

Back to the Moon I

Background



Jim Rauf

Back to the Moon - Subjects

- USSR's Sputnik and the "Space Race"
- U.S. response
- U.S. and USSR "manned" orbital missions
- Race to go to the Moon
- Space Stations USSR and U.S.
- U.S. "Space Shuttle" orbiter (STS)
- International Space Station
- Energy to reach orbits and the Moon
- Private launch vehicles
- Post STS programs- Constellation Program
- Budgets and politics
- International partners
- What is needed to go to the Moon
- Launch vehicles
- Rocket engines/motors
- Crewed spacecraft
- Moon lander
- Gateway
- Crewed spacecraft reentry –heat shield , landing
- Supporting infrastructure
- Artemis Program – major components
- Space Launch System (SLS)
- Orion crew capsule
- Orion service module
- Human Landing System (HLS)
- Missions to Mars

Back to the Moon – The Artemis Program

- The **Artemis Program** is a **NASA** multi year program to send astronauts to the moon and beyond – Mars?
- Its first goal is to land astronauts on the moon and return them safely to earth
- It is intended to establish a sustainable lunar base and to prepare humanity for the long journey to Mars and beyond
- **NASA** is working with both international space agencies **ESA** , **JXA** and **Canada** as well as commercial partners **SpaceX** and others to carry out the mission
- **Artemis** builds on **NASA's** previous experience with manned space flight going back to the 1961 **Mercury Redstone 3 Alan Shepherd** flight



The Moon



Temperature range

Moon -280F to +260F

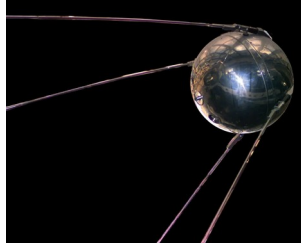
Earth -128F to +134F



| <u>Moon</u> | AVERAGE ORBIT DISTANCE | <i>Earth</i> |
|---------------------------|--------------------------|-------------------------|
| 238,855miles | | 92,956,050miles |
| | MEAN ORBIT VELOCITY | |
| 2,287.0mph | | 66,622mph |
| | ORBIT ECCENTRICITY | |
| 0.0554 | | 0.01671123 |
| | EQUATORIAL INCLINATION | |
| 6.68 degrees | | 23.4393 degrees |
| | EQUATORIAL RADIUS | |
| 1,079.6miles | | 3,958.8miles |
| | EQUATORIAL CIRCUMFERENCE | |
| 6,783.5miles | | 24,873.6miles |
| | SURFACE AREA | |
| 14,647,439.75square miles | | 196,936,994square miles |
| | SURFACE GRAVITY | |
| 5.328ft/s ² | | 32.041ft/s ² |
| | ESCAPE VELOCITY | |
| 5,314mph | | 25,031mph |

Beginning of the Space Race - Earth Orbit Satellites

October 4, 1957 USSR: Sputnik (184 lbs) launched



November 3, 1957 **USSR: Sputnik II** (1,120 lbs), with dog **Laika** as passenger, launched

December 6, 1957 **USA: Vanguard TV-3** explodes on launch pad

January 31, 1958 USA: Explorer 1 launched from Cape Canaveral



February 3, 1958 **USSR: First try to launch Sputnik III fails**

February 5, 1958 **USA: A second Vanguard try fails**

March 5, 1958 **USA: Explorer 2 fails to orbit**

March 17, 1958 **USA: Vanguard 1** (3.3 lbs) successfully orbits, establishes the pear-shapeness of Earth

March 26, 1958 **USA: Explorer 3** orbits, collects radiation and micrometeoroid data

April 28, 1958 **USA: Another Vanguard fails to orbit (third failure)**

May 15, 1958 **USSR: Sputnik III** (2,920 lbs) orbits, carrying large array of scientific instruments, but tape recorder fails, so it can't map *Van Allen belts*

May 27, 1958 **USA: Vanguard fails for the fourth time**

June 26, 1958 **USA:**
Vanguard fails for the fifth time

July 26, 1958 **USA: Explorer 4** orbits and maps **Van Allen** radiation belts for 2 1/2 months

August 24, 1958 **USA: Explorer 5 fails to orbit**

September 26, 1958 **USA: Vanguard fails for the sixth time**

The Space Race - Human Space Flight Programs

- Vostok program (USSR, 1956–1964)
- **Project Mercury** (USA, 1959–1963)
- Voskhod program (USSR, 1964–1965)
- **Project Gemini** (USA, 1965–1966)
- Soyuz program (USSR/Russia, 1967–ongoing)
- **Apollo Program*** (USA, 1961–1975)
- **Space Shuttle** (USA, 1972–2011)
- China Manned Space Program (China, 1992–ongoing)



Vostok

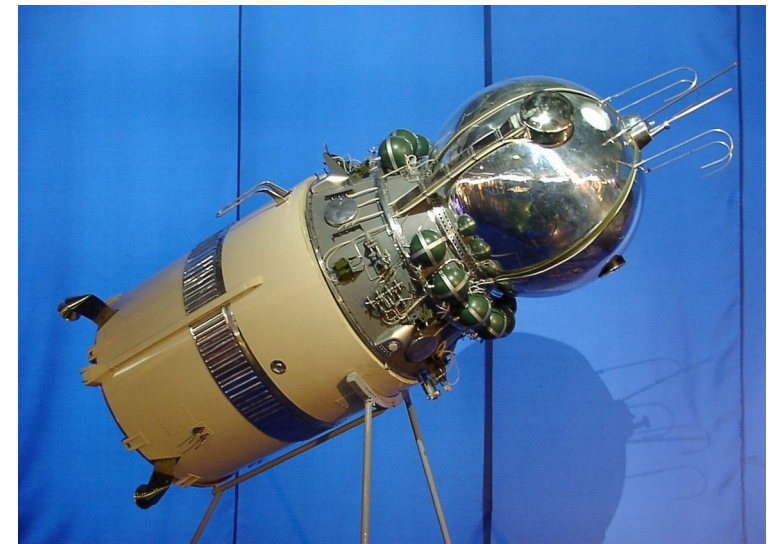


Space Shuttle

* Moon landings

Vostok program (USSR, 1956–1964)

- The **Vostok program** was a project that put a person into orbit for the first time
- The **Vostok 3KA** spacecraft was launched on April 12, 1961, taking **Yuri Gagarin** into space
- The first human into outer space and the first to orbit the earth
- There were six **Vostok** flights in total, including the June, 1963 Vostok 6 flown by **Valentina Tereshkova**, the first woman in space
- **Vostok 7 to 13 flights** were canceled, and the components recycled into the **Voskhod** program



Project Mercury (USA, 1959–1963)

- **Project Mercury** - the first U.S. human spaceflight program
- Its goal was putting a human in orbit around the Earth
- Planning and research was carried out by the **National Advisory Committee for Aeronautics**, the program was officially conducted by the newly created (1958) **National Aeronautics and Space Administration (NASA)**
- **Mercury-Redstone 3** mission brought the first American into space, **Alan Shepard**
 - It featured the first manual pilot control of the spacecraft
 - The capsule's 60 cu ft of habitable volume was just large enough for the single crew member
- **Mercury - Atlas 6 -John Glenn's** flight on February 20,1962 was the first **Mercury** flight to achieve the goal of placing a human in orbit around the Earth



Background- Mercury Redstone

| | MR-3 | Flight designation | Rocket designation | Launch date | Comments |
|-------------------|--|---------------------------|---------------------------|--------------------|--|
| Spacecraft name | Freedom 7 | | | | Empty capsule; launch abort; rocket shut down at liftoff due to electrical fault |
| Spacecraft mass | Launch: 4,040 pounds Landing ; 2,316 pounds | MR-1 | MR-1 | November 21, 1960 | |
| Launch date | May 5, 1961, 14:34:13 UTC | MR-1A | MR-3 | December 19, 1960 | Empty capsule |
| Landing | May 5, 1961, 14:49:35 UTC | | | | |
| Mission duration | 15 min 22 sec | MR-2 | MR-2 | January 31, 1961 | Carried chimpanzee Ham |
| Apogee (altitude) | 116.5 miles | | | | |
| Distance traveled | 303 miles downrange | MR-BD | MR-5 | March 24, 1961 | Empty nonfunctional "boilerplate" capsule |
| Maximum velocity | 5,134 miles per hour | | | | |
| Peak acceleration | Launch: 6.3 g. Re-entry: 11 g | MR-3 | MR-7 | May 5, 1961 | Carried astronaut Alan Shephard |
| | | MR-4 | MR-8 | July 21, 1961 | Carried astronaut Gus Grissom |

Background –Mercury Atlas 6- Friendship 7



Launch of Friendship 7, the first American manned orbital space flight. Astronaut John Glenn aboard, the Mercury-Atlas rocket is launched from Pad 14.



John H. Glenn

| | |
|-------------------|----------------------|
| Spacecraft mass | 2,700 lb |
| Crew | John H. Glenn |
| Call sign | Friendship 7 |
| Launch vehicle | Atlas LV-3B |
| Launch pad | LC-14 |
| Mission duration | 04:55:23 (hh:mm:ss) |
| Number of orbits | 3 |
| Apogee | 143 nmi |
| Perigee | 86 nmi |
| Orbital period | 88.5 min. |
| Distance traveled | 75,679 mi |
| Maximum velocity | 17,526 mph |
| Peak acceleration | 7.7 g |

Background- Project Mercury- Manned Flights

- **Mercury-Redstone 3FREEDOM 7**
May 5, 1961
Alan B. Shepard, Jr.

15 minutes, 28 seconds
Suborbital flight that successfully put the first American in space.
- **Mercury-Redstone 4LIBERTY BELL 7**
July 21, 1961
Virgil I. Grissom

15 minutes, 37 seconds
Also suborbital; successful flight but the spacecraft sank shortly after splashdown.
- **Mercury-Atlas 6FRIENDSHIP 7**
February 20, 1962
John H. Glenn, Jr.

04 hours, 55 minutes 23 seconds
Three-orbit flight that placed the first American into orbit.
- **Mercury-Atlas 7AURORA 7**
May 24, 1962
M. Scott Carpenter

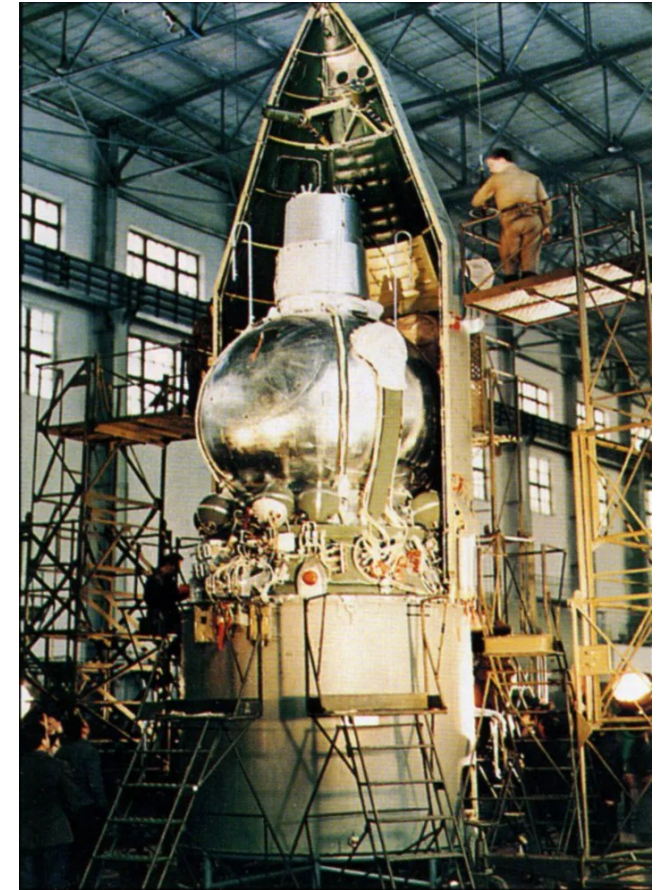
04 hours, 56 minutes, 5 seconds
Confirmed the success of Mercury-Atlas 6 by duplicating 3 **orbit flight**.
- **Mercury-Atlas 8SIGMA 7**
October 03, 1962
Walter M. Schirra, Jr.

09 hours, 13 minutes, 11 seconds
Six-orbit engineering test flight.
- **Mercury-Atlas 9FAITH 7**
May 15-16, 1963
L. Gordon Cooper, Jr.

34 hours, 19 minutes, 49 seconds
Last Mercury mission; completed **22 orbits** to evaluate effects of one day in space.

Voskhod program (USSR, 1964–1965)

- The **Voskhod program** was a follow-on to the **Vostok program**, recycling components left over from that program's cancellation following its first six flights
- The **Voskhod** spacecraft was basically a **Vostok** spacecraft that had a backup, solid fuel retrorocket added to the top of the descent module
- The heavier weight of the craft was made possible by improvements to the **R-7 Semyorka**-derived booster
- Two or three crew couches were added to the interior
- The **Vostok** program was dedicated towards understanding the effects of space travel and microgravity on the human body
- **Voskhod's** two flights were aimed towards spectacular "firsts":
 - The first multi-person crew into orbit during **Voskhod 1**
 - The first **EVA** ("spacewalk") during **Voskhod 2**



NASA Manned Space Flight “Building Block” Approach to Moon Landing

Mercury Redstone - Sub orbital
Flights

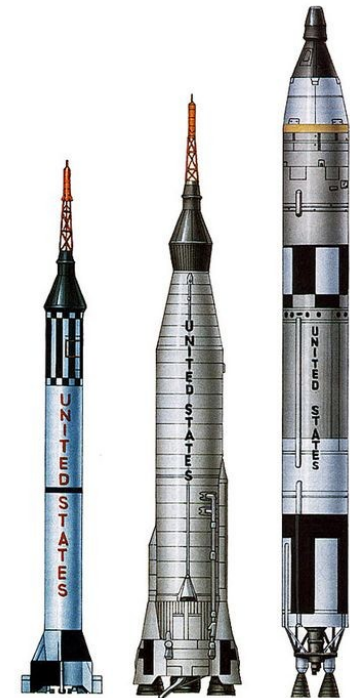
Mercury Atlas - Orbital Flights

Gemini Titan - Orbital Flights-
rendezvous and docking

Apollo /Saturn IB - Orbital Flights

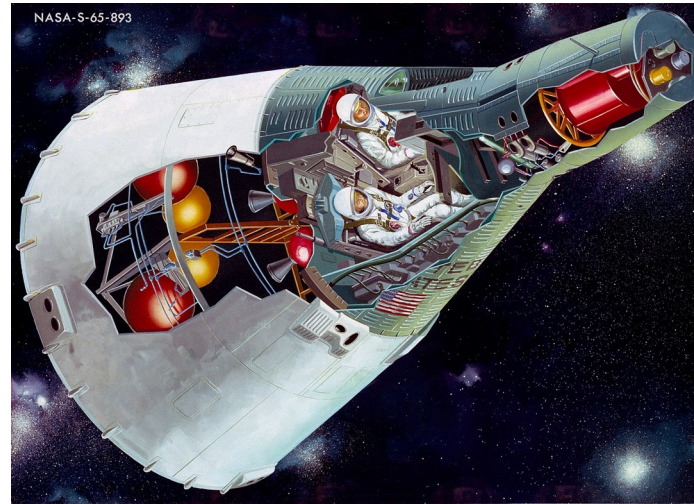
Apollo/ Saturn V - Orbit Moon,
LM Partial Descent

Apollo /Saturn V - Moon Landing/Return



Project Gemini (USA, 1965–1966)

- **Project Gemini** was **NASA's** the second human spaceflight program
- It conducted 10 crewed flights during 1965 and 1966
- It developed techniques necessary for Project Apollo
- **Gemini** missions included the first American **extravehicular activity (EVA)** , and new orbital maneuvers including **rendezvous and docking**
- **Gemini** capsules were launched on modified **Titan** ICBMs
- Astronaut corps expanded beyond "*Mercury Seven*"



Background – Gemini Spacecraft



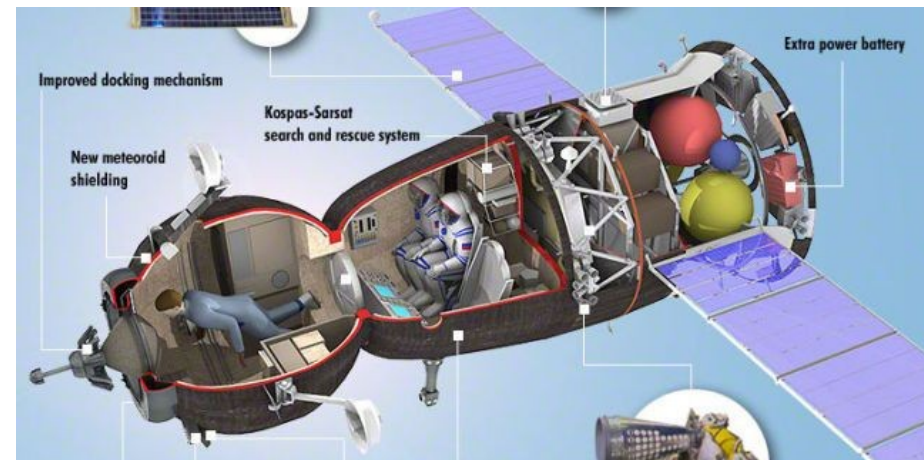
NASA Astronaut Corps Expanded Beyond Original Mercury Seven



| Group | Astronaut | Service |
|---------|-----------------------|----------|
| Group 1 | L. Gordon Cooper | USAF |
| | Virgil "Gus" Grissom | |
| | Walter M. Schirra | USN |
| Group 2 | Neil A. Armstrong | Civilian |
| | Frank Borman | USAF |
| | Charles "Pete" Conrad | USN |
| | James A. Lovell | USN |
| | James A. McDivitt | USAF |
| | Thomas P. Stafford | |
| | Edward H. White II | |
| | John W. Young | USN |
| Group 3 | Edwin "Buzz" Aldrin | USAF |
| | Eugene A. Cernan | USN |
| | Michael Collins | USAF |
| | Richard F. Gordon | USN |
| | David R. Scott | USAF |

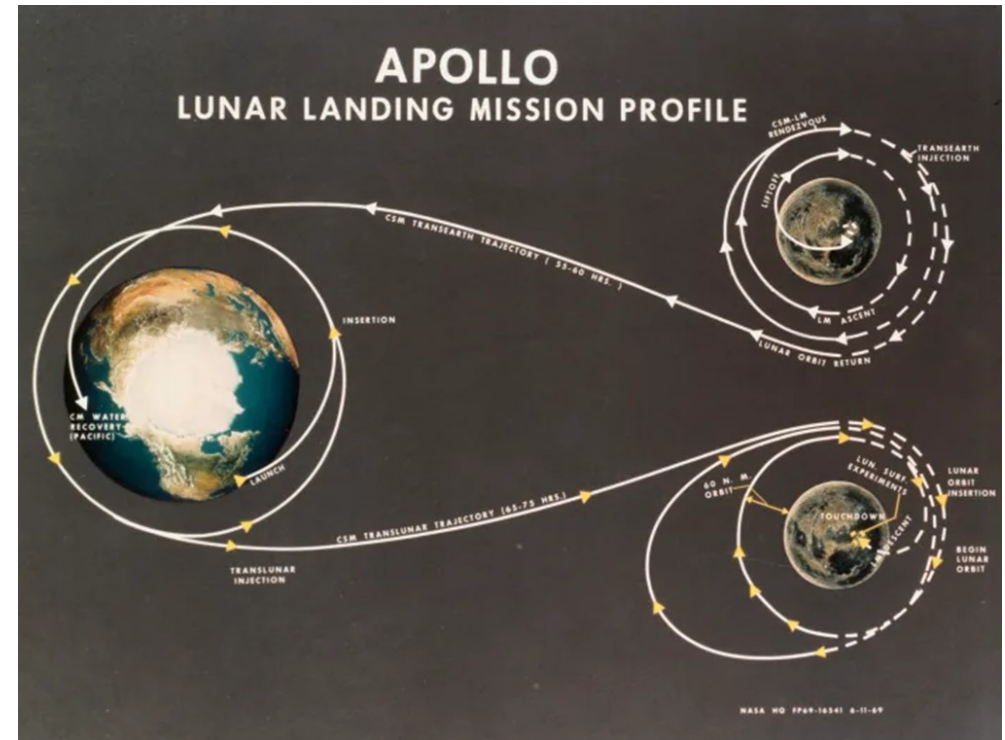
Soyuz Program (USSR/Russia, 1967–ongoing)

- The **Soyuz Program** was initiated by the **USSR** in early 1967 as a part of their moon landing program
- The basic **Soyuz** spacecraft design was the basis for many projects including supplying the **International Space Station**
- **Soyuz** launch vehicles are expendable
- **Soyuz** is 23-ft long and 15,400 lb spacecraft that consists of three modules
 - A central, bell-shaped three person descent section
 - A cylindrical rear mounted service module that provides propulsion, life support, and electrical power
 - A spheroidal orbital module in front that carries the docking system and contains living facilities and cargo for the orbital missions
- They remain together until the spacecraft is deorbited
- Only the descent module returns to Earth intact



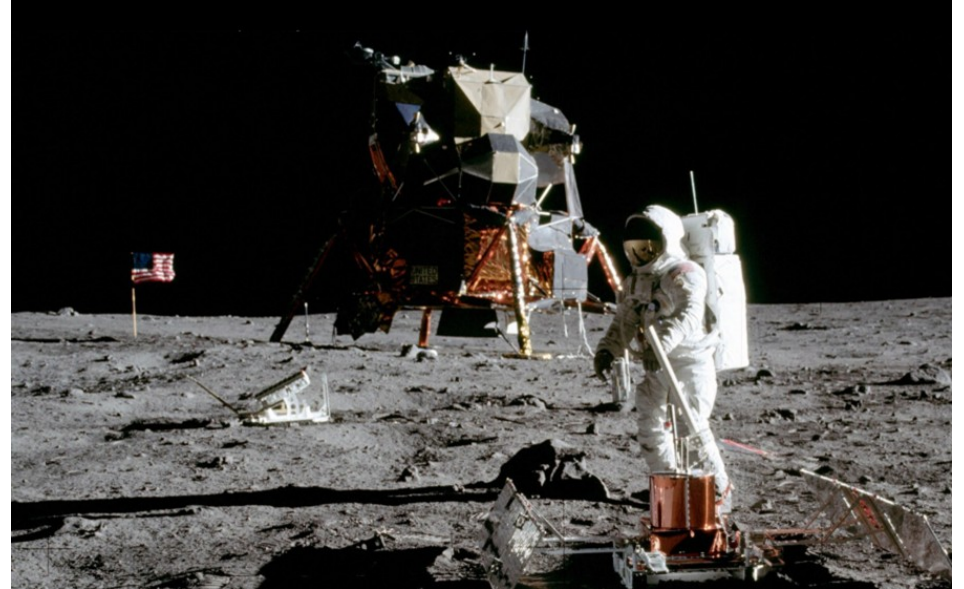
Apollo Program (USA, 1961–1975)

- May 25, 1961 **President John F. Kennedy** announced a goal of sending an American safely to the Moon before the end of the decade
- This decision involved much study and review prior to making it public
- Lots of debate about how to go to the Moon
- Tremendous expenditure and effort to make it a reality by 1969
 - Some 400,000 people involved in the program
- Only the building of the Panama Canal rivaled the **Apollo** program's size as the largest non-military technological endeavor ever undertaken by the United States
- Only the **Manhattan Project** was comparable in a wartime setting
- The human spaceflight programs, **Mercury** and **Gemini** were “building blocks” for **Apollo**



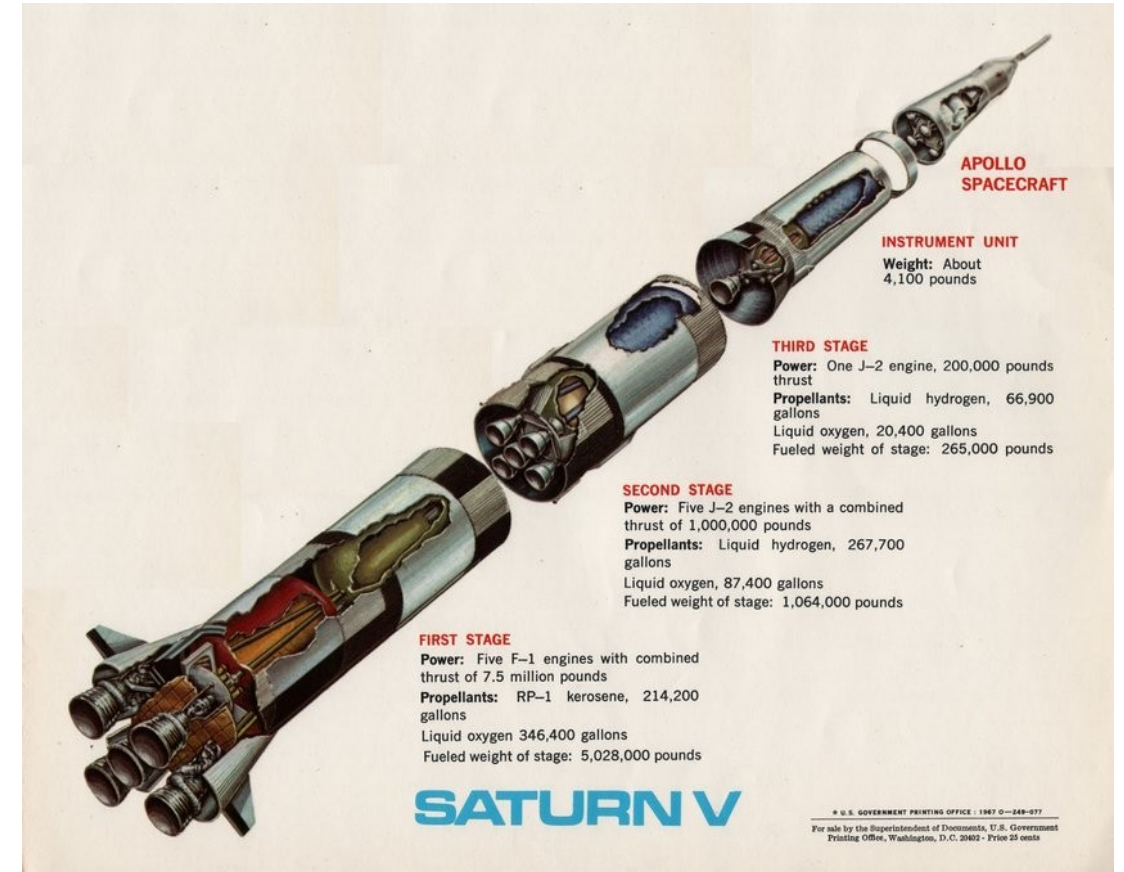
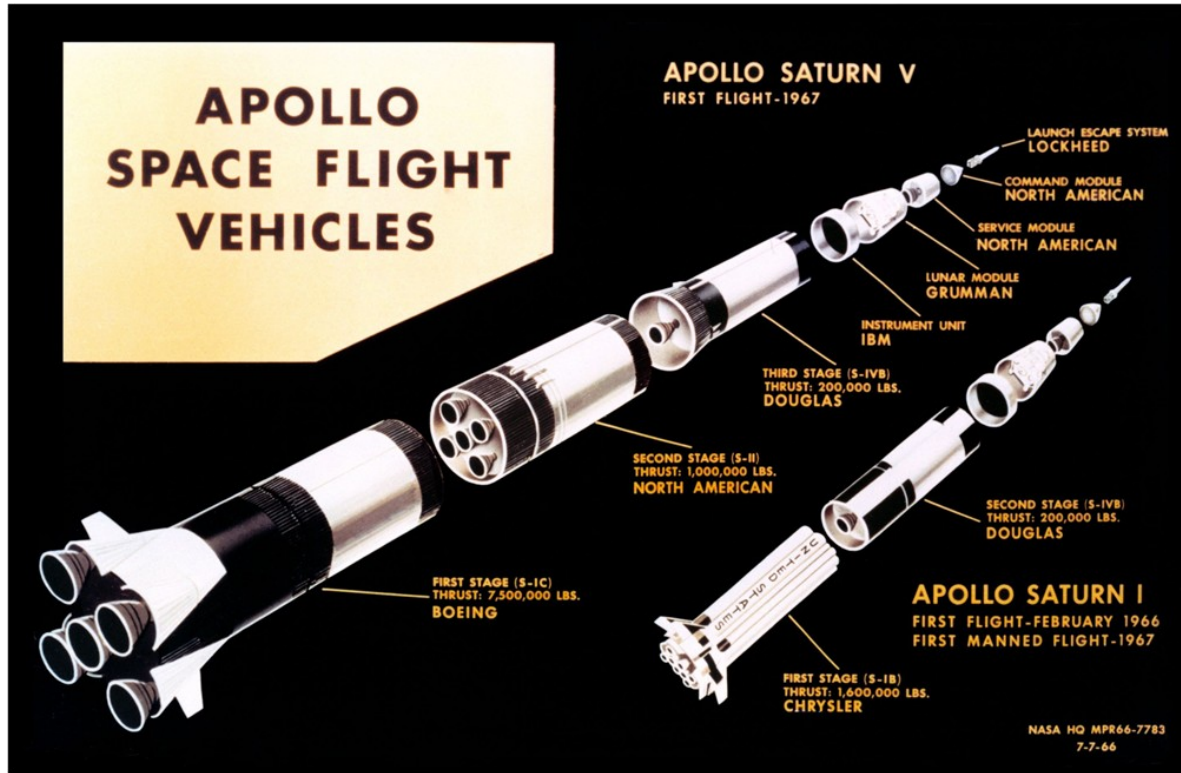
Apollo Program (USA, 1961–1975)

- **Apollo Program's** goal of landing a man on the Moon by the end of the decade was accomplished on July 20, 1969, by the landing of astronauts **Neil Armstrong** and **Buzz Aldrin**, with **Michael Collins** orbiting above during the **Apollo 11** mission
 - Five other **Apollo** missions also landed astronauts on the Moon, the last one in 1972
- The six **Apollo** spaceflights are the only times humans have landed on another celestial body
- **Apollo** program used **Apollo** spacecraft and **Saturn** launch vehicles

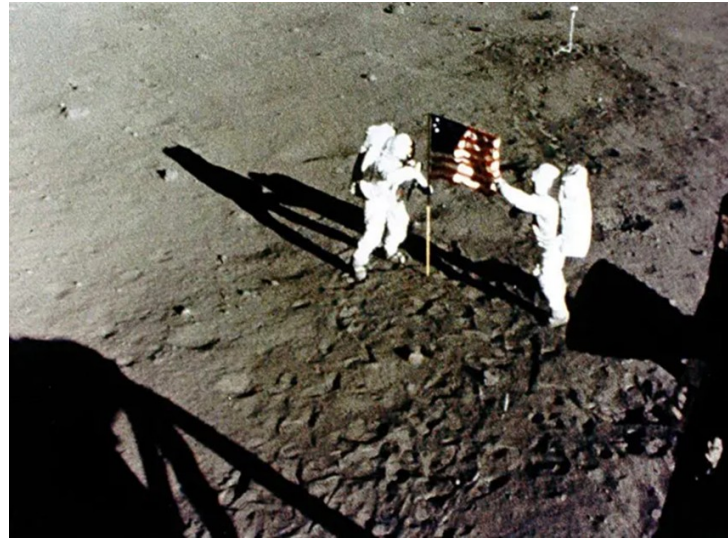
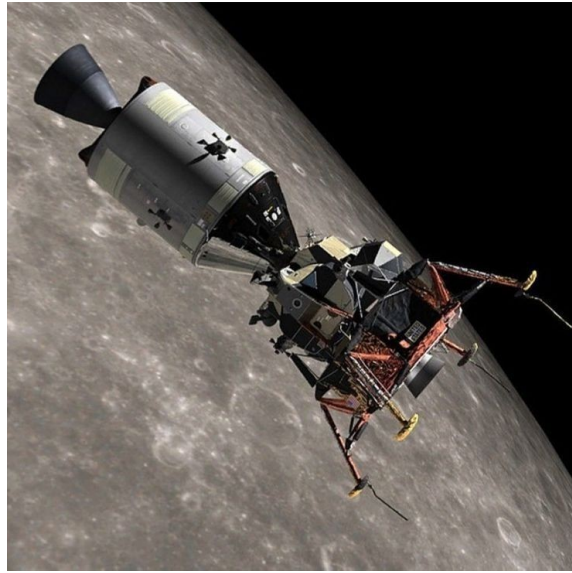


- The program suffered two major failures
 - The **Apollo 1** launchpad fire with the deaths of three astronauts, **Gus Grissom**, **Ed White** and **Roger Chaffee**
 - **Apollo 13** in-space explosion which badly damaged the spacecraft on the moonward leg of its journey
 - The three astronauts, **James A Lovell Jr.**, **John L. Swigert Jr.** and **Fred W. Haise Jr.**, returned to earth safely

Apollo Program - Hardware



Apollo Program (USA, 1961–1975)



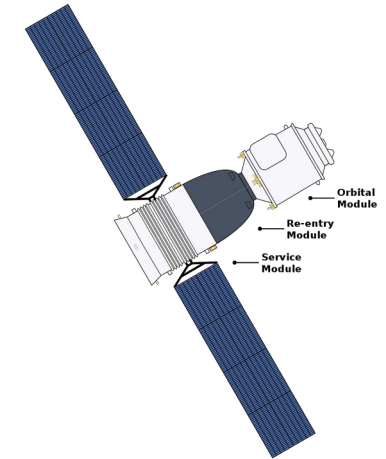
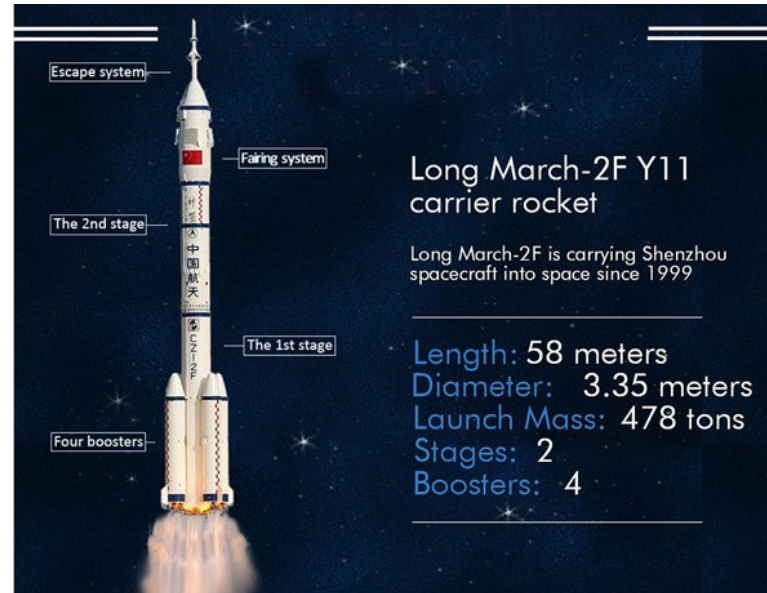
Space Shuttle (STS) (USA,1972–2011)

- In 1972, **Nixon Administration** announced that **NASA** would develop a *reusable space shuttle* or **Space Transportation System (STS)**
- **NASA** decided that the shuttle would consist of an **orbiter** attached to **solid rocket boosters** and an **external fuel tank** because this design was considered safer and more cost effective
- **Space Shuttle** was designed to place crew and payloads into low earth orbit (**LEO**) – re-enter atmosphere and land like an airplane and after some refurbishment be re launched
- Five **Shuttles** flew 135 missions with 335 astronauts aboard from 4-12-81 to 7-8-11
- The program did not meet its reuse expectations
- It suffered two catastrophic failures
 - **Challenger** accident January 28, 1986
 - **Columbia** accident February 1, 2003



China Manned Space Program (China, 1992–ongoing)

- China was the third nation in the world to send humans into space
- China initiated its crewed space program in July 1967
- In 1992, under **China Manned Space Program (CMS)** authorization and funding was given for the first phase of a successful attempt at crewed spaceflight
- China developed **Shenzhou** spacecraft and **Long March 2F** rocket dedicated for human spaceflight
- The first of four uncrewed spacecraft, **Shenzhou 1**, was launched on November 20, 1999
- On October 15, 2003 **Shenzhou 5**, China's first crewed spaceflight mission, put **Yang Liwei** in orbit for 21 hours and returned safely back to Inner Mongolia



Space Stations – Orbiting Spacecraft

- Salyut stations (USSR, 1971–1986)
- **Skylab** (USA, 1973–1974)
- *Mir* (USSR/Russia, 1986–2001)
- **International Space Station** (USA, Russia, Japan, Europe, Canada, 1998–ongoing)
- Tiangong program (China, 2010–ongoing)



Early concept of a “space station”

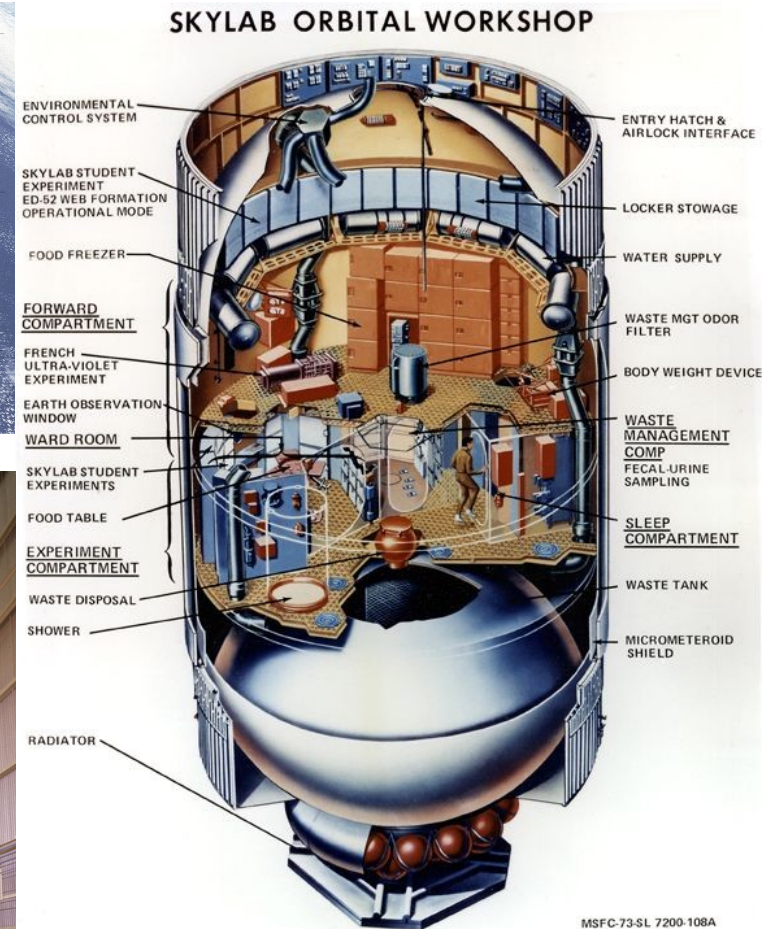
Salyut stations (USSR, 1971–1986)

- The **Salyut program** was the world's first space station program undertaken by the **USSR** which consisted of a series of four crewed scientific research space stations and two crewed military reconnaissance space stations over a period of 15 years from 1971 to 1986
- **Salyut** was designed to carry out long-term research into the problems of living in space and a variety of astronomical, biological and Earth-resources experiments
- This civilian program was used as a cover for the highly secretive military **Almaz** stations, which flew under the **Salyut** designation
- **Salyut 1**, the first station in the program, became the world's first crewed space station
- **Salyut** broke several spaceflight records, including several mission duration records, the first ever orbital handover of a space station from one crew to another, and various spacewalk records



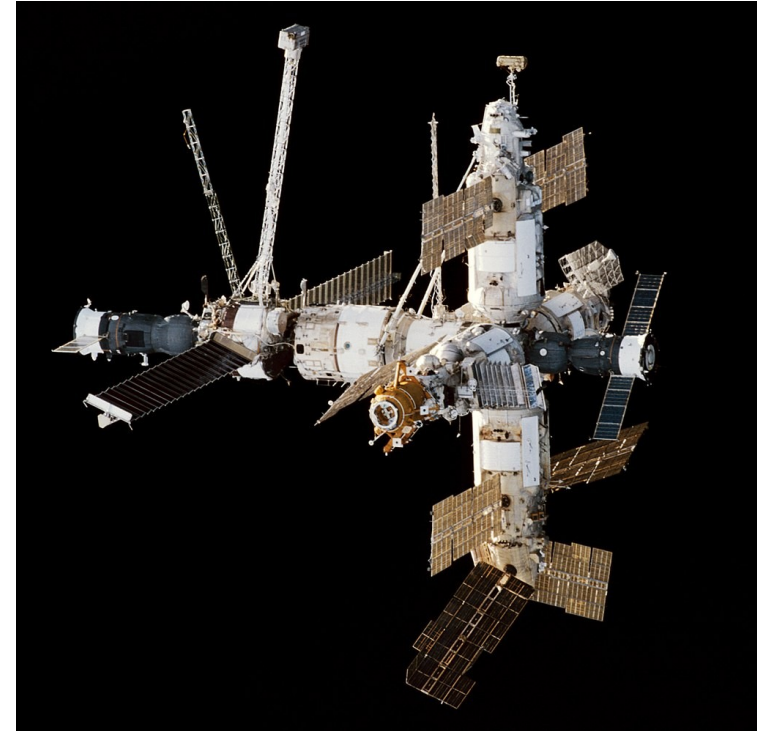
Skylab (USA, 1973–1974)

- **Skylab** was **NASA's** first space station
- **Skylab** orbited Earth from 1973 to 1979, and included a workshop, a solar observatory, and other systems
- It was a modified **S-IVB** stage of a **Saturn V** rocket
- It was launched uncrewed by a modified **Saturn V** rocket, with a weight of 169,950 pounds
- Three crewed missions to the station, conducted between 1973 and 1974 using the **Apollo** command and service module (**CSM**) atop the smaller **Saturn IB**, each delivered a crew of three astronauts
- On the last two crewed missions, an additional **Apollo / Saturn IB** stood by ready to rescue the crew in orbit if needed



Mir (USSR/Russia, 1986–2001)

- **Mir** was the first *modular* space station and was assembled in orbit from 1986 to 1996
- Until 21 March 2001 it was the largest artificial satellite in orbit, succeeded by the **International Space Station** after **Mir's** orbit decayed
- The station served as a microgravity research laboratory in which crews conducted experiments in biology, human biology, physics, astronomy, meteorology and spacecraft systems with a goal of developing technologies required for permanent occupation of space
- **Mir** was the first continuously inhabited long-term research station in orbit and set the record for the longest continuous human presence in space at 3,644 days until October 23, 2010 when it was surpassed by the **ISS**



- **Mir** was occupied for a total of *twelve and a half years* out of its fifteen-year lifespan
- It had the capacity to support a resident crew of three, or larger crews for short term visits

International Space Station (USA, Russia, Japan, Europe, Canada, 1998–ongoing)

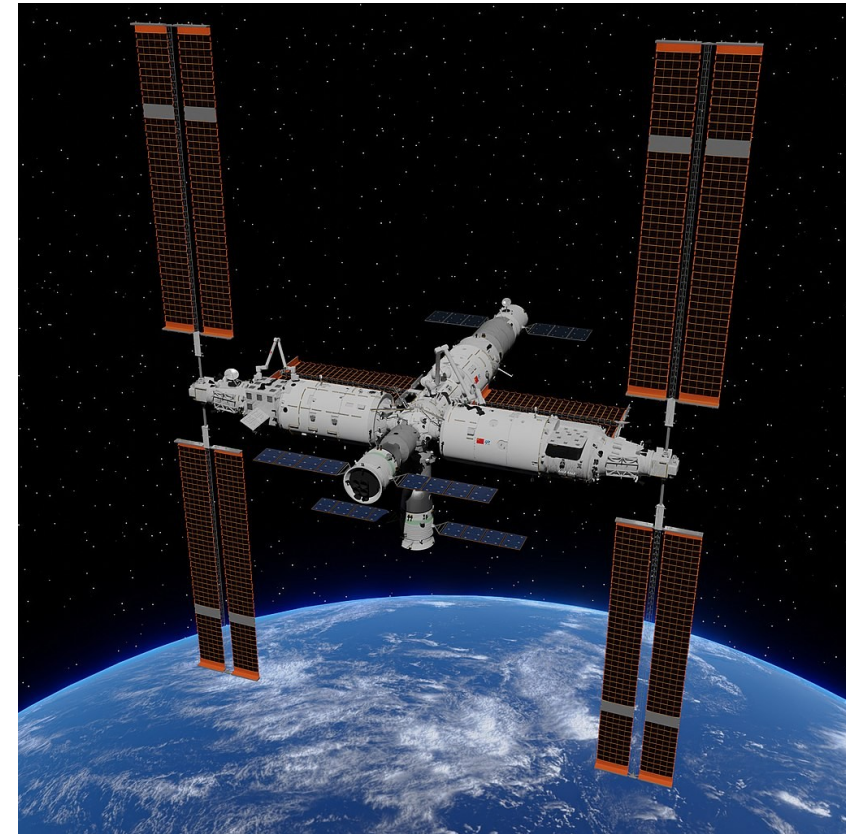
- The **International Space Station (ISS)** is in low Earth orbit
- Its first component launched into orbit in 1998, and the **ISS** is now the largest artificial body in orbit and can often be seen with the naked eye from Earth
- The **ISS** consists of pressurized *modules*, external trusses, solar arrays and other components
- **ISS** components have been launched by Russian **Proton** and **Soyuz** rockets and the American **Space Shuttles**.
- The **ISS** program is a joint project among five participating space agencies: **NASA, Roscosmos, JAXA, ESA, and CSA**
- The station is divided into two sections, the **Russian Orbital Segment (ROS)** and the **US Orbital Segment (USOS)**, which is shared by many nations



- As of May 2022 there have been 66 long duration crews
- The **US** portion of **ISS** was funded until 2024 **Roscosmos** has also endorsed the continued operation of **ISS** through 2024
- Russia has proposed using elements of the Russian Orbital Segment to construct a new space station called **OPSEK**

Tiangong program (China, 2010–ongoing)

- In September 2016, **Tiangong 2** was launched into orbit
- A month later, **Shenzhou 11** was launched and docked with **Tiangong 2**
- Two astronauts entered **Tiangong 2** and stayed for about 30 days
- In April 2017, China's first cargo spacecraft docked with **Tiangong 2** and completed multiple in-orbit propellant refueling tests
- The goal of the next phase of China Manned Space Program is to build China's own space station, **Tiangong**
- The first module of **Tiangong**, the **Tianhe** core module, was launched into orbit by China's most powerful **rocket Long March 5B** on April 29, 2021
- It was later visited by multiple cargo and crewed spacecrafts and demonstrated China's capability of sustaining Chinese astronauts' long-term stay in space
- All missions of **Tiangong Space Station** were scheduled to be carried out by the end of 2022



Back to the Moon –Next Session

- Constellation Evolves into Artemis

