designed the ISS had to integrate module designs, computer systems, and other technologies from several different countries. The proposed design of the ISS changed frequently throughout the 1980's and 1990's.

The first ISS module, called Zarya, was launched into orbit in 1998. The station's first mission, Expedition 1, began in 2000. Bill Shepherd of the United States and Yuri Gidzenko and Sergei Krikalev of Russia made up the Expedition 1 crew. Since 2000, there has been a crew living on the ISS at all times. Before each crew returns to Earth, they officially transfer command of the station to a new crew.

The Shenzhou spacecraft. In the 1990's, China began developing the Shenzhou, a spacecraft designed to carry astronauts. The Shenzhou resembles Russia's Soyuz capsule. It is slightly larger than the Soyuz.

In 2003, China became the third nation to launch a person into space. The Chinese astronaut Yang Liwei orbited Earth aboard a Shenzhou craft for 21 hours. During a Shenzhou mission in 2008, two astronauts performed the country's first spacewalk. Many missions in the Shenzhou program have worked toward evaluating the technology and procedures needed to operate a permanent space station.

Ending the space shuttle program. In the early 2000's, NASA planned to continue using the space shuttle for transportation until at least 2020. Then, in 2003, the space shuttle Columbia broke apart during reentry. The accident killed the seven-person crew. Once more, NASA's management was heavily criticized. Investigators uncovered significant communication problems and organizational flaws within NASA. The shuttle program had been under intense pressure to meet deadlines and stay within budgets. The investigators concluded that this pressure had compromised the safety of the space shuttle.

In 2004, U.S. President George W. Bush announced

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Yang Liwei was the first astronaut launched into space by the Chinese space program. He orbited Earth for 21 hours in 2003.

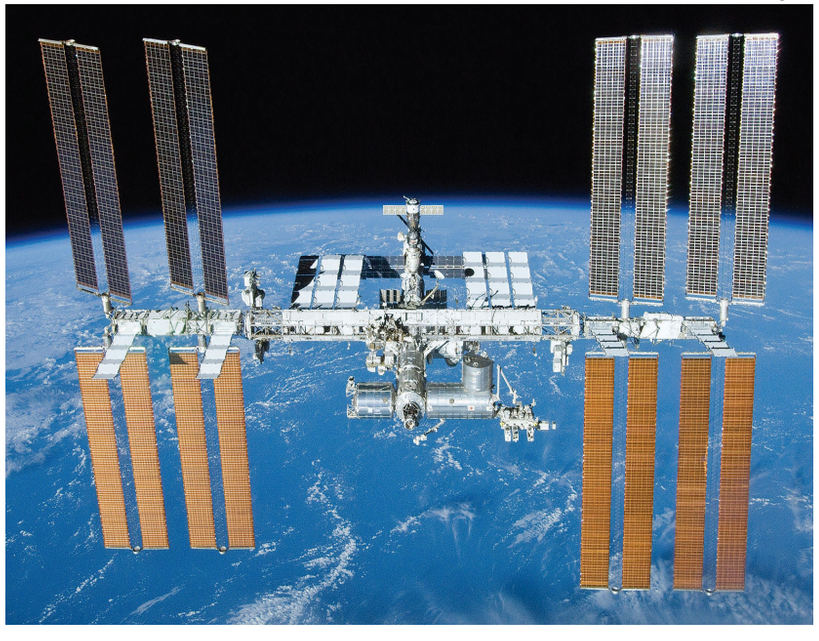
that after construction finished on the ISS, the space shuttles would be retired. The final space shuttle mission took place in 2011. After this mission, NASA purchased seats on Soyuz spacecraft from Roscosmos to deliver astronauts to the ISS.

The commercial space era

As the space shuttle program ended, private space launch companies became more prominent in the United States. They worked to develop new vehicles and commercial launch services.

Developing new reusable spacecraft. In the early 2000's, space agencies and private companies worked to develop new reusable launch vehicles (RLV's). NASA officials decided that it would be unrealistic to develop a new RLV quickly enough to be ready when the shuttle program ended. However, without the space shuttle,

K. Oldenburg/ESA



The International Space Station (ISS) is a large satellite that orbits Earth. It has been continuously inhabited since 2000. The station has been used as an observatory, laboratory, and workshop by astronauts from about 15 nations.

NASA

SpaceX's Dragon vehicle carries crews and supplies to and from Earth orbit. This unpiloted Dragon, carrying supplies, is held by Canadarm2, the International Space Station's robotic arm. After this 2016 photograph was taken, astronauts used the robotic arm to dock the Dragon with the station.

NASA had no way to carry astronauts to and from the ISS. The agency would have to pay for astronauts to travel on Soyuz vehicles. In 2008, NASA hired the American companies Orbital ATK and SpaceX to develop spacecraft that could reach Earth orbit.

In the meantime, NASA concentrated on developing the Crew Exploration Vehicle, also known as Orion. Orion is a capsule-shaped spacecraft for transporting crew and cargo. It could eventually carry astronauts to the moon or Mars. In 2011, NASA announced plans for the Space Launch System (SLS), a rocket designed to carry Orion into space.

Private companies developed diverse designs for reusable spacecraft. The American company Scaled Composites built a rocket-powered plane called SpaceShipOne. SpaceShipOne launched in the air from a carrier plane and landed on a runway. Boeing's Starliner capsule and SpaceX's Dragon are reusable capsules launched by rockets. After reentry, the Starliner capsule lands on the ground. Dragon capsules land in the water.

Some companies have also designed reusable boosters. SpaceX's Falcon rockets have a fully reusable first stage. When the rocket's stages separate, the used first stage lands upright on four legs. The company Rocket Lab has tested a different method of recovering boosters. As the used booster falls toward the ocean, a helicopter equipped with a grappling hook catches the booster in midair.

Commercial spacecraft take flight. In the 2010's, private companies contracted by NASA began carrying supplies and crew to the ISS. Dragon and Cygnus spacecraft deliver supplies to the ISS. The Cygnus expendable spacecraft was designed by Orbital ATK and is now built by the American company Northrup Grumman.

The development of commercial spacecraft enabled the era of space tourism to begin. Although Soyuz missions to the ISS occasionally included space tourists, these opportunities ceased in 2011. In that year, the space shuttle program ended, and extra Soyuz seats were filled by NASA astronauts. In 2021, several companies began launching short suborbital spaceflights for the purposes of space tourism.

Today, NASA's Commercial Crew program contracts with private companies to take astronauts to the ISS. In

Aubrey Gemignani/NASA

NASA's Space Launch System (SLS) is a huge rocket designed to carry astronauts to the moon. The SLS is an *expendable* (not reusable) rocket.

ESA

ESA's JUICE is one of several spacecraft planned to study moons of Jupiter or Saturn. These engineers are inspecting one of the spacecraft's antennas.

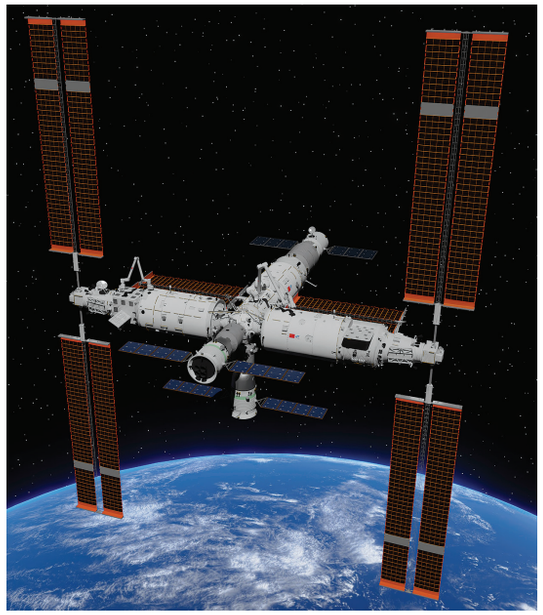
2020, the SpaceX Crew Dragon capsule became the first private spacecraft to take astronauts into orbit. The mission was the first crewed launch from the United States since the last shuttle mission.

Space stations today. In the 2010's, the Chinese space program worked to develop the capabilities needed to support a permanent space station. First, temporary space stations were launched into orbit and inhabited by astronauts. In 2022, construction was completed on China's permanent space station, Tiangong. The station consists of a core module, where astronauts live, and two science modules, where they conduct experiments. Tiangong can accommodate three crew members.

In 2014, the United States' relationship with Russia became strained when Russia seized control of Crimea. The two countries' relationship was further strained in 2022, when Russia invaded Ukraine. The ISS is expected to continue operating until 2030. NASA plans to collaborate with private corporations to maintain the station until it is de-orbited.

Plans for the future

Searching for life in our solar system. Many people once thought that Earth was the only place whose current planetary conditions could support life. It was widely believed that if extraterrestrial life existed, it would be found in another star system on a planet that closely resembled Earth.



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The Tiangong space station, shown in this illustration, is China's first permanent space station. It was completed in 2022. China does not work on the ISS because U.S. policy prevents NASA from collaborating with the Chinese government.

Then, scientists found evidence of oceans on worlds entirely different from Earth, such as Jupiter's moon Europa. This discovery transformed the search for extraterrestrial life. If such "ocean worlds" are common in our solar system, they are also likely common in other star systems. If moons within the solar system are found to support life, millions of other star systems could also support life.

Recently, this exciting idea has influenced the planning of space missions. Several probes are preparing to explore moons in our solar system. The results of these investigations will likely determine the future of the search for extraterrestrial life.

New moon missions. NASA's Artemis program is a plan for future crewed moon missions. The stated goals of the program are to send astronauts to the surface of the moon and to gain experience for future missions to Mars. NASA has contracted several private companies, such as SpaceX, to develop technology for the Artemis program. The first Artemis mission, an uncrewed test flight, launched in 2022.

The China National Space Administration has also announced plans to develop a crewed moon exploration program. Future Chang'e missions have been planned for the 2020's and the early 2030's. These uncrewed missions would assess technology for a crewed lunar outpost.

NASA, ESA, JAXA, and CSA plan to develop a permanent space station in orbit around the moon. The station would provide a place for astronauts to prepare for lunar landing missions. Crewed missions on their way to Mars could stop at the station to fuel a spacecraft or pick up supplies.

Traveling to Mars. NASA aims to send astronauts to Mars in the 2030's or 2040's. Many technical and logistical challenges will need to be overcome before humans can safely reach the planet.

Exploring other star systems. Over the past few decades, astronomers have discovered thousands of exoplanets orbiting other stars. Some of these planets resemble familiar worlds like Jupiter or even Earth. Others are unlike any of the planets in our solar system. Scientists can study these planets using telescopes. But because these planets are many light-years away, it is difficult to obtain precise information about them. A probe to another star system could study exoplanets close up. Space agencies and nonprofit organizations have begun to create early designs for such probes. But great developments in technology are needed to enable travel to other star systems. It is likely that the first of these probes will not be launched for several decades or more.

Roger D. Launius and Emma Flickinger

JPL/NASA

Artemis 2 is scheduled to be the first crewed mission to travel around the moon since the 1970's. The crew members chosen in 2023 were, from left to right, Canadian Space Agency astronaut Jeremy Hansen and NASA astronauts Victor Glover, Reid Wiseman, and Christina Koch.

Related articles in *World Book.* For information on the astronauts and cosmonauts and on how they are selected and trained, see **Astronaut.** For details on how rockets work and how they are used in space exploration, see **Rocket.** For information on artificial satellites, see **Satellite, Artificial.** See also the following articles:

Biographies

For biographies of astronauts and cosmonauts, see the *Related articles* listed in the **Astronaut** article. See also **Goddard, Robert Hutchings; Korolev, Sergei Pavlovich;** and **Von Braun, Wernher.**

Organizations

American Institute of Aeronautics and Astronautics
European Space Agency
National Aeronautics and Space Administration

Other related articles

Aerospace medicine
Apollo [space program]
Astrobiology
Astronomy (Space probes)
Cape Canaveral
Cassini
Challenger disaster
Columbia disaster
Cosmic rays
Eros
Galileo
Gravitation
Guided missile
Hubble Space Telescope
International Space Station
Jet propulsion
Jet Propulsion Laboratory
Jodrell Bank Observatory
Johnson Space Center
Jupiter (History of Jupiter study)
Kennedy Space Center
Life (The search for life on other worlds)
Map (Mapmaking and modern technology)
Mars (Observation by spacecraft)
Mercury (Flights to Mercury)
Meteor
Mir
Moon
Musk, Elon
Orbit
Planet
Radar (In space travel)
Radiation
Relativity
Satellite (Exploration by spacecraft)
Saturn (History of study)
SETI Institute
Solar system
Sun (Studying the sun)
Telemetry
Venus (Flights to Venus)
Voyager

Outline

Space travel. See **Space exploration.**

Spaghetti. See **Pasta.**

Spahn, Warren (1921-2003), became one of the greatest pitchers in baseball history. During his major league career, he won 363 games, more than any other left-handed pitcher. Spahn won 20 or more games in one season 13 times, and led the National League in games won eight different times. He set the major league record for the most shut outs by a left-handed pitcher, 63.

Warren Edward Spahn was born on April 23, 1921, in Buffalo, New York. He played for the Boston Braves—later the Milwaukee Braves—from 1942 to 1964. In 1965, Spahn pitched for the New York Mets and San Francisco Giants. He retired from baseball after the 1965 season. Spahn was elected to the National Baseball Hall of Fame in 1973. He died on Nov. 24, 2003.

Dave Nightingale

Spaight, *spayt,* **Richard Dobbs** (1758-1802), was a North Carolina signer of the Constitution of the United States. At the Constitutional Convention of 1787, Spaight was one of the few delegates to attend every session. He also helped win *ratification* (approval) of the Constitution by North Carolina.

Spaight was born on March 25, 1758, in New Bern, North Carolina, and educated in Ireland. He served in the North Carolina legislature for much of the 1780's, and he served in the Congress of the Confederation from 1783 to 1785. Spaight was governor of North Carolina from 1792 to 1795 and a member of the United States House of Representatives from 1798 to 1801. He died on Sept. 6, 1802, from a wound he received in a duel with John Stanly, a political rival.

Joan R. Gundersen