,
FIRST ASTRONAUT CREW ON APOLLO -
SUCCESS

DECEMBER

APOLLO 8 – **FIRST HUMANS TO ORBIT THE MOON AND
RETURN TO EARTH**

1969 - Apollo on the Moon



1969 MOON PROGRAM – USSR



JANUARY

ZOND - **PROTON FAILED TO REACH ORBIT**

FEBRUARY

LUNOKHOD – **PROTON BLEW UP DURING LAUNCH**

N-1 MOON ROCKET -**FAILED DURING TEST LAUNCH**

JUNE

LUNA SAMPLE RETURN -**PROTON FAILED TO REACH ORBIT**

JULY

N-1 MOON ROCKET - **BLEW UP ON LAUNCH PAD**

LUNA SAMPLE RETURN -**CRASHED ON MOON (LUNA 15)**

AUGUST

ZOND 7 – **SUCCESSFUL FLYBY/RETURN**

SEPTEMBER

LUNA SAMPLE RETURN -
STUCK IN EARTH ORBIT (K300)

OCTOBER

LUNA SAMPLE RETURN -
STUCK IN EARTH ORBIT (K305)

NOVEMBER

HEAVY ZOND – **PROTON FAILED TO REACH ORBIT**

USA



MARCH

APOLLO 9 – **EARTH ORBITAL TEST
FLIGHT OF CSM AND LM**

MAY

APOLLO 10 – **DRESS REHEARSAL FLIGHT FOR LANDING**

JULY

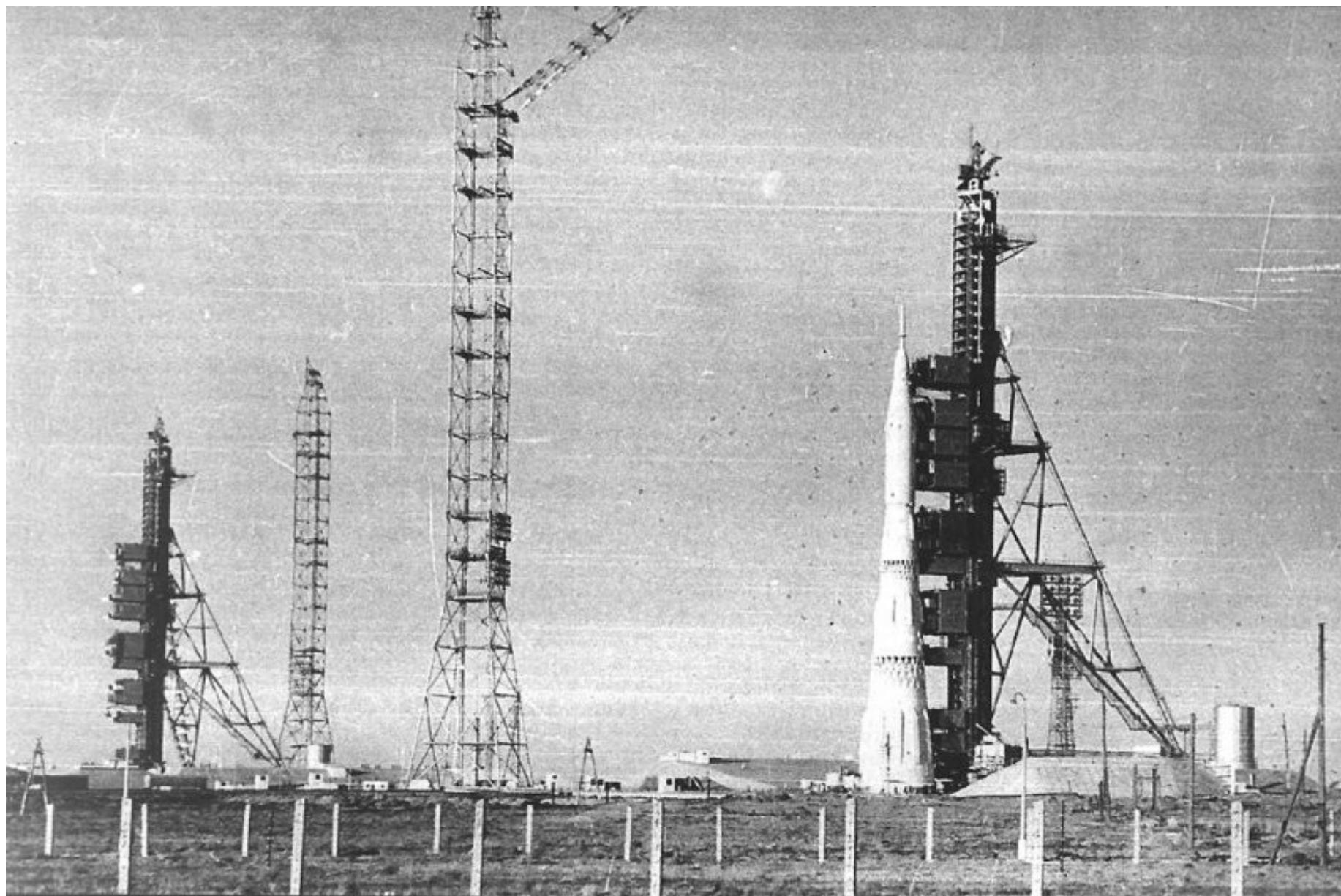
APOLLO 11 – **FIRST LUNAR LANDING BY HUMANS**

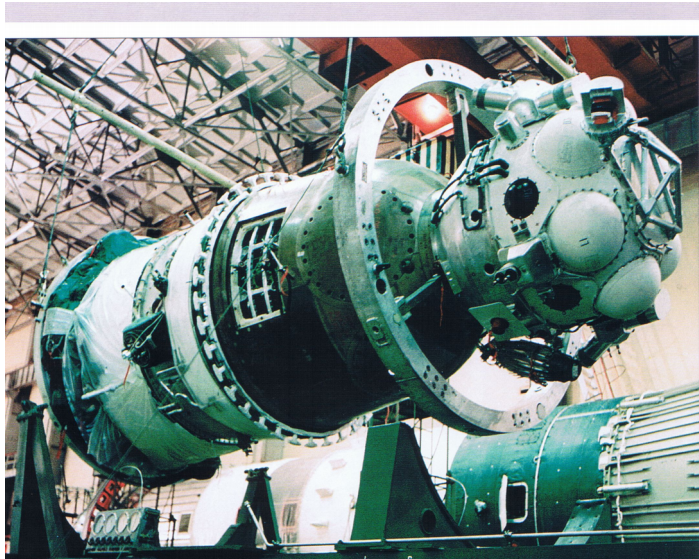
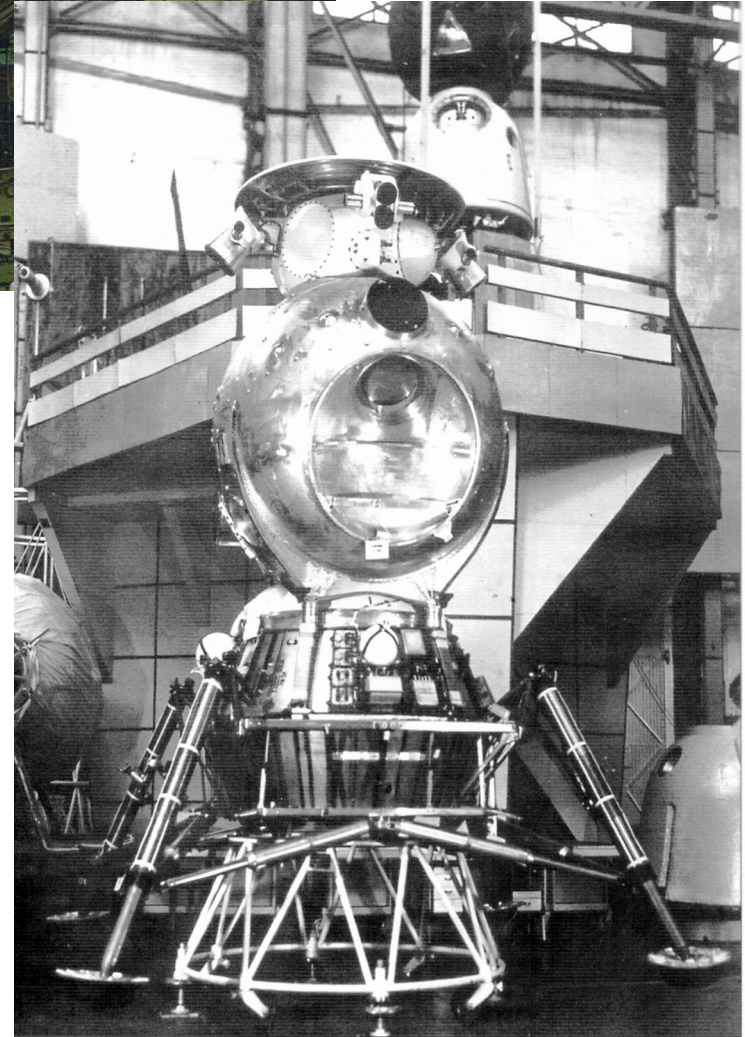
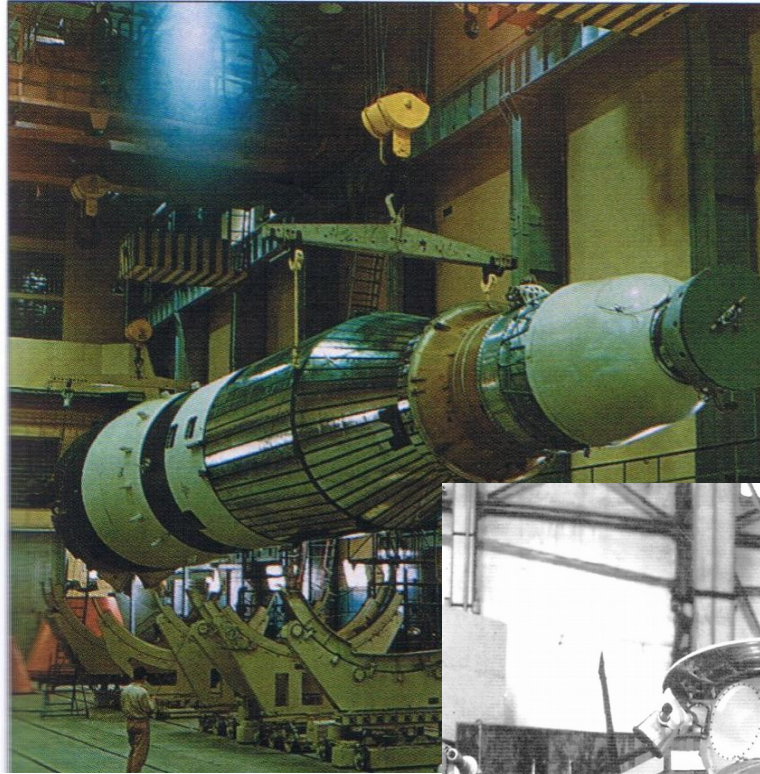
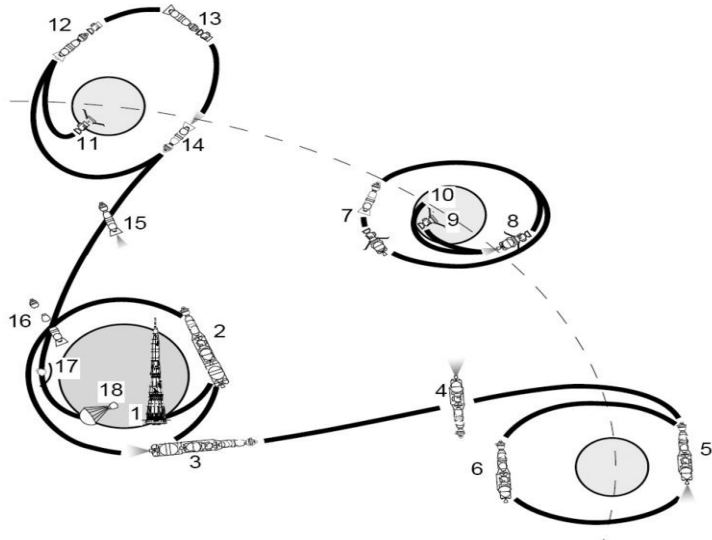
NOVEMBER

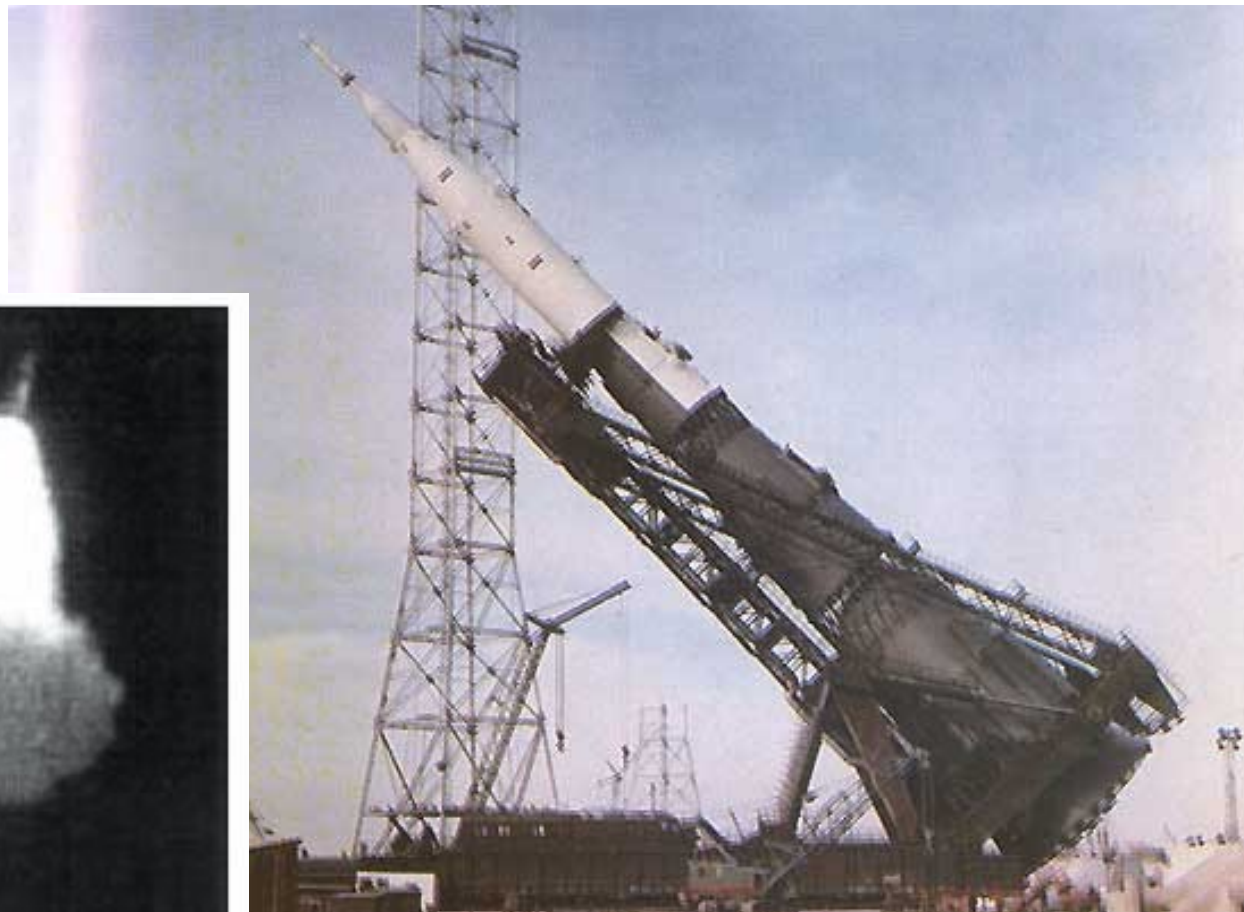
APOLLO 12 – **SECOND LUNAR LANDING**



1969 – Soviet N-1 Moon Rocket







**MAY 20, 1969: SATURN 506 ROLLS TO PAD 39A
SPACECRAFT APOLLO 11 IS ABOARD**



Apollo 8, 1968

Launch vehicle: SATURN V serial number SA-506

First stage:	S-IC-506	2280 t
Second stage:	S-II-6	480 t
Third stage:	S-IVB-506	120 t

Apollo Spacecraft: Apollo 11

SC Lunar Adapter:	SLA-14	1.2 t
Lunar Module:	LM 5 "Eagle"	5t
Lunar Module Descent Stage:	LM-5 DS	10t
Command Module:	CM-107 "Columbia"	5t
Service Module:	SM-107	23t
Escape Tower:	LES-107	4

Total – Apollo spacecraft	50 t
Total – Apollo/Saturn V	2902 t
Returned to Earth	5 t



SUNDAY JULY 13, 1969

**STATE TEST RANGE No. 5
KAZAKH SOVIET
SOCIALIST REPUBLIC**

**LAUNCH OF ROCKET
8K82K No. 242-01**

**SPACE PROBE E-8-5 No.
401 ON TRANSLUNAR
TRAJECTORY**

**TASS ANNOUNCES
LAUNCH OF "LUNA-15"**

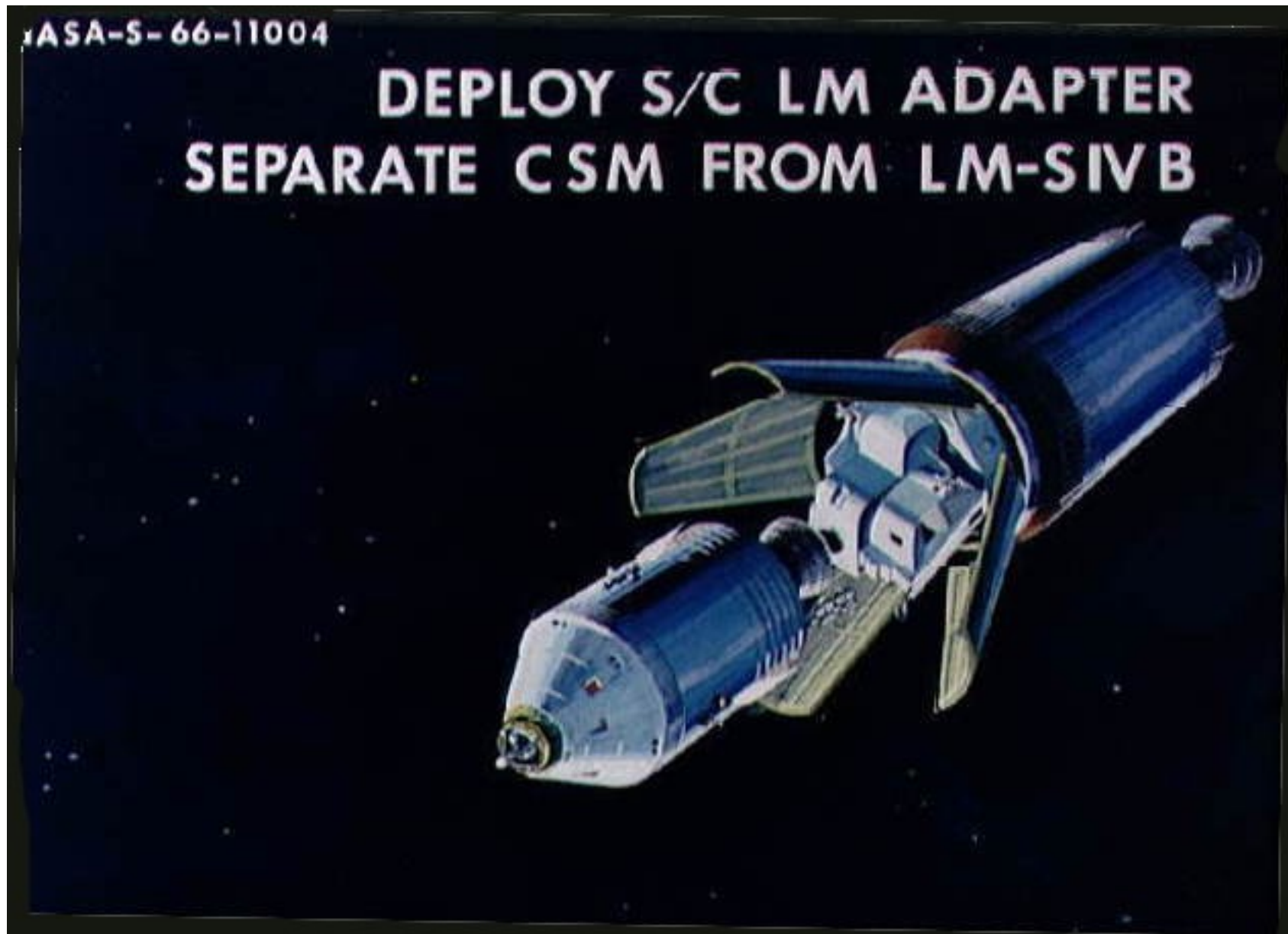
WED, JUL 16, 1969, 1:32pm GMT: APOLLO 11 LAUNCHES FROM KENNEDY SPACE CENTER, FLORIDA



**Wed. July 16, 4:22pm GMT TLI: Translunar Injection
Apollo spacecraft and Saturn S-IVB third stage reach near-escape velocity
Orbit 262 x 565954 km**



**Wed, Jul 16, 1969, 4:47pm GMT – Transposition and Docking
Columbia separates from rocket, turns around, docks with Eagle**



**Lunar module still attached to Saturn rocket stage
Seen from approaching command module**

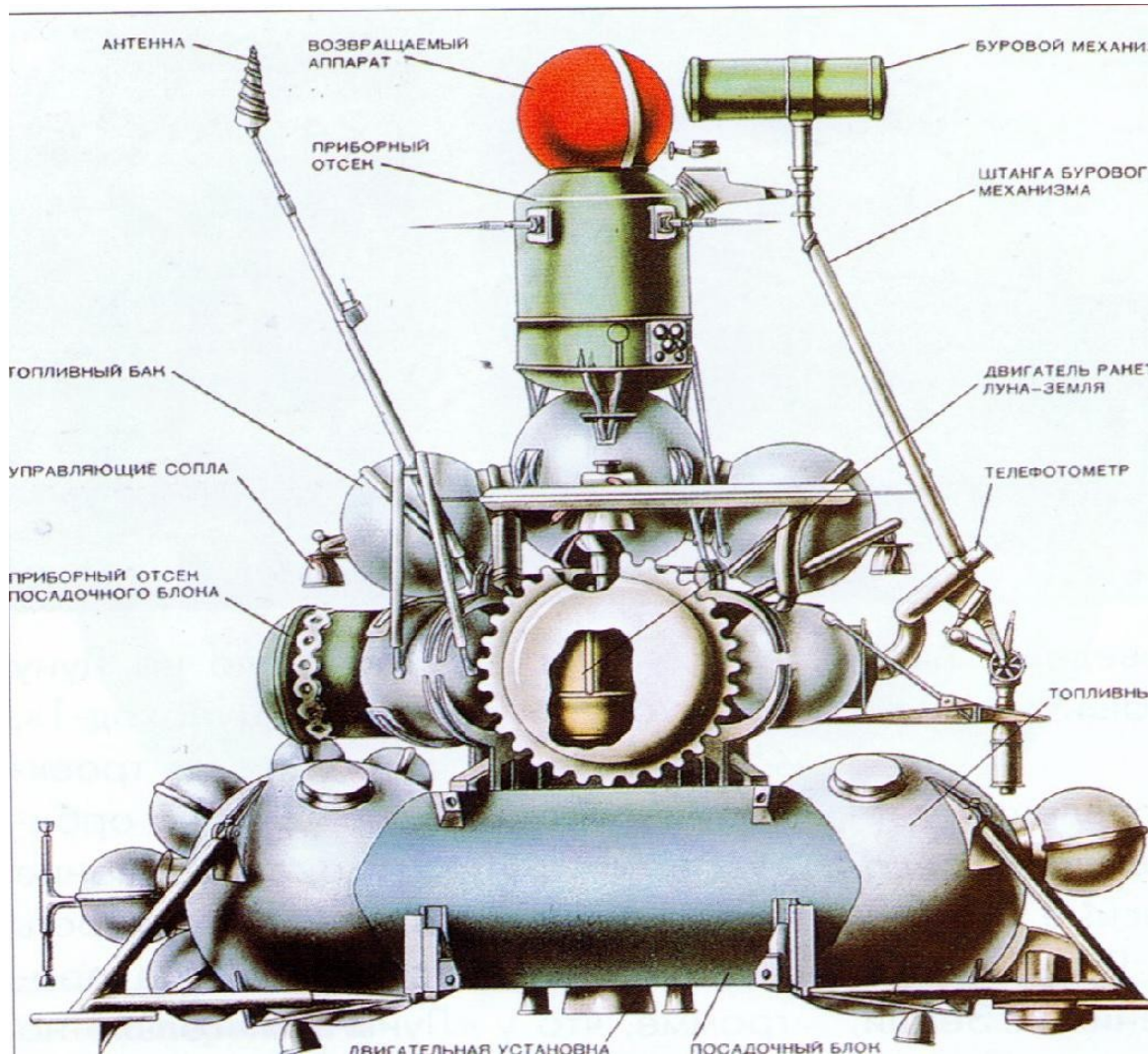


Apollo 12 Nov 1969

Wed, Jul 16, 1969, 5:49pm GMT: Columbia and Eagle docked, Apollo 11 spaceship backs out from the Saturn S-IVB stage



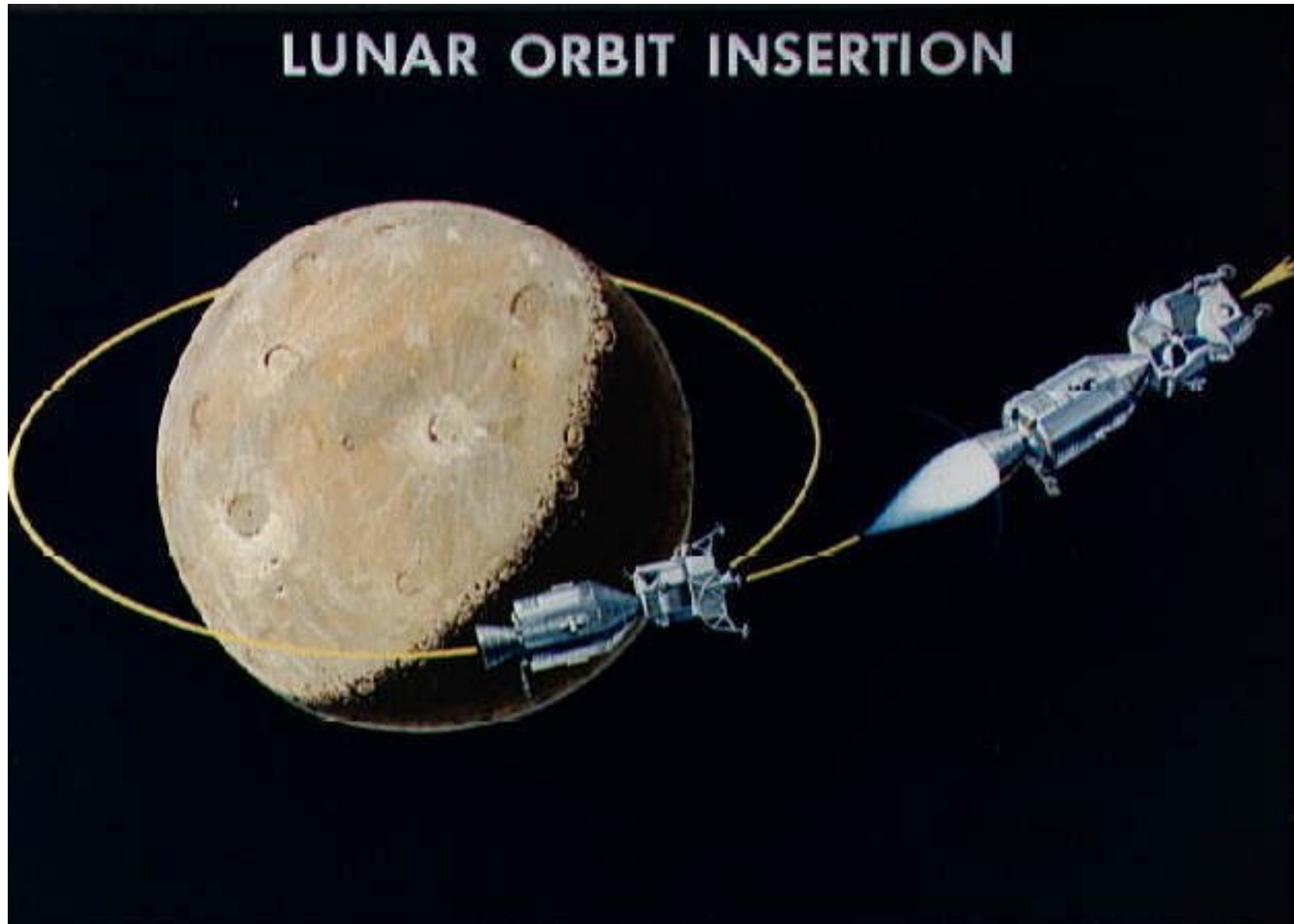
Thu Jul 17, 1969: Luna-15 in orbit around the Moon

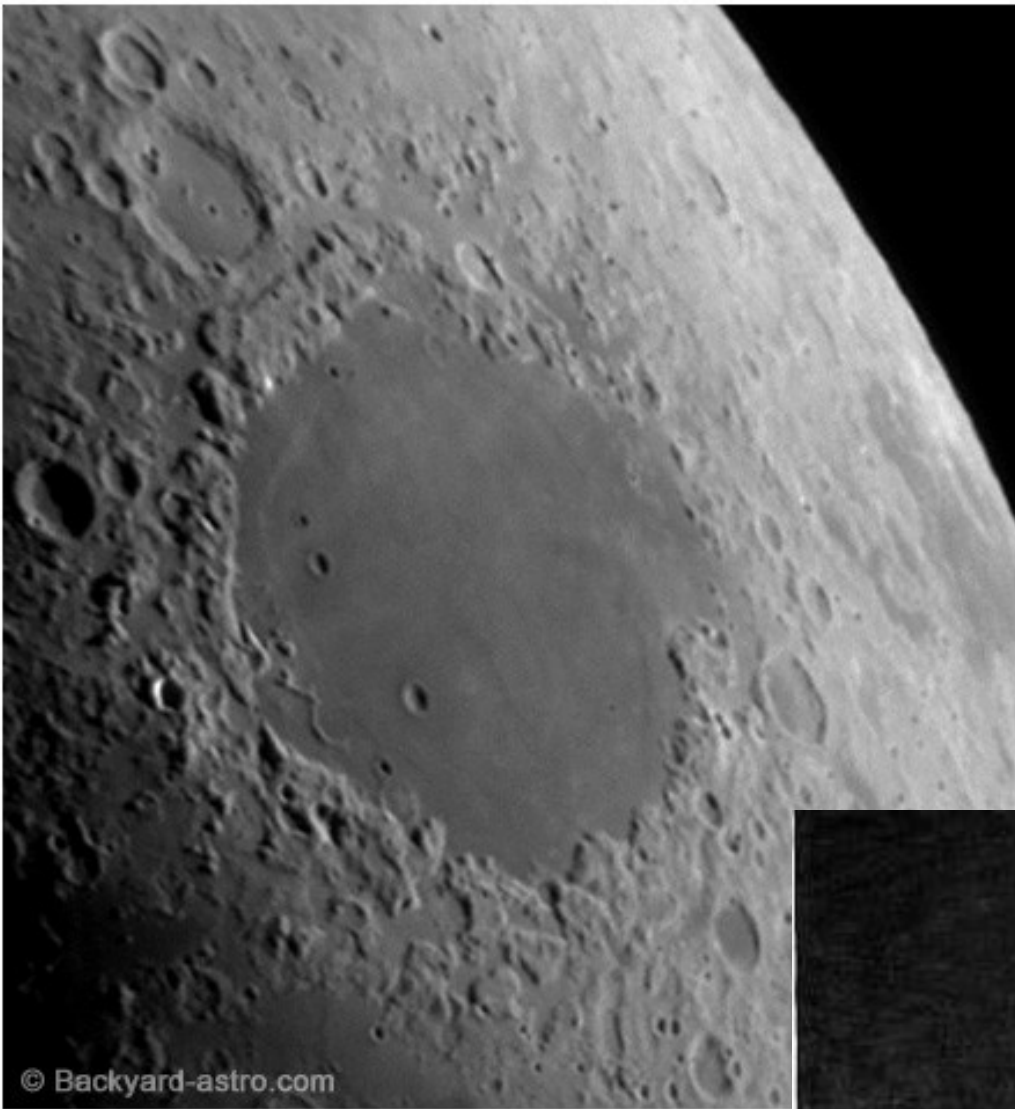


On July 17, 1969 the Soviet automated probe Luna-15 was introduced into a near-moon orbit and thus became another artificial satellite of the Moon.

Pravda, July 18, 1969

**Sat. Jul 19, 1969, 5:27pm: Apollo 11 in orbit around the Moon
111 x 311 km elliptical path adjusted at 9:43pm to 100 x 122 km**

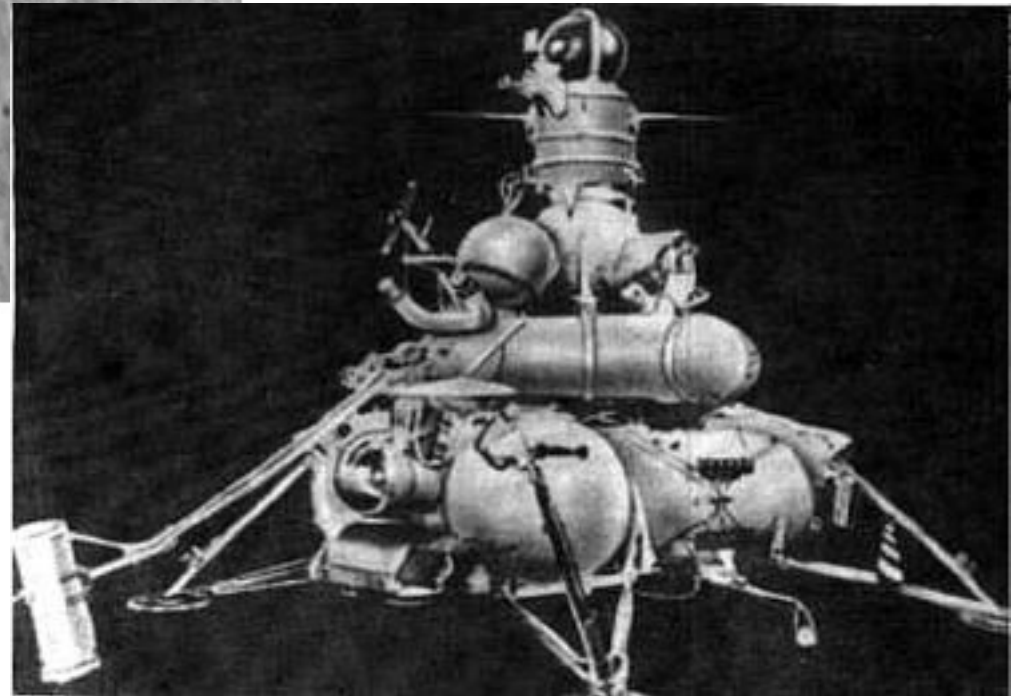




Luna-15

Sun July 20, 2:16 pm

**Luna-15 lowers orbit to
only 16 km from the
surface**

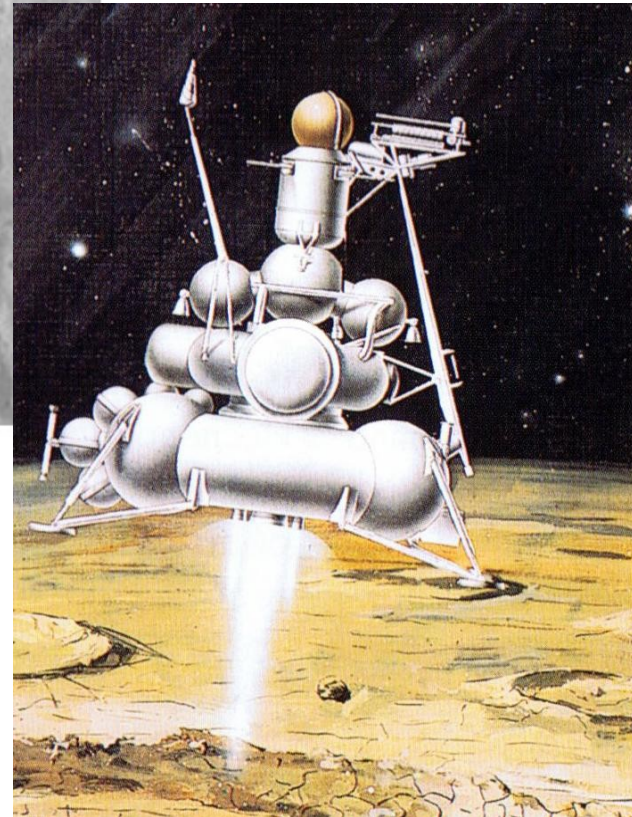


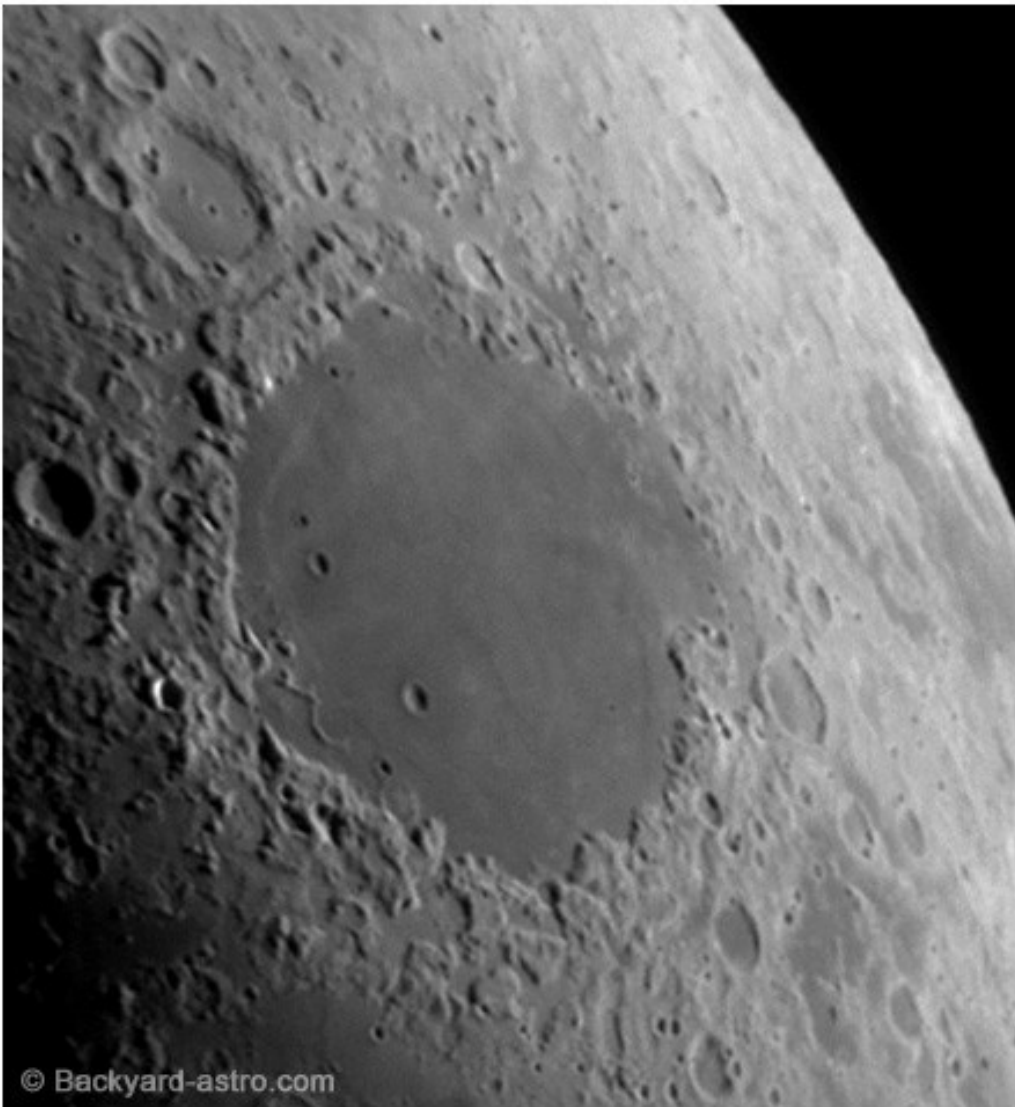


Luna-15

July 21, 3:47 pm

**Luna-15 begins descent
to lunar surface towards
Mare Crisium (“the Sea
of Crises”)**





Luna-15

July 21, 3:51 pm

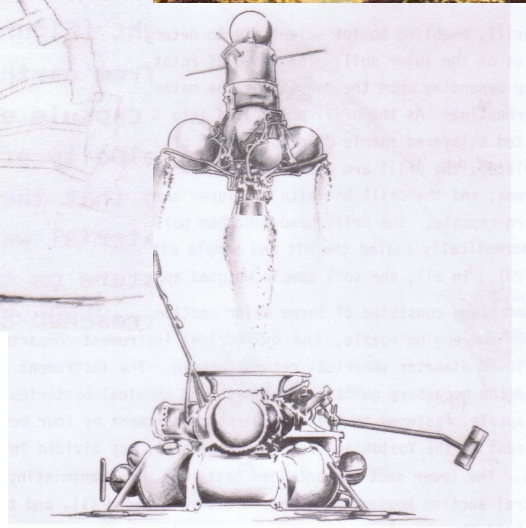
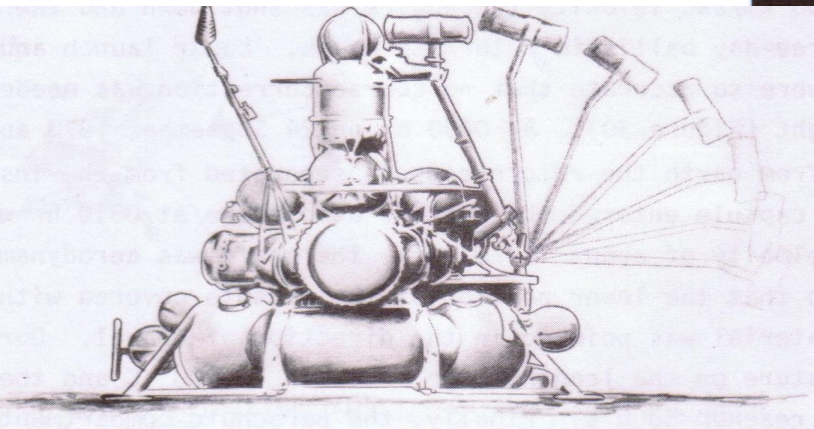
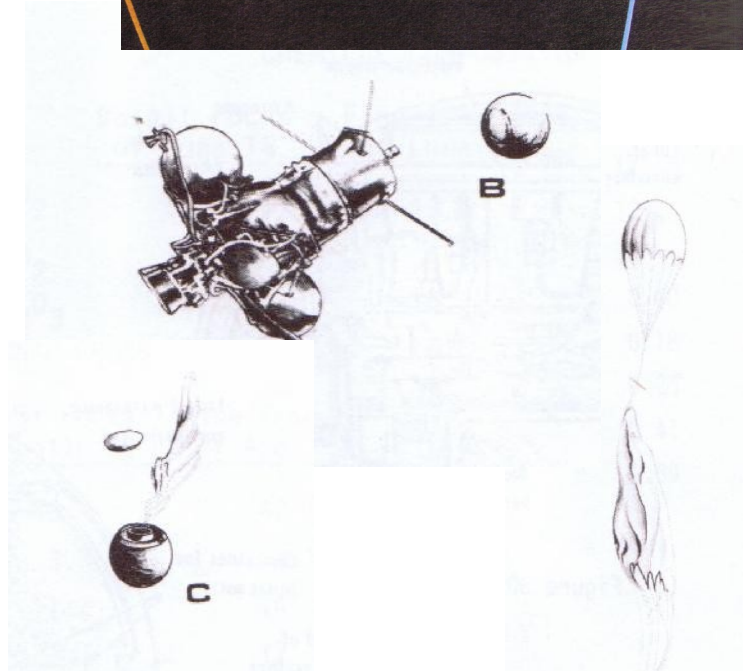
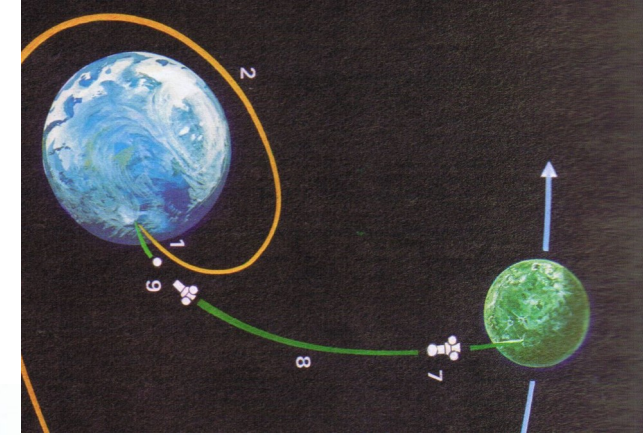
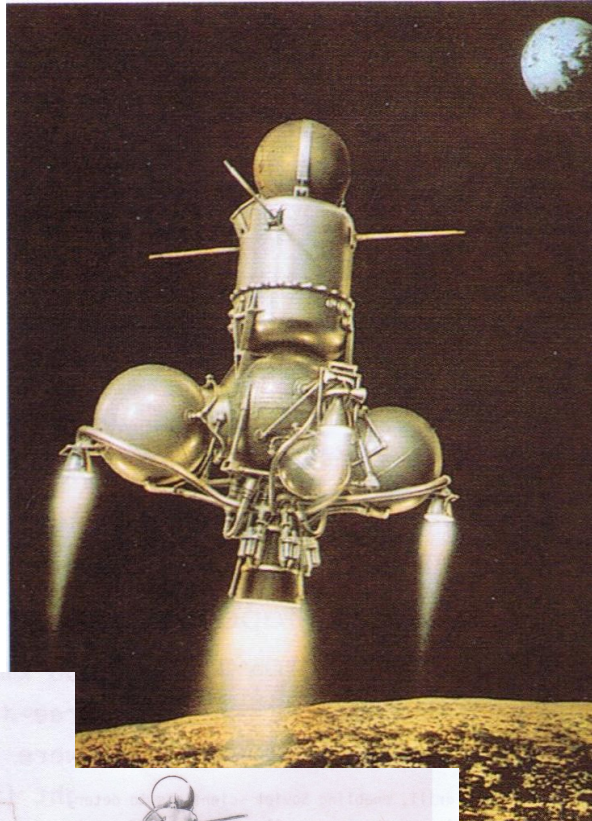
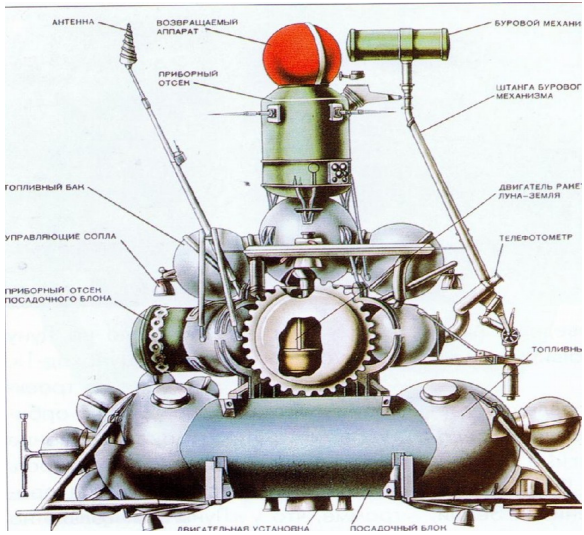
**TASS ANNOUNCEMENT:
AUTOMATED PROBE
LUNA-15 COMPLETES
FLIGHT**

**“THE PROBE LEFT THE
ORBIT AND REACHED
THE LUNAR SURFACE
AT A PREDETERMINED
PLACE. THE WORK OF
THE PROBE WAS OVER
AT 1851 HOURS
MOSCOW TIME.”**

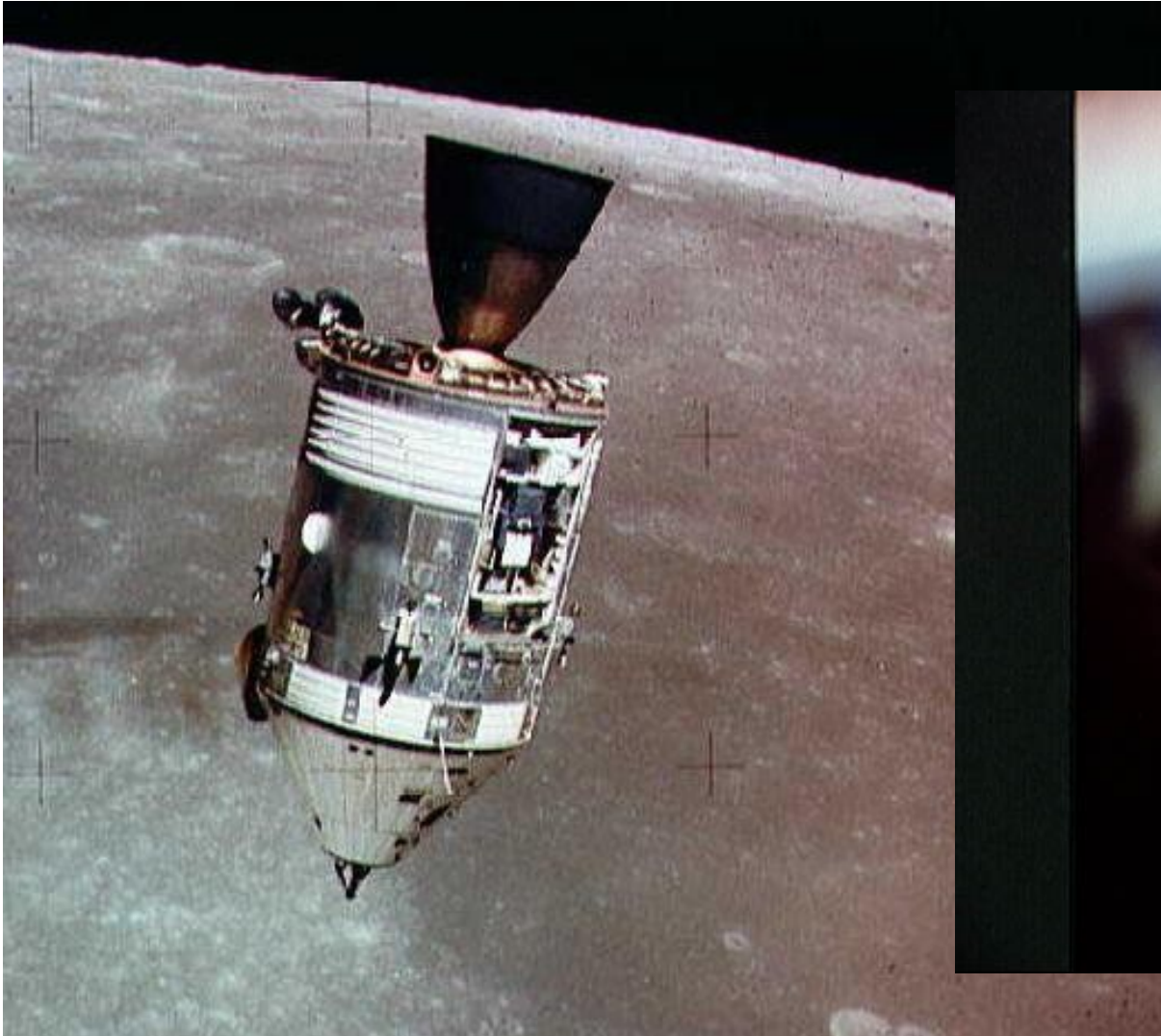
**In England, Jodrell Bank radio observatory tracks the probe's signals,
and deduces that Luna-15 landed on the Moon at a speed of 300 mph.
The braking engines failed to operate...**

The last-minute challenge to Apollo 11 is over!

WHAT NEARLY HAPPENED: LUNA-16, SEPTEMBER 1970



**Sun. Jul 20, 5:45pm: Columbia undocks from Eagle
Command and Service Module (CSM) and Lunar Module (LM)
in separate lunar orbit**



**Command and Service Module CSM-107 "Columbia"
(This image: Apollo 16 CSM-113 "Casper", May 1972)**

**"Eagle"
Lunar Module 5**

Sun Jul 20, 1969: 8:05 pm: Powered Descent
15 km above the Moon



Sun Jul 20 1969, 8:17pm GMT: TOUCHDOWN

Houston: "30 seconds" [of fuel left]

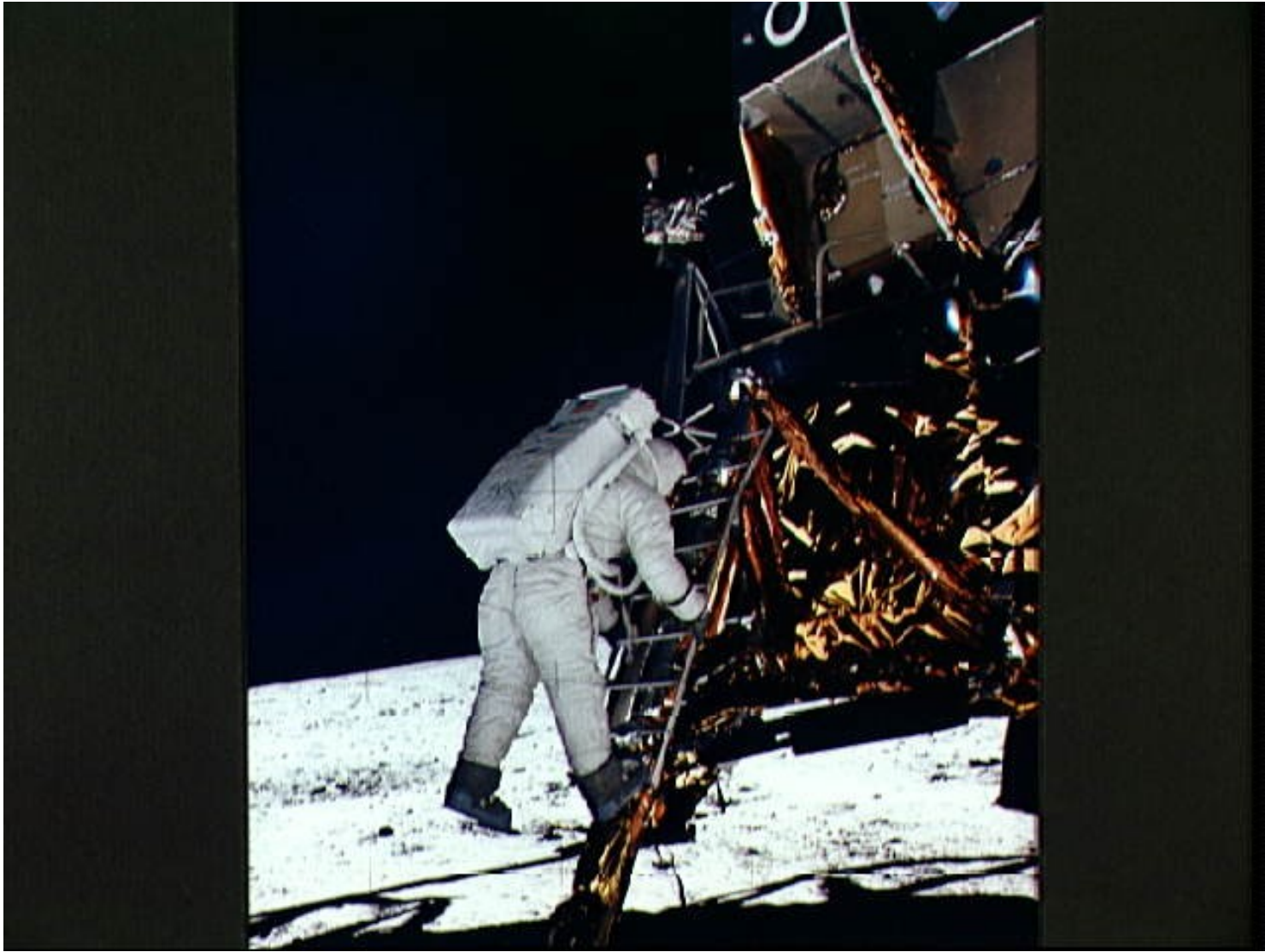
Eagle: "Contact light.. OK, engine stop....."

Houston: "We copy you down, Eagle".

Eagle: "Houston, Tranquility Base here... the Eagle has landed."



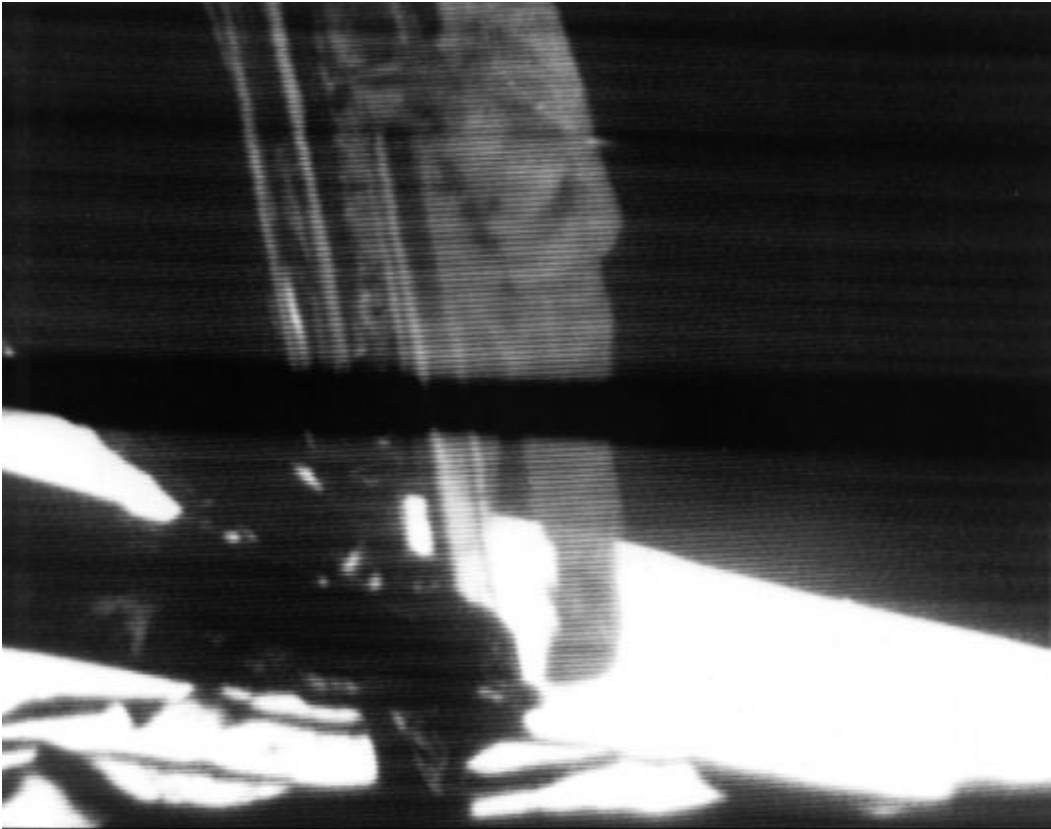
Monday July 21, 2:50am Armstrong out the hatch and on the ladder

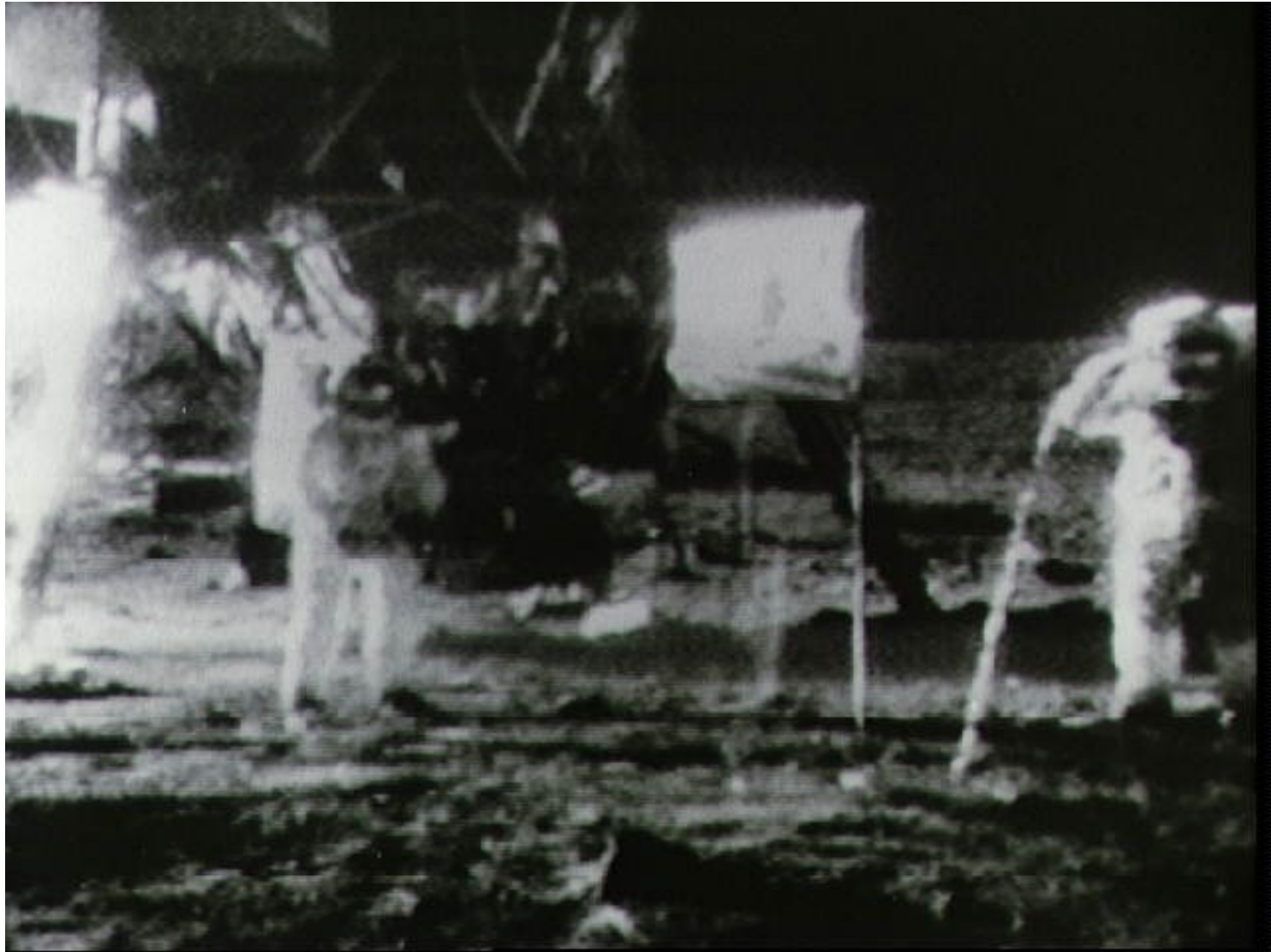


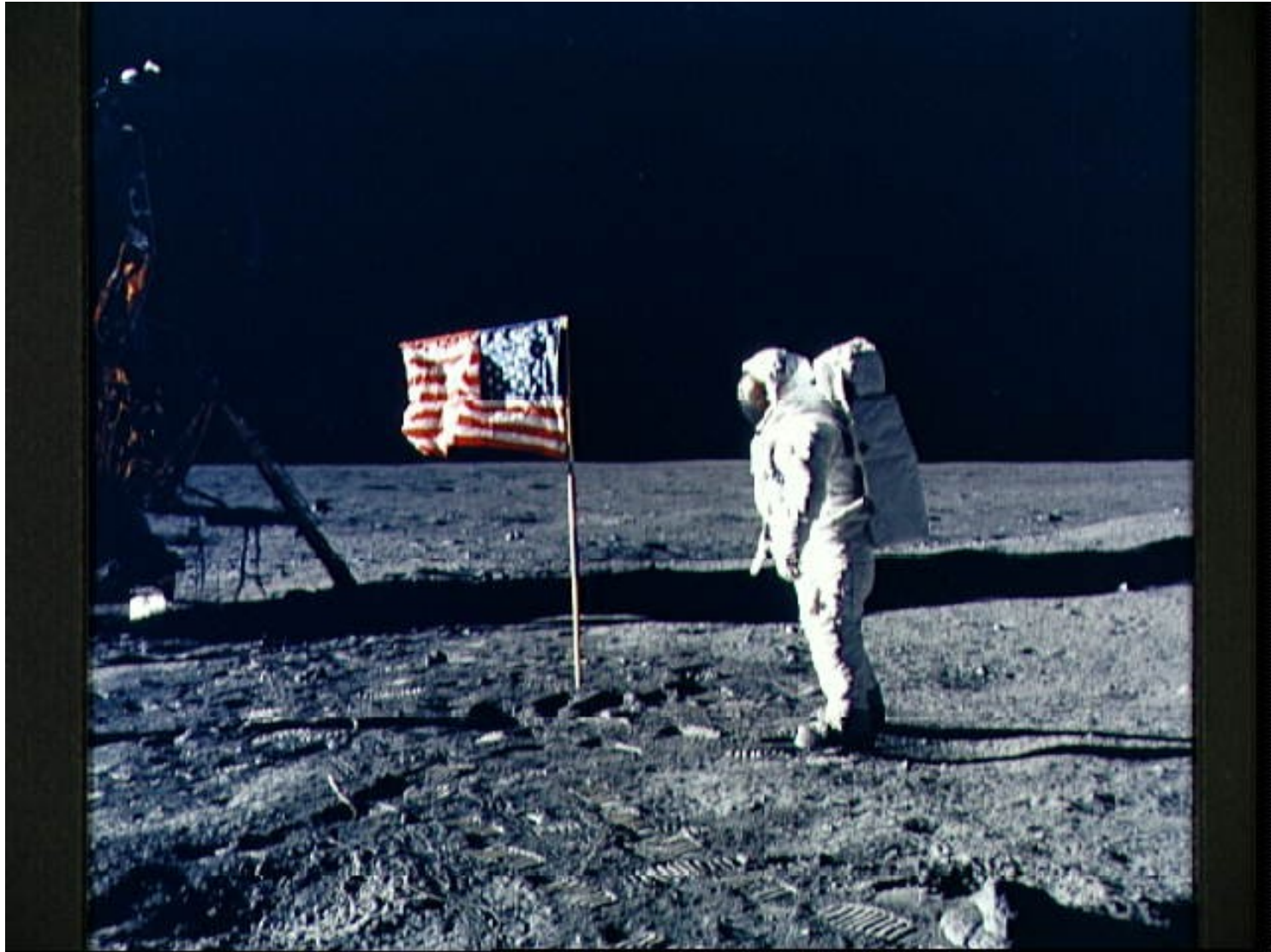
This photo actually from 3:12am, showing Aldrin coming down the ladder

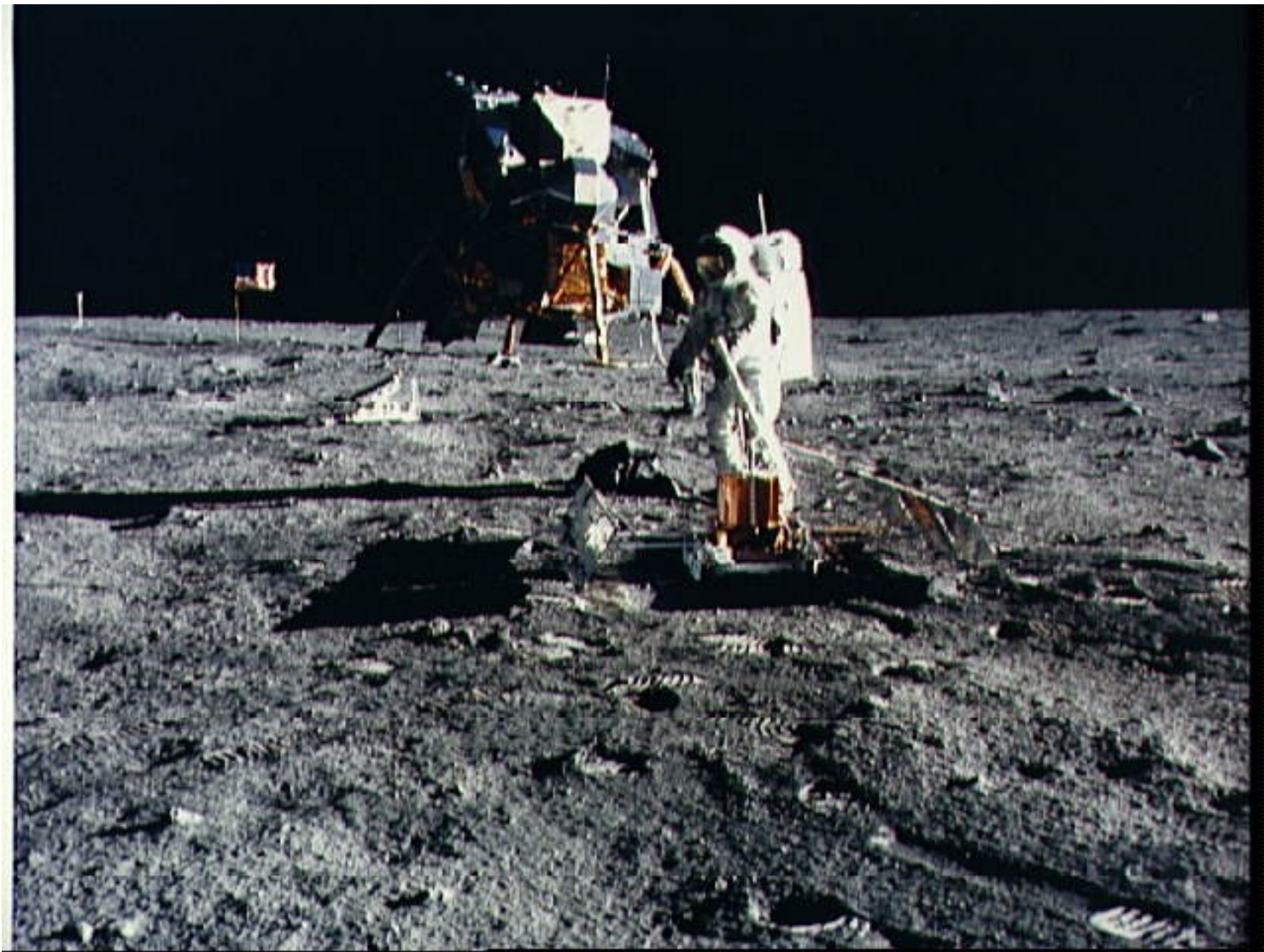
Monday Jul 21, 2:56am GMT

**“That's one small step for (a) man,
One giant leap for mankind”**











Neil Armstrong aboard Eagle after the moonwalk



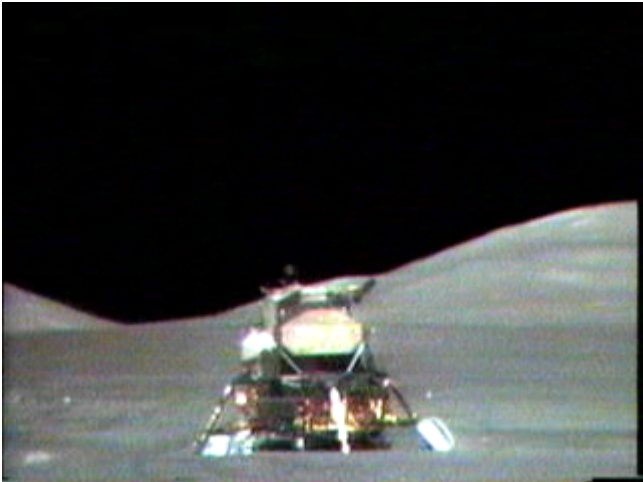
Buzz Aldrin aboard Eagle after the moonwalk



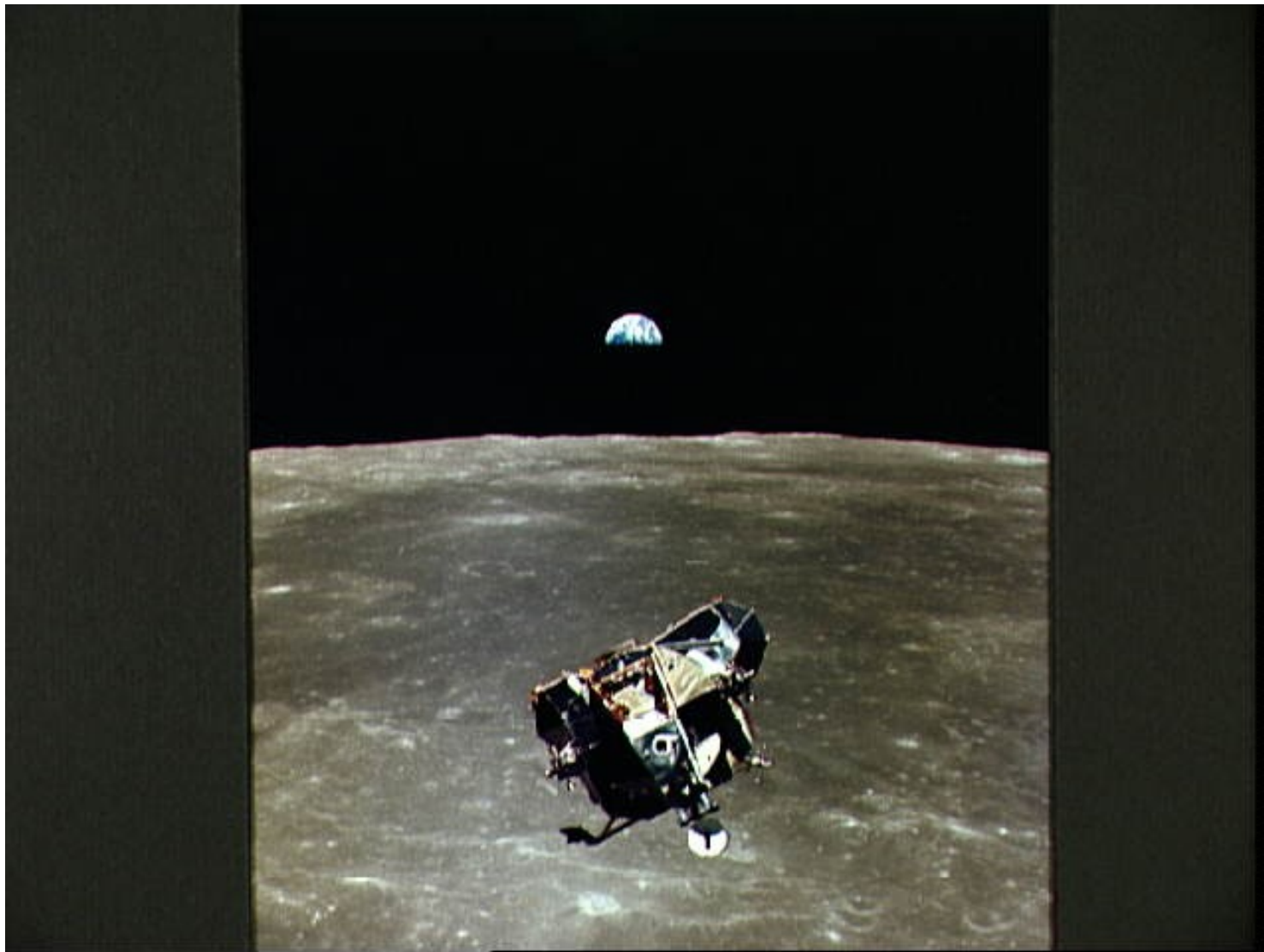
**Mon Jul 21, 5:54pm: Eagle's Ascent Stage
lifts off, using Descent Stage as launch pad.**



Apollo 17 - Dec 1972



**Mon Jul 21, 9:17pm:
Rendezvous with Mike Collins in Columbia**





Tue Jul 22, 04:58 am
En route to Earth



**Thurs Jul 24, 4:50pm
Splashdown in the Pacific**



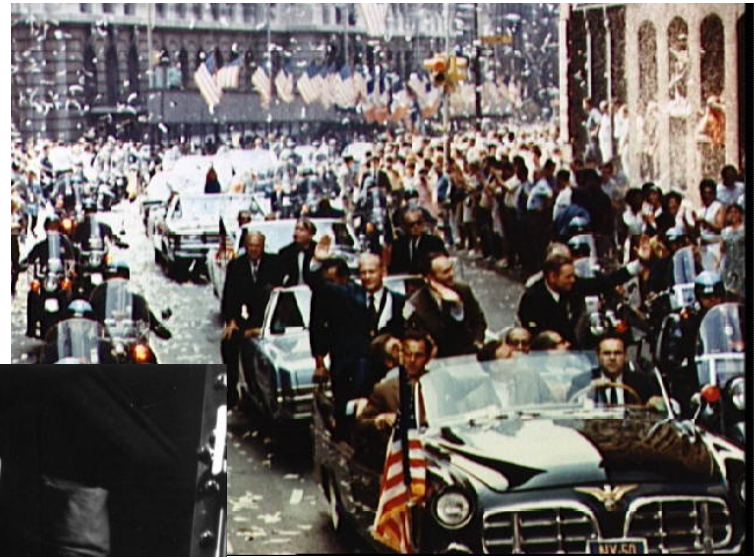
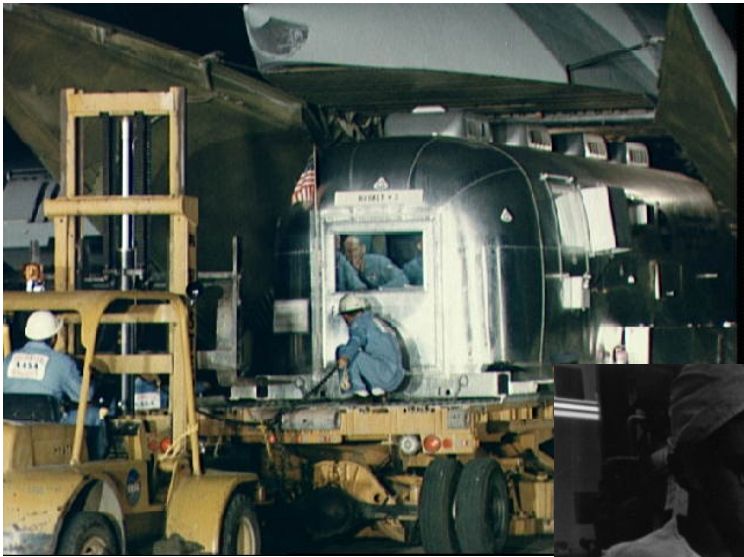
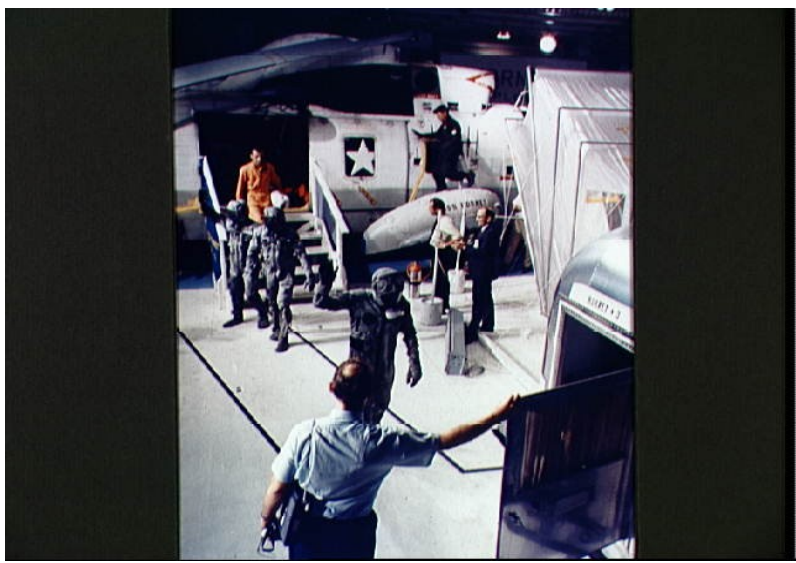
Apollo 17 – Dec 1972

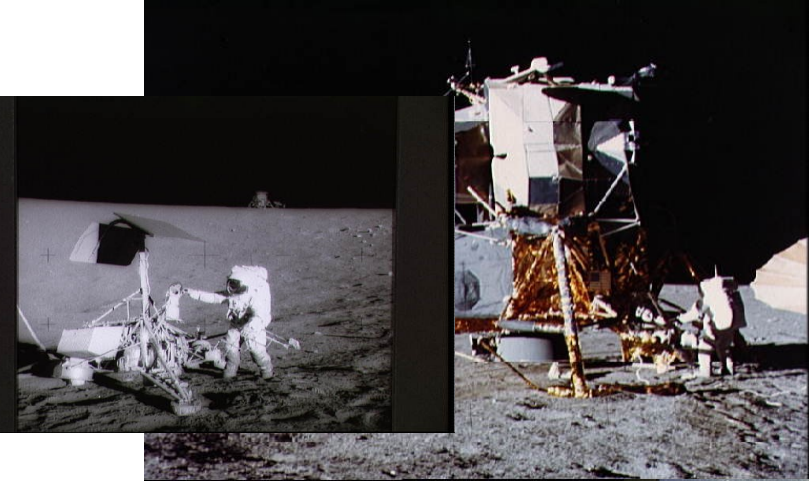
Command Module “Columbia”

Pacific Ocean, 13 N 169 W

July 24, 1969: “... and returning him safely to the Earth”.



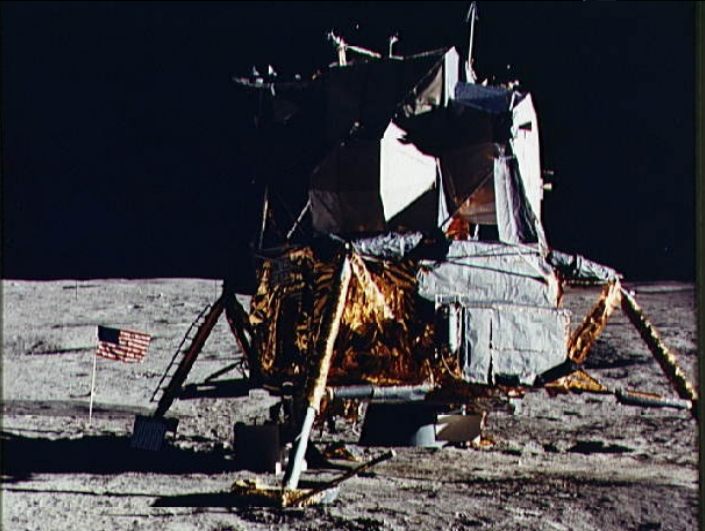
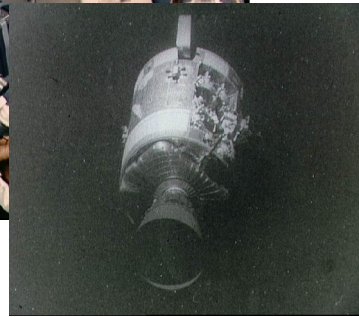
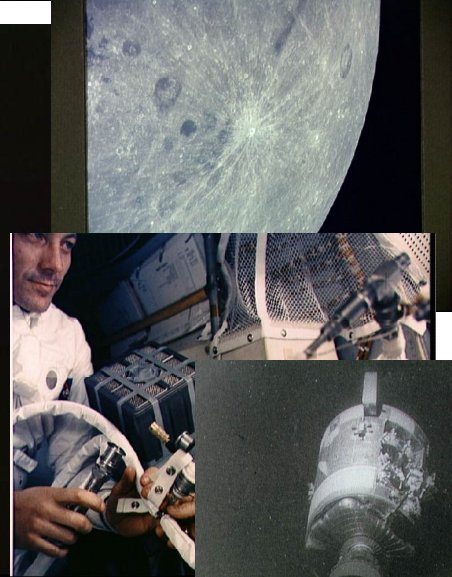
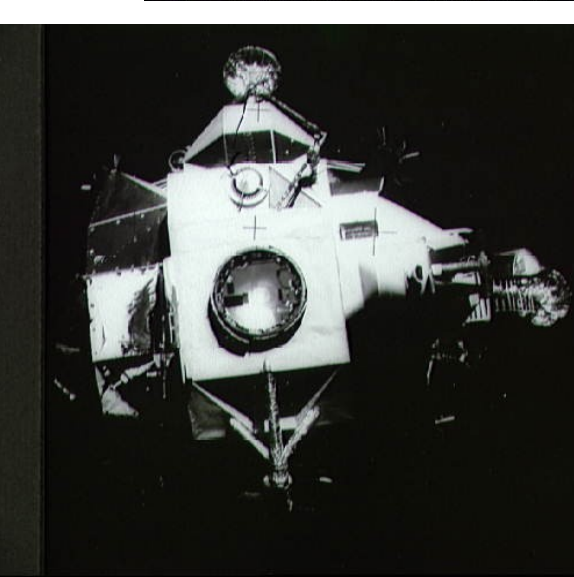
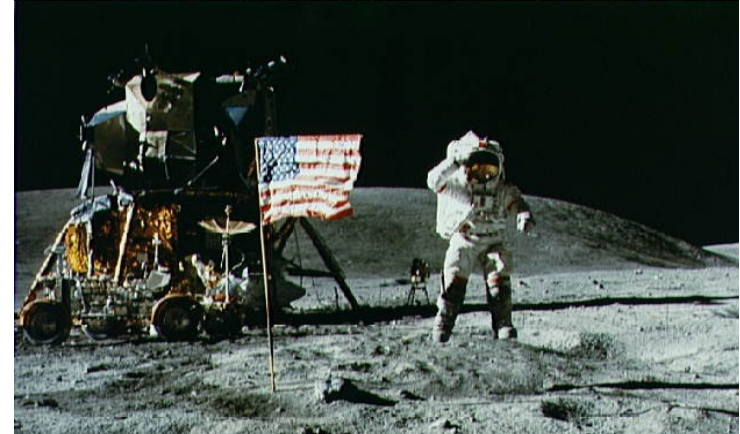
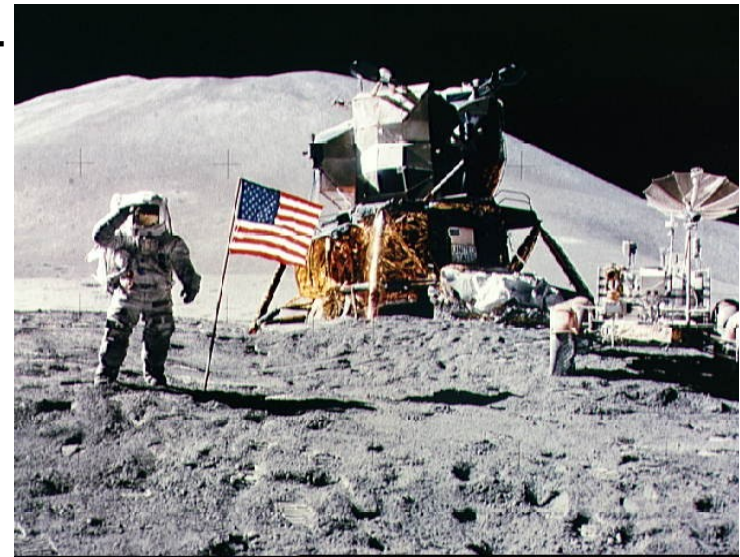




**APOLLO 12 AT SURVEYOR 3 –
NOV 1969**

APOLLO 13 – APR 1970

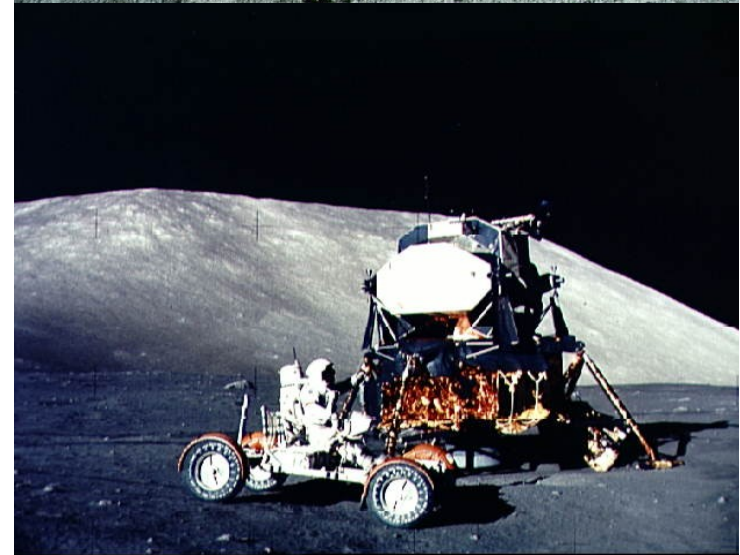
**APOLLO 14 AT FRA MAURO –
FEB 1971**



APOLLO 15 AT HADLEY – JUL 1971

**APOLLO 16 AT DESCARTES – MAY
1972**

**APOLLO 17 AT TAURUS-LITTROW
– DEC 1972**

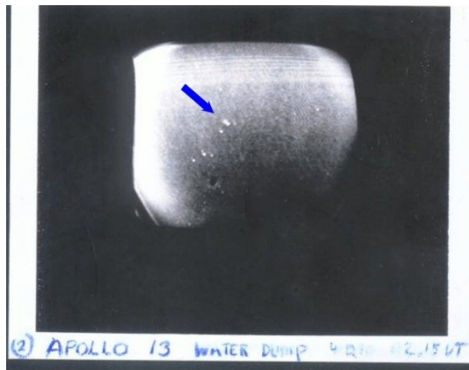


YES – WE REALLY WENT TO THE MOON.

- THE SATURN V EXISTS. THE VAB EXISTS. THE ROCKET FACTORIES EXIST.
- THE DOCUMENTATION EXISTS, IN DETAIL. WE KNEW HOW TO DO IT.
- THOUSANDS OF PEOPLE WORKED ON APOLLO.
- PEOPLE SAW THE ROCKETS GO UP! WHERE DID THEY GO?
THEY WENT TO THE MOON! WE SAW THE SPACECRAFT IN TELESCOPES
HALF WAY TO THE MOON.

APR 1970: Paul Maley
photo of water dump from
Apollo 13 en route to the
Moon

APR 1970: Apollo
13 reentry at 2500
0 mph



BOGUS IDEAS:

Van Allen Belt radiation and solar flares would have killed the astronauts.

BOGUS! Went through belts at 25000 mph, taking less than an hour – low total dose.

Solar flares monitored by NRL satellites, no big flares during Apollo flights.

Photos are faked because daytime Moon temperature is 250F and film would melt.

BOGUS! No air, temperature experienced by camera is not 250F, white paint reflects the heat, and special Kodak Estar film used doesn't melt until 490F anyway.

Sky is dark but no stars are visible in photos, so must be faked.

BOGUS! Sky is dark, but Moon in sunlight, so exposure times v short to avoid glare.

Longer exposures would show stars but wash out detail on Moon and astronauts.

Shadows do not line up, and astronauts visible in shadow, so must be faked.

BOGUS! Shadow apparent directions are as expected given bumps in topography, and astronauts illuminated by reflected light from elsewhere on surface (as confirmed by experiments)

No rocket plume visible from Ascent Stage liftoff, so must be faked.

BOGUS! N2O4/Hydrazine propellants burn with transparent flame.

The Moon rocks were really returned by robotic spacecraft.

BOGUS! 3 Soviet Luna robot probes returned 0.3 kg in total. Apollo returned over 350 kg. To do this would need a robotic mission almost as massive and expensive as Apollo, and we'd have noticed it. Easier to send astros?

No blast crater underneath the LM despite big rocket engine, but: dust not blown away where astronaut footprints are.

BOGUS! LM descent engine throttled down low for landing, blew away dust but only directly under LM (since no air to spread the blast) and did not damage underlying rock.