

Astronomy and Astrophysics – the Beginning

Nicolaus Copernicus

- Copernicus was born in Poland and studied mathematics and optics in Italy.
- In 1530 he published *De Revolutionibus*, which asserted that the sun was the center of our solar system.
- He stated that the earth rotated on its axis once daily and traveled around the sun once each year.

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Galileo

- Galileo was an Italian mathematician and physicist who made a number of significant discoveries.
- The period of a pendulum is independent of its amplitude.
- The path of a projectile is a parabola.
- In 1609 he constructed the first astronomical telescope, which he used to discover
 - the rings of Saturn
 - the four largest moons of Jupiter
 - the Milky Way

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Johann Kepler

- Kepler, born in Germany, studied with the Danish astronomer *Tycho Brahe* and used Brahe's data on observations of Mars to determine its orbit.
- At home in Germany, Kepler determined that the orbits of planets could be drawn as ellipses with the sun always at one of the foci. (Kepler's First Law)
- Also in *Astronomia Nova* (1609) he published his Second Law: "A line connecting a planet and the sun will sweep over equal areas in equal times as the planet moves about its orbit." This means that the closer a planet is to the sun the faster it would move, according to a calculable rule.

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Sir Isaac Newton



Sir Isaac Newton

- Newton is often referred to as the greatest physicist of all time.
- His most significant accomplishments were
 - differential calculus
 - the Laws of Motion
 - the Law of Gravitational Attraction
- The laws of motion and gravitation were published in his *Philosophia Naturalis Principia Mathematica*, 1687.
- Using his calculus, Newton determined the mass of the sun and each of the planets, earth included. He estimated that the earth's density was between 5 and 6 times that of water. The current estimate is 5.5.
- “Truth is ever to be found in the simplicity, and not in the multiplicity and confusion of things. “
- “If I have been able to see further, it was only because I stood on the shoulders of giants.”

Early Rocket Development

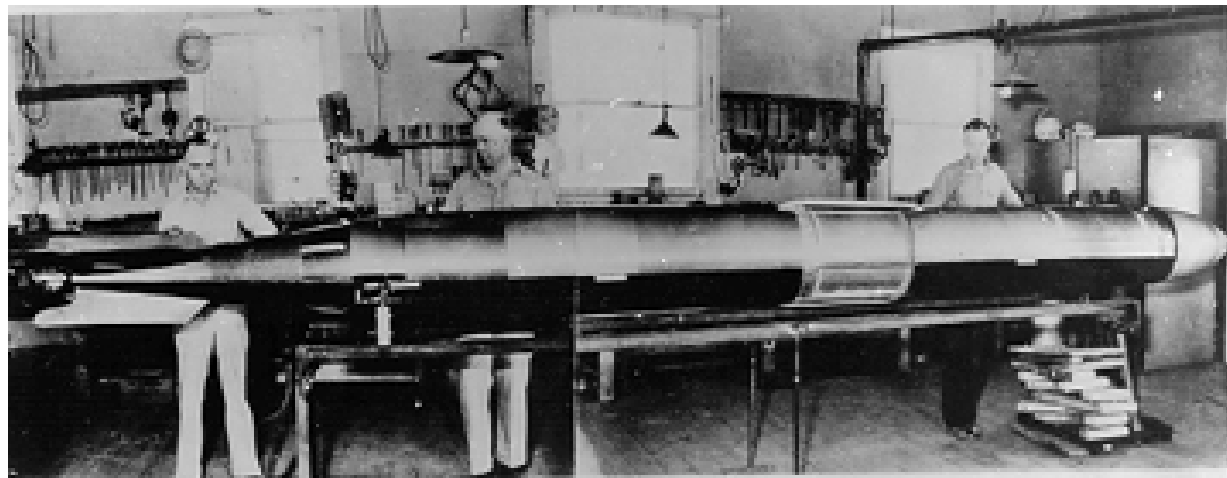
- The *Verein für Raumschiffahrt* (VfR), or “Society for Space Travel” was founded in Germany in 1927 to popularize the idea of space travel and to perform serious experiments with rocket engines.
- Within two years, the VfR had 870 members, including a young student, Wernher von Braun.
- By 1932, VfR rockets had a range of 5 km and could reach an altitude of 1,500 m.
- In the U.S. Robert H. Goddard performed experiments with rockets and, in 1919, published “A Method of Reaching Extreme Altitudes.”

Robert Goddard – the Father of Rocketry

In 1926, Goddard launched the first liquid propellant rocket, using gasoline and liquid oxygen as fuel.



Goddard's 1932 rocket



German Rocket Developments

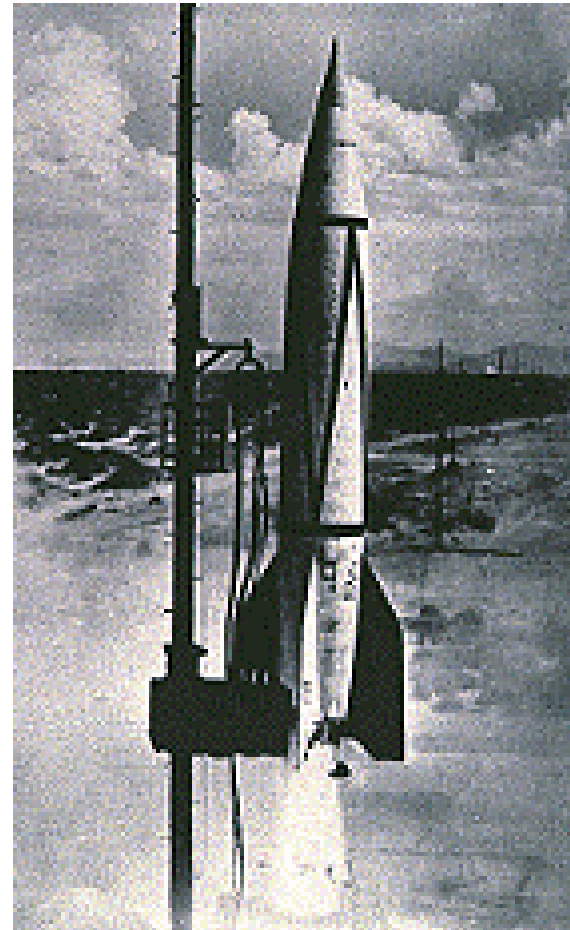
In 1936, the German government established a rocket development and test facility near Peenemünde. It covered 45 km² and employed as many as 18,000 people.

At Peenemünde, developments included

- anti-aircraft missiles,
- submarine-launched solid propellant rockets,
- surface-to-surface missiles, including the V-2.

The V-2 was based on Goddard's work, including

- gyroscopic control,
- steering by means of motor exhaust,
- gimbal steering,
- exhaust-powered fuel pumps.



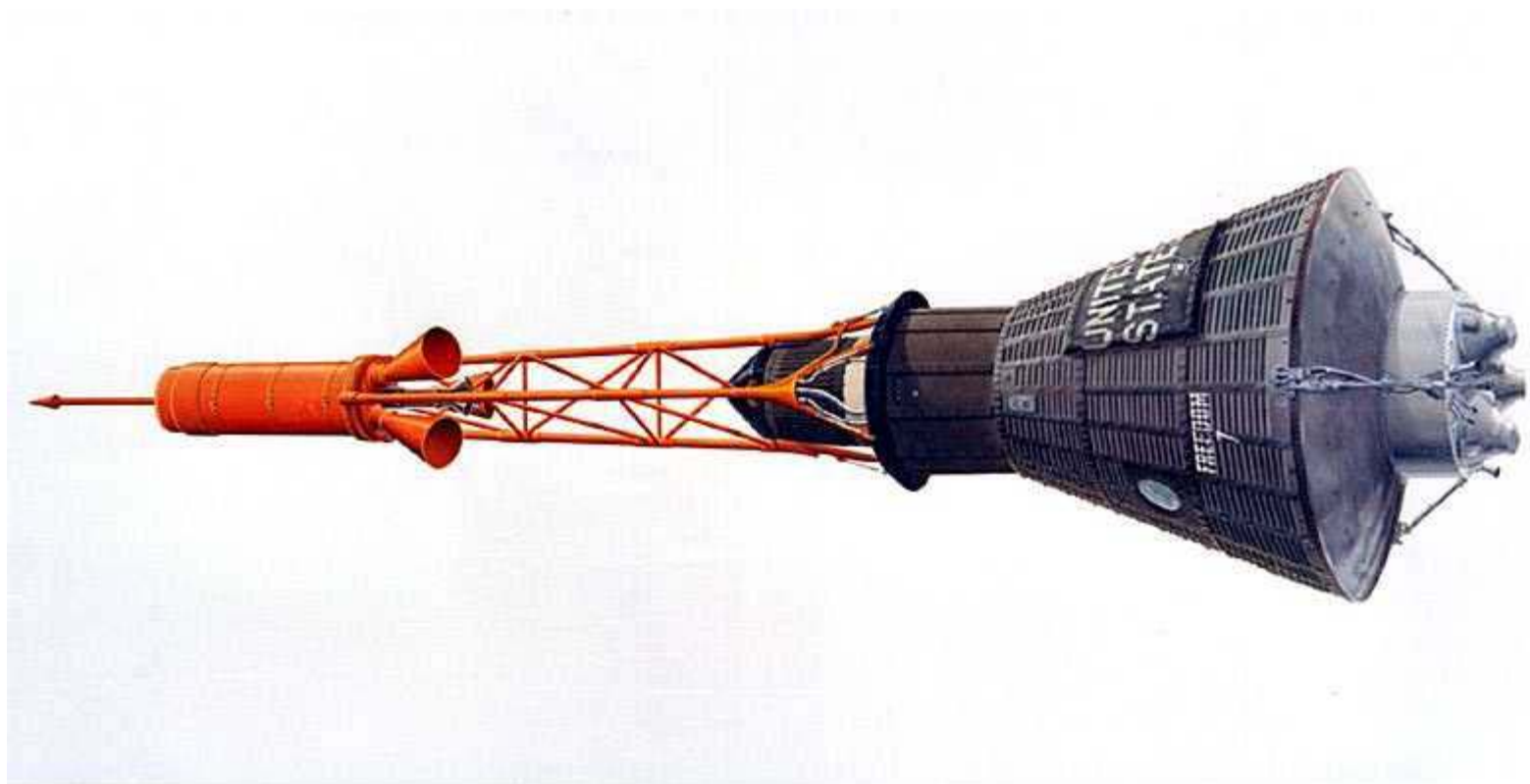
The First Space Flights

- After WWII, the U.S. and Soviet Union acquired rockets, facilities, and researchers from Germany.
- The U.S. obtained the majority of equipment and people, including Wernher von Braun.
- Both countries began programs to develop large rockets capable of carrying nuclear warheads.
- The Soviet Union saw the potential of using space to demonstrate technical superiority.
- On Oct. 4, 1957, they launched *Sputnik I*, the world's first artificial satellite, into orbit.
- *Sputnik*, circling the earth every 96 minutes, was viewed by the U.S. as a challenge.
- November 1957 -- Laika, a dog, was launched aboard *Sputnik 2*.

Early Space Flights

- In January 1958, the U.S. launched *Explorer I*, which stayed in orbit for 12 years and discovered the Van Allen radiation belt around the earth.
- **NASA** was created in July 1958, incorporating NACA and most existing military rocket facilities.
- The **Mercury** human spaceflight program was initiated.
- In April 1961, Soviet Major **Yuri Gagarin** was launched into orbit aboard *Vostok I* – the first human being in space. Full orbit in 108 min at 200 km.
- Three weeks later, the U.S. launched Commander **Alan Shepard** on a ballistic trajectory lasting 15 minutes.
- **John Glenn** was the first American to make an earth orbit on February 20, 1962.

Mercury Spacecraft



One-man capsule, 2 m long, 1.9 m in diameter, with escape tower on top. The blunt end was covered with an ablative heat shield to protect against heat of re-entry.

Gemini Program

The Soviet Union launched more spacecraft.

On May 25, 1961, President John F. Kennedy announced the goal to land humans on the surface of the moon and return them safely to earth by the end of the decade.

The Gemini program (two astronauts) proved multiperson crew and docking capabilities.

Gemini Launch on Titan rocket, 1966.



Apollo Program

- The *Apollo* program had the goal of carrying three astronauts in preparation for an eventual moon landing.
- *Apollo 1* was destroyed by fire during a launch rehearsal, and all three astronauts perished.
- Successive *Apollo* missions were successful.
- *Apollo 8* was the first flight in which humans orbited the moon.
- *Apollo* spacecraft modules
 - **Command module (CM)** -- the crew's quarters and flight control section
 - **Service module (SM)** – propulsion and spacecraft support systems. CM + SM = **CSM**
 - **Lunar module (LM)** – to take two of the crew to the lunar surface, support them there, and return to CSM in orbit.

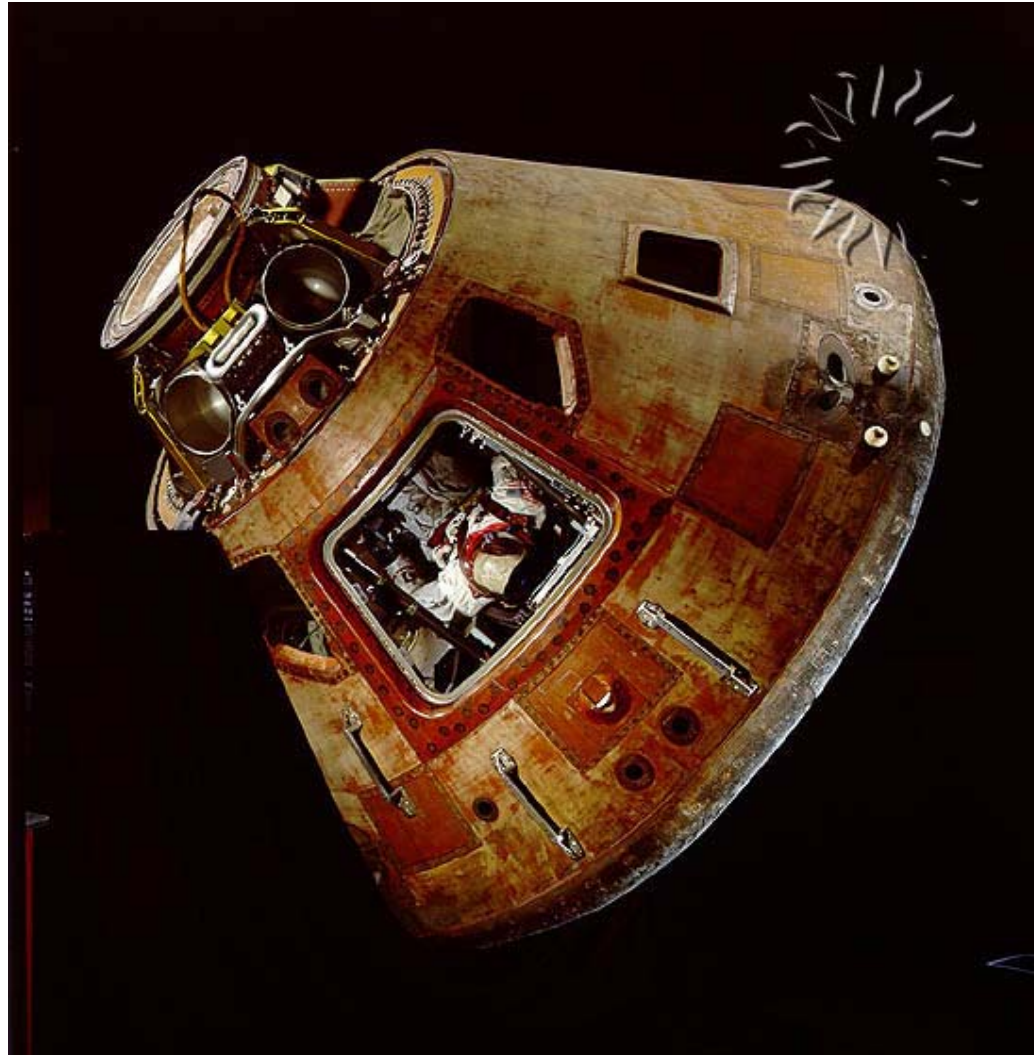
Apollo Spacecraft on Saturn V Rocket



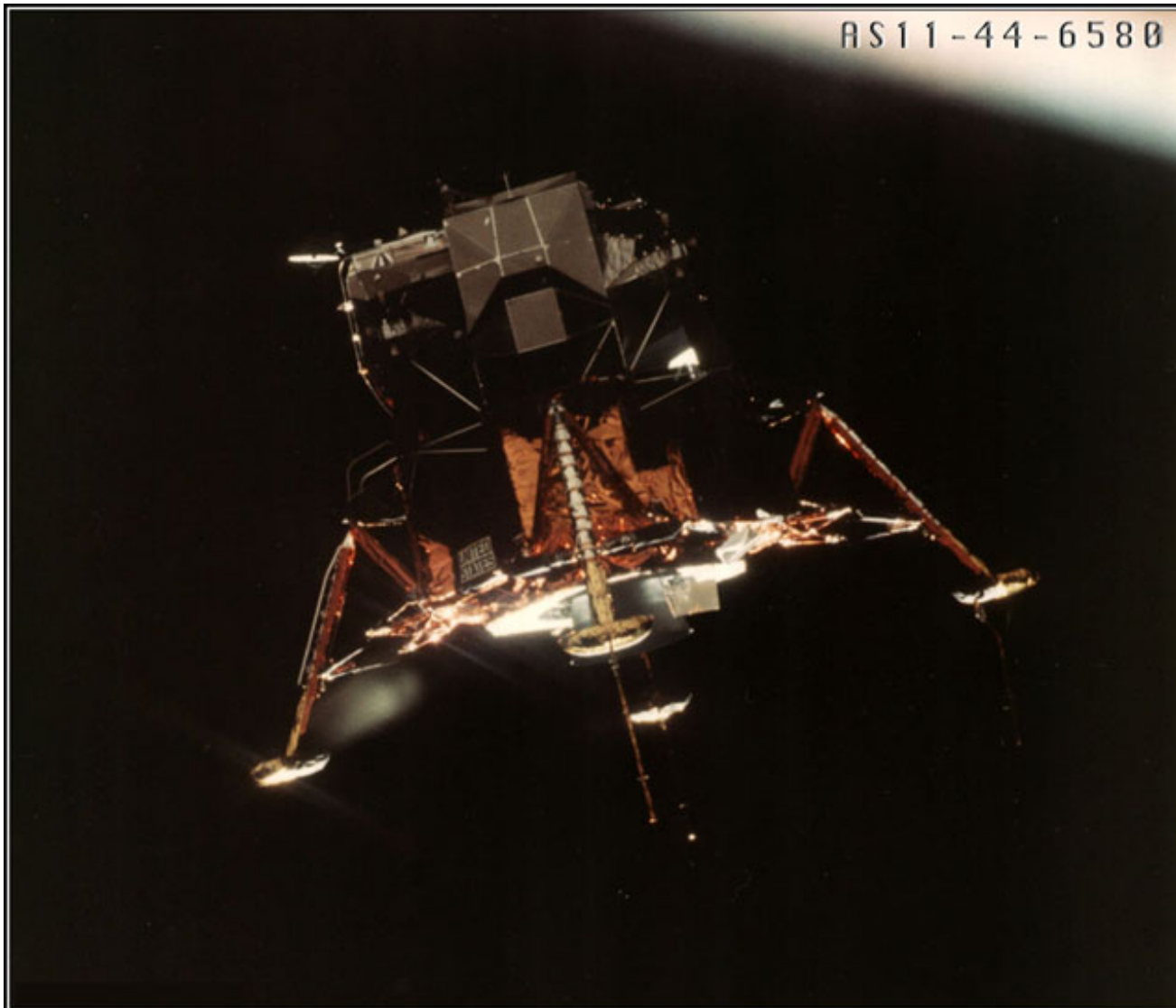
Apollo 11

- *Apollo 11* (Neil Armstrong, Buzz Aldrin, Michael Collins) was launched on July 16, 1969.
- On July 20, 1969, Armstrong and Aldrin departed in the lunar module and landed on the moon in the “Sea of Tranquility.” Collins remained in the command module.
- “Houston, Tranquility Base here. The Eagle has landed.”
- After a stay of 21.6 hours on the lunar surface, Armstrong and Aldrin returned to the CSM.
- The three returned to earth on July 24 with a splashdown in the Pacific.
- Five more missions landed on the moon, ending with Apollo 17 in December 1972.

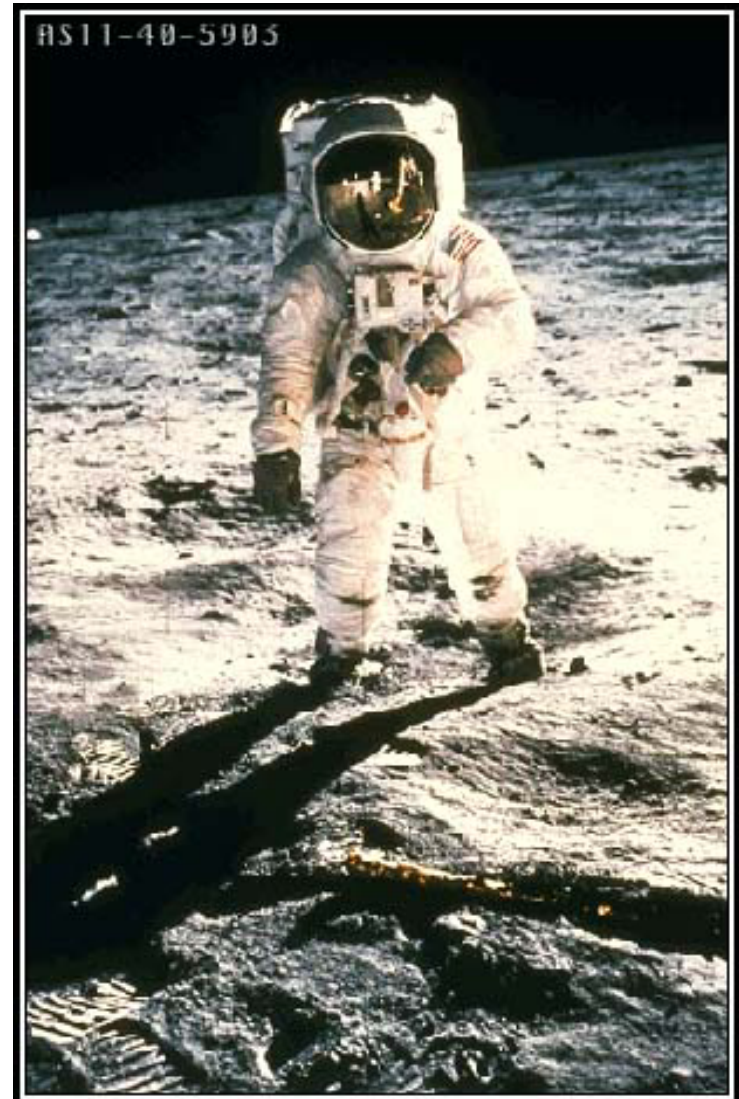
Apollo 11 Command Module



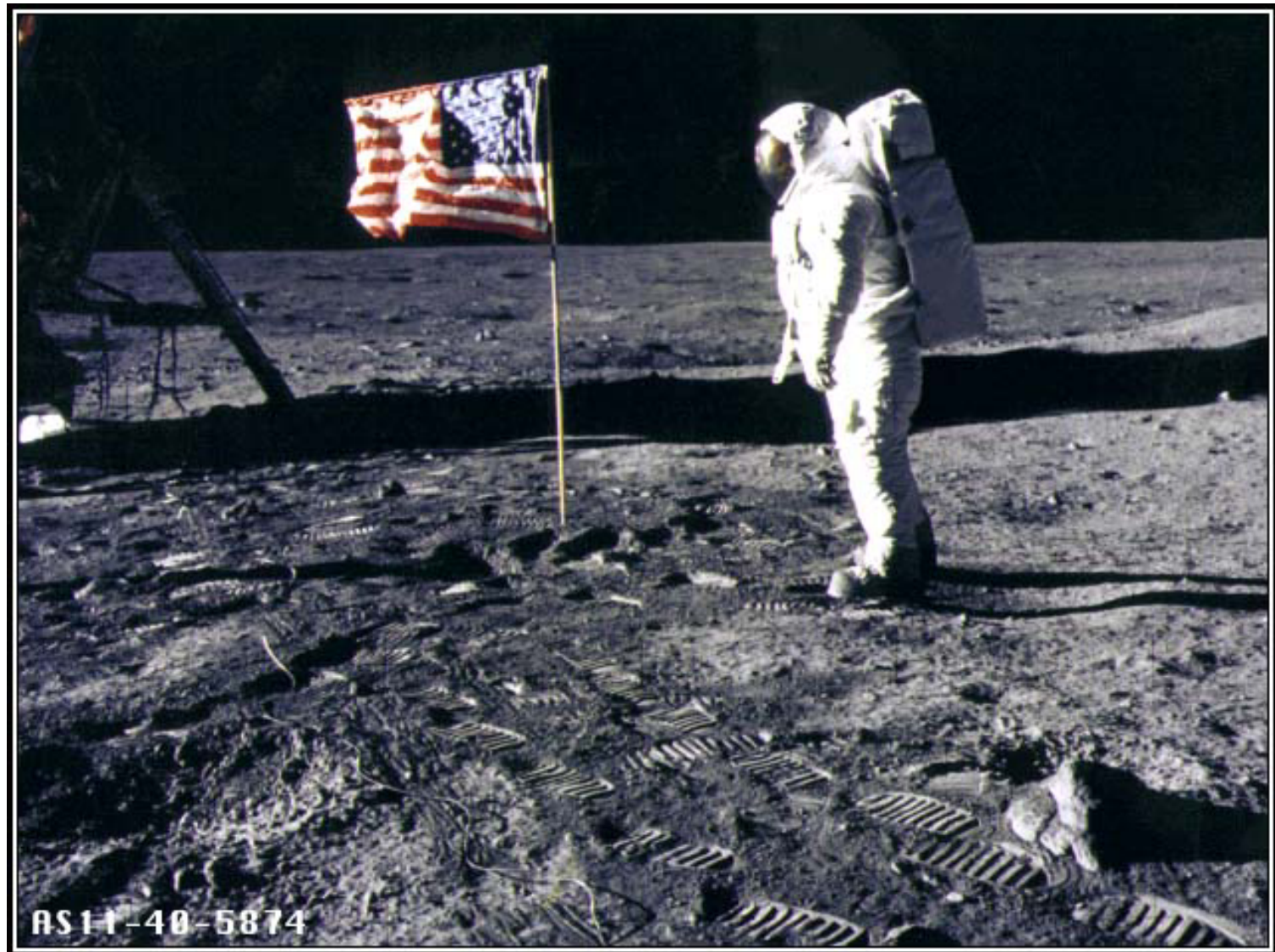
Apollo 11 Lunar Module



Apollo 11 Lunar Module and Astronaut



Historic Apollo 11 Photo



Skylab

One of three Saturn rockets remaining from the Apollo program was kept flight ready. Its third stage was modified into the Skylab space station by converting the fuel tank into cabins.

Skylab was launched into orbit in May 1973. The 75-ton space station hosted 3 crews of 3 astronauts, each for 171 days.



Commercial Use of Space

- The U.S. Air Force launched the first active communications satellite, *Score*, in 1958.
- *Tiros*, the first civilian satellite was launched in 1960 for weather observation.
- *Telstar*, launched in 1963, carried TV programs across the Atlantic.
- *Syncomm III*, in 1963, was the world's first geostationary satellite. In an orbit 35,800 km above the equator, satellites appear stationary from earth.
- *Ariane* (European Space Agency) is the most successful commercial expendable launch vehicle. Since first launch in 1979, *Ariane* has carried over half of all commercial satellites into orbit.

Space Shuttle

- Planning for a permanent space station began in 1960. After budget cuts, the Shuttle was the only part to survive.
- The design was finalized in 1972, and the program was renamed Space Transportation System.
- *Columbia* was launched on April 12, 1981.
- A fleet of four orbiters has delivered satellites into orbit and served as a platform for microgravity experiments. It has also been used in satellite repair.
- The Challenger accident in 1986, killing the seven astronauts on board, halted the program for two years. After the cause was found, flights resumed.
- A replacement joined the fleet in 1991.

Space Shuttle Launch

The Shuttle consists of three major parts:

- an orbiter with wings for landing
- an external tank
- two solid rocket boosters.

At lift-off, the Shuttle stands 56 m high and weighs about 2,000,000 kg.

