

Encyclopedia of International Space Agencies



Vance Hawkins

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NASA

Coordinates:  38°52'59"N 77°0'59"W / 38.88306°N 77.01639°W

National Aeronautics and Space Administration



NASA seal



NASA insignia

Motto: *For the Benefit of All*

Agency overview

Formed	July 29, 1958 (52 years ago)
Preceding agency	NACA
Jurisdiction	United States government
Headquarters	Washington, D.C.

 38°52′59″N 77°0′59″W / 38.88306°N
77.01639°W

Employees 18,800+

Annual budget US\$17.6 billion (FY 2009)

Agency Charles Bolden, administrator

executives Lori Garver, deputy administrator

Website

www.nasa.gov

The **National Aeronautics and Space Administration** (**NASA**, pronounced /' næsə/) is an Executive Branch agency of the United States government, responsible for the nation's civilian space program and aeronautics and aerospace research. Since February 2006, NASA's self-described mission statement is to "pioneer the future in space exploration, scientific discovery and aeronautics research."

NASA was established by the National Aeronautics and Space Act on July 29, 1958, replacing its predecessor, the National Advisory Committee for Aeronautics (NACA). The agency became operational on October 1, 1958. NASA has led U.S. efforts for space exploration since, including the Apollo moon-landing missions, the Skylab space station, and later the Space Shuttle. Currently, NASA is supporting the International Space Station and has been developing the manned Orion spacecraft.

NASA science is focused on better understanding Earth through the Earth Observing System, advancing heliophysics through the efforts of the Science Mission Directorate's Heliophysics Research Program, exploring bodies throughout the Solar System with advanced robotic missions such as New Horizons, and researching astrophysics topics, such as the Big Bang, through the Great Observatories and associated programs. NASA shares data with various national and international organizations such as from the Greenhouse Gases Observing Satellite.

History

Space race

After the Soviet space program's launch of the world's first artificial satellite (*Sputnik 1*) on October 4, 1957, the attention of the United States turned toward its own fledgling space efforts. The U.S. Congress, alarmed by the perceived threat to national security and technological leadership (known as the "Sputnik crisis"), urged immediate and swift action; President Dwight D. Eisenhower and his advisers counseled more deliberate measures. Several months of debate produced an agreement that a new federal agency was needed to conduct all non-military activity in space. The Advanced Research

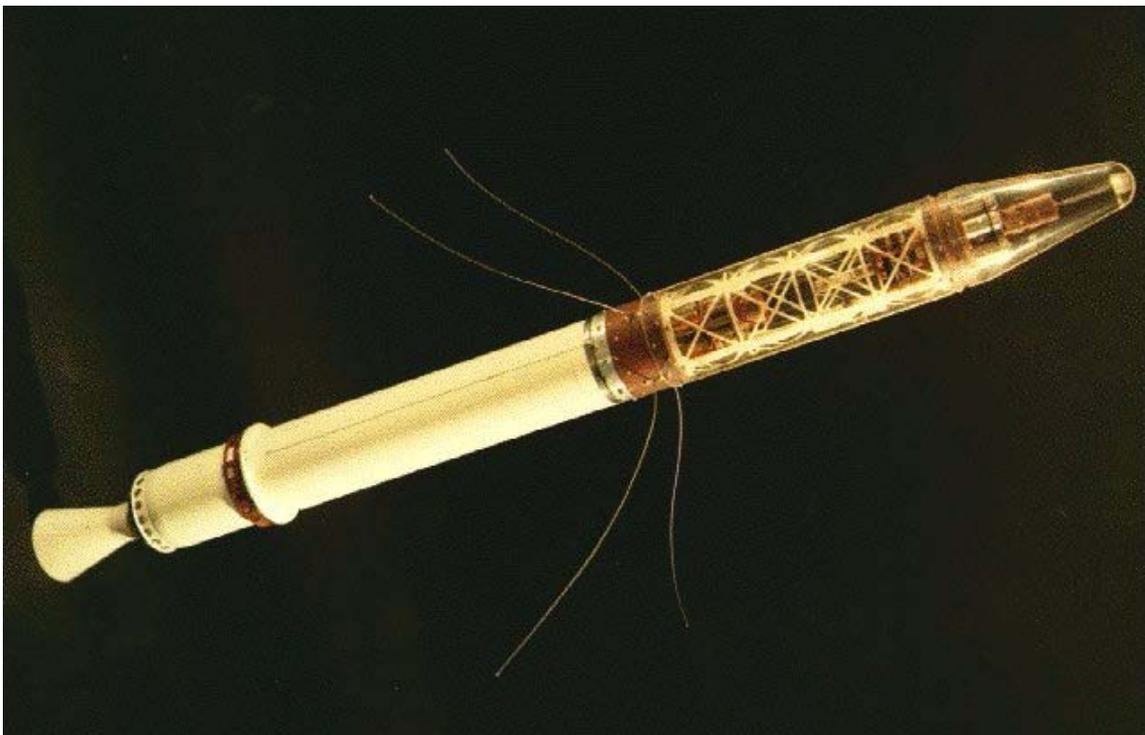
Projects Agency (ARPA) was also created at this time to develop space technology for military application.

NACA

From late 1957 to early 1958, the National Advisory Committee for Aeronautics (NACA) began studying what a new non-military space agency would entail, as well as what its role might be, and assigned several committees to review the concept. On January 12, 1958, NACA organized a "Special Committee on Space Technology", headed by Guyford Stever. Stever's committee included consultation from the Army Ballistic Missile Agency's large booster program, referred to as the Working Group on Vehicular Program, headed by Wernher von Braun, a German scientist who became a naturalized US citizen after World War II.

On January 14, 1958, NACA Director Hugh Dryden published "A National Research Program for Space Technology" stating:

“ It is of great urgency and importance to our country both from consideration of our prestige as a nation as well as military necessity that this challenge [*Sputnik*] be met by an energetic program of research and development for the conquest of space... It is accordingly proposed that the scientific research be the responsibility of a national civilian agency... NACA is capable, by rapid extension and expansion of its effort, of providing leadership in space technology. ”



Explorer 1, first US satellite

Launched on January 31, 1958, Explorer 1, officially Satellite 1958 Alpha, became the U.S.'s first earth satellite. The Explorer 1 payload consisted of the Iowa Cosmic Ray Instrument without a tape data recorder which was not modified in time to make it onto the satellite.

On March 5, PSAC Chairman James Killian wrote a memorandum to President Eisenhower, entitled "Organization for Civil Space Programs", encouraging the creation of a civil space program based upon a "strengthened and redesignated" NACA which could expand its research program "with a minimum of delay." In late March, a NACA report entitled "Suggestions for a Space Program" included recommendations for subsequently developing a hydrogen fluorine fueled rocket of 4,450,000 newtons (1,000,000 lb_f) thrust designed with second and third stages.

In April 1958, Eisenhower delivered to the U.S. Congress an executive address favoring a national civilian space agency and submitted a bill to create a "National Aeronautical and Space Agency." NACA's former role of research alone would change to include large-scale development, management, and operations. The U.S. Congress passed the bill, somewhat reworded, as the National Aeronautics and Space Act of 1958, on July 16. Only two days later von Braun's Working Group submitted a preliminary report severely criticizing the duplication of efforts and lack of coordination among various organizations assigned to the United States' space programs. Stever's Committee on Space Technology concurred with the criticisms of the von Braun Group (a final draft was published several months later, in October).

NASA



President Kennedy, Vice President Johnson and other officials at the Launch Operations Center's LC-34 blockhouse during a 1962 tour

On July 29, 1958, Eisenhower signed the National Aeronautics and Space Act, establishing NASA. When it began operations on October 1, 1958, NASA absorbed the 46-year-old NACA intact; its 8,000 employees, an annual budget of US\$100 million, three major research laboratories (Langley Aeronautical Laboratory, Ames Aeronautical Laboratory, and Lewis Flight Propulsion Laboratory) and two small test facilities.

Elements of the Army Ballistic Missile Agency, of which von Braun's team was a part, and the Naval Research Laboratory were incorporated into NASA. A significant contributor to NASA's entry into the Space Race with the Soviet Union was the technology from the German rocket program (led by von Braun) which in turn incorporated the technology of Robert Goddard's earlier works. Earlier research efforts within the U.S. Air Force and many of ARPA's early space programs were also transferred to NASA. In December 1958, NASA gained control of the Jet Propulsion Laboratory, a contractor facility operated by the California Institute of Technology.

NASA programs

Manned programs

Project Mercury



May 5, 1961 launch of Redstone rocket and *Freedom 7* with Alan Shepard on first US manned sub-orbital spaceflight

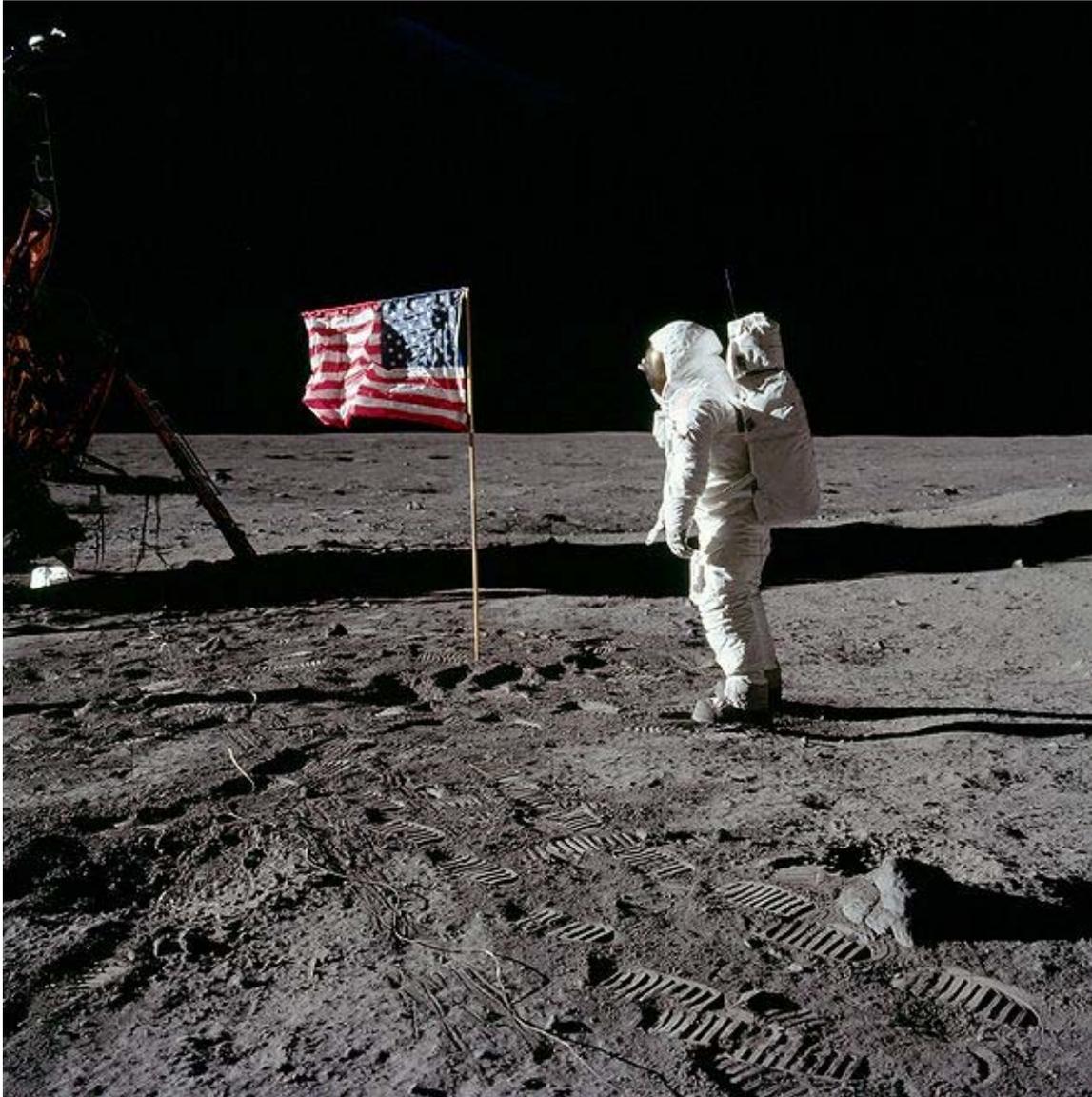
Conducted under the pressure of the competition between the U.S. and the Soviet Union that existed during the Cold War, Project Mercury was initiated in 1958 and started NASA down the path of human space exploration with missions designed to discover if man could survive in space. Representatives from the U.S. Army, Navy, and Air Force were selected to provide assistance to NASA. Pilot selections were facilitated through

coordination with U.S. defense research, contracting, and military test pilot programs. On May 5, 1961, astronaut Alan Shepard became the first American in space when he piloted *Freedom 7* on a 15-minute suborbital flight. John Glenn became the first American to orbit the Earth on February 20, 1962 during the flight of *Friendship 7*. Three more orbital flights followed.

Project Gemini

Project Gemini focused on conducting experiments and developing and practicing techniques required for lunar missions. The first Gemini flight with astronauts on board, Gemini 3, was flown by Gus Grissom and John Young on March 23, 1965. Nine missions followed, showing that long-duration human space flight and rendezvous and docking with another vehicle in space were possible, and gathering medical data on the effects of weightlessness on humans. Gemini missions included the first American spacewalks, and new orbital maneuvers including rendezvous and docking.

Apollo program



Apollo 11 Lunar Module Pilot Buzz Aldrin salutes US flag

The Apollo program landed the first humans on Earth's Moon. Apollo 11 landed on the moon on July 20, 1969 with astronauts Neil Armstrong and Buzz Aldrin, while Michael Collins orbited above. Five subsequent Apollo missions also landed astronauts on the Moon, the last in December 1972. In these six Apollo spaceflights twelve men walked on the Moon. These missions returned a wealth of scientific data and 381.7 kilograms (842 lb) of lunar samples. Experiments included soil mechanics, meteoroids, seismic, heat flow, lunar ranging, magnetic fields, and solar wind experiments.

Apollo set major milestones in human spaceflight. It stands alone in sending manned missions beyond low Earth orbit, and landing humans on another celestial body. Apollo

8 was the first manned spacecraft to orbit another celestial body, while Apollo 17 marked the last moonwalk and the last manned mission beyond low Earth orbit. The program spurred advances in many areas of technology peripheral to rocketry and manned spaceflight, including avionics, telecommunications, and computers. Apollo sparked interest in many fields of engineering and left many physical facilities and machines developed for the program as landmarks. Many objects and artifacts from the program are on display at various locations throughout the world, notably at the Smithsonian's Air and Space Museums.

Skylab



NASA's Skylab space station

Skylab was the first space station the United States launched into orbit. The 100 short tons (91 t) station was in Earth orbit from 1973 to 1979, and was visited by crews three times, in 1973 and 1974. It included a laboratory for studying the effects of microgravity, and a solar observatory. A Space Shuttle was planned to dock with and elevate Skylab to a higher safe altitude, but Skylab reentered the atmosphere and was destroyed in 1979, before the first shuttle could be launched.

ASTP

The Apollo-Soyuz Test Project (ASTP) was the first joint flight of the U.S. and Soviet space programs. The mission took place in July 1975. For the United States, it was the last Apollo flight, as well as the last manned space launch until the flight of the first Space Shuttle in April 1981. Manned Skylab and ASTP missions used the smaller Saturn IB with Apollo CSM, not the Saturn V.

Space Shuttle program



The first space shuttle launch, April 12, 1981 for STS-1

The Space Shuttle became the major focus of NASA in the late 1970s and the 1980s. Planned as a frequently launchable and mostly reusable vehicle, four space shuttle orbiters were built by 1985. The first to launch, *Columbia*, did so on April 12, 1981.

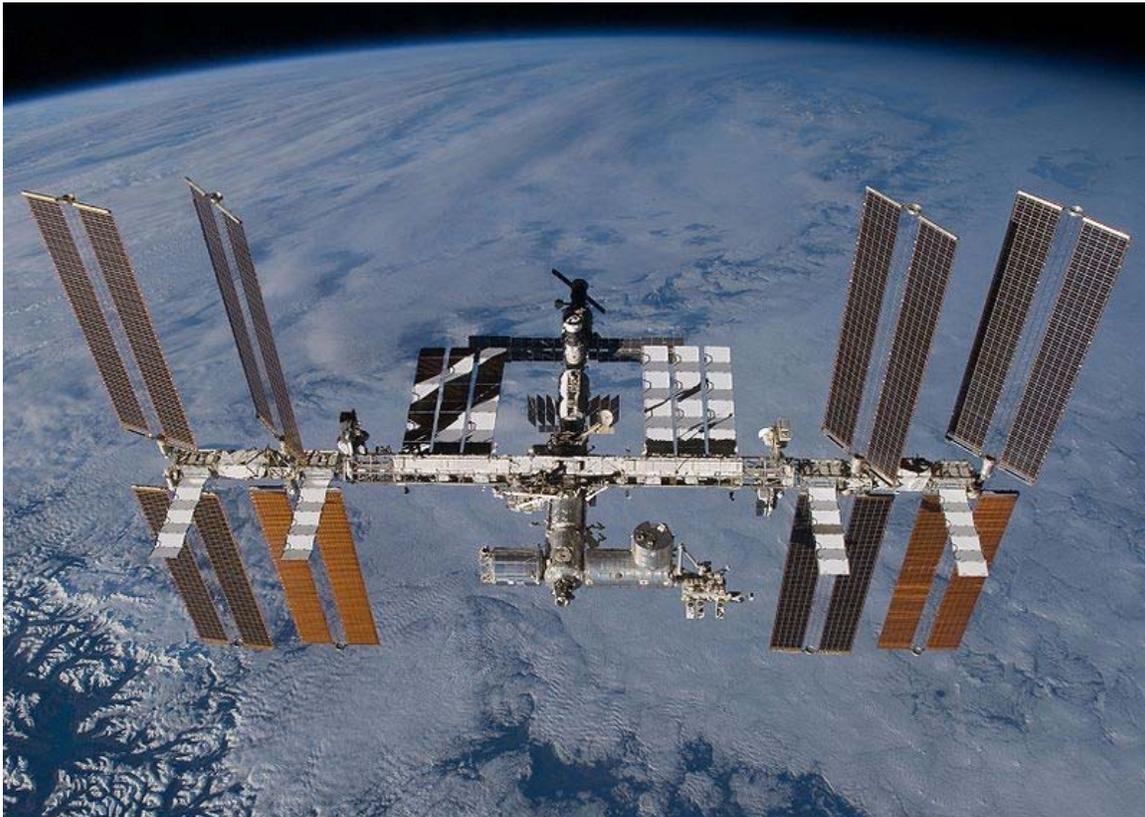


NASA "worm" logo used 1975–1992

In 1995 Russian-American interaction resumed with the Shuttle-Mir missions. Once more an American vehicle docked with a Russian craft, this time a full-fledged space station. This cooperation continues to today, with Russia and America the two biggest partners in the largest space station ever built: the International Space Station (ISS). The strength of their cooperation on this project was even more evident when NASA began relying on Russian launch vehicles to service the ISS during the two-year grounding of the shuttle fleet following the 2003 Space Shuttle *Columbia* disaster.

The shuttle fleet lost two orbiters and 14 astronauts in two disasters: *Challenger* in 1986, and *Columbia* in 2003. While the 1986 loss was mitigated by building the Space Shuttle *Endeavour* from replacement parts, NASA did not build another orbiter to replace the second loss. NASA's shuttle program has made 132 successful launches as of May 2010.

International Space Station



The International Space Station

The International Space Station (ISS) is an internationally developed research facility currently being assembled in Low Earth Orbit. On-orbit construction of the station began in 1998 and is scheduled to be completed by 2011, with operations continuing until at least 2015. The station can be seen from the Earth with the naked eye, and, as of 2009, is

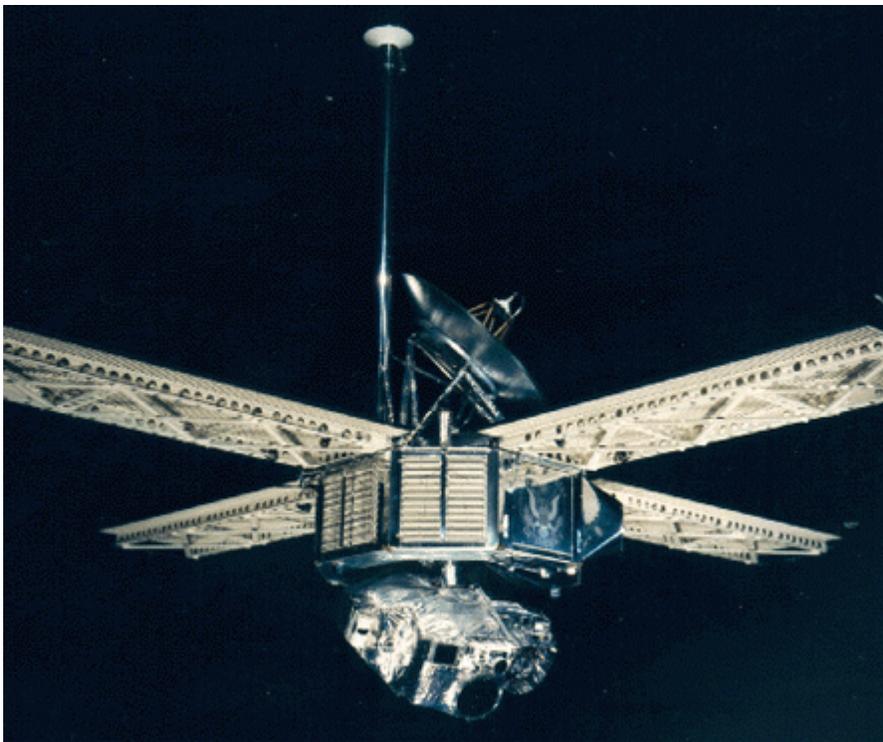
the largest artificial satellite in Earth orbit, with a mass larger than that of any previous space station.

The ISS is operated as a joint project among NASA, the Russian Federal Space Agency, the Japan Aerospace Exploration Agency, the Canadian Space Agency, and the European Space Agency (ESA). Ownership and utilization of the space station is set out via several intergovernmental treaties and agreements, with the Russian Federation retaining full ownership of its own modules, and the rest of the station being allocated among the other international partners. The International Space Station relied on the Shuttle fleet for all major construction shipments.

The cost of the station project has been estimated by ESA as €100 billion over a course of 30 years, although cost estimates vary between 35 billion dollars and 160 billion dollars, making the ISS the most expensive object ever constructed.

Unmanned programs

Mariner program



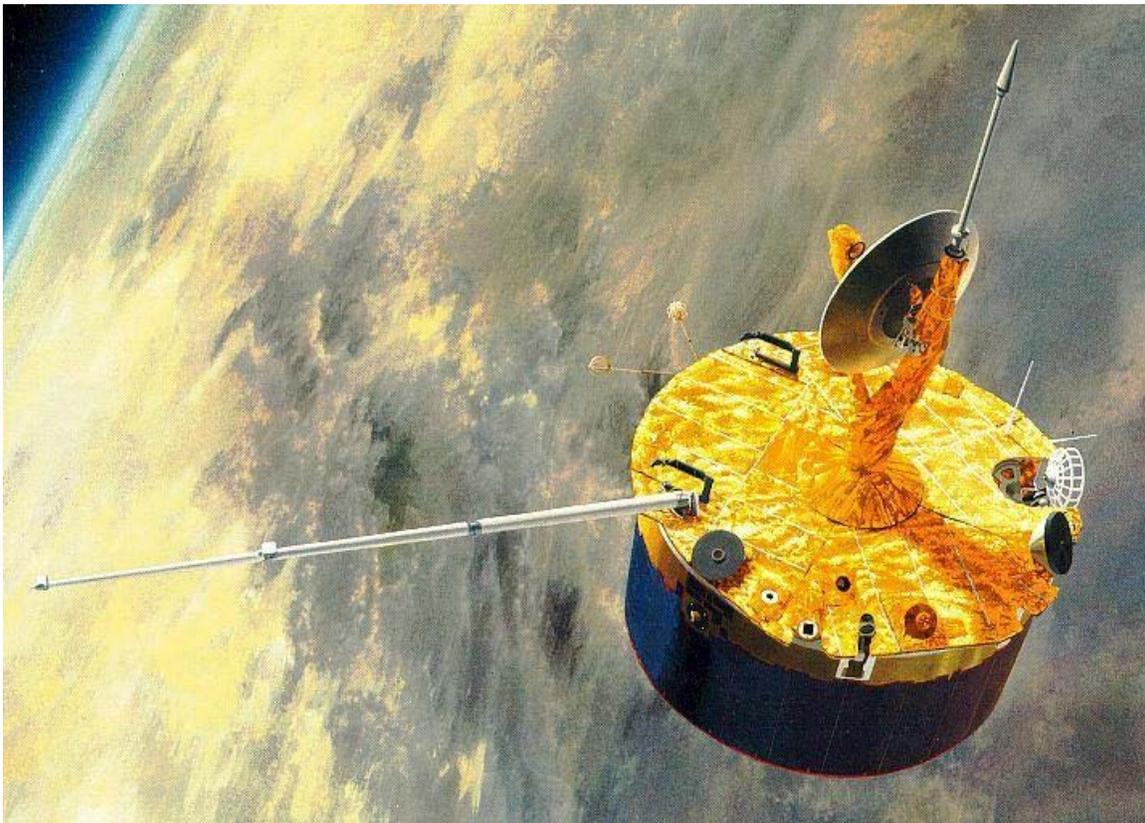
Picture of Mariner 6

The Mariner program conducted by NASA launched a series of robotic interplanetary probes designed to investigate Mars, Venus and Mercury. The program included a number of firsts, including the first planetary flyby, the first pictures from another planet, the first planetary orbiter, and the first gravity assist maneuver.

Of the ten vehicles in the Mariner series, seven were successful and three were lost. The planned Mariner 11 and Mariner 12 vehicles evolved into Voyager 1 and Voyager 2 of the Voyager program, while the Viking 1 and Viking 2 Mars orbiters were enlarged versions of the Mariner 9 spacecraft. Other Mariner-based spacecraft, launched since Voyager, included the Magellan probe to Venus, and the Galileo probe to Jupiter. A second-generation Mariner spacecraft, called the Mariner Mark II series, eventually evolved into the Cassini-Huygens probe, now in orbit around Saturn.

All Mariner spacecraft were based on a hexagonal or octagonal "bus", which housed all of the electronics, and to which all components were attached, such as antennae, cameras, propulsion, and power sources. All probes except Mariner 1, Mariner 2 and Mariner 5 had TV cameras. The first five Mariners were launched on Atlas-Agena rockets, while the last five used the Atlas-Centaur. All Mariner-based probes after Mariner 10 used the Titan IIIE, Titan IV unmanned rockets or the Space Shuttle with a solid-fueled Inertial Upper Stage and multiple planetary flybys.

Pioneer program



Artist's conception of the Pioneer Venus Orbiter

The Pioneer program is a series of NASA unmanned space missions that was designed for planetary exploration. There were a number of such missions in the program, but the most notable were Pioneer 10 and Pioneer 11, which explored the outer planets and left the solar system. Both carry a golden plaque, depicting a man and a woman and

information about the origin and the creators of the probes, should any extraterrestrials find them someday.

Additionally, the Pioneer mission to Venus consisted of two components, launched separately. Pioneer Venus 1 or *Pioneer Venus Orbiter* was launched in 1978 and studied the planet for more than a decade after orbital insertion in 1978. Pioneer Venus 2 or *Pioneer Venus Multiprobe* sent four small probes into the Venusian atmosphere.

Voyager program



Voyager 1 launch, September 5, 1977

The Voyager program is a series of NASA unmanned space missions that consists of a pair of unmanned scientific probes, *Voyager 1* and *Voyager 2*. They were launched in 1977 to take advantage of a favorable planetary alignment of the late 1970s. Although they were officially designated to study just Jupiter and Saturn, the two probes were able to continue their mission into the outer solar system. Both probes have achieved escape velocity from the solar system and will never return. Both missions have gathered large amounts of data about the gas giants of the solar system, of which little was previously known.

As of November 12, 2010, *Voyager 1* was at a distance of 115.251 AU (17.242 billion km, or 10.712 billion miles), traveling away from both the Earth and the Sun at a speed of 17 kilometres (11 mi)/s, which corresponds to a greater specific orbital energy than any other probe.

Viking program



Dr. Carl Sagan With the full-scale model of the Viking Lander

The Viking program consisted of a pair of space probes sent to Mars—Viking 1 and Viking 2. Each vehicle was composed of two main parts, an orbiter designed to photograph the surface of Mars from orbit, and a lander designed to study the planet from the surface. The orbiters also served as communication relays for the landers once they touched down. Viking 1 was launched on August 20, 1975, and the second craft, Viking 2, was launched on September 9, 1975, both riding atop Titan III-E rockets with Centaur upper stages. By discovering many geological forms that are typically formed from large

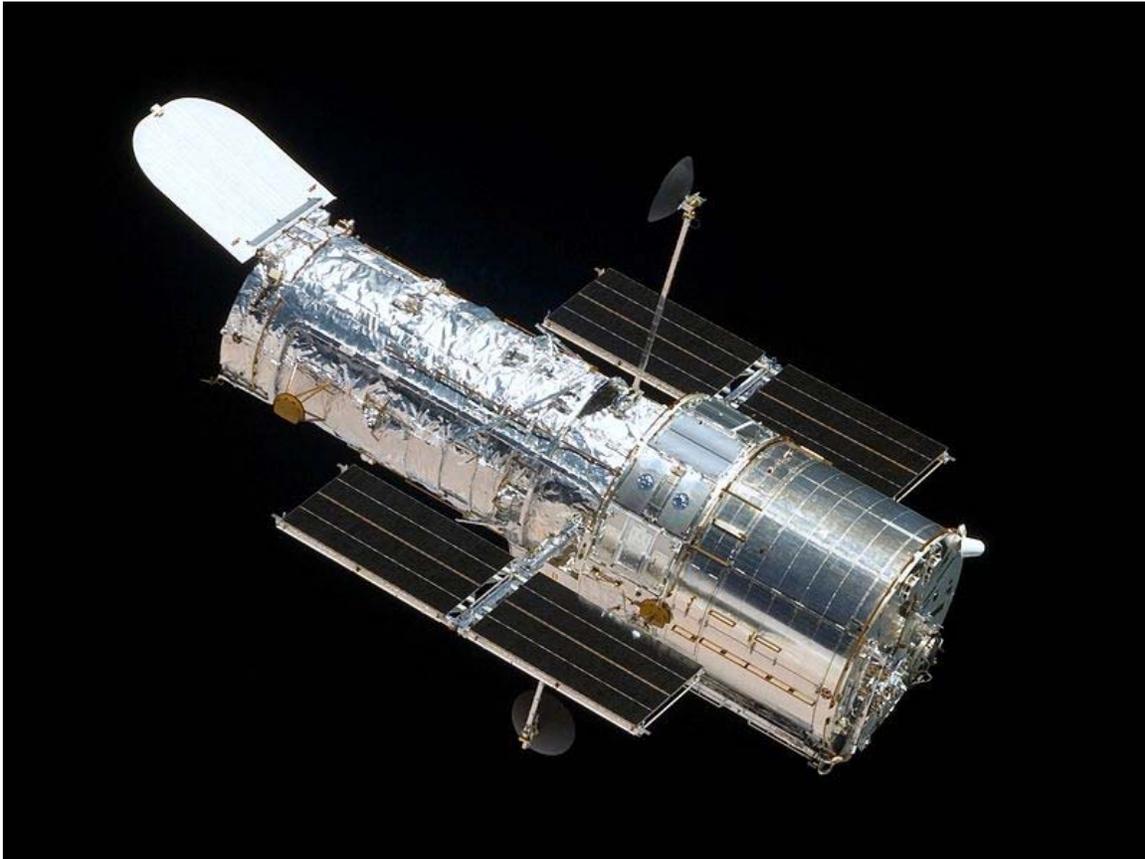
amounts of water, the Viking program caused a revolution in scientific ideas about water on Mars.

The primary objectives of the Viking orbiters were to transport the landers to Mars, perform reconnaissance to locate and certify landing sites, act as a communications relays for the landers, and to perform their own scientific investigations. The orbiter, based on the earlier Mariner 9 spacecraft, was an octagon approximately 2.5 m across. The total launch mass was 2,328 kilograms (5,130 lb), of which 1,445 kilograms (3,190 lb) were propellant and attitude control gas.

Helios probes

The Helios I and Helios II space probes, also known as Helios-A and Helios-B, were a pair of probes launched into heliocentric orbit for the purpose of studying solar processes. A joint venture of the Federal Republic of Germany (West Germany) and NASA, the probes were launched from Cape Canaveral Air Force Station, Florida, on Dec. 10, 1974, and Jan. 15, 1976, respectively. The probes are notable for setting a maximum speed record among spacecraft at 252,792 kilometres (157,078 mi)/h (157,078 mi/h or 43.63 mi/s or 70.22 kilometres (43.63 mi)/s or 0.000234c). The Helios space probes completed their primary missions by the early 1980s, but they continued to send data up to 1985. The probes are no longer functional but still remain in their elliptical orbit around the Sun.

Hubble Space Telescope

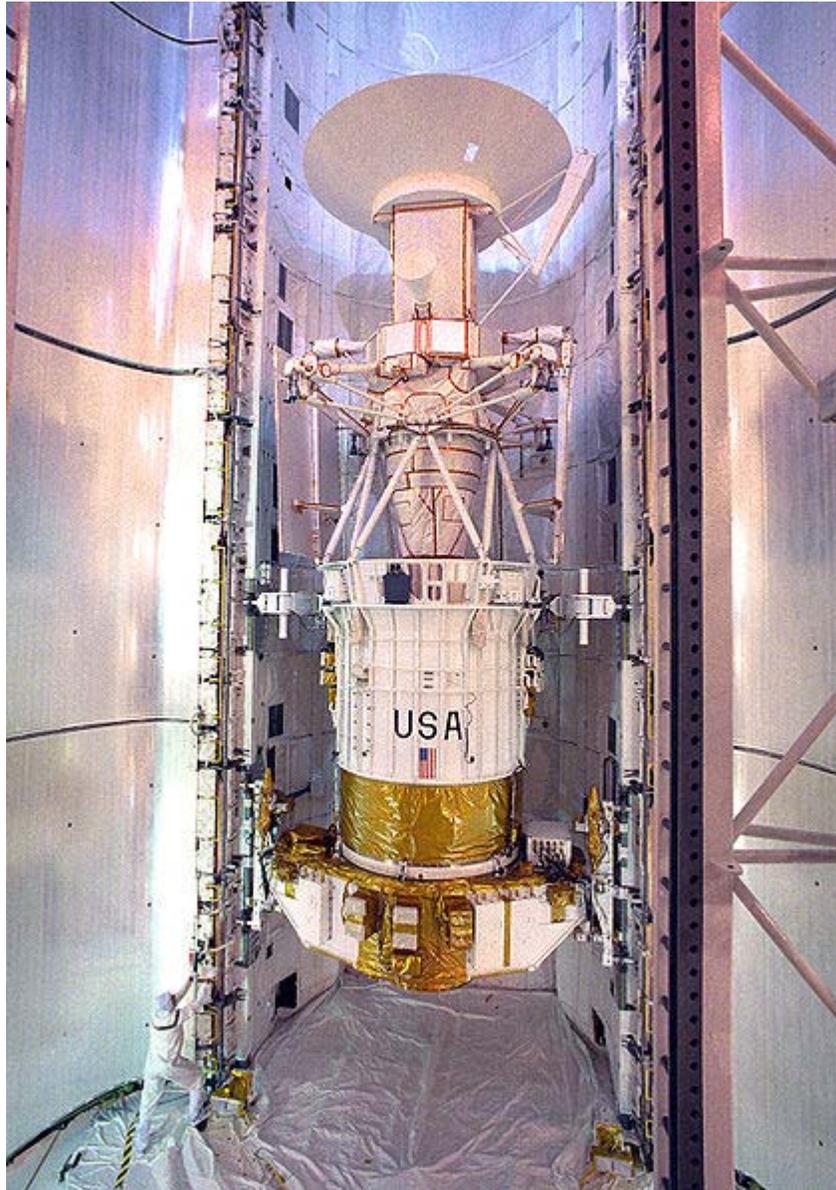


The Hubble Space Telescope

The Hubble Space Telescope (HST) is a space telescope that was carried into orbit by a space shuttle in April 1990. It is named after American astronomer Edwin Hubble. Although not the first space telescope, Hubble is one of the largest and most versatile, and is well-known as both a vital research tool and a public relations boon for astronomy. The HST is a collaboration between NASA and the European Space Agency, and is one of NASA's Great Observatories, along with the Compton Gamma Ray Observatory, the Chandra X-ray Observatory, and the Spitzer Space Telescope. The HST's success has paved the way for greater collaboration between the agencies.

The HST was created with a relatively small budget of \$2 billion and has continued operation since 1990, delighting both scientists and the public. Some of its images, such as the groundbreaking Hubble Deep Field, have become famous.

Magellan probe



The Magellan Probe prepared for launch

The Magellan spacecraft was a space probe sent to the planet Venus, the first unmanned interplanetary spacecraft to be launched by NASA since its successful Pioneer Orbiter, also to Venus, in 1978. It was also the first of three deep-space probes to be launched on the Space Shuttle, and the first spacecraft to employ aerobraking techniques to lower its orbit.

Magellan created the first (and currently the best) high resolution mapping of the planet's surface features. Prior Venus missions had created low resolution radar globes of general, continent-sized formations. Magellan, performed detailed imaging and analysis of craters,

hills, ridges, and other geologic formations, to a degree comparable to the visible-light photographic mapping of other planets.

Galileo probe



The Galileo probe

Galileo was an unmanned spacecraft sent by NASA to study the planet Jupiter and its moons. It was launched on October 18, 1989 by the Space Shuttle *Atlantis* on the STS-34 mission. It arrived at Jupiter on December 7, 1995, a little more than six years later, via gravitational assist flybys of Venus and Earth.

Despite antenna problems, *Galileo* conducted the first asteroid flyby, discovered the first asteroid moon, was the first spacecraft to orbit Jupiter, and launched the first probe into Jupiter's atmosphere. *Galileo*'s prime mission was a two-year study of the Jovian system. The spacecraft traveled around Jupiter in elongated ellipses, each orbit lasting about two months. The differing distances from Jupiter afforded by these orbits allowed *Galileo* to sample different parts of the planet's extensive magnetosphere. The orbits were designed for close up flybys of Jupiter's largest moons. Once *Galileo*'s prime mission was concluded, an extended mission followed starting on December 7, 1997; the spacecraft made a number of daring close flybys of Jupiter's moons Europa and Io. The closest approach was 180 kilometres (110 mi) (112 mi) on October 15, 2001.

On September 21, 2003, after 14 years in space and eight years of service in the Jovian system, *Galileo*'s mission was terminated by sending the orbiter into Jupiter's atmosphere at a speed of nearly 50 kilometers per second to avoid any chance of it contaminating local moons with bacteria from Earth. Of particular interest was the ice-crust moon Europa, which, thanks to *Galileo*, scientists now suspect harbors a salt water ocean beneath its surface.



Artist's conception of the Mars Global Surveyor

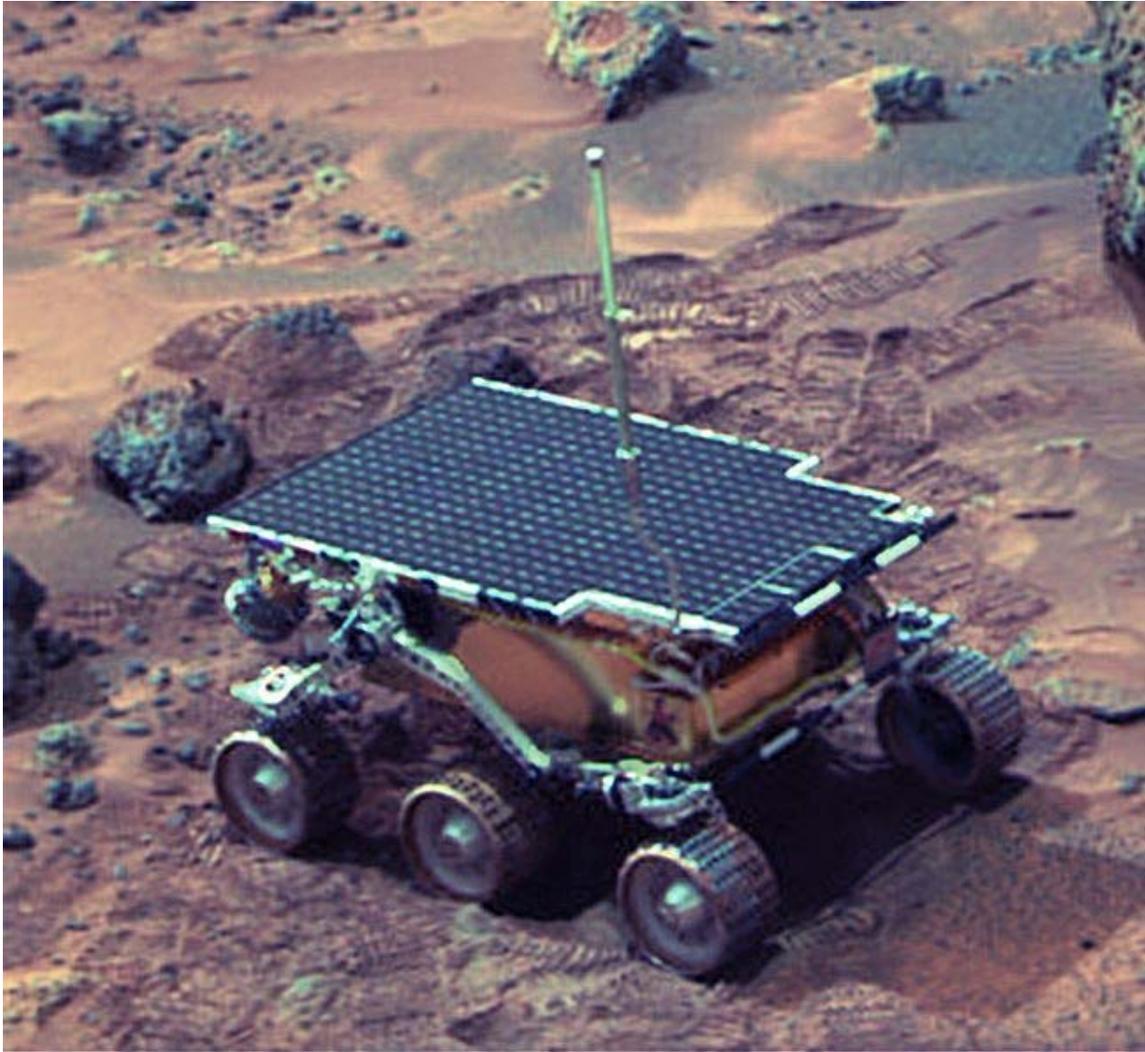
Mars Global Surveyor

The *Mars Global Surveyor* (MGS) was developed by NASA's Jet Propulsion Laboratory and launched November 1996. It began the United States's return to Mars after a 10-year absence. It completed its primary mission in January 2001 and was in its third extended mission phase when, on November 2, 2006, the spacecraft failed to respond to commands. In January 2007 NASA officially ended the mission.

The *Surveyor* spacecraft used a series of high-resolution cameras to explore the surface of Mars during its mission, returning more than 240,000 images spanning portions of 4.8 Martian years, from September 1997 to November 2006. The surveyor's cameras utilized 3 instruments: a narrow angle camera that took (black-and-white) high resolution images

(usually 1.5 to 12 m per pixel) red and blue wide angle pictures for context (240 m per pixel) and daily global imaging (7.5 kilometres (4.7 mi) per pixel).

Mars Pathfinder

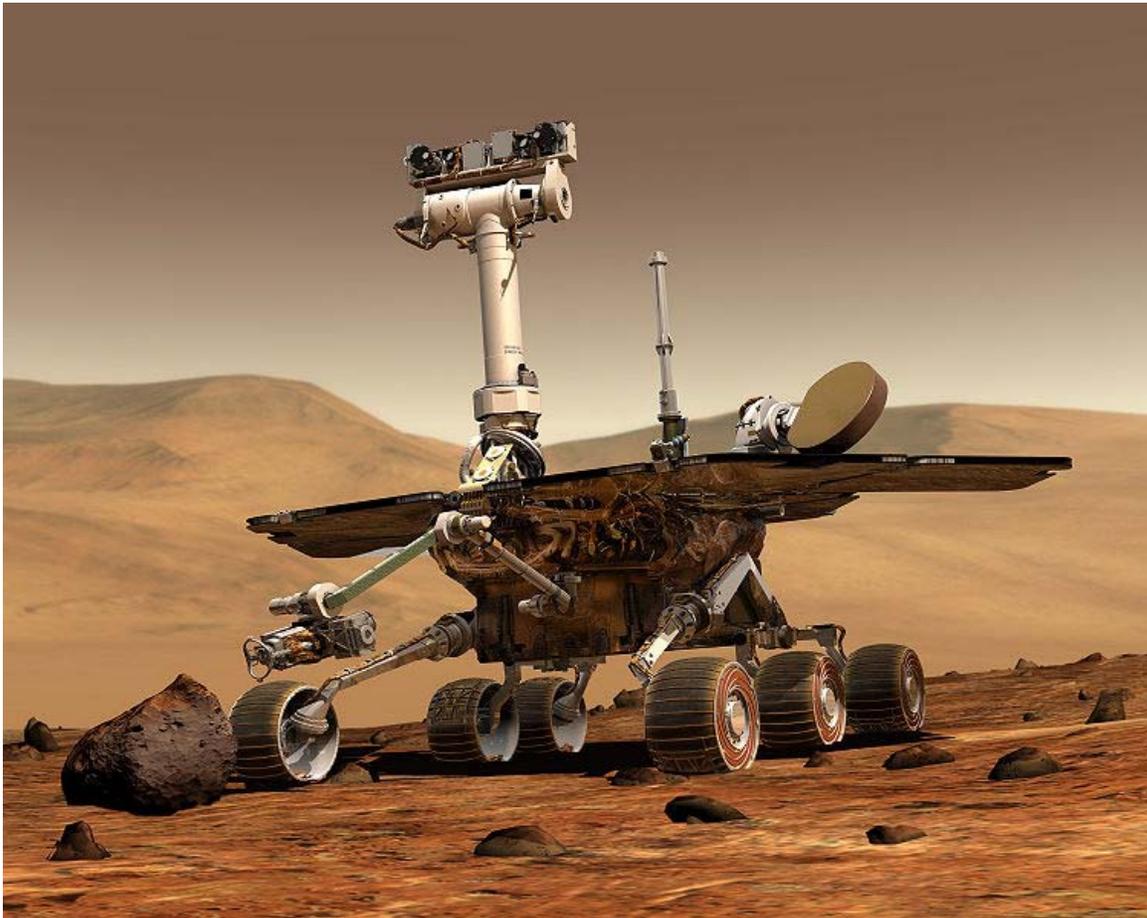


The Sojourner rover on Mars

The *Mars Pathfinder* (MESUR Pathfinder,) later renamed the *Carl Sagan Memorial Station*, was launched on December 4, 1996, just a month after the *Mars Global Surveyor* was launched. Onboard the lander was a small rover called *Sojourner* that would execute many experiments on the Martian surface. It was the second project from NASA's Discovery Program, which promotes the use of low-cost spacecraft and frequent launches under the motto "cheaper, faster and better" promoted by the then administrator, Daniel Goldin. The mission was directed by the Jet Propulsion Laboratory, a division of the California Institute of Technology, responsible for NASA's Mars Exploration Program.

This mission, besides being the first of a series of missions to Mars that included rovers (robotic exploration vehicles), was the most important since the *Vikings* landed on the red planet in 1976, and also was the first successful mission to send a rover to a planet. In addition to scientific objectives, the Mars Pathfinder mission was also a "proof-of-concept" for various technologies, such as airbag-mediated touchdown and automated obstacle avoidance, both later exploited by the Mars Exploration Rovers. The Mars Pathfinder was also remarkable for its extremely low price relative to other unmanned space missions to Mars.

Mars Exploration Rovers



Artist's conception of MER on Mars

NASA's *Mars Exploration Rover Mission* (MER), is an ongoing robotic space mission involving two rovers exploring the planet Mars. The mission is managed for NASA by the Jet Propulsion Laboratory, which designed, built and is operating the rovers.

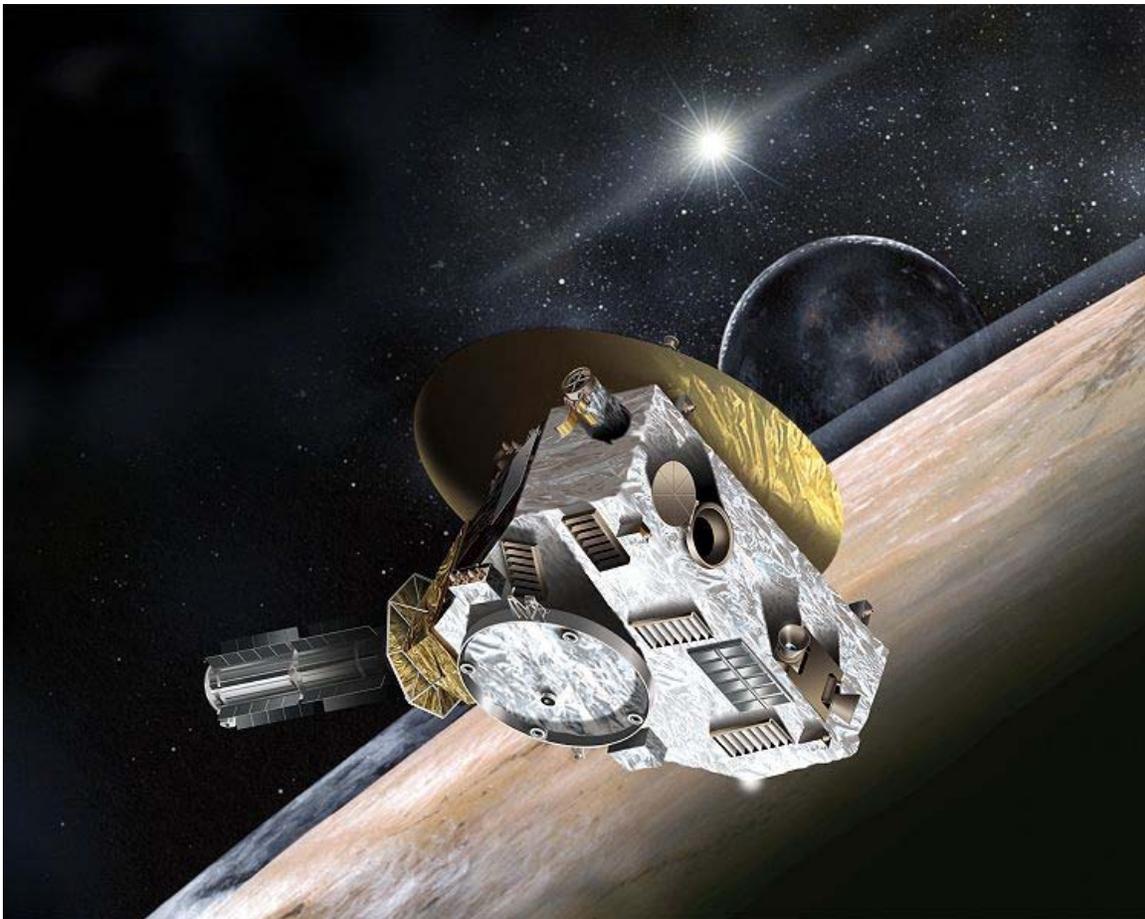
The mission began in 2003 with the sending of the two rovers — MER-A *Spirit* and MER-B *Opportunity* — to explore the Martian surface and geology. The mission's scientific objective is to search for and characterize a wide range of rocks and soils that hold clues to past water activity on Mars. The mission is part of NASA's Mars

Exploration Program which includes three previous successful landers: the two Viking program landers in 1976 and Mars Pathfinder probe in 1997.

The total cost of building, launching, landing and operating the rovers on the surface for the initial 90-Martian-day (sol) primary mission was US\$820 million. Since the rovers have continued to function far beyond their initial 90 sol primary mission (to date both rovers have been functioning on Mars's surface for nearly seven years), they have each received multiple mission extensions.

In recognition of the vast amount of scientific information amassed by both rovers, two asteroids have been named in their honor: 37452 Spirit and 39382 Opportunity.

New Horizons probe

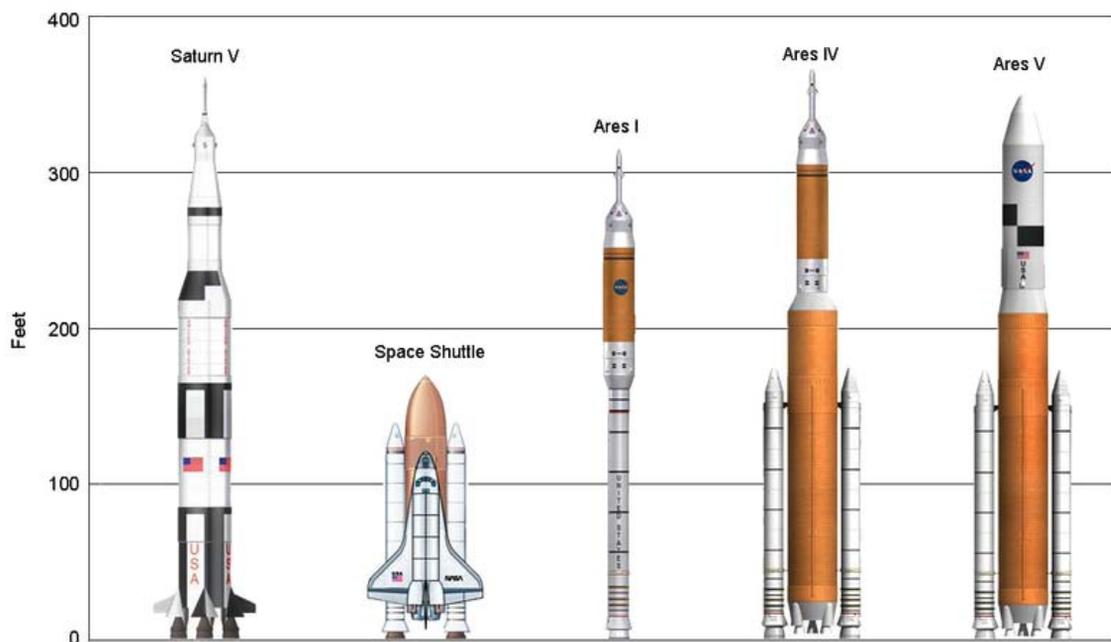


Artist's conception of New Horizons orbiting Pluto

New Horizons is a NASA robotic spacecraft mission currently en route to the dwarf planet Pluto. It is expected to be the first spacecraft to fly by and study Pluto and its moons, Charon, Nix, and Hydra. Once *New Horizons* leaves the Solar System, NASA may also approve flybys of one or more other Kuiper Belt Objects.

New Horizons was launched on January 19, 2006 directly into an Earth-and-solar-escape trajectory. It had an Earth-relative velocity of about 16.26 kilometres (10.10 mi)/s or 58,536 kilometres (36,373 mi)/h (10.10 mi/s or 36,373 mi/h) after its last engine shut down. Thus, it left Earth at the fastest launch speed ever recorded for a man-made object (although its specific orbital energy is less than that of Voyager 1, and the Helios Probes retain the maximum speed record for a spacecraft). *New Horizons* flew by Jupiter on February 28, 2007 and Saturn's orbit on June 8, 2008. It will arrive at Pluto on July 14, 2015 and then continue into the Kuiper belt.

NASA's future



Left to Right: Saturn V, which carried men to the Moon, the Space Shuttle, and the canceled Ares I, Ares IV and Ares V launch vehicles

During much of the 1990s, NASA was faced with shrinking annual budgets due to congressional belt-tightening. In response, NASA's ninth administrator, Daniel Goldin, pioneered the "faster, better, cheaper" approach that enabled NASA to cut costs while still delivering a wide variety of aerospace programs (Discovery Program). That method was criticized and re-evaluated following the twin losses of Mars Climate Orbiter and Mars Polar Lander in 1999.

It is the current space policy of the United States that NASA, "execute a sustained and affordable human and robotic program of space exploration and develop, acquire, and use civil space systems to advance fundamental scientific knowledge of our Earth system, solar system, and universe." NASA's ongoing investigations include in-depth surveys of Mars and Saturn and studies of the Earth and the Sun. Other NASA spacecraft are

presently en route to Mercury, Pluto and the asteroid belt. With missions to Jupiter in planning stages, NASA's itinerary covers over half the solar system.

An improved and larger planetary rover, Mars Science Laboratory, is under construction and slated to launch in 2011, after a slight delay caused by hardware challenges, which has bumped it back from the October 2009 scheduled launch. The New Horizons mission to Pluto was launched in 2006 and will fly by Pluto in 2015. The probe received a gravity assist from Jupiter in February 2007, examining some of Jupiter's inner moons and testing on-board instruments during the fly-by. On the horizon of NASA's plans is the MAVEN spacecraft as part of the Mars Scout Program to study the atmosphere of Mars.

Orion contractor selected August 31, 2006, at NASA Headquarters

Vision for Space Exploration

On January 14, 2004, ten days after the landing of the Mars Exploration Rover *Spirit*, US President George W. Bush announced a new plan for NASA's future, dubbed the Vision for Space Exploration. According to this plan, mankind would return to the Moon by 2018, and set up outposts as a testbed and potential resource for future missions. The Space Shuttle will be retired in 2010 and Orion may replace it by 2015, capable of both docking with the International Space Station (ISS) and leaving the Earth's orbit. The future of the ISS is somewhat uncertain—construction will be completed, but beyond that is less clear. Although the plan initially met with skepticism from Congress, in late 2004 Congress agreed to provide start-up funds for the first year's worth of the new space vision.

Hoping to spur innovation from the private sector, NASA established a series of Centennial Challenges, technology prizes for non-government teams, in 2004. The Challenges include tasks that will be useful for implementing the Vision for Space Exploration, such as building more efficient astronaut gloves. In February 2010, NASA announced that it would be awarding \$50 million in contracts to commercial spaceflight companies including Blue Origin, Boeing, Paragon Space Development Corporation, Sierra Nevada Corporation and United Launch Alliance to design and develop viable reusable launch vehicles.

Moon base

On December 4, 2006, NASA announced it was planning a permanent moon base. NASA Associate Administrator Scott Horowitz said the goal was to start building the moonbase by 2020, and by 2024, have a fully functional base that would allow for crew rotations and in-situ resource utilization. Additionally, NASA plans to collaborate and partner with other nations for this project. As of February 1, 2010, however, President Obama has scrapped the possibility of a moon base through his budget as he believes that NASA should be more focused on deep space missions.

Human exploration of Mars

On September 28, 2007 Michael D. Griffin, who was at the time Administrator of NASA, stated that NASA aims to put a man on Mars by 2037.

Alan Stern, NASA's "hard-charging" and "reform-minded" associate administrator for the Science Mission Directorate, resigned on March 25, 2008, effective April 11, 2008, after he allegedly ordered funding cuts to the Mars Exploration Rover (MER) and Mars Odyssey that were overturned by NASA Administrator Michael D. Griffin. The cuts were intended to offset cost overruns for the Mars Science Laboratory. Stern has stated that he "did not quit over MER" and that he "wasn't the person who tried to cut MER". Stern, who served for nearly a year and has been credited with making "significant changes that have helped restore the importance of science in NASA's mission", says he left to avoid cutting healthy programs and basic research in favor of politically sensitive projects. Griffin favored cutting "less popular parts" of the budget, including basic research, and Stern's refusal to do so led to his resignation.

Recent developments



President Obama and Senator Bill Nelson arrive at Kennedy Space Center in April 2010.

The Office of Science and Technology Policy (OSTP) established the Augustine Commission to ensure the nation is on "a vigorous and sustainable path to achieving its boldest aspirations in space" on May 7, 2009. In its October 22, 2009 report, the Commission proposed three basic options for exploration beyond low Earth orbit:

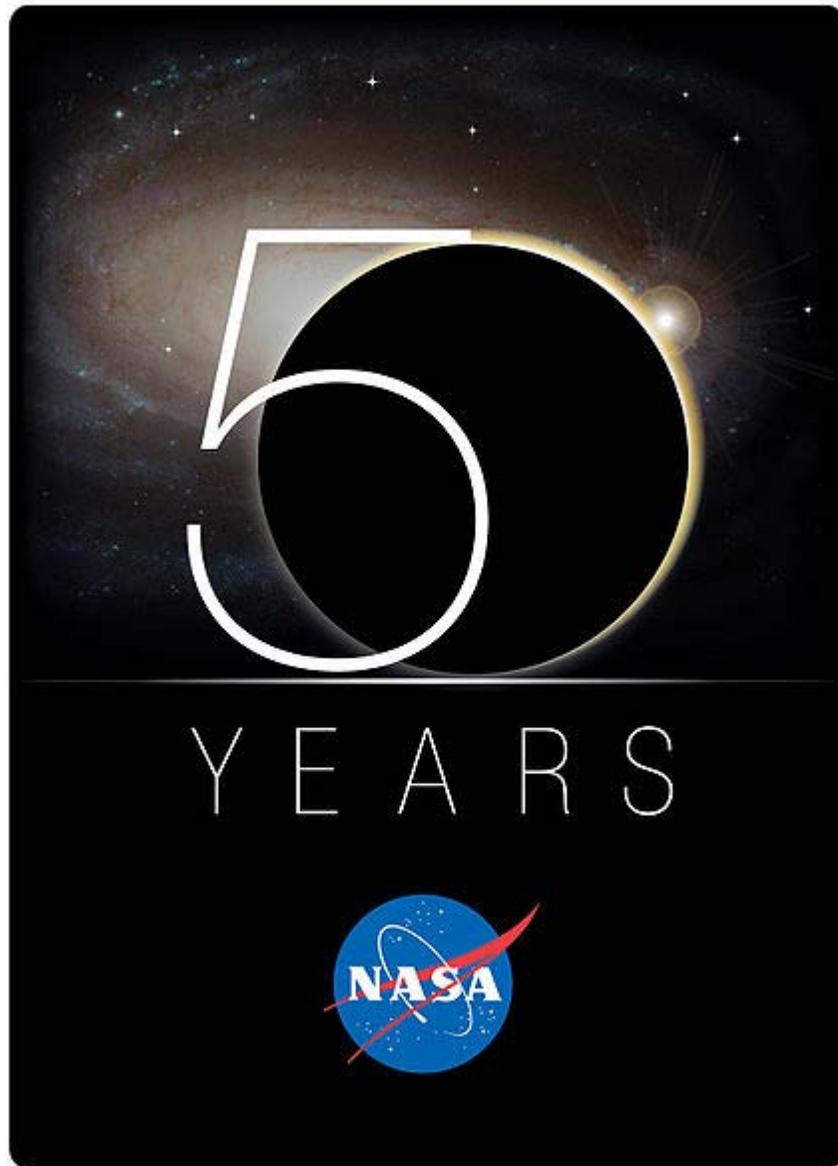
- Mars First, with a Mars landing, perhaps after a brief test of equipment and procedures on the Moon.
- Moon First, with lunar surface exploration focused on developing the capability to explore Mars.
- A Flexible Path to inner solar system locations, such as lunar orbit, Lagrange points, near-Earth objects and the moons of Mars, followed by exploration of the lunar surface and/or Martian surface.

President Barack Obama announced changes to NASA space policy, in his April 15, 2010 space policy speech at Kennedy Space Center, from the Moon-first approach adopted previously under the Vision for Space Exploration and Constellation program to a variety of destinations resembling the flexible path approach.

The new plan calls for NASA to extend the life of the ISS by five years and use launch vehicles designed, manufactured, and operated by private aerospace companies with NASA paying for flights for government astronauts to the ISS and LEO, much like the way private space tourism company Space Adventures bought Soyuz flights from the Russian government for space tourists. Boeing and Lockheed Martin have expressed doubts about the new plan, while other aerospace companies, including SpaceX, have strongly endorsed it.

NASA's selected SpaceX and Orbital Sciences for its Commercial Orbital Transportation Services (COTS) program. The first launch of SpaceX's Falcon 9 occurred on December 8, 2010; it was the unmanned first spaceflight of the SpaceX Dragon spacecraft, which orbited the Earth. It was the first demonstration flight for the COTS program. On February 8 the idea for a new rocket to replace the aging space shuttle was presented in the form of the Liberty. Mostly a combination of the already existing Ariane 5 and the cancelled Ares I; it is thought that it could be finished by 2013, and ready for launch by 2015 if approved.

Mission statement and vision



NASA's 50th Anniversary logo

- To improve life here, to extend life to there, to find life beyond. — Mission Statement
- NASA's mission is to pioneer the future in space exploration, scientific discovery and aeronautics research. — Mission
- To understand and protect our home planet, to explore the Universe and search for life, and to inspire the next generation of explorers... as only NASA can. — NASA Vision

Controversy

The chair and ranking member of the U.S. Senate Committee on Homeland Security and Governmental Affairs wrote NASA Administrator Griffin on July 31, 2006 expressing concerns about the change. NASA also canceled or delayed a number of earth science missions in 2006.

In 2009, NASA announced that the agency plans to provide \$1.75 million in funding to Jack Bergman of Harvard's McLean Hospital to conduct an experiment on monkeys to determine the health effects of radiation exposure during travel in deep space. The plan has faced opposition from animal rights groups such as PETA and HSUS, a physicians' group PCRM, and several federal legislators lead by Representative Jim Moran of Virginia who claim that the grant should be cancelled because during the course of the experiment, the primates will likely contract malignant tumors as well as blindness, skin damage, cognitive decline, premature aging and death. PCRM also claims that the proposed use and isolation of primates would violate NASA's stated principles regarding animal ethics. The group has filed a federal complaint alleging that the experiments would also violate the Animal Welfare Act.

Public perception of the NASA budget is very different from reality and has been the subject of controversy since the agency's creation. A 1997 poll reported that Americans had an average estimate of 20% for NASA's share of the federal budget. In reality, NASA's budget has been between 0.5% and 1% from the late 1960s on. NASA budget briefly peaked at over 4% of the federal budget in the mid-1960s during the build up to the Apollo program.

Leadership

The administrator of NASA is the highest-ranking official of that organization and serves as the senior space science adviser to the President of the United States. On May 24, 2009, President Obama announced the nomination of Charles Bolden as NASA administrator, and Lori Garver as deputy administrator. Bolden was confirmed by the US Senate on July 15, 2009 as the twelfth administrator of NASA. Lori Garver was confirmed as NASA's deputy administrator.

Other leadership positions within NASA include:

- Office of the Administrator
 - Associate Administrator (currently Christopher Scolese)
 - Chief of Staff (currently David Radzanowski)
- Advisory Groups
 - NASA Advisory Council (NAC)
 - Chairman: Dr. Kenneth Ford
 - Aerospace Safety Advisory Panel (ASAP)
 - Chairman: Vice Admiral Joe Dyer USN, (Ret.)
- Office of the Inspector General

- Inspector General: Paul K. Martin

Facilities

NASA Headquarters in Washington, DC provides overall guidance and direction to the agency. NASA's Shared Services center is located on the grounds of the John C. Stennis Space Center, near Bay St. Louis, Mississippi. Construction of the Shared Services facility began in August 2006 and it was completed in June 2008. NASA operates a short-line railroad at the Kennedy Space Center. Various field and research installations are listed below by application. Some facilities serve more than one application for historic or administrative reasons.

Research centers



JPL complex in Pasadena, California

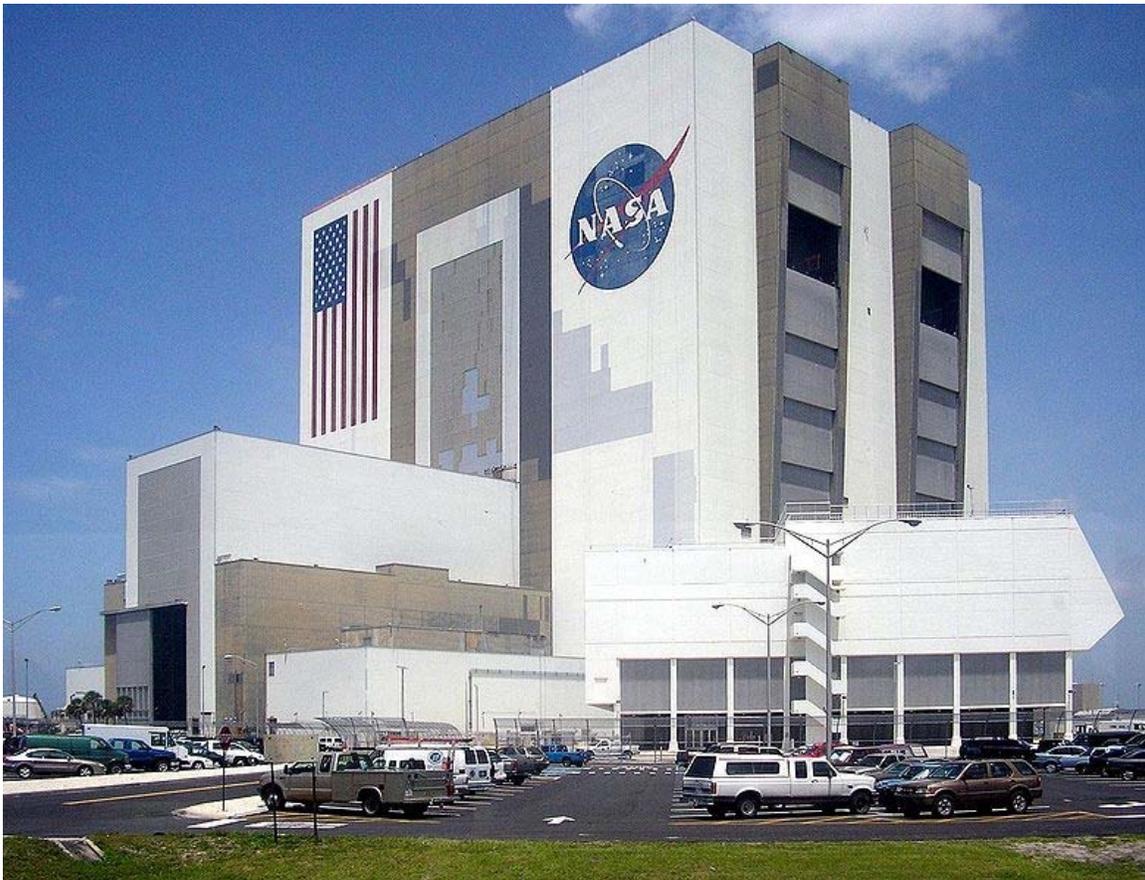
- Ames Research Center, Moffett Federal Airfield, Mountain View, California
- Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California
- Goddard Institute for Space Studies, New York City
- Goddard Space Flight Center, Greenbelt, Maryland

- John H. Glenn Research Center at Lewis Field, Cleveland, Ohio
- Langley Research Center, Hampton, Virginia

Test facilities

- Glenn Research Center, Plum Brook Station, Sandusky, Ohio
- Ames Research Center, Moffett Federal Airfield, Mountain View, California
- Dryden Flight Research Center, Edwards Air Force Base, Los Angeles County, California
- Independent Verification and Validation Facility, Fairmont, West Virginia
- John C. Stennis Space Center, near Bay St. Louis, Mississippi
- Langley Research Center, Hampton, Virginia

Construction and launch facilities



The Vehicle Assembly Building and Launch Control Center at Kennedy Space Center.

- George C. Marshall Space Flight Center, Huntsville, Alabama
- John F. Kennedy Space Center, Florida
- Lyndon B. Johnson Space Center, Houston, Texas
- Michoud Assembly Facility, New Orleans, Louisiana
- Wallops Flight Facility, Wallops Island, Virginia

- White Sands Test Facility, Las Cruces, New Mexico

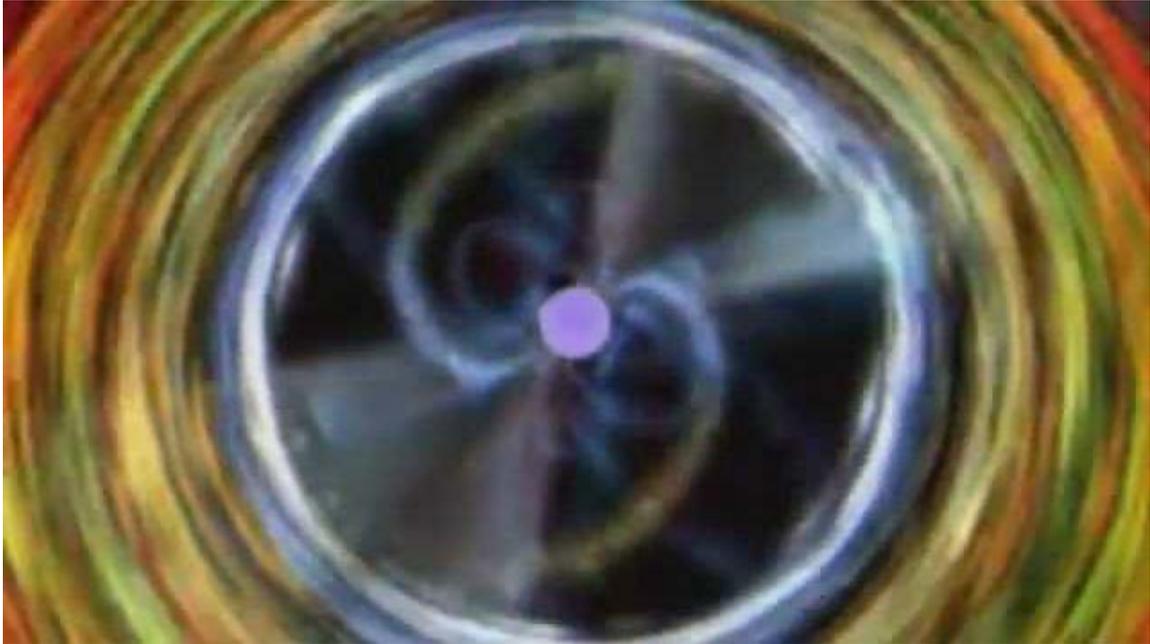
Deep Space Network

- Deep Space Network (DSN) stations
 - Canberra Deep Space Communication Complex, Canberra, Australian Capital Territory
 - Goldstone Deep Space Communications Complex, Barstow, California
 - Madrid Deep Space Communication Complex, Madrid, Spain



Florida, USA, taken from shuttle mission STS-95 on October 31, 1998

NASA science



Crab Nebula by NASA

Ozone depletion

In the middle of the 20th century NASA augmented its mission of Earth's observation and redirected it toward environmental quality. The result was the launch of Earth Observing System (EOS) in 1980s, which was able to monitor one of the global environmental problems—ozone depletion. The first comprehensive worldwide measurements were obtained in 1978 with the Nimbus-7 satellite and NASA scientists at the Goddard Institute for Space Studies.

Salt evaporation and energy management

In one of the nation's largest restoration projects, NASA technology helps state and federal government reclaim 15,100 acres (61 km²) of salt evaporation ponds in South San Francisco Bay. Satellite sensors are used by scientists to study the effect of salt evaporation on local ecology.

NASA has started Energy Efficiency and Water Conservation Program as an agency-wide program directed to prevent pollution and reduce energy and water utilization. It helps to ensure that NASA meets its federal stewardship responsibilities for the environment.

Medicine in space

A variety of large scale medical studies are being conducted in space via the National Space and Biomedical Research Institute (NSBRI). Prominent among these is the Advanced Diagnostic Ultrasound in Microgravity Study in which Astronauts (including former ISS Commanders Leroy Chiao and Gennady Padalka) perform ultrasound scans under the guidance of remote experts to diagnose and potentially treat hundreds of medical conditions in space. Usually, there is no physician onboard the International Space Station and diagnosis of medical conditions is challenging. In addition, Astronauts are susceptible to a variety of health risks including decompression sickness, barotrauma, immunodeficiencies, loss of bone and muscle, orthostatic intolerance due to volume loss, sleep disturbances, and radiation injury. Ultrasound offers a unique opportunity to monitor these conditions in space. This study's techniques are now being applied to cover professional and Olympic sports injuries as well as ultrasound performed by non-expert operators in populations such as medical and high school students. It is anticipated that remote guided ultrasound will have application on Earth in emergency and rural care situations, where access to a trained physician is often rare.

Earth Science Enterprise

Understanding of natural and human-induced changes on the global environment is the main objective of NASA's Earth Science Enterprise. NASA currently has more than a dozen Earth science spacecraft/instruments in orbit studying all aspects of the Earth system (oceans, land, atmosphere, biosphere, cyrosphere), with several more planned for launch in the next few years.

For years it has been cooperating with major environment related agencies and creating united projects to achieve their goal. Past Enterprise's programs include:

- Carbon sequestration assessment for Carbon Management (USDA, DOE)
- Early warning systems for air and water quality for Homeland Security (OHS, NIMA, USGS)
- Enhanced weather prediction for Energy Forecasting (DOE, United States Environmental Protection Agency (EPA))
- Environmental indicators for Coastal Management (NOAA)
- Environmental indicators for Community Growth Management (EPA, USGS, NSGIC)
- Environmental models for Biological Invasive Species (USGS, USDA)
- Regional to national to international atmospheric measurements and predictions for Air Quality Management (United States Environmental Protection Agency, NOAA)
- Water cycle science for Water Management and Conservation (EPA, USDA)

NASA is working in cooperation with National Renewable Energy Laboratory (NREL). The goal is to obtain~to produce worldwide solar resource maps with great local detail. NASA was also one of the main participants in the evaluation innovative technologies for

the clean up of the sources for dense non-aqueous phase liquids (DNAPLs). On April 6, 1999, the agency signed The Memorandum of Agreement (MOA) along with the United States Environmental Protection Agency, DOE, and USAF authorizing all the above organizations to conduct necessary tests at the John F. Kennedy Space center. The main purpose was to evaluate two innovative in-situ remediation technologies, thermal removal and oxidation destruction of DNAPLs. National Space Agency made a partnership with Military Services and Defense Contract Management Agency named the “Joint Group on Pollution Prevention”. The group is working on reduction or elimination of hazardous materials or processes.

On May 8, 2003, Environmental Protection Agency recognized NASA as the first federal agency to directly use landfill gas to produce energy at one of its facilities—the Goddard Space Flight Center, Greenbelt, Maryland.

Awards and decorations

NASA presently bestows a number of medals and decorations to astronauts and other NASA personnel. Some awards are authorized for wear on active duty military uniforms. The highest award is the Congressional Space Medal of Honor, which has been awarded to 28 individuals (17 posthumously), and is said to recognize "any astronaut who in the performance of his duties has distinguished himself by exceptionally meritorious efforts and contributions to the welfare of the Nation and mankind."

The second highest NASA award is the NASA Distinguished Service Medal, which may be presented to any member of the federal government, including both military astronauts and civilian employees. It is an annual award, given out at the National Aeronautics Space Foundation plant, located in Orlando, Florida.

Chapter- 2

Russian Federal Space Agency

Russian Federal Space Agency

Федеральное космическое агентство России



РОСКОСМОС

Logo of Roscosmos

1992

Established *(formerly the Soviet space program, 1922-1991)*

Headquarters Moscow

Primary spaceport Baikonur Cosmodrome
Plesetsk Cosmodrome

Administrator Anatoly Perminov

Budget 82 billion RUB (\$2.4 billion) (2009)

Website www.roscosmos.ru

The **Russian Federal Space Agency** (Russian: Федеральное космическое агентство России *Federal'noye kosmicheskoye agentstvo Rossii*), commonly called **Roscosmos** (Роскосмос *Roskosmos*) and abbreviated as **ФКА** (ФКА) and **РКА** (РКА), is the government agency responsible for the Russian space science program and general aerospace research. It was previously the **Russian Aviation and Space Agency** (Russian: Российское авиационно-космическое агентство *Rossiyskoe aviatsionno-kosmicheskoye agentsvo*, commonly known as "**Rosaviakosmos**").

Headquarters of Roscosmos are located in Moscow. Main Mission Control space flight operations center is located in a nearby city of Korolev. Cosmonauts Training Centre (GCTC) is in Star City. Launch facilities used are Baikonur Cosmodrome in Kazakhstan (with most launches taking place there, both manned and unmanned) and Plesetsk Cosmodrome in northern Russia used primarily for unmanned flights of military designations.

Since his appointment as General Director in March 2004, Anatoly Perminov has led Russia's efforts to consolidate its space program.

History



The Hall of Space Technology in the Tsiolkovsky State Museum of the History of Cosmonautics, Kaluga, Russia. The exhibition includes the models and replicas of the following Russian/Soviet inventions:

- the first satellite, *Sputnik 1* (a ball under the ceiling);
- the first spacesuits (lower-left corner);
- the first human spaceflight module, *Vostok 1* (center);
- the first Molniya-type satellite (upper right corner);
- the first space rover, *Lunokhod 1* (bucket on wheels on the right);
- the first space station, *Salyut 1* (left);
- the first modular space station, *Mir* (upper left).

The Soviet space program did not have central executive agencies. Instead, its organizational architecture was multi-centered; it was the design bureaus and the council of designers that had the most say, not the political leadership. The creation of a central agency after the separation of Russia from the Soviet Union was therefore a new development. Russian Space Agency was formed on February 25, 1992 by a decree of President Yeltsin. Yuri Koptev, who had previously worked with designing Mars landers at NPO Lavochkin, became the agency's—later renamed to Roskosmos—first director.

Historic Russian space gallery

People



Sergey Korolyov was the mastermind behind the first satellite, first human in orbit and first spacewalk.



The first human in space and to orbit the Earth, Yuri Gagarin.



Cosmonaut Aleksei Leonov, the first person to perform an EVA (spacewalk), in 1965.

In the early years, the agency suffered from lack of authority as the powerful design bureaus fought to protect their own spheres of operation and to survive. For example, the decision to keep Mir in operation beyond 1999 was not taken by the agency; instead, it was made by the private shareholder board of the Energia design bureau. Another example is that the decision to develop the new Angara rocket was rather a function of Khrunichev's ability to attract resources than a conscious long-term decision by the agency.

Crisis years

The 1990s saw serious financial problems because of the decreased cash flow, which encouraged Roskosmos to improvise and seek other ways to keep space programs running. This resulted in Roskosmos' leading role in commercial satellite launches and space tourism. While scientific missions, such as interplanetary probes or astronomy missions during these years played a very small role, Roskosmos managed to operate the space station Mir well past its planned lifespan, contribute to the International Space Station, and continue to fly additional Soyuz and Progress missions.

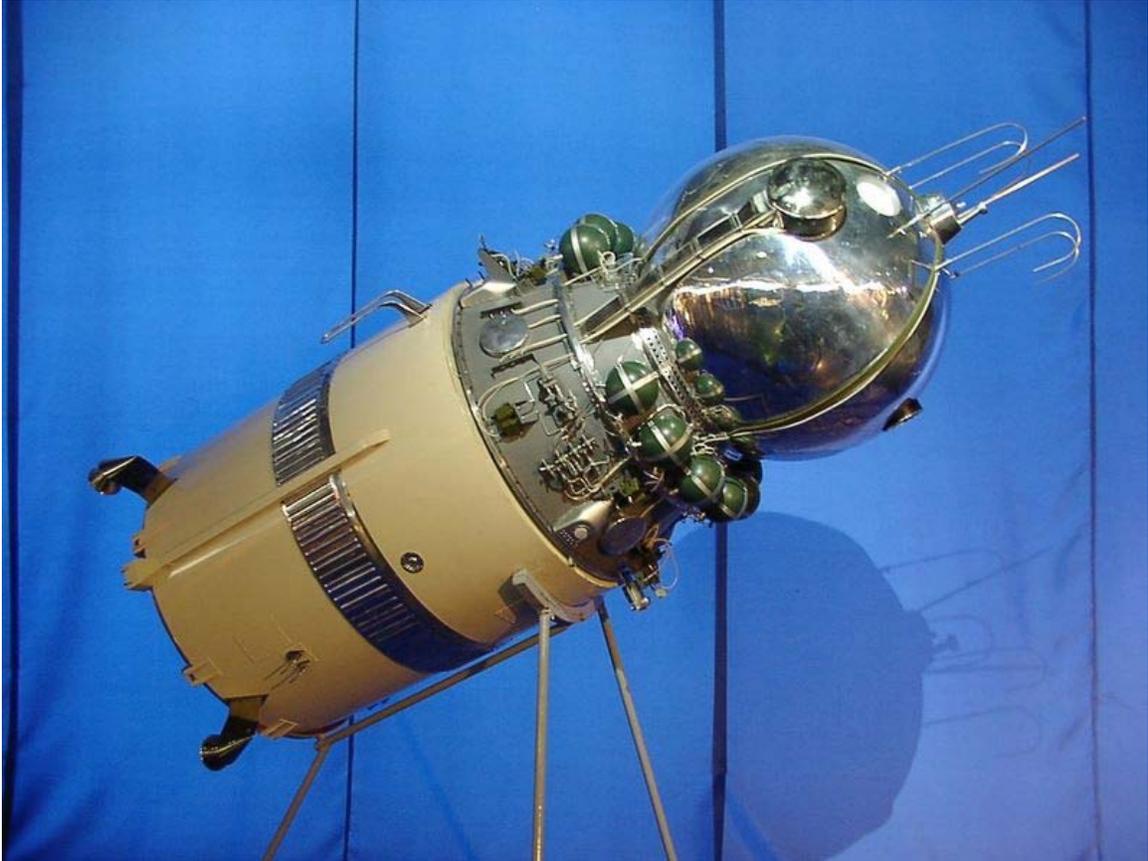
In March 2004, director Yuri Koptev was replaced by Anatoly Perminov, who had previously served as the first commander of the Space Forces.

Improved situation in 2005–2006

The Russian economy boomed throughout 2005 from high prices for exports, such as oil and gas, the outlook for future funding in 2006 appeared more favorable. This resulted in the Russian Duma approving a budget of 305 billion rubles (about 11 billion USD) for the Space Agency from 2006 to 2015, with overall space expenditures in Russia total about 425 billion rubles for the same time period. The budget for 2006 was as high as 25 billion rubles (about 900 million USD), which is a 33% increase from the 2005 budget. Under the current 10 year budget approved, the budget of the Space Agency shall increase 5–10% per year, providing the space agency with a constant influx of money. In addition to the budget, Roskosmos plans to have over 130 billion rubles flowing into its budget by other means, such as industry investments and commercial space launches.

Historic Russian space gallery

Spacecraft



Vostok was the first spacecraft to carry a human being in space



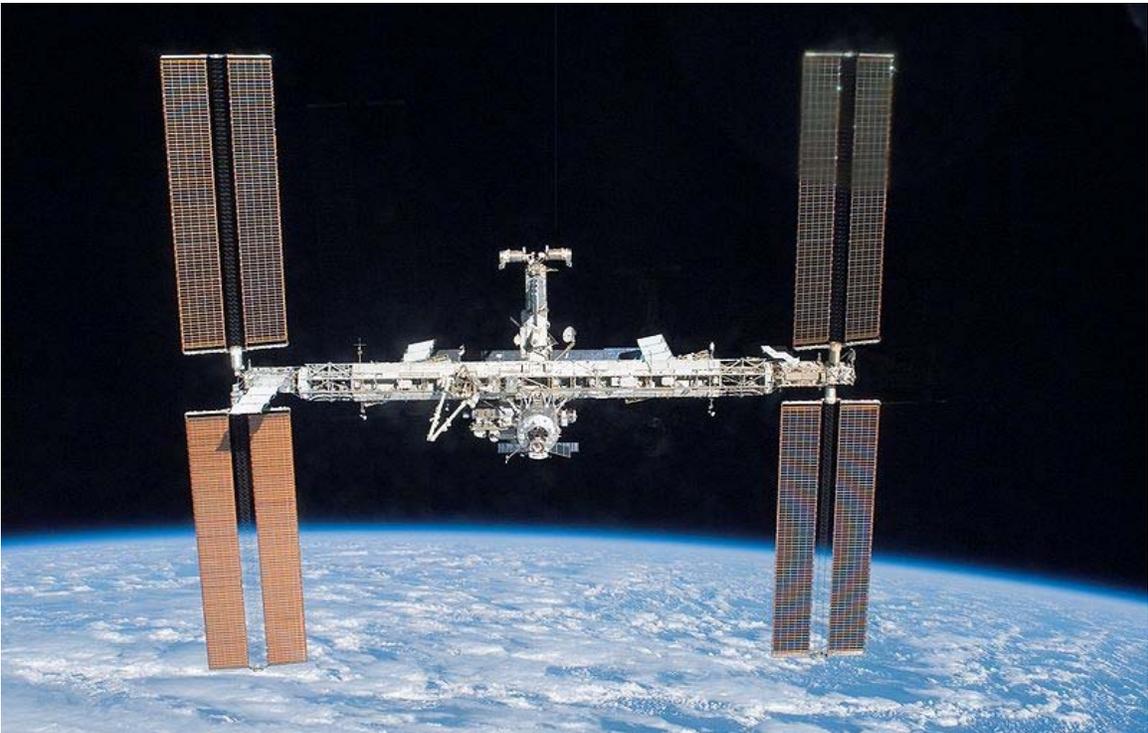
Soyuz is the longest serving manned spacecraft design in history (1967–) , upgraded regularly



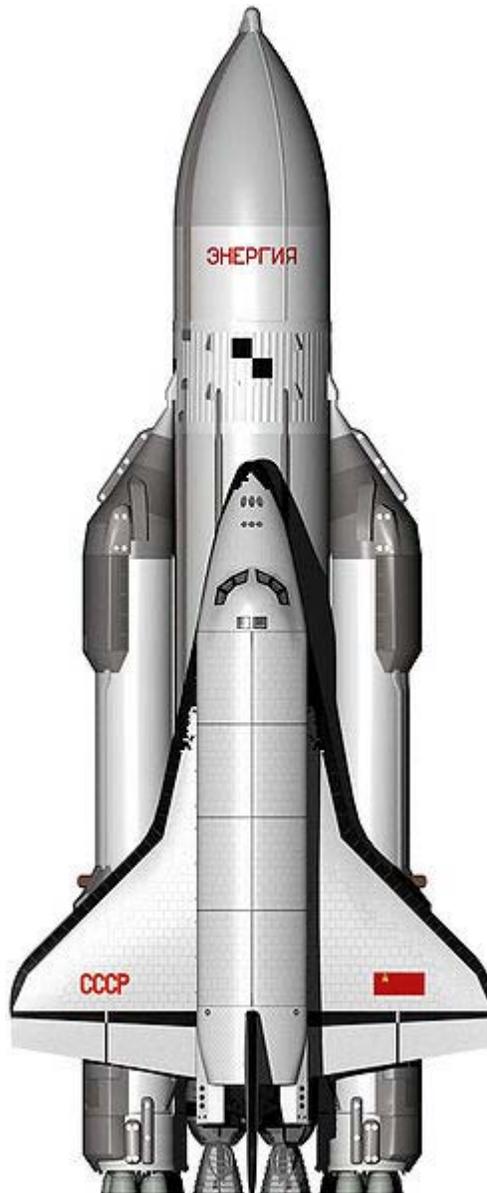
Progress is the longest serving unmanned cargo spacecraft (1978–)



First permanently manned space station, the Soviet/Russian Mir, which orbited the Earth from 1986 until 2001



Russia and the US are the main partners of the International Space Station (ISS).



The Soviet space program produced the canceled Space Shuttle Buran based on the discontinued Energia launcher.

Current status of the space program

Budget

The federal space budget for the year 2009 was left unchanged despite the global economic crisis, standing at about 82 billion rubles (\$2.4 billion). In 2011, the government is planning to spend 115 billion rubles (\$3.8 bln) in the national space programs.

Current priorities of the Russian space program include the new Angara rocket family and development of new communications, navigation and remote Earth sensing spacecraft. The GLONASS global navigation satellite system has for many years been one of the top priorities and has been given its own budget line in the federal space budget. In 2007, GLONASS received 9.9 billion rubles (\$360 million), and under the terms of a directive signed by Prime Minister Vladimir Putin in 2008, an additional \$2.6 billion will be allocated for its development.

Problems

Due to International Space Station involvements, up to 50% of Russia's space budget is spent on the manned space program. Some observers have pointed out that this has a detrimental effect on other aspects of space exploration, and that the other space powers spend much lesser proportions of their overall budgets on maintaining human presence in orbit.

Despite the considerably improved budget, attention of legislative and executive authorities, positive media coverage and broad support among the population, the Russian space program continues to face several problems. Wages in the space industry are low; the average age of employees is high (46 years in 2007), and much of the equipment is obsolete. On the positive side, many companies in the sector have been able to profit from contracts and partnerships with foreign companies; several new systems such as new rocket upper stages have been developed in recent years; investments have been made to production lines, and companies have started to pay more attention to educating a new generation of engineers and technicians.

The federal space plan for 2006–2015

The key elements of the current space plan, introduced in 2005, are:

- Replacement of the Soyuz spacecraft: Prospective Piloted Transport System
- New rocket for manned flights: Rus-M
- Return to Moon: Luna Glob (launch of the first probe planned for 2012)
- Return to Mars: Phobos Grunt (scheduled for launch in 2011)
- Return to Venus: Venera D
- Mars 500 simulation (under way in 2009)
- Introduction of the Angara launcher (first launch expected in 2011)
- Completion of the Russian segment of the International Space Station
- Completion of the GLONASS group to 18 operational satellites by end of 2007
- New Earth resources programs using the Resurs DK platform: Resurs P (2009) and Smotr (2007) and a small platform Arkon (2007)
- Earthquake monitoring satellite Vulkan (2007)
- New science missions: Koronas Foton (launched in January 2009), Spektr R (RadioAstron, 2007), Spektr RG (Roentgen Gamma, 2009) and Spektr UV (Ultra Violet, 2010), Intergelizond (2011), Venera D (2016), Celsta (2018) and Terion (2018)

- Resumption of Bion missions with Bion M (2010)
- New weather satellites Elektro L (launched in January, 2011) and Elektro P (2015)

Current programs

ISS involvement



The Zarya module was the first module of the ISS, launched in 1998.

The Russian Space Agency is one of the partners in the International Space Station (ISS) program; it contributed the core space modules Zarya and Zvezda, which were both launched by Proton rockets and later were joined by NASA's Unity Module. The Rassvet

module was launched aboard Space Shuttle *Atlantis* and will be primarily used for cargo storage and as a docking port for visiting spacecraft. The Nauka module will be the last component of the ISS and is expected to launch December 2011. Roskosmos is furthermore responsible for expedition crew launches by Soyuz-TMA spacecrafts and resupplies the space station with Progress space transporters. After the initial ISS contract with NASA expired, RKA and NASA, with the approval of the US government, entered into a space contract running until 2011, according to which Roskosmos will sell NASA spots on Soyuz spacecrafts for approximately \$21 million per person each way (thus \$42 million to and back from the ISS per person) as well as provide Progress transport flights (\$50 million per progress as outlined in the Exploration Systems Architecture Study study). RKA has announced that according to this arrangement, manned Soyuz flights will be doubled to 4 per year and Progress flights also doubled to 8 per year beginning in 2008.

RKA also provides space tourism for fare-paying passengers to ISS through the Space Adventures company. As of 2009, six space tourists have contracted with Roskosmos and have flown into space, each for an estimated fee of at least \$20 million (USD).

Science programs

RKA operates a number of programs for earth science, communication, and scientific research. Future projects include the Soyuz successor, the Prospective Piloted Transport System, scientific robotic missions to one of the Mars moons as well as an increase in Earth orbit research satellites.

- Luna-Glob Moon orbiter with penetrators
- Venera-D Venus lander
- Phobos-Grunt Mars mission

Rockets

Roskosmos is using a launch family of several rockets, the most famous of them is the R-7, commonly known as the Soyuz rocket, capable of launching about 7.5 tons into low Earth orbit (LEO). The Proton rocket (or UR-500K) has a lift capacity of over 20 tons to LEO. Smaller rockets include Cosmos-3M, the German-Russian cooperation Rockot and other launchers.

Currently rocket development encompasses both a new rocket system, Angara, as well as enhancements of the Soyuz rocket, Soyuz-2 and Soyuz-2-3. Two modifications of the Soyuz, the Soyuz-2.1a and Soyuz-2.1b has already been successfully tested, enhancing the launch capacity to 8.5 tons to LEO.

Historic Russian space gallery

Launch vehicles



Soyuz rockets are responsible for launching all Soyuz and Progress spacecraft into space



Proton rockets are the heavylift workhorse of Russian space industry

New piloted spacecraft

One of RKA's projects that has made a large impact on the media in 2005 is Kliper, a small lifting body reusable spacecraft. While Roskosmos has reached out to ESA and JAXA as well as others to share development costs of the project, it also has stated that it will go forward with the project even without support of other space agencies. This statement was backed by the above-described approval of its budget for 2006–2015, which includes the necessary funding of Kliper. However, the Kliper program was cancelled, to be replaced by the new Prospective Piloted Transport System proposal.

Launch control

The military counterpart of the RKA is the Military Space Forces (VKS). The VKS controls Russia's Plesetsk Cosmodrome launch facility. The RKA and VKS share control of the Baikonur Cosmodrome, where the RKA reimburses the VKS for the wages of many of the flight controllers during civilian launches. The RKA and VKS also share control of the Yuri Gagarin Cosmonaut Training Center. It has been announced that

Russia is to build another spaceport in Vostochny. The Vostochny Cosmodrome is scheduled to be finished by 2018.

Russian aerospace industry

Many of the former Soviet Design Bureaus transformed into private aerospace companies and some remained as state research centers.

Soviet OKB (if applicable)	New organization	Ownership	Notable products	
Korolev	RKK Energia	private		
	NPO Lavochkin			
	NPO Mashinostroyeniya			
	NPO Energomash	state		
	Khrunichev			
	TsSKB-Progress			
	NPO Molniya			
		NPO PM		
		NPO Polyot		
		MKB Raduga		
Kuznetsov				
Khimavtomatika				
Makeyev	JSC Khartron	private		
	Moscow Institute of Thermal Technology			
related Ukrainian organizations:				
Yuzhnoye Design Bureau				
Makarov	Yuzhmash			

Chapter- 3

European Space Agency

European Space Agency



Owner	18 European states
Established	1975
Headquarters	Paris
Primary spaceport	Guiana Space Centre
Administrator	Jean-Jacques Dordain
Budget	▲€3.99 billion / \$5.43 billion US dollars (2011)
Official language(s)	English, French and German
Website	www.esa.int

The **European Space Agency (ESA)**, established in 1975, is an intergovernmental organisation dedicated to the exploration of space, currently with 18 member states. Headquartered in Paris, ESA has a staff of more than 2,000 with an annual budget of about €3.99 billion / \$5.43 billion US dollars (2011).

ESA's space flight program includes human spaceflight, mainly through the participation in the International Space Station program, the launch and operations of unmanned exploration missions to other planets and the Moon, Earth observation, science, telecommunication as well as maintaining a major spaceport, the Guiana Space Centre at Kourou, French Guiana, and designing launch vehicles. The main European launch vehicle Ariane 5 is operated through Arianespace with ESA sharing in the costs of launching and further developing this launch vehicle.

ESA science missions are based at ESTEC in Noordwijk, Netherlands, Earth Observation missions at ESRIN in Frascati, Italy, ESA Mission Control (ESOC) is in Darmstadt, Germany, the European Astronaut Centre (EAC) that trains astronauts for future missions is situated in Cologne, Germany, and the European Space Astronomy Centre is located in Villanueva de la Cañada, Spain.

History

Foundation



ESTEC buildings in Noordwijk. ESTEC was the main technical centre of ESRO and remains so for the successor organization, ESA

After World War II, many European scientists left Western Europe in order to work either in the United States or the Soviet Union. Although the 1950s boom made it possible for Western European countries to invest in research and specifically in space related activities, Western European scientists realised solely national projects would not be able to compete with the two main superpowers. In 1958, only months after the Sputnik shock, Edoardo Amaldi and Pierre Auger, two prominent members of the western European scientific community at that time, met to discuss the foundation of a common western European space agency. The meeting was attended by scientific representatives from eight countries, including Harrie Massey (UK).

The Western European nations decided to have two different agencies, one concerned with developing a launch system ELDO (European Launch Development Organization) and the precursor of the European Space Agency, ESRO (European Space Research Organization). The latter was established on 20 March 1964 by an agreement signed on 14 June 1962. From 1968 to 1972, ESRO carried out numerous successful projects. Seven research satellites were brought into orbit, all by US launch systems. Ariane did not exist at that time.

ESA in its current form was founded in 1975, when ESRO was merged with ELDO. ESA had 10 founding members: Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the United Kingdom. ESA launched its first major scientific mission in 1975, Cos-B, a space probe monitoring gamma-ray emissions in the universe first worked on by ESRO.

End of space race



Mock-up of the Ariane 1

Beginning in the 1970s, when the space race between the US and the Soviet Union had cooled down and space budgets were cut dramatically in both countries, ESA established itself as a forerunner in space exploration. ESA joined NASA in the IUE, the world's first high-orbit telescope, which was launched in 1978 and operated very successfully for 18 years. A number of successful Earth-orbit projects followed, and in 1986 ESA began Giotto, its first deep-space mission, to study the Comets Halley and Grigg-Skjellerup. Hipparcos, a star-mapping mission, was launched in 1989 and in the 1990s SOHO, Ulysses and the Hubble Space Telescope were all jointly carried out with NASA. Recent scientific missions in cooperation with NASA include the Cassini-Huygens space probe, to which ESA contributed by building the Titan landing module Huygens.

As the successor of ELDO, ESA has also constructed rockets for unmanned scientific and commercial payloads. Ariane 1, launched in 1979, brought mostly commercial payloads into orbit from 1984 onward. The next two developments of the Ariane rocket were intermediate stages in the development of a more advanced launch system, the Ariane 4, which operated between 1988 and 2003 and established ESA as the world leader in commercial space launches in the 1990s. Although the succeeding Ariane 5 experienced a failure on its first flight, it has since firmly established itself within the heavily competitive commercial space launch market with 40 successful launches as of 2009. The successor launch vehicle of Ariane 5, the Ariane 6 is already in the definition stage and is envisioned to enter service in the 2020s.

The beginning of the new millennium saw ESA become, along with agencies like NASA, JAXA, ISRO and Roscosmos, one of the major participants in scientific space research. While ESA had relied on cooperation with NASA in previous decades, especially the 1990s, changed circumstances (such as tough legal restrictions on information sharing by the United States military) led to decisions to rely more on itself and on cooperation with Russia. A recent press issue thus stated:

Russia is ESA's first partner in its efforts to ensure long-term access to space. There is a framework agreement between ESA and the government of the Russian Federation on cooperation and partnership in the exploration and use of outer space for peaceful purposes, and cooperation is already under way in two different areas of launcher activity that will bring benefits to both partners.

Most notable for its new self-confidence are ESA's own recent successful missions SMART-1, a probe testing cutting-edge new space propulsion technology, the Mars Express and Venus Express missions as well as the development of the Ariane 5 rocket and its role in the ISS partnership. ESA maintains its scientific and research projects mainly for astronomy-space missions such as Corot, launched on 27 December 2006, a milestone in the search for extrasolar planets.

Mission statement

Since the Cold War ended with the fall of the Soviet Union's "iron curtain", space agencies around the world had to refocus and revise their visions and goals. In an interview with JAXA, the Japanese national space agency, Jean-Jacques Dordain ESA's Director General (since 2003) outlined briefly the European Space Agency's mission:

Today space activities are pursued for the benefit of citizens, and citizens are asking for a better quality of life on earth. They want greater security and economic wealth, but they also want to pursue their dreams, to increase their knowledge, and they want younger people to be attracted to the pursuit of science and technology.

I think that space can do all of this: it can produce a higher quality of life, better security, more economic wealth, and also fulfil our citizens' dreams and thirst for knowledge, and attract the young generation. This is the reason space exploration is an integral part of

overall space activities. It has always been so, and it will be even more important in the future.

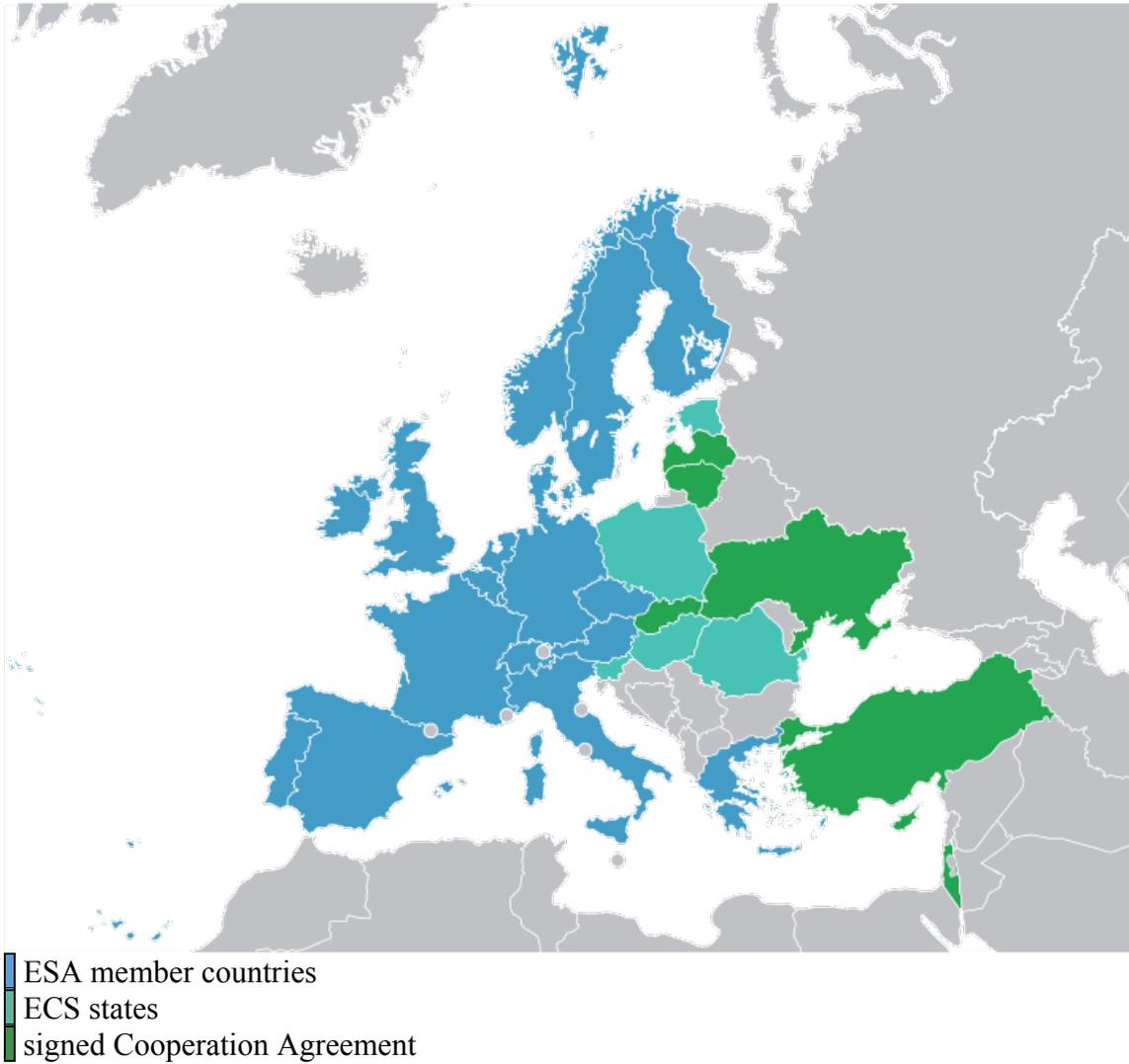
Article II, Purpose, Convention of establishment of a European Space Agency, SP-1271(E) from 2003 also defines ESA's mission statement:

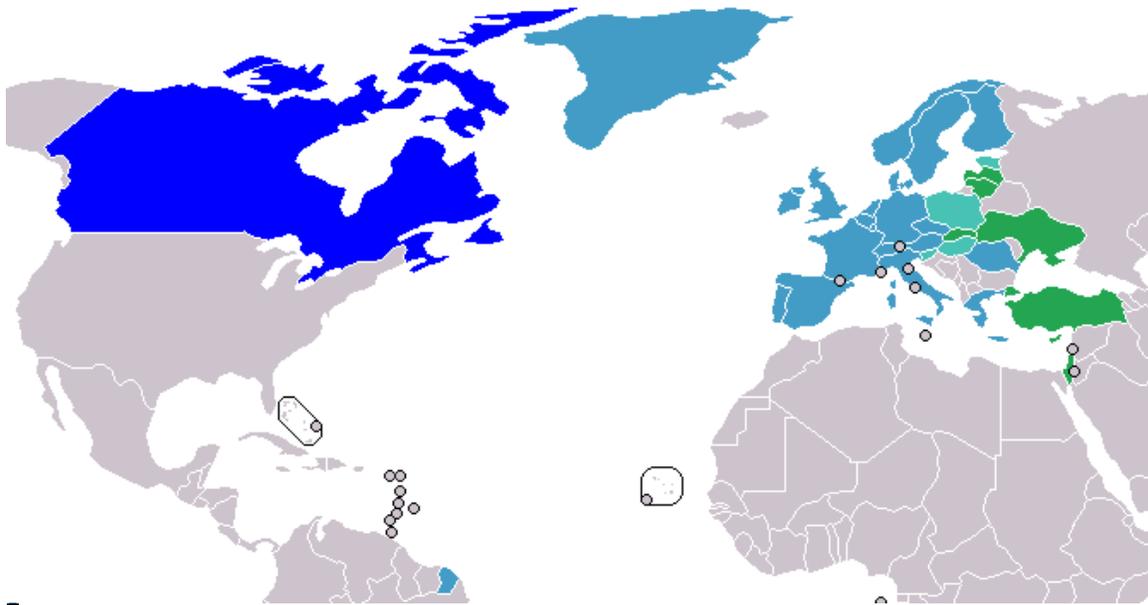
ESA's purpose shall be to provide for, and to promote, for exclusively peaceful purposes, cooperation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems:

- by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions;
- by elaborating and implementing activities and programmes in the space field;
- by coordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites;
- by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States.

Member countries and budget

Membership and contribution to ESA





- ESA member countries
- ESA associate members
- ECS states
- signed Cooperation Agreement

ESA is an intergovernmental organisation of 18 member states. Member states participate to varying degrees in the mandatory (25% of total expenditures in 2008) and optional space programmes (75% of total expenditures in 2008). The total budget in 2010 amounted to about €3.7 billion. The 2008 budget amounted to €3.0 billion and the 2009 budget to €3.6 billion.

The following table gives an overview of all member states and adjunct members and their contributions to ESA in 2011:

Member state	ESA membership	National Program	Contr. (mill. €)	Contr. (%)
 France	30 October 1980	CNES	751.4	18.8%
 Germany	30 October 1980	DLR	713.8	17.9%
 Italy	30 October 1980	ASI	380.0	9.5%
 United Kingdom	30 October 1980	UKSA	265.3	6.6%
 Spain	30 October 1980	INTA	201.9	5.1%
 Belgium	30 October 1980	BELSPO	164.8	4.1%
 Netherlands	30 October 1980	SRON	84.2	2.1%
 Switzerland	30 October 1980	SSO	96.2	2.4%
 Sweden	30 October 1980	SNSB	59.9	1.5%
 Denmark	30 October 1980	DNSSC	31.2	0.8%

 Ireland	10 December 1980	SI	15.6	0.4%
 Norway	30 December 1986	NSC	63.2	1.6%
 Austria	30 December 1986	ASA	54.0	1.3%
 Finland	1 January 1995	TEKES	20.1	0.5%
 Portugal	14 November 2000	FCT SO	15.8	0.4%
 Greece	9 March 2005	ISARS	14.9	0.4%
 Luxembourg	30 June 2005	through MoHER	11.5	0.3%
 Czech Republic	8 July 2008	CSO	10.4	0.3%
Associate Members				
 Canada	1 January 1979	CSA	20.5	0.5%
Total Members and Associates			2,975.0	74.5%
 European Union	28 May 2004	ESP	777.9	19.5%
ECS states	various	various	7.9	0.2%
Other income	—	—	233.0	5.8%
Total ESA			3,993.8	100.0%

1. ^{^ a b c d e f g h i j k} Founding members drafted the ESA charter which entered into force on 30 October 1980.
2. [^] Ireland is considered an initial signatory, but since it was a member of neither ESRO nor ELDO (the precursor organizations to ESA) the Convention entered into force when the last of the other 10 founders ratified it.
3. ^{^ a b c d e f g} Acceded members became ESA member states upon signing an accession agreement.
4. [^] Canada is an associated member of ESA.
5. [^] Framework Agreement establishing the legal basis for cooperation between ESA and the European Union came into force in May 2004.

Associate Members

Currently the only associated member of ESA is Canada. Previously associated members were Austria, Norway and Finland, all of which later joined ESA as full members.

Canada

Since 1 January 1979, Canada has had the special status of a Cooperating State within ESA. By virtue of this accord, the Canadian Space Agency takes part in ESA's

deliberative bodies and decision-making and also in ESA's programmes and activities. Canadian firms can bid for and receive contracts to work on programmes. The accord has a provision ensuring a fair industrial return to Canada.

Budget appropriation and allocation

The budget of ESA was €2.977 billion in 2005, €2.904 billion in 2006 and grew to €3.018 billion in 2008 and €3.600 billion in 2009. Every 3–4 years, ESA member states agree on a budget plan for several years at an ESA member states conference. This plan can be amended in future years, however provides the major guideline for ESA for several years. The last major conference was held at the end of 2008, setting the budget for the years to 2012.

The 2011 funding allocations for major areas of ESA activity are shown on the pie-chart on the right. The section called 'Other' includes Technology Development, Space Situational Awareness and spending related to European Cooperating States.

Countries typically have their own space programmes that differ in how they operate organisationally and financially with ESA. For example, the French space agency CNES has a budget double the amount it contributes to ESA. Several space-related projects are joint projects between national space agencies and ESA (e.g. COROT). Also, ESA is not the only European space organisation (for example European Union Satellite Centre).

Enlargement

After the decision of the ESA Council of 21/22 March 2001 the procedure for accession of the European states was detailed as described here. Nations who want to become a full member of ESA do so in 3 stages. First a Cooperation Agreement is signed between the country and ESA. In this stage, the country has very limited financial responsibilities. If a country wants to cooperate more fully with ESA, it signs a European Cooperating State (ECS) Agreement. The ECS Agreement makes companies based in the country eligible for participation in ESA procurements. The country can also participate in all ESA programmes, except for the Basic Technology Research Programme. While the financial contribution of the country concerned increases, it is still much lower than that of a full member state. The agreement is normally followed by a Plan For European Cooperating State (or PECS Charter). This is a 5-year programme of basic research and development activities aimed at improving the nation's space industry capacity. At the end of the 5-year period, the country can either begin negotiations to become a full member state or an associated state or sign a new PECS Charter. ESA is likely to expand quite rapidly in the coming years. Many countries, most of which joined the EU in both 2004 and 2007, have started to cooperate with ESA on various levels:

Applicant state	Cooperation Agreement	ECS Agreement	PECS Charter(s)	ESA Convention	National Program
 Hungary	April 1991	7 April 2003	1st: 5		HSO

			November 2003 2nd: 26 September 2008		
 Romania	December 1992	17 February 2006	16 February 2007	20 January 2011	ROSA
 Poland	28 January 1994	27 April 2007	28 April 2008		CBK-PAN
 Turkey	15 July 2004				TÜBİTAK
 Estonia	26 June 2007	10 November 2009			through MoEC
 Ukraine	25 January 2008				SSAU
 Slovenia	28 May 2008	22 January 2010	30 November 2010		through MoHEST
 Latvia	23 July 2009				through MoES
 Cyprus	27 August 2009				through MoCW
 Slovakia	28 April 2010				through MoE
 Lithuania	7 October 2010				through MoE
 Israel	30 January 2011				ISA

Romania signed the ESA Convention on 20 January 2011 and will become the 19th member of ESA once it deposits its instrument of ratification with the government of France. This is due to happen later in 2011.

Possible future cooperation

The political perspective of the European Union (EU) is to make ESA an agency of the EU by 2014, although this date may not be met.

So far the only two EU member states that have not signed an ESA Cooperation Agreement are Bulgaria and Malta. Both of them, however, have already announced their intention to participate in the activities of ESA.

- On 9 April 2009  Bulgaria announced their intention to participate in the activities of ESA through IKI-BAN.
- On 20 June 2009  Malta announced their intention to participate in the activities of ESA through the Malta Council for Science and Technology.

 Croatia and  Iceland, both in negotiations with the EU for membership in the near future, are also possible future candidates.

Launch vehicle fleet

ESA has made great progress towards its goal of having a complete fleet of launch vehicles in service, competing in all sectors of the launch market. ESA's fleet will soon consist of three major rocket designs, Ariane 5, Soyuz-2 and Vega. Rocket launches are carried out by Arianespace, which has 23 shareholders representing the industry that manufactures the Ariane 5 as well as CNES, at the spaceport in French Guiana. Because many communication satellites have equatorial orbits, launches from French Guiana are able to take larger payloads into space than from more northerly spaceports. In addition, equatorial launches give spacecraft an extra 'push' of nearly 500 m/s due to the higher rotation velocity of someone standing on the equator than near the Earth's axis where rotation velocity approaches nil.

Ariane 5



An Ariane 5

The Ariane 5 rocket is the primary launcher of ESA. Its maximum estimated payload is 6–10 tons to GTO and up to 21 tons to LEO. The launch craft has been in service since 1997 and replaced Ariane 4. The Ariane rocket exists in several specifications, the heaviest being Ariane 5 ECA, which failed during its first test flight in 2002, but has since made twenty-two consecutive successful flights.

ESA's Ariane 1, 2, 3 and 4 launchers (the latter of which was ESA's long-time workhorse) have been retired.

Soyuz

Soyuz-2 (also called the Soyuz-ST) is a Russian medium payload (ca. 3 metric tons to GTO) launcher to be brought into ESA service in April 2010. ESA has entered into a €340 million joint venture with the Russian Federal Space Agency over the use of the Soyuz launcher. Under the agreement, the Russian agency manufactures Soyuz rocket parts for ESA, which are then shipped to French Guiana for assembly. ESA benefits because it gains a medium payload launcher, complementing its fleet while saving on development costs. In addition, the Soyuz rocket—which has been the Russian's space launch workhorse for some 40 years—is proven technology with a good safety record, which ESA might use for launching humans into space. Russia also benefits in that it gets access to the Kourou launch site. Launching from Kourou rather than Baikonur will allow the Russians to almost double the Soyuz payload (3.0 tonnes vs. 1.7 tonnes to GTO), because of Kourou's closer proximity to the equator. Both agencies benefit from the long term strategic cooperation, which is also intended to enable future joint technology developments. Maiden launch is planned for third quarter 2011.

Vega

Vega is ESA's small payload (ca. 1.5 metric tons to 700 km orbit) launcher; its first launch is planned for 2010 or early 2011. The leading ESA member state for the *Vega* Programme is Italy, contributing 65% of the costs. *Vega* itself has been designed to be a body launcher with three solid propulsion stages and an additional liquid propulsion upper module to place the cargo into the exact orbit intended. For a small-cargo rocket it is remarkable that *Vega* will be able to place multiple payloads into orbit.

Vega's first and main stage (P80) is a direct modification of the Ariane 5 EAP (solid boosters) developed by CNES, the French space agency.

Human space flight

History



Ulf Merbold became the first ESA astronaut to fly into space.

At the time ESA was formed, its main goals did not encompass human space flight, rather it considered itself to be primarily a scientific research organisation for unmanned space exploration in contrast to its American and Soviet counterparts. It is therefore not surprising that the first non-Soviet European in space was not an ESA astronaut on a European space craft: It was Czechoslovak Vladimír Remek who in 1978 became the first non-Soviet European in space (the first European in space being Yuri Gagarin of the Soviet Union) — on a Soviet Soyuz spacecraft, followed by the Pole Mirosław

Hermaszewski and East German Sigmund Jähn in the same year. This Soviet cooperation programme, known as Intercosmos, primarily involved the participation of Eastern bloc countries, however in 1982, Jean-Loup Chrétien became the first western European on a flight to the Soviet Salyut 7 space station.

Because Chrétien did not officially fly into space as an ESA astronaut, but rather as a member of the French CNES astronaut corps, the German Ulf Merbold is considered the first ESA astronaut to fly into space. He participated in the STS-9 Space Shuttle mission that included the first use of the European built Spacelab in 1983. STS-9 marked the beginning of an extensive ESA/NASA joint partnership that included dozens of space flights of ESA astronauts in the following years. Some of these missions with Spacelab were fully funded and organizationally and scientifically controlled by ESA (like separate two by Germany and one by Japan) with European astronauts as masters not as guests on a board. Besides paying for Spacelab flights and seats on the shuttles, ESA continued its human space flight cooperation with the Soviet Union and later Russia, including numerous visits to Mir.

During the latter half of the 1980s, European human space flights changed from being the exception to routine and therefore, in 1990, the European Astronaut Centre in Cologne, Germany was established. It selects and trains prospective astronauts and is responsible for the coordination with international partners especially with regards to the International Space Station. As of 2006, the ESA astronaut corps officially includes 12 members, including nationals from all the large Western European countries except the United Kingdom.

In the summer of 2008 ESA started to recruit new astronauts so that final selection would be due spring 2009. Almost 10,000 people registered as astronaut candidates till the registration ended in June 2008. 8,413 fulfilled the initial application criteria. Of the applicants 918 were chosen to take part in the first stage of psychological testing which narrowed down the field to 192. After two stage psychological tests and medical evaluation in early 2009 as well as formal interviews, six new members of the European Astronaut Corps were selected: five men and one woman.

Astronaut Corps

The astronauts of the European Space Agency are:

-  Jean-François Clervoy
-  Samantha Cristoforetti
-  Frank De Winne
-  Pedro Duque
-  Reinhold Ewald
-  Léopold Eyharts
-  Alexander Gerst
-  Christer Fuglesang
-  André Kuipers
-  Andreas Mogensen
-  Paolo Nespoli
-  Claude Nicollier
-  Luca Parmitano
-  Timothy Peake
-  Thomas Pesquet
-  Thomas Reiter
-  Hans Schlegel
-  Gerhard Thiele
-  Michel Tognini
-  Roberto Vittori

-  Umberto Guidoni
-  Philippe Perrin

1. ^{^ a b c d e} have visited Mir
2. ^{^ a b c d e f} 2009 selection
3. ^{^ a b c d e f g h i j k} have visited the International Space Station
4. ^{^ a b c d e} retired now

Manned launch vehicles

In the 1980s France pressed for an independent European manned launch vehicle. Around 1978 it was decided to pursue a reusable spacecraft model and starting in November 1987 a project to create a mini-shuttle by the name of Hermes was introduced. The craft itself was modelled comparable to the first proposals of the Space Shuttle and consisted of a small reusable spaceship that would carry 3 to 5 astronauts and 3 to 4 metric tons of payload for scientific experiments. With a total maximum weight of 21 metric tons it would have been launched on the Ariane 5 rocket, which was being developed at that time. It was planned solely for use in Low-Earth orbit space flights. The planning and pre-development phase concluded in 1991; however, the production phase was never fully implemented because at that time the political landscape had changed significantly. With the fall of the Soviet Union ESA looked forward to cooperation with Russia to build a next-generation human space vehicle. Thus the Hermes program was cancelled in 1995 after about 3 billion dollars had been spent.

In the 21st century ESA started new programs in order to create its own manned spacecraft, most notable among its various projects and proposals is Hopper, whose prototype by EADS, called Phoenix, has already been tested. While projects such as Hopper are neither concrete nor to be realised within the next decade, other possibilities for human spaceflight in cooperation with the Russian Space Agency have emerged. Following talks with the Russian Space Agency in 2004 and June 2005, a cooperation between ESA and the Russian Space Agency was announced to jointly work on the Russian-designed Kliper, a reusable spacecraft that would be available for space travel beyond LEO (e.g. the moon or even Mars). It was speculated that Europe would finance part of it. However, a €50 million participation study for Kliper, which was expected to be approved in December 2005, was finally not approved by the ESA member states. The Russian state tender for the Kliper project was subsequently cancelled in the summer of 2006.

In June 2006 ESA member states granted 15 million to the Crew Space Transportation System (CSTS) study, a two-year study to design a spacecraft capable of going beyond Low-Earth orbit based on the current Soyuz design. This project is pursued with Roskosmos instead of the previously cancelled Kliper proposal. A decision on the actual implementation and construction of the CSTS spacecraft is contemplated for 2008, with the major design decisions being made before the summer of 2007. In mid-2009 EADS Astrium was awarded a €21 million study into designing a manned variation of the

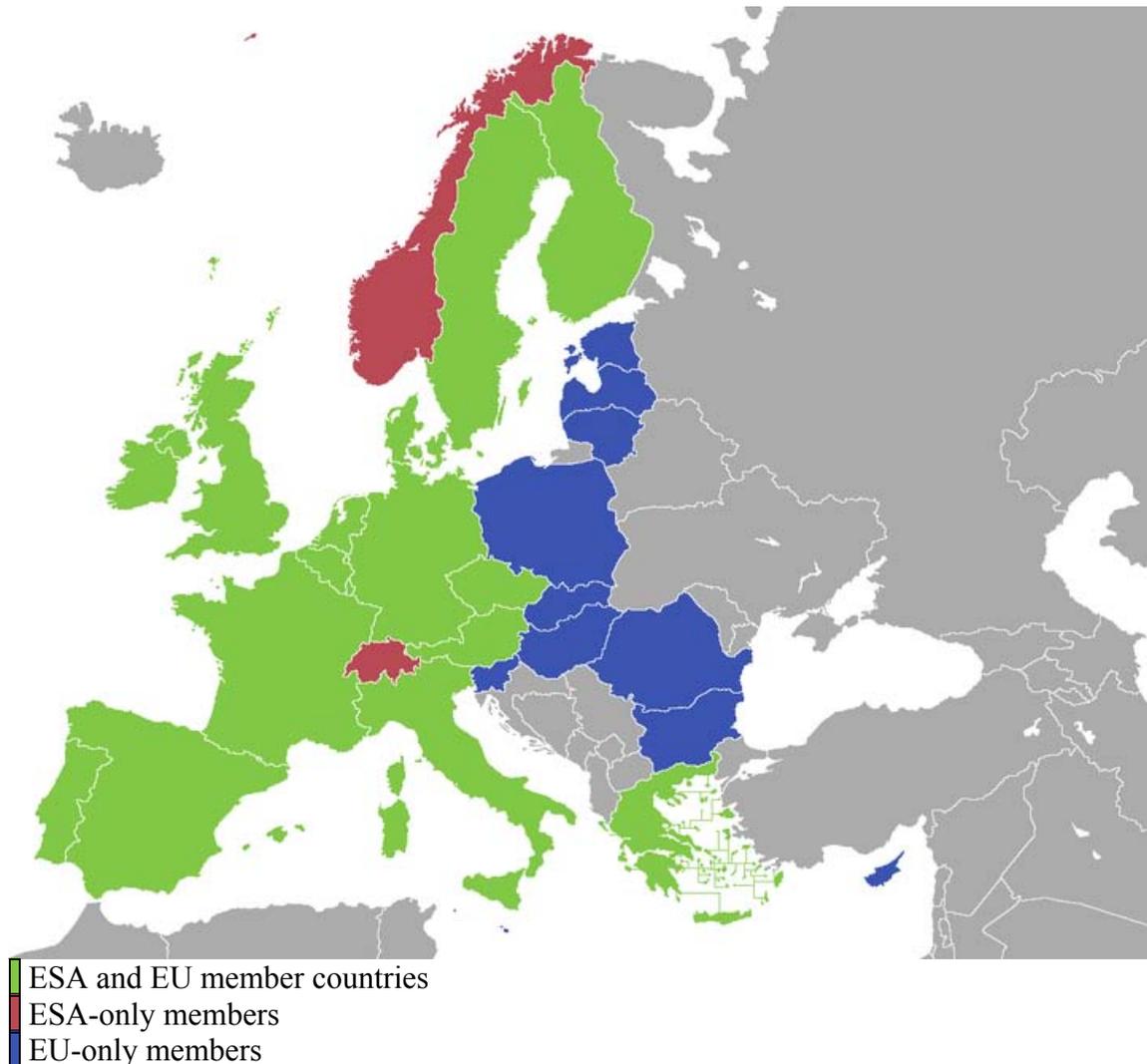
European ATV vehicle which is believed to now be the basis of the Advanced Crew Transportation System design.

Cooperation with other countries and organisations

ESA has signed cooperation agreements with the following states that currently neither plan to integrate as tightly with ESA institutions as Canada, nor envision future membership of ESA: Argentina, Brazil, China, India (for the Chandrayan mission), and Russia.

Additionally, ESA has joint projects with the European Union, NASA of the United States and is participating in the International Space Station together with the United States (NASA), Russia and Japan (JAXA).

European Union



ESA is not an agency or body of the European Union (EU), and has non-EU countries Switzerland and Norway as members. There are however ties between the two, with various agreements in place and being worked on, to define the legal status of ESA with regard to the EU. There are common goals between ESA and the EU, and ESA has an EU liaison office in Brussels. On certain projects, the EU and ESA cooperate, such as the upcoming Galileo satellite navigation system. Space policy has since December 2009 been an area for voting in the European Council. Under the European Space Policy of 2007, the EU, ESA and its Member States committed themselves to increasing coordination of their activities and programmes and to organising their respective roles relating to space.

Former Italian astronaut Umberto Guidoni, during his tenure as a Member of the European Parliament from 2004 to 2009, stressed the importance of the European Union as a driving force for space exploration, "since other players are coming up such as India and China it is becoming ever more important that Europeans can have an independent access to space. We have to invest more into space research and technology in order to have an industry capable of competing with other international players."

An independent report on the future of ESA, requested by its director-general, recommends further integration of ESA into the structures of the EU. Space policy would be decided by the European Council and ESA would be the *de facto* space agency of the European Union, not excluding the possibility of making it a formal EU agency. This would also help with co-operation between space policy and environmental or security policy, Galileo itself has a security dimension.

The first EU-ESA International Conference on Human Space Exploration took place in Prague on 22 and 23 October 2009. A road map which would lead to a common vision and strategic planning in the area of space exploration was discussed. Ministers from all 29 EU and ESA members as well as members of parliament were in attendance. If a roadmap is accepted at the November 2010 Brussels conference as planned, it is estimated that an additional €3 billion annually would be made available for European space exploration activities by the European Commission. The political perspective of the European Union (EU) is to make ESA an agency of the EU by 2014, although this date may not be met.

National space organisations of member countries

- The *Centre National d'Études Spatiales* (CNES) (National Centre for Space Study) is the French government space agency (administratively, a "public establishment of industrial and commercial character"). Its headquarters are in central Paris. CNES is the main participant on the Ariane project. Indeed CNES designed and tested all Ariane family rockets (mainly from its centre in Évry near Paris)
- The UK Space Agency is a partnership of the UK government departments which are active in space. Through the UK Space Agency, the partners provide delegates

- to represent the UK on the various ESA governing bodies. Each partner funds its own programme.
- The Italian Space Agency (*Agenzia Spaziale Italiana* or ASI) was founded in 1988 to promote, coordinate and conduct space activities in Italy. Operating under the Ministry of the Universities and of Scientific and Technological Research, the agency cooperates with numerous entities active in space technology and with the president of the Council of Ministers. Internationally, the ASI provides Italy's delegation to the Council of the European Space Agency and to its subordinate bodies.
 - The German Aerospace Center (DLR) (German: *Deutsches Zentrum für Luft- und Raumfahrt e. V.*) is the national research centre for aviation and space flight of the Federal Republic of Germany and of other member states in the Helmholtz Association. Its extensive research and development projects are included in national and international cooperative programmes. In addition to its research projects, the centre is the assigned space agency of Germany bestowing headquarters of German space flight activities and its associates.
 - The Instituto Nacional de Técnica Aeroespacial (INTA) (National Institute for Aerospace Technique) is a Public Research Organization specialized in aerospace research and technology development in Spain. Between other functions, it serves as a platform for space research and acts as a significant testing facility for the aeronautic and space sector in the country.

NASA

ESA has a long history of collaboration with NASA. Since ESA's astronaut corps was formed, the Space Shuttle has been the primary launch vehicle used by ESA's astronauts to get into space through partnership programs with NASA. In the 1980s and 1990s, the Spacelab program was an ESA-NASA joint research program that had ESA develop and manufacture orbital labs for the Space Shuttle for several flights on which ESA participate with astronauts in experiments.

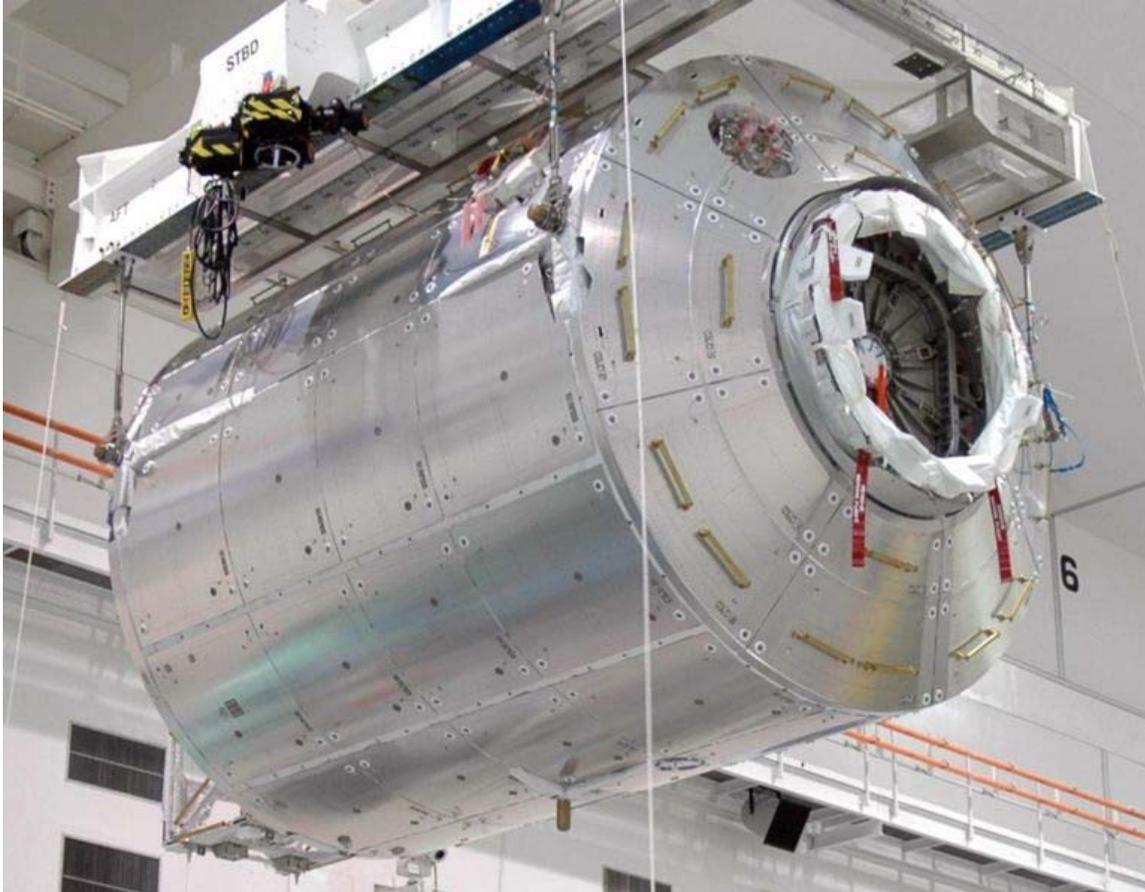
In robotic science mission and exploration missions, NASA has been ESA's main partner. Cassini-Huygens was a joint NASA-ESA mission, the Infrared Space Observatory, INTEGRAL, SOHO, and others. Also, the Hubble space telescope is a joint project of NASA and ESA. Future unmanned projects that are in development right now and are ESA-NASA joint projects include the James Webb Space Telescope or the Laser Interferometer Space Antenna. NASA and ESA will also likely join together for a Mars Sample Return Mission.

Cooperation with other space agencies

Since China has started to invest more money into space activities, the Chinese Space Agency has sought international partnerships. ESA is, beside the Russian Space Agency, one of its most important partners. Recently the two space agencies cooperated in the development of the Double Star Mission.

ESA entered into a major joint venture with Russia in the form of the CSTS, the preparation of French Guyana spaceport for launches of Soyuz rockets and other projects. With India ESA agreed to send instruments into space aboard the ISRO 's Chandrayaan in 2008. ESA is also cooperating with Japan, the most notable current project in collaboration with JAXA is the BepiColombo mission to Mercury.

International Space Station



ISS module Columbus at Kennedy Space Center

With regard to the International Space Station (ISS) ESA is not represented by all of its member states: 10 of the 18 ESA member countries currently participate in the project. ESA is taking part in the construction and operation of the ISS with contributions such as Columbus, a science laboratory module that was brought into orbit by NASA's STS-122 Space Shuttle mission and the Cupola observatory module that was completed in July 2005 by Alenia Spazio for ESA. The current estimates for the ISS are approaching €100 billion in total (development, construction and 10 years of maintaining the station) of which ESA has committed to paying €8 billion. About 90% of the costs of ESA's ISS share will be contributed by Germany (41%), France (28%) and Italy (20%). German ESA astronaut Thomas Reiter was the first long-term ISS crew member.

As of 2008, the spacecraft establishing supply links to the ISS are the Progress, Soyuz and Space Shuttle. ESA has developed the Automated Transfer Vehicle (ATV) for ISS resupply. Each ATV has a cargo capacity of 7,667 kilograms (16,900 lb). The first ATV, *Jules Verne*, was launched on 9 March 2008 and on 3 April 2008 successfully docked with the ISS. This manoeuvre, considered a major technical feat, involved using automated systems to allow the ATV to track the ISS, moving at 27,000 km/h, and attach itself with an accuracy of 2 cm. No other spacefaring nations or space agency currently possess this level of autonomy in rendezvous and docking activities, considered key to future space exploration. With the Space Shuttle reaching its retirement age in 2010, until NASA has a replacement for it such as COTS the ATV together with Progress, Soyuz and the Japanese transporter HTV will be the only links between Earth and the ISS.

Miscellaneous

Languages

According to Annex 1, Resolution No. 8 of the *Convention for the establishment of a European Space Agency*, English, French and German may be used in all meetings of the Agency, with interpretation provided into these three languages. All official documents are available in English and French with all documents concerning the ESA Council being available in German as well.

Facilities

- Headquarters of ESA, Paris, France
- European Space Operations Centre (ESOC), Darmstadt, Germany
- Centre Spatial Guyanais, Kourou, French Guiana
- European Space Research and Technology Centre (ESTEC), Noordwijk, The Netherlands
- ESA Centre for Earth Observation (ESRIN), Frascati, Italy
- European Astronaut Centre (EAC), Cologne, Germany
- European Space Astronomy Centre (ESAC), Madrid, Spain
- ESTRACK European Space Tracking Network
- European Robotics and Climate Change Centre, Harwell Science and Innovation Campus, United Kingdom

Chapter- 4

Canadian Space Agency

Canadian Space Agency
Agence spatiale canadienne



Agency overview

Formed	December 14, 1989
Jurisdiction	Government of Canada
Headquarters	John H. Chapman Space Centre
Employees	575
Annual budget	CAD \$332.2 million (2010-2011)
Minister responsible	Tony Clement, Minister of Industry
Agency executive	Steve MacLean

The **Canadian Space Agency CSA** or, in French, **l'Agence spatiale canadienne, ASC** is the Canadian government space agency responsible for Canada's space program. It was established in March 1989 by the Canadian Space Agency Act and sanctioned in December 1990. The Chief Executive Officer of the agency is the President who reports to the Minister of Industry.

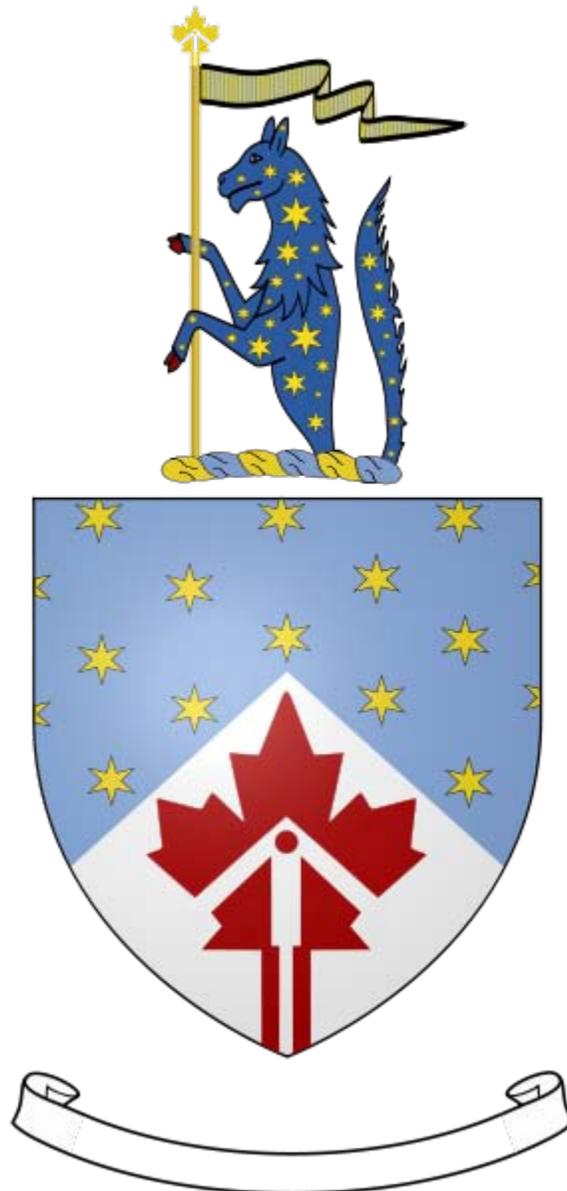
The headquarters of the CSA is located at John H. Chapman Space Centre in Saint-Hubert, Quebec. The agency also has offices in Ottawa, Ontario at the David Florida Laboratory (which is mainly an engineering installation) and small liaison offices in Washington, D.C.; Paris, France; Cape Canaveral, Florida; and Houston, Texas.

The agency is a relatively modest federal establishment, with 575 employees and a rotating student population of about 100 interns or summer workers. Most of the staff is employed at the Chapman Centre.

Steve MacLean was named as president of the Canadian Space Agency on September 2, 2008.

History, Mission and mandate

With the launch of Alouette 1 in 1962 Canada became the third country to put a man-made satellite into space. Because Canada did not have any domestic launch capabilities of its own, (and still does not), Alouette 1, which was entirely built and funded by Canada, was launched by the American National Aeronautics and Space Administration (NASA) from Vandenberg AFB in California. The technical excellence of the satellite, which lasted for ten years instead of the expected one, prompted the further study of the ionosphere with the Canadian designed US launched, international ISIS program. This undertaking was designated an International Milestone of Electrical Engineering by IEEE in 1993. The launch of Anik A-1 in 1972, made Canada the first country in the world to establish its own domestic geostationary communication satellite network.



The coat of arms of the Canadian Space Agency granted on 25 July 1991, by the Canadian Heraldic Authority

These and other space related activities in the 1980s compelled the Canadian government to promulgate the **Canadian Space Agency Act** which established the Canadian Space Agency. The Act received royal assent on May 10, 1990 and came into force on December 14, 1990.

The mandate of the Canadian Space Agency is to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians. The Canadian Space Agency's mission statement says that the agency is committed to leading the development and application of space knowledge for the benefit of Canadians and humanity.

Presidents of the Canadian Space Agency

- March 1, 1989 -1992 - Larkin Kerwin
- May 4, 1992-July 15, 1994 - Dr. Roland Doré
- November 21, 1994 - William MacDonald (Mac) Evans
- September 28, 2001 - Marc Garneau
- April 12, 2007 - Larry J. Boisvert
- January 1, 2008-September 2, 2008 - Guy Bujold
- September 2, 2008–present Steven MacLean

Canadian Space Program

The Canadian Space Program is administered by the Canadian Space Agency. Canada has contributed technology, expertise and personnel to the world space effort, especially in collaboration with NASA and ESA.

There have been three recruiting campaigns for astronauts for the CSA. The first, in 1983, led to the selection of Roberta Bondar, Marc Garneau, Robert Thirsk, Kenneth Money, Bjarni Tryggvason and Steve MacLean. The second, in 1992, selected Chris Hadfield, Julie Payette, Dafydd Williams and Mike Mackay. On May 13, 2009 it was announced after the completion of a third selection process that two new astronauts, Jeremy Hansen of Ailsa Craig, Ontario and David Saint-Jacques, of Quebec City, Quebec., had been chosen. As of January 2011 there have been 16 space flights by Canadians.

In addition to its astronauts, some of the most notable Canadian technological contributions to space exploration include the Canadarm on the Space Shuttle, as well as the Canadarm2 and the rest of the Mobile Servicing System on the International Space Station. The Canadarm and Canadarm2 employ the Advanced Space Vision System which allows more efficient use of the robotic arms. Another Canadian technology of note is the Orbiter Boom Sensor System, which is an extension of the Canadarm used to inspect the Space Shuttle's thermal Protection System for damage while in orbit.

Canadians in space

Nine Canadians have participated in 13 NASA manned missions and two Soyuz ones:

Name	Launch Vehicle	Mission	Launch date	International Space Station Expedition	Notes
Marc Garneau	<i>Challenger</i>	STS-41-G	1984, October 5		<i>First Canadian in space</i>
Roberta	<i>Discovery</i>	STS-42	1992,		<i>First</i>

Bondar			January 22		<i>Canadian woman in space</i>
Steven MacLean	<i>Space Shuttle Columbia</i>	STS-52	1992, October 22		
Chris Hadfield	<i>Atlantis</i>	STS-74	1995, November 12	Expedition 34 (forthcoming), Expedition 35 (commander; forthcoming)	<i>Only Canadian to visit Mir; first Canadian ISS commander</i>
Marc Garneau	<i>Endeavour</i>	STS-77	1996, May 19		<i>First Canadian to return to space</i>
Robert Thirsk	<i>Columbia</i>	STS-78	1996, June 20		
Bjarni Tryggvason	<i>Discovery</i>	STS-85	1997, August 7		
Dafydd Williams	<i>Columbia</i>	STS-90	1998, April 17		
Julie Payette	<i>Discovery</i>	STS-96	1999, May 27		<i>First Canadian to visit International Space Station (ISS mission)</i>
Marc Garneau	<i>Endeavour</i>	STS-97	2000, November 30		<i>ISS mission, Return to space (third visit)</i>
Chris Hadfield	<i>Endeavour</i>	STS-100	2001, April 19		<i>ISS mission, Return to space (second visit), First spacewalk by a Canadian</i>
Steven MacLean	<i>Atlantis</i>	STS-115	2006, September 9		<i>ISS mission, Return to space (second visit), Canadian Spacewalk</i>

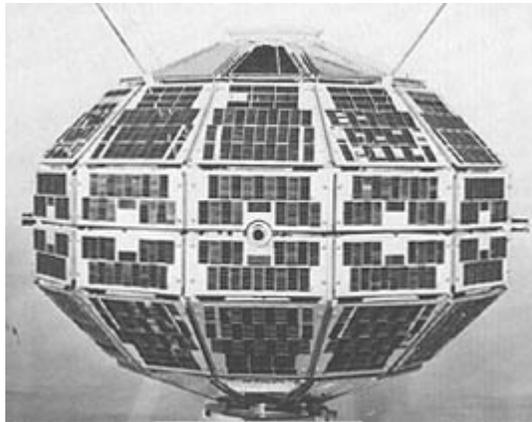
Dafydd Williams	<i>Endeavour</i>	STS-118	2007, August 27		ISS mission, Return to space (second visit), Canadian Spacewalk
Robert Thirsk	<i>Soyuz-FG</i>	Soyuz TMA-15 (Союз TMA-15)	2009, May 27	Expedition 20, Expedition 21	Return to space (second visit), <i>First flight on a Russian launch vehicle by a Canadian, first Canadian on a permanent ISS crew</i>
Julie Payette	<i>Endeavour</i>	STS-127	2009, July 15		ISS mission, <i>First Canadian woman to return to space, First time two Canadians were in space simultaneously (with Thirsk), Largest gathering (13) of humans in space, as 7 STS-127 arrivals join 6 already on ISS, Largest gathering (5) of nationalities in space, as USA, Russia, Japan, Canada, and Belgium have</i>

*astronauts
together on
ISS*

Guy Laliberté	<i>Soyuz</i>	Soyuz TMA-16 (Союз TMA-16)	2009, September 30	First Canadian space tourist
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Note: Two former Canadian astronauts never flew in space; Michael McKay resigned due to medical reasons and Kenneth Money resigned in 1992, eight years after his selection.

Canadian satellites



The *Alouette 1* was the first satellite launched by a country other than the United States or Soviet Union.

Name	Launched	Retired	Purpose
Alouette 1	September 29, 1962	1972	Explore the ionosphere
Alouette 2	November 29, 1965	August 1, 1975	Explore the ionosphere
ISIS-I	January 30, 1969	1990	Explore the ionosphere
ISIS-II	April 1, 1971	1990	Explore the ionosphere

Hermes	January 17, 1976	November, 1979	Experimental communications satellite
RADARSAT-1	November 4, 1995	Still in use	Commercial Earth observation satellite
MOST	June 30, 2003	Still in use	Space telescope
SCISAT-1	August 12, 2003	Still in use	Observe the Earth's atmosphere
RADARSAT-2	December 14, 2007	Still in use	Commercial Earth observation satellite
CASSIOPE	Scheduled for 2011		CAScade, Smallsat and IOnospheric Polar Explorer

Additionally, there are some commercial satellites launched by the telecommunications company Telesat Canada. These are the 13 Anik satellites (3 of which are still in use), the 3 Nimiq satellites (all currently used by Bell TV), and a satellite called M-Sat 1 launched April 20, 1996 at 22h36 UTC.

Further, technology/research satellites have been launched by the University of Toronto, including the CanX series.

Cooperation with other national agencies

The CSA has several formal and informal partnerships and collaborative programs or agreements with space agencies in other countries, such as NASA, ESA, JAXA and ISRO.

Since January 1, 1979 Canada has had the special status of a cooperating state with the ESA, paying for the privilege and also investing in working time and providing scientific instruments which are placed on European probes. On June 21, 2000 the accord was renewed for a fourth period, this time for 10 years. By virtue of this accord Canada takes part in ESA deliberative bodies and decision-making and in ESA's programmes and activities. Canadian firms can bid for and receive contracts to work on programmes. The accord has a provision specifically ensuring a fair industrial return to Canada. The head of the Canadian delegation to ESA is the president of the Canadian Space Agency. As of

February 2009, there are currently 30 Canadians that are employed as staff members at ESA. (Distributed over various ESA sites: 20 at ESTEC; 4 at ESOC; 4 at ESA HQ; 2 at ESRIN).

The CSA visited the China National Space Administration in October 2005 to explore the possibility of placing Canadian designed scientific instruments aboard two Chinese satellites. There was also speculation about China in the future perhaps wanting the Canadarm2 technology for its planned space station, but as of 22 October 2005, the CNSA has not raised the possibility.

Canadian Participation in International Satellite Projects

Name	Country	Agency	Date	Canadian Contribution	Notes
CloudSat	USA	NASA	1998	Radar Components	
Earth Observing System (EOS)	USA	NASA	1999	MOPITT (measurements of pollution in the troposphere)	

Future Programmes

With the successful launching of Radarsat 2 in December 2007 and near completion of Canada's C\$1.4 billion contribution to the ISS the agency in early 2008 found itself with no major follow-on projects. This fact was highlighted by Marc Garneau, Canada's first astronaut and former head of the CSA who in the fall of 2007 called upon the Canadian government to develop and institute a space policy for Canada.

A modest step has been taken to resolve this problem. In November 2008, the Agency signed a \$40 million 16-month contract with MacDonald Dettwiler and Associates Ltd. of Vancouver to begin the design of the RADARSAT Constellation (3 satellite) earth observation mission. In August 2010 further funding was awarded for detailed design work scheduled for completion by 2012. Launch of the three satellites is scheduled for 2014-15. Also in the 2009 Federal budget, the agency was awarded funding for the preliminary design of robotic Lunar/Martian rovers.

However a number of initiatives are without funding. The CSA is the lead agency for the Polar Communication and Weather mission (PCW) which involves the planned launch of two satellites in polar orbit to provide Canadian authorities with improved weather information and communications capabilities in the high arctic. Launch of the two

satellites is proposed to take place in 2016. Funding for further development of the mission has yet to be approved.

In November 2012, Canadian Astronaut Chris Hadfield will launch aboard a Soyuz spacecraft to reach the International Space Station (ISS) where he will live and work for six months as part of the crew of Expedition 34/35. During the second half of his mission Hadfield will become the first Canadian Commander of the ISS—a milestone for Canadian space exploration. In addition to overseeing operations as Commander, he will carry out scientific experiments, operate Canadarm2 and perform various robotics tasks. This mission marks the last provided by NASA as "compensation" for Canada's contribution to the Shuttle and ISS programmes. After this mission, the CSA will have to pay NASA for any flights for Canadian astronauts. There is at present no funding for further missions by Canadian astronauts.

The CSA has been researching locations in Cape Breton Nova Scotia and Fort Churchill Manitoba for a possible launch site for the CSA. This would allow the CSA the ability to launch satellites and future spacecraft, for the first time, into orbit without the reliance of other "outside" facilities. There is as of yet no funding for these activities.

The Agency is without overall government direction and the support of the government of Canada is grudging at best. As of 2009 funding remained stagnant at about C\$350,000,000 a year. Revenues for the 2009-2010 FY stood at C\$328,000,000.

Space Agency Locations

- John H. Chapman Space Centre - Longueuil, Quebec
- David Florida Laboratory - Ottawa, Ontario
- Fort Churchill - Manitoba
- Canadian Space Agency Building - Innovation Place Research Park - Saskatoon, Saskatchewan

A number of launch facilities have been used by the CSA to launch their payload:

- Baikonur Cosmodrome in Kazakhstan (leased to Russian Federal Space Agency and Russian Space Forces)
- Vandenburg Air Force Base in California (USAF)
- Cape Canaveral in Florida (NASA)
- Plesetsk Cosmodrome in Russia (Russian Federal Space Agency)

Chapter- 5

Japan Aerospace Exploration Agency

Japan Aerospace Exploration Agency

宇宙航空研究開発機構



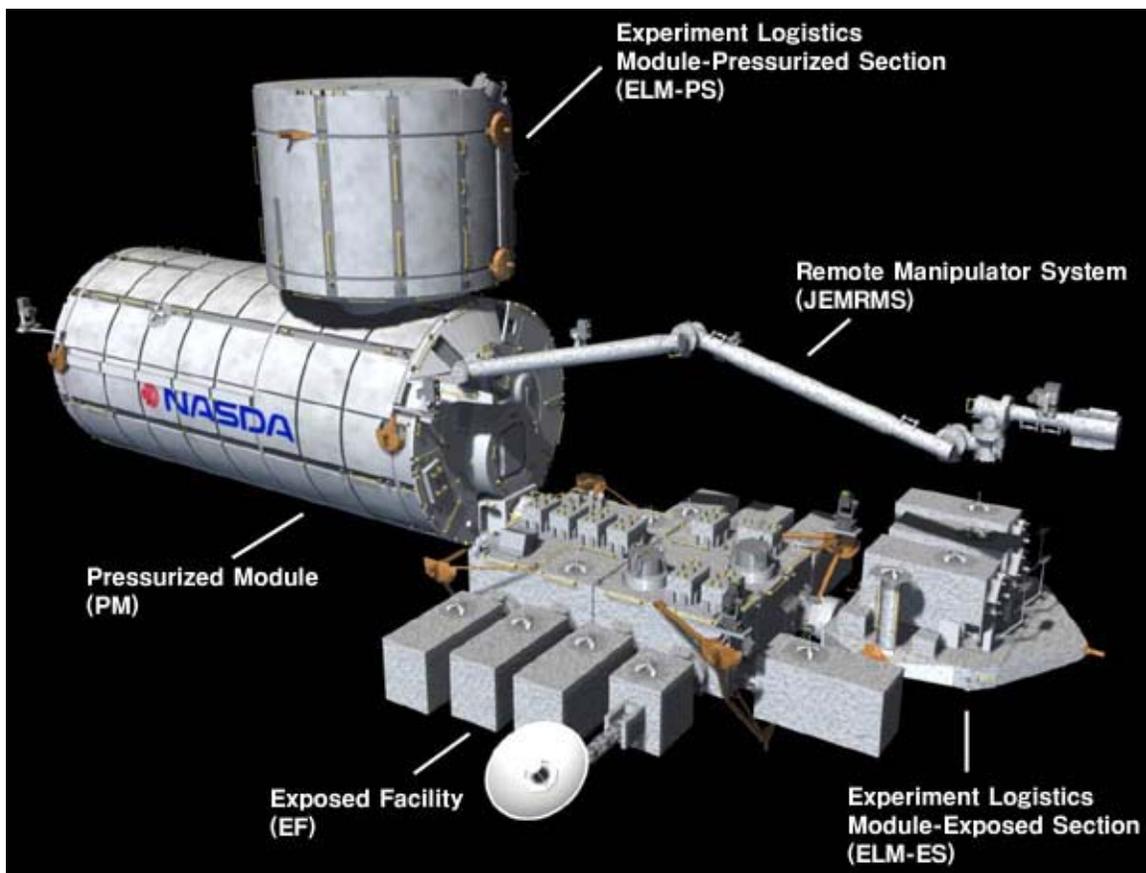
Reaching for the skies, exploring space

Owner	● Japan
	October 1, 2003
Established	<i>(Successor agency to NASDA 1969-2003, ISAS 1981-2003 and NAL 1955-2003)</i>
Headquarters	Chōfu, Tokyo
Primary spaceport	Tanegashima Space Center
Motto	One JAXA
Administrator	Keiji Tachikawa
Budget	¥229 billion/ \$2.46 billion (FY2010)
Website	www.jaxa.jp

The **Japan Aerospace Exploration Agency** (独立行政法人宇宙航空研究開発機構 *Dokuritsu-gyōsei-hōjin Uchū Kōkū Kenkyū Kaihatsu Kikō*?, literally "Independent Administrative Institution on Aerospace Research and Development"), or **JAXA**, is Japan's national aerospace agency. Through the merger of three previously independent

organizations, JAXA was formed on October 1, 2003, as an Independent Administrative Institution administered by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the Ministry of Internal Affairs and Communications (MIC). JAXA is responsible for research, development and launch of satellites into orbit, and is fundamentally involved in many missions such as asteroid exploration and a possible human mission to the Moon. Its motto is *One JAXA* and corporate message is *Reaching for the skies, exploring space*.

History



JAXA Kibo, the largest module for the ISS

On October 1, 2003, three organizations were merged to form the new JAXA: Japan's Institute of Space and Astronautical Science (or ISAS), the National Aerospace Laboratory of Japan (NAL), and National Space Development Agency of Japan (NASDA).

Before the merger, ISAS was responsible for space and planetary research, while NAL was focused on aviation research. NASDA, which was founded on October 1, 1969, had developed rockets, satellites, and also built the Japanese Experiment Module. The old NASDA headquarters were located at the current site of the Tanegashima Space Center,

on Tanegashima Island, 115 kilometers south of Kyūshū. NASDA also trained Japanese astronauts, who flew with the US Space Shuttles.

Rockets

JAXA uses the H-IIA (H "two" A) rocket from the former NASDA body to launch engineering test satellites, weather satellites, etc. For science missions like X-ray astronomy, JAXA has been using the M-V ("Mu-five") solid-fueled rocket from the former ISAS. Additionally, JAXA is developing together with IHI, United Launch Alliance, and Galaxy Express Corporation (GALEX), the GX rocket. The GX will be the first rocket world wide to use liquefied natural gas (LNG) as the propellant. For experiments in the upper atmosphere JAXA uses the SS-520, S-520, and S-310 sounding rockets.

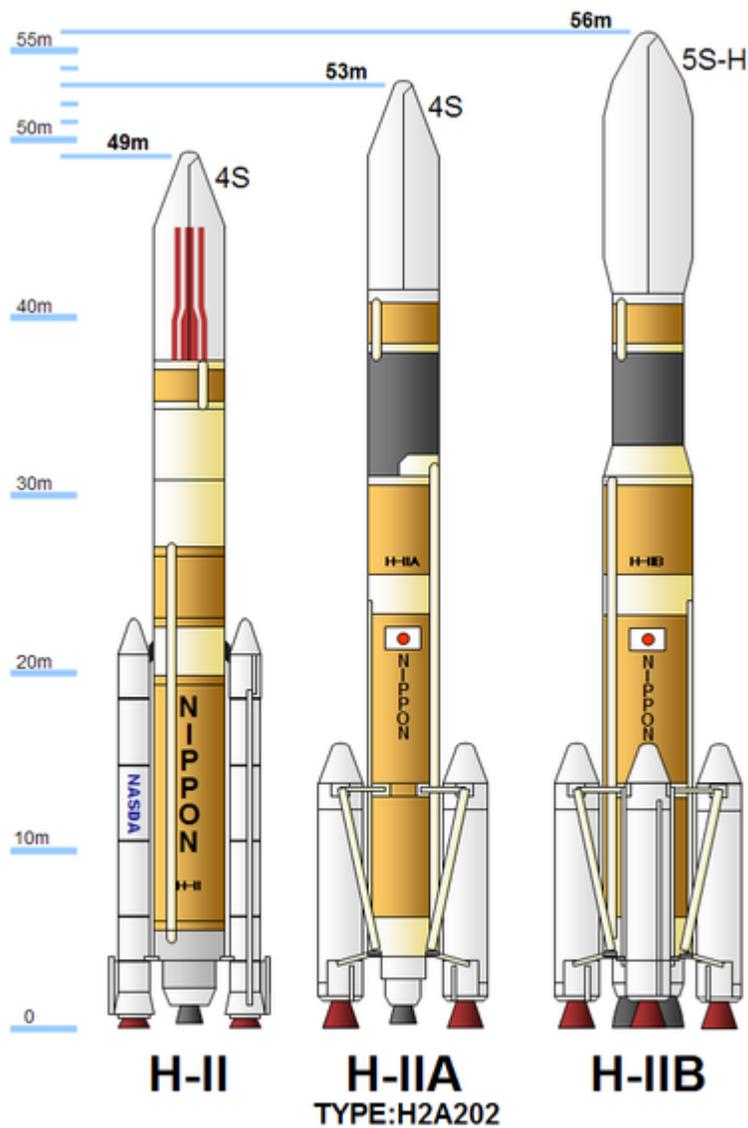
Success

Prior to the establishment of JAXA, ISAS had been most successful in its space program in the field of X-ray astronomy during the 1980s and 1990s. Another successful area for Japan has been Very Long Baseline Interferometry (VLBI) with the HALCA mission. Additional success was achieved with solar observation and research of the magnetosphere, among other areas.

NASDA was mostly active in the field of communication satellite technology. However, since the satellite market of Japan is completely open, the first time a Japanese company won a contract for a civilian communication satellite was only in 2005. Another prime focus of the NASDA body is Earth climate observation.

JAXA was awarded the Space Foundation's John L. "Jack" Swigert, Jr., Award for Space Exploration in 2008.

Launch development and missions



H-IIA & H-IIB

Rocket history

Japan launched its first satellite Ōsumi in 1970 with the L-4S rocket by ISAS. Unlike solid fueled rockets, Japan chose a much slower path with liquid fueled rocket technology. In the beginning NASDA used American models in license. The first model developed in Japan was the H-II introduced in 1994. However at the end of the 90s with two H-II launch failures, Japanese rocket technology came under criticism.

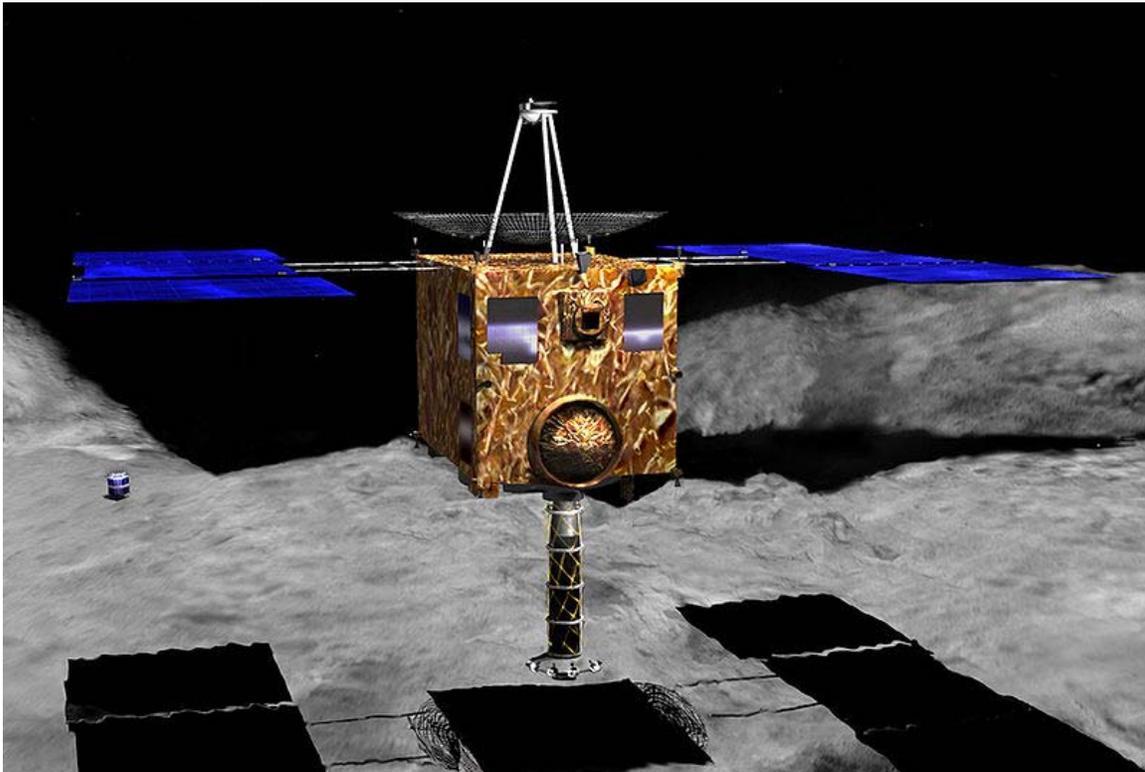
Early H-IIA missions

Japan's first space mission under JAXA, an H-IIA rocket launch on November 29, 2003, ended in failure due to stress problems. After a 15 month hiatus, JAXA performed a successful launch of an H-IIA rocket from Tanegashima Space Center, placing a satellite into orbit on February 26, 2005.

Lunar and interplanetary missions

Japan's first missions beyond Earth orbit were the 1985 Halley comet observation satellites Suisei and Sakigake. To prepare for future missions, ISAS tested Earth swing by orbits with the Hiten mission in 1990. The first Japanese interplanetary mission was the Mars Orbiter Nozomi (Planet-B), which was launched in 1998. It reached its target in 2003, but orbit injection had to be given up. Currently interplanetary missions remain at the ISAS group under the JAXA umbrella. However for FY 2008 JAXA is planning to set up an independent working group within the organization. New head for this group will be Hayabusa project manager Kawaguchi. **Active Mission:** Hayabusa, SELENE, **Under Development:** Planet-C, BepiColombo, Hayabusa 2?

Small body exploration: Hayabusa mission



Hayabusa

On May 9, 2003, Hayabusa (meaning, Peregrine falcon), was launched from an M-V rocket. The goal of this mission is to collect samples from a small near-Earth asteroid

named 25143 Itokawa. The craft was scheduled to rendezvous in November 2005, and return to Earth with samples from the asteroid by July 2007. It was confirmed that the spacecraft successfully landed on the asteroid on November 20, 2005, after some initial confusion regarding the incoming data. On November 26, 2005, Hayabusa succeeded in making a soft contact, but whether it gathered the samples or not is unknown. Hayabusa returned to Earth on June 13, 2010.

Solar sail research

On August 9, 2004, ISAS successfully deployed two prototype solar sails from a sounding rocket. A clover type sail was deployed at 122 km altitude and a fan type sail was deployed at 169 km altitude. Both sails used 7.5 micrometer thick film.

ISAS tested a solar sail again as a sub payload to the Astro-F (Akari) mission on February 22, 2006. However the solar sail did not deploy fully. ISAS tested a solar sail again as a sub payload of the Solar-B launch at September 23, 2006, but contact with the probe was lost. The IKAROS solar sail was launched on May 21, 2010. The solar sail deployed successfully. The goal is to have a solar sail mission to Jupiter after 2010.

Lunar explorations

After Hiten in 1990, ISAS planned a lunar exploration mission LUNAR-A but after delays due to technical problems, the project was terminated in January 2007. The seismometer penetrator design for Lunar-A may be reused in future mission.

On September 14, 2007, JAXA succeeded in launching lunar orbit explorer *Kaguya*, also known as SELENE (costing 55 billion yen including launch vehicle), the largest such mission since the Apollo program, on an H-2A rocket. Its mission is to gather data on the moon's origin and evolution. It entered into a lunar orbit on October 4, 2007.

Astronomy program

The first Japanese astronomy mission was x-ray satellite Hakucho (Corsa-B), which was launched in 1979. Later ISAS moved into solar observation, radio astronomy through Space VLBI and infrared astronomy. **Active Mission:** Suzaku, Akari, Hinode **Under Development:** ASTRO-G, ASTRO-H

Infrared astronomy



AKARI (Astro-F)



ASTRO-E

Japan's first infrared astronomy mission was the 15 cm IRTS telescope which was part of the SFU multipurpose satellite in 1995. IRTS scanned during its one month lifetime around 7% of the sky before SFU got brought back to Earth by the Space Shuttle. During the 1990s JAXA also gave ground support for the ESA Infrared Space Observatory (ISO) infrared mission.

The next step for JAXA was the AKARI spacecraft, with the pre-launch designation ASTRO-F. This satellite was launched on 21 February 2006. Its mission is infrared astronomy with a 68 cm telescope. This is the first all sky survey since the first infrared mission IRAS in 1983. (A 3.6 kg nanosatellite named CUTE-1.7 was also released from the same launch vehicle.)

JAXA is also doing further R&D for increasing the performance of its mechanical coolers for its future infrared mission SPICA. This would enable a warm launch without liquid helium. SPICA has the same size as the ESA Herschel Space Observatory mission, but is planned with a temperature of just 4.5 K to be much colder. The launch is planned for the year 2015, however the mission is not yet fully funded. Also ESA and NASA might contribute an instrument each.

X-ray astronomy

Starting from 1979 with Hakucho (CORSA-B), Japan achieved for nearly 20 years continuous observation with its Hinotori, Tenma, Ginga and Asuka (ASTRO-A to D) x-ray observation satellites. However in the year 2000 the launch of Japan's fifth x-ray observation satellite ASTRO-E failed (as it failed at launch it never received a proper name).

Then on July 10, 2005, JAXA was finally able to launch a new X-ray astronomy mission named Suzaku (ASTRO-E II). This launch was important for JAXA, because in the five years since the launch failure of the original ASTRO-E satellite, Japan was without an x-ray telescope. Three instruments were included in this satellite: an X-ray spectrometer (XRS), an X-ray imaging spectrometer (XIS), and a hard X-ray detector (HXD). However, the XRS was rendered inoperable due to a malfunction which caused the satellite to lose its supply of liquid helium.

The next planned x-ray mission is the MAXI all-sky X-ray scanner. It will continuously monitors astronomical X-ray objects over a broad energy band (0.5 to 30 keV). MAXI will be installed on the Japanese external module of the ISS. After this mission JAXA plans to launch ASTRO-H, also known under the name NeXT, in the summer of 2013.

Solar astronomy

Japan's solar astronomy started in the early 80s with the launch of the *Hinotori* (ASTRO-A) x-ray mission. The Hinode (SOLAR-B) spacecraft, the follow-on to the Japan/US/UK

Yohkoh (SOLAR-A) spacecraft, was launched on 23 September 2006. A SOLAR-C can be expected sometime after 2010. However no details are worked out yet other than it will not be launched with the former ISASs Mu rockets. Instead H-2A from Tanegashima could launch it. As H-2A is more powerful SOLAR-C could either be heavier or be stationed at L₁ (Lagrange point 1).

Radio astronomy

In 1998 Japan launched the HALCA (Muses-B) Mission, the world first spacecraft dedicated to create SPACE VLBI observations of Pulsars among others. To do so, ISAS set up a ground network around the world through international cooperation. The observation part of the mission lasted until 2003 and the satellite was retired at the end of 2005. In FY 2006 Japan funded the ASTRO-G as the succeeding mission. Launch is planned for FY 2012.

Technology tests

One of the primary duties of the former NASDA body was the testing of new space technologies, mostly in the field of communication. The first test satellite was ETS-I, launched in 1975. However during the 1990s NASDA was hit by bad luck with the problems surrounding the ETS-VI and COMETS missions.

Testing of communication technologies remains as one of the Jaxas key duties in cooperation with NICT. **Active Mission:** ETS-VIII, WINDS, Index **Under Development:** QZSS-1 **Retired:** OICETS

ETS-VIII and WINDS

To upgrade Japan's communication technology the Japanese state launched the i-Space initiative with the ETS-VIII and WINDS missions.

ETS-VIII was launched on December 18, 2006. The purpose of ETS-VIII is to test communication equipment with two very large antennas and an atomic clock test. On December 26 both antennas were successfully deployed. This didn't come unexpected, since JAXA tested the deployment mechanism before with the LDREX-2 Mission, which was launched on October 14 with the European Ariane 5. The test was successful. The mission of WINDS is to create the worlds fastest satellite internet connection. WINDS was launched in February 2008.

OICETS and INDEX

On August 24, 2005, JAXA launched the experimental satellites OICETS and INDEX with the Dnepr rocket. OICETS mission is to test optical links with the European Space Agency (ESA) satellite ARTEMIS, which is around 40,000 km away from OICETS. The experiment was successful on December 9, when the link could be established. In March

2006 Jaxa could establish with OICETS the worldwide first optical links between a LEO satellite and a ground station first in Japan and in June 2006 with a mobile station in Germany.

INDEX is a small 70 kg satellite for testing various equipment and for a small aurora observation mission. The satellite is currently in the extended mission phase.

Earth observation programme

Japan's first Earth observation satellites were MOS-1a and MOS-1b launched in 1987 and 1990. During the 1990s and the new millennium this programme came under heavy fire, because both Adeos (Midori) and Adeos 2 (Midori 2) satellites failed after just 10 months in orbit.

Active Mission: ALOS, GOSAT **Under Development:** GCOM-W, GCOM-C, ALOS 2 SAR

ALOS



MTSAT-1

In January 2006, JAXA successfully launched the Advanced Land Observation Satellite (ALOS/Daichi). Communication between ALOS and the ground station in Japan will be done through the Kodama Data Relay Satellite, which was launched during 2002. This project is under intense pressure due to the shorter than expected life time of the ADEOS II (Midori) Earth Observation Mission. For the following on mission JAXA plans to split the mission into a radar satellite and an optical satellite. ALOS 2 SAR is currently planned for the winter of FY 2012.

Rainfall observation

Since Japan is an island nation and gets struck by typhoons every year, research about the dynamics of the atmospheric is a very important issue. For this reason Japan launched in 1997 the TRMM mission in cooperation with NASA, to observe the tropical rainfall

seasons. JAXA and NASA are planning a successor to the TRMM mission. However because of NASA budget problems the launch date of the GPM project got pushed back to the year 2013. For further research NASDA although launched the ADEOS and ADEOS II missions in 1996 and 2003. However due to various reasons both satellites had a much shorter than expected life term.

Monitoring of carbon dioxide

At the end of the 2008 fiscal year, JAXA launched the satellite GOSAT (Greenhouse Gas Observing SATellite) to help scientists determine and monitor the density distribution of carbon dioxide in the atmosphere. The satellite is being jointly developed by JAXA and Japan's Ministry of the Environment. JAXA is building the satellite while the Ministry is in charge of the data that will be collected. Since the number of ground-based carbon dioxide observatories cannot monitor enough of the world's atmosphere and are distributed unevenly throughout the globe, the GOSAT may be able to gather more accurate data and fill in the gaps on the globe where there are no observatories on the ground. Sensors for methane and other greenhouse gasses are also being considered for the satellite, although the plans are not yet finalized. The satellite weighs approximately 1650 kg and is expected to have a life span of 5 years.

GCOM series

Next funded earth observation mission after GOSAT is the GCOM earth observation programme as a successor to ADEOS II (Midori) and the Aqua mission. To reduce the risk and for a longer observation time the mission will be split into smaller satellites. Altogether GCOM will be a series of six satellites. First launch, GCOM-W is scheduled for February 2012 with the H-IIA. Second launch GCOM-C is currently planned for February 2014.

Satellites for other agencies

For weather observation Japan launched on February 2005 the Multi-Functional Transport Satellite 1R (MTSAT-1R). The success of this launch was critical for Japan, since the original MTSAT-1 couldn't be put into orbit because of a launch failure with the H-2 rocket in 1999. Since then Japan relied for weather forecasting on an old satellite which was already beyond its useful life term and on American systems.

On February 18, 2006, JAXA, as head of the H-IIA at this time, successfully launched the MTSAT-2 aboard a H-2A rocket. MTSAT-2 is the backup to the MTSAT-1R. The MTSAT-2 uses the DS-2000 satellite bus developed by Mitsubishi Electric. The DS-2000 is also used for the DRTS Kodama, ETS-VIII and the Superbird 7 communication satellite, making it the first commercial success for Japan.

As a secondary mission both the MTSAT-1R and MTSAT-2 help to direct air traffic.

Other JAXA satellites currently in use

- Exos-D (Akebono) Aurora Observation, since 1989.
- GEOTAIL magnetosphere observation satellite (since 1992)
- DRTS (Kodama) Data Relay Satellite, since 2002. (Projected Life Span is 7 years)

On going joint missions with NASA are the Tropical Rainfall Measuring Mission (TRMM), the Aqua Earth Observation Satellite.

Finished missions

- OICETS, Technology Demonstration 2005-2009 (retired)
- SELENE, Moon probe 2007-2009 (retired)
- Micro Lab Sat 1, Small engineering mission, launch 2002. (retired 27 September 2006)
- HALCA, Space VLBI 1997-2005 (retired)
- Nozomi, Mars Mission 1998-2003 (failed)
- MDS-1, Technology Demonstration 2002-2003 (retired)
- ADEOS 2, (Midori 2) Earth Observation 2002-2003 (lost)

Future missions



HTV-1

As JAXA shifted away from international efforts beginning in 2005, plans are developing for independent space missions, such as a proposed manned mission to the moon.

2009 and beyond

On February 23, 2008 JAXA launched the Wideband InterNetworking engineering test and Demonstration Satellite (WINDS), also called "KIZUNA." WINDS will facilitate experiments with faster internet connections. The launch, using H-IIA launch vehicle 14, took place from the Tanegashima Space Center.

On September 10, 2009 the first H-IIB rocket was successfully launched, delivering the HTV-1 freighter to resupply the International Space Station.

Another project is the Global Precipitation Measurement/Dual-frequency Precipitation Radar (GPM/DPR) which is a joint development with NASA. This mission is the successor to the highly successful TRMM mission. JAXA will develop the radar and provide the launch vehicle. Other countries/agencies like China, India, ESA etc. will provide the subsatellites. The aim of this mission is to measure global rainfall. However because of NASA budget limitations this project was pushed back to 2010.

In the year 2009 JAXA plans to launch the first satellite of the Quasi Zenith Satellite System (QZSS), a subsystem of the global positioning system (GPS). Two others are expected to follow later. If successful, one satellite will be in a zenith position over Japan full time. The QZSS mission is the last scheduled major independent mission for JAXA, as no major civilian projects were funded after that for now. The only exception is the IGS programme which will be continued beyond 2008. However it seems Japan is pressing forward now with the GCOM earth observation satellites as successors to the ADEOS missions. First launch is planned for 2010. In 2009 Japan also plans to launch a new version of the IGS with an improved resolution of 60 cm.

Launch schedule

First launch of the H-IIB and the HTV is September 1, 2009. After the first flight one HTV launch is planned during each FY until 2015. (If not mentioned otherwise launch vehicle for the following missions is the H-IIA.)

FY 2010

- H-II Transfer Vehicle, Unmanned resupply spacecraft, launch: Winter, 2010
- Quasi Zenith Satellite System, launch: Aug, 2010
- Akatsuki, probe to Venus, launch: May, 2010
- IKAROS, Solar-sail Technology Demonstration satellite, launch: May, 2010

FY 2011

- GCOM-W, Climate Observation satellite, launch: Feb, 2012

FY 2012

- ALOS 2 SAR, Earth Observation satellite, launch: Winter 2012
- ASTRO-G (VSOP-2) successor to the Halca mission, launch: Summer 2012
- TOPS Telescope Observatory for Planets on Small-satellite launch Feb, 2012 (First launch of the new Advanced Solid Rocket, the successor to the M-V).

FY 2013

- GPM, successor to the TRMM joint NASA mission
- BepiColombo, joint ESA mission to Mercury, launch: 2013 (LV: Ariane 5)
- ASTRO-H x-ray observatory, launch: summer 2013.
- GCOM-C, Climate Observation satellite, launch: Feb, 2014

Other missions

For the 2012 ESA EarthCare mission, JAXA will provide the radar system on the satellite. JAXA is also providing the Light Particle Telescope(LPT) for the 2008 Jason 2 satellite by the French CNES. JAXA will provide the Auroral Electron Sensor (AES) for the Taiwanese FORMOSAT-5.

- SmartSat-1, small communication test and sun corona observation, Mission status unclear
- XEUS joint X-Ray telescope with ESA, launch after 2015.
- Sohla-2 Small PETSAT Demonstration Satellite

New orientation of JAXA

Planning interstellar research missions can take up to seven years, such as the ASTRO-E. Due to the lag time between these interstellar events and mission planning time, opportunities to gain new knowledge about the cosmos might be lost. To prevent this, JAXA plans on using smaller, faster missions from 2010 onwards. JAXA is also planning to develop a new solid fueled rocket to replace the twelve year old M-V.

Developing projects

- IKAROS (Interplanetary Kite-craft Accelerated by Radiation Of the Sun), a small size powered-solar sail experimental spacecraft. Future mission will use solar sail for Jupiter and Trojan asteroids exploration.

Plans

- Selene-2, a moon landing mission
- Hayabusa 2, for launch in 2010-2011 for target 1999JU3
- Hayabusa Mk2/Marco Polo

- Human Lunar Systems, conceptual system study on the future human lunar outpost
- ALOS 2, earth observation
- SPICA, a 3,5 meter infrared telescope to be placed at L2
- JASMINE, infrared telescope for measuring the universe
- DIOS, small scale x-ray observation
- Space Solar Power System (SSPS), space-based solar power prototype launch in 2020, aiming for a full power system in 2030

Human space program



The *Spacelab-J* shuttle flight, funded by Japan, included several tons of Japanese science research equipment

Japan has ten astronauts but has not yet developed its own manned spacecraft and is not currently developing one officially. Sometime ago an unmanned mainly and manned prospectively space shuttle-spaceplane HOPE-X project launched by conventional space launcher H-II was developed for several years (including test flights of Hyflex/OREX prototypes) but was postponed. Then the simpler manned capsule Fuji was proposed but not adopted. Projects of single-stage to orbit, reusable launch vehicle horizontal takeoff and landing ASSTS and vertical takeoff and landing Kankoh-maru also exist but have not been adopted.

The first Japanese citizen to fly in space was Toyohiro Akiyama, a journalist sponsored by TBS, who flew on the Soviet Soyuz TM-11 in December 1990. He spent more than seven days in space on the Mir space station, in what the Soviets called their first commercial spaceflight which allowed them to earn \$14 million.

Japan participates in US and international manned space programs including flights of Japanese astronauts on a board of US Space Shuttles, Russian Soyuz spacecraft and ISS. Besides this paid for seat flights, one Space Shuttle mission (STS-47, which occurred in September 1992) was partially funded by Japan. On board STS-47 was Japan's first professional astronaut Mamoru Mohri, as the Payload Specialist for the Spacelab-J, one of the European built Spacelab modules. This mission was also designated *Japan*.



A view of the completed Kibo module.

Mainly for Japan, another three US Space Shuttles missions (STS-123, STS-124, STS-127) were in 2008-2009 for delivery of parts of Japan built spacelab-module Kibo to ISS.

Under a new plan, Japan and JAXA has set a goal of constructing a manned lunar base. Japanese robots and then astronauts would be sent to the Moon by beyond 2020 which is approximately the same time as Indian Space Research Organisation (ISRO) manned lunar mission beyond 2020, China National Space Administration (CNSA) manned lunar mission near 2030 and NASA's Project Constellation planned to return to the Moon in 2019 with its Orion-Altair project) so that they will start construction of the base to be completed by 2030.

Before this Moon goals JAXA intends to develop the manned capsule spacecraft launched by space launcher H-IIB.

Supersonic aircraft development

Besides the H-IIA and M-5 rockets, JAXA is also developing technology for a next-generation supersonic transport that could become the commercial replacement for the Concorde. The design goal of the project (working name NEXST) is to develop a jet that can carry 300 passengers at Mach 2. A subscale model of the jet underwent aerodynamic testing in September and October 2005 in Australia. The economic success of such a project is still unclear, and as a consequence the project has been met with limited interest from Japanese aerospace companies like Mitsubishi Heavy Industries so far.

Reusable launch vehicles

Until 2003 JAXA (ISAS) conducted research on a reusable launch vehicle under the Reusable Vehicle Testing (RVT) project.

Research centers and offices



Head Office



Tanegashima Space Center

JAXA has research centers in many locations in Japan, and some offices overseas. Its headquarters are in Chōfu, Tokyo. It also has

- Earth Observation Research Center (EORC), Tokyo
- Earth Observation Center (EOC) in Hatayama
- Noshiro Testing Center (NTC) - Established in 1962. It carries out development and testing of rocket engines.
- Sanriku Balloon Center (SBC) - Balloons have been launched from this site since 1971.
- Kakuda Space Propulsion Center (KSPC) - Leads the development of rocket engines. Works mainly with development of liquid fuel engines.
- Sagami-hara Campus (ISAS) - Development of experimental equipment for rockets and satellites. Also administrative buildings.
- Tanegashima Space Center
- Tsukuba Space Center (TKSC) in Tsukuba. This is the center of Japan's space network. It is involved in research and development of satellites and rockets, and tracking and controlling of satellites. It develops experimental equipment for the Japanese Experiment Module ("Kibo"). Training of astronauts also takes place here. For International Space Station operations, the Japanese Flight Control Team is located at the Space Station Integration & Promotion Center (SSIPC) in

Tsukuba. SSIPC communicates regularly with ISS crewmembers via S-band audio.

- Uchinoura Space Center

Other space agencies in Japan

Not included into the JAXA organization is the Institute for unmanned space experiment free flyer (USEF), Japan's other space agency.

Chapter- 6

Brazilian Space Agency



Brazilian Space Agency Agência Espacial Brasileira



Established	10 February 1994 <i>(formerly the Brazilian space program, 1961-1993)</i>
Command structure	Ministry of Science and Technology
Operational center	Alcântara Launch Center
President	Carlos Ganem
Annual budget	\$275 million (2011)

The **Brazilian Space Agency** (Portuguese: *Agência Espacial Brasileira*; **AEB**) is the civilian authority in Brazil responsible for the country's burgeoning space program. It operates a spaceport at Alcântara and a rocket launch site at Barreira do Inferno. The agency has given Brazil a leading role in space in South America, and has made Brazil a valuable and dependable partner for cooperation in the International Space Station.

The Brazilian Space Agency is the heir to Brazil's space program. Previously, the program had been under the control of the Brazilian military; the program was transferred into civilian control on 10 February 1994.

It suffered a major setback in 2003, when a rocket explosion killed 21 technicians. Brazil successfully launched its first rocket into space on 23 October 2004 from the Alcântara Launch Center; it was a VSB-30 launched on a sub-orbital mission. Several other successful launches have followed.

On March 30, 2006, AEB astronaut Marcos Pontes became the first Brazilian and the first native Portuguese-speaking person to go into space, where he stayed on the International Space Station for a week. During his trip, Pontes carried out eight experiments selected by the Brazilian Space Agency. He landed in Kazakhstan on April 8, 2006, with the crew of Expedition 12.

The Brazilian Space Agency has pursued a policy of joint technological development with more advanced space programs. Initially it relied heavily on the United States, but after meeting difficulties from them on technological transfers, Brazil has branched out, working with other nations, including China, Russia and Ukraine.

Launch sites



The Brazilian Space Agency's control room at the Alcântara Launch Center

Alcântara Launch Center

 2°20'S 44°24'W / 2.333°S 44.4°W

The Alcântara Launch Center (Portuguese: *Centro de Lançamento de Alcântara*; CLA) is the main launch site and operational center of the Brazilian Space Agency. It is located in the peninsula of Alcântara, in the state of Maranhão. This region presents some excellent requirements, such as low population density, excellent security conditions and easiness of aerial and maritime access. The most important factor is its closeness to the Equator - Alcântara is the closest launching base to the Equator. This gives the launch site a significant advantage in launching geosynchronous satellites.

Barreira do Inferno Launch Center

 5°55'30"S 35°9'47"W / 5.925°S 35.16306°W

The Barreira do Inferno Launch Center (Portuguese: *Centro de Lançamento da Barreira do Inferno*; CLBI) is a rocket launch base of the Brazilian Space Agency. It is located in the city of Parnamirim, in the state of Rio Grande do Norte. It is primarily used to launch sounding rockets and to support the Alcântara Launch Center.

Launch vehicles



The VLS on the launch pad at the Alcântara Launch Center

Sounding rockets

The Brazilian Space Agency has operated a series of sounding rockets.

- Sonda I
- Sonda II
- Sonda III
- Sonda IV
- VSB-30
- VS-30
- VS-40

VLS

The VLS - Satellite Launch Vehicle (Portuguese: *Veículo Lançador de Satélites*) is the Brazilian Space Agency's main satellite launch vehicle. It is a four-stage rocket composed of a core and four strap-on motors. The vehicle's first stage has four solid fuel motors derived from the Sonda sounding rockets. It is intended to deploy 100 to 380 kg satellites into 200 to 1200 km orbit, or to deploy 75 to 275 kg payloads into 200 to 1000 km polar orbit. The first 3 prototypes for the vehicle failed to launch, with the 3rd exploding on the launch pad in 2003 resulting in the deaths of 21 AEB personnel. A new version of the launcher is under design with Russian assistance.

VLM

The VLM-1 "Veículo Lançador de Microsatélites" (Microsatellite Launch Vehicle) is also being developed based on the VLS rocket engines.

Southern Cross program

The Brazilian Space Agency is currently developing a new family of launch vehicles in cooperation with the Russian Federal Space Agency. The five rockets of the Southern Cross family will be based on Russia's Angara vehicle and liquid-propellant engines.

The program was named "Southern Cross" in reference to the Crux constellation, present on the flag of Brazil and composed of five stars. Hence the names of the future launch vehicles :

- Alpha (light-weight rocket)
- Beta (light-weight rocket)
- Gamma (light-weight rocket)
- Delta (medium-weight rocket)
- Epsilon (heavy-weight rocket)

The first stage of the Gamma, Delta and Epsilon rockets will be powered by a unit based on the RD-191 engine. The second stage, which will be the same for all the Southern

Cross rockets, will be driven by an engine based on the Molniya rocket. The third stage will be a solid-propellant booster based on an upgraded version of the VLS-1.

The Gamma launcher is part of the light-weight class, but using the near-equatorial position of the Alcântara Launch Center, it can place almost 1 ton of payload into a GSO.

The Delta launcher is a medium-weight rocket and differs from the Gamma by having four solid-propellant boosters attached to the first stage. Its payload deliverable to a GSO is 1.7 tons.

The Epsilon launcher is a heavy-weight rocket with three identical units attached to the first stage. It can place a four-ton spacecraft in orbit, if it is launched from Alcântara.

The Brazilian government is planning to allocate \$1 billion dollars for the project in the next six years. It has already set aside \$650 million dollars for the construction of five launch pads able to handle up to 12 launches per year. The program is scheduled to be completed by 2022.

Engines

A number of different engines were developed for usage on the several launch vehicles:

- S-10-1 solid rocket engine. Used on Sonda 1.
- S-10-2 solid rocket engine. Used on Sonda 1.
- S-20 Avibras solid rocket engine. Used on Sonda 2 and Sonda 3.
- S-23 Avibras solid rocket engine. Used on Sonda 3M1.
- S-30 IAE solid rocket engine. Used on Sonda 3, Sonda 3M1, Sonda 4, VS-30, VS-30/Orion and VSB-30.
- S-31 IAE solid rocket engine. Used on VSB-30.
- S-40TM IAE solid rocket engine. Used on VLS-R1, VS-40, VLS-1 and VLM.
- S-43TM IAE solid rocket engine. Used on VLS-R1, VLS-1 and VLM.
- S-43 IAE solid rocket engine. Used on Sonda 4, VLS-R1 and VLS-1.
- S-44 IAE solid rocket engine. Used on VLS-R1, VS-40, VLS-1 and VLM.

Satellites

The Brazilian Space Agency has several active imagery intelligence satellites in orbit, including reconnaissance and earth observation satellites.

Satellite	Origin	Type	Operational	Status
SCD1	 Brazil	Earth observation	1993	Active
SCD2	 Brazil	Earth observation	1998	Active
CBERS-1	 Brazil /  China	Earth observation	1999-2003	Retired
CBERS-2	 Brazil /  China	Earth observation	2003-	Active

Human Spaceflight

Marcos Pontes, a Lieutenant colonel in the Brazilian Air Force, is a Mission Specialist astronaut for the Brazilian Space Agency. Pontes is the first professional Brazilian astronaut to go into space. He launched with the Expedition 13 crew from the Baikonur Cosmodrome in Kazakhstan on March 29, 2006 aboard a Soyuz-TMA spacecraft, docking with the station on March 31, 2006, where he lived and worked for 9 days. Pontes returned to earth with the Expedition 12 crew landing in Kazakhstan on April 8, 2006. Currently, Pontes continues with his technical duties for the International Space Station program in the development and fabrication of the Brazilian parts for the ISS. He is on stand-by for training for future Brazilian space flights.

	Name	Position	Time in space	Launch date	Mission	Mission insignia	Status
	Marcos Pontes	Mission Specialist	9d 21h 17m	March 30, 2006	Soyuz TMA-8 Soyuz TMA-7		Active, on stand-by

International cooperation

International Space Station

The Brazilian Space Agency is a bilateral partner of NASA in the International Space Station. The agreement for the design, development, operation and use of Brazilian developed flight equipment and payloads for the Space Station was signed in 1997. It includes the development of six items, among which are a Window Observational Research Facility and a Technology Experiment Facility. In return, NASA will provide Brazil with access to its ISS facilities on-orbit, as well as a flight opportunity for one Brazilian astronaut during the course of the ISS program.

Ukraine

On October 21, 2003, the Brazilian Space Agency and the State Space Agency of Ukraine established a cooperation agreement creating a joint venture space enterprise called Alcântara Cyclone Space. The new company will focus on launching satellites from the Alcântara Launch Center using the Tsyklon-4 rocket. The company will invest \$160 million dollars in infrastructure for the new launch pad that will be constructed at the Alcântara Launch Center.

In March 2009, the Brazilian Government increased its financial capital by US\$ 50 million.

Chapter- 7

Italian Space Agency

Italian Space Agency Agenzia Spaziale Italiana



ASI logo

Agency overview

Formed	January 1, 1988 (23 years ago)
Jurisdiction	Italian government
Headquarters	Rome, Italy
Employees	200
Annual budget	€700 million (\$1 billion) in 2010
Agency executives	Enrico Saggese, President Luciano Criscuoli, Director General

Website

www.asi.it

The **Italian Space Agency** (Italian: *Agenzia Spaziale Italiana*; **ASI**) is a government agency established in 1988 to fund, regulate and coordinate space exploration activities in Italy. Operating under the Ministry of Education, Universities and Research (MIUR), the agency cooperates with numerous national and international entities who are active in

aerospace research and technology, and with the Italian President of the Council of Ministers.

Nationally, ASI is responsible for both drafting the National Aerospace Plan and ensuring it is carried out. To do this the agency operates as the owner/coordinator of a number of Italian space research agencies and assets such as CIRA as well as organising the calls and opportunities process for Italian industrial contractors on spaceflight projects. Internationally, the ASI provides Italy's delegation to the Council of the European Space Agency and to its subordinate bodies as well as representing the country's interests in foreign collaborations.

ASI's main headquarters are located in Rome, Italy, and the agency also has direct control over three operational centres. The Centre for Space Geodesy (CGS) located in Matera and the stratospheric balloon launch site at Trapani are both in Italy. As well as these ASI has access to its own spaceport, the Broglio Space Centre (formerly the *San Marco Equatorial Range*) on the coastal sublittoral of Kenya, currently used only as a communications ground station. In 2008 ASI's annual budget was approximately €820 m and directly employed around 200 workers.

Following a decision by the Council of Ministers, Enrico Saggese became president of the agency on July 3, 2009. Luciano Criscuoli is the organisation's director general.

History

Early Italian aerospace



San Marco 1 (top), Italy's first artificial satellite, at checkout on Wallops Island

Activities started officially in 1988 but the agency drew extensively on the work of earlier national organisations as well as the consolidated experience of the many Italian scientists that had been investigating space and astronautics since the end of the 19th century. Some of the most outstanding names in Italian space exploration since its inception were the following:

- Giulio Costanzi (1875-1965), his 1914 writing of space navigation and nuclear propulsion are considered the first Italian contribution to astronautics.
- Luigi Gussalli (1885-1950), astronautics pioneer since the '20s, corresponded with international space scientists such as Oberth and Goddard. He invented a double-reaction jet engine, developed multi-stage rockets, suggested a Moon mission and solar radiation powered spaceships.
- Gaetano Arturo Crocco (1877-1968), aeronautics and astronautics pioneer, invented the first all-Italian liquid-fuelled combustion chamber and aided in the development of the gravity assist technique for use on planetary fly-by's by space probes.
- Luigi Crocco (1909-1986), son of Gaetano Arturo, an internationally renowned scientist in aerodynamics theory and jet propulsion.

- Aurelio Robotti, expert on rocket liquid fuels, father of the first Italian liquid-fuelled rocket, AR3.
- Luigi Broglio (1911-2001), the unanimously recognized father of Italian astronautics, sometimes referred to as the “Italian von Braun”. Under his guide Italy became the fourth country in the world to build and operate a satellite in orbit around the Earth and the first country to deploy an equatorial launching pad, the San Marco, and to experiment successful launching from it.
- Carlo Buongiorno, Broglio’s pupil and the first director general of ASI.

San Marco programme

Early Italian space efforts during the Space Race era were built around cooperation between the Italian Space Commission (a branch of the National Research Council) and NASA supported primarily by the Centro Ricerche Aerospaziali, the aerospace research group of the University of Rome La Sapienza. This plan, conceived by Luigi Broglio, led to the San Marco programme of Italian-built satellites beginning with the launch of Italy’s first, San Marco 1, from Wallops Island. Italy would later launch further satellites in the series (San Marco 2 in 1967, San Marco 3 in 1971, San Marco 4 in 1974 and San Marco D/L in 1988) using the American Scout rockets like the original, but from its own spaceport.

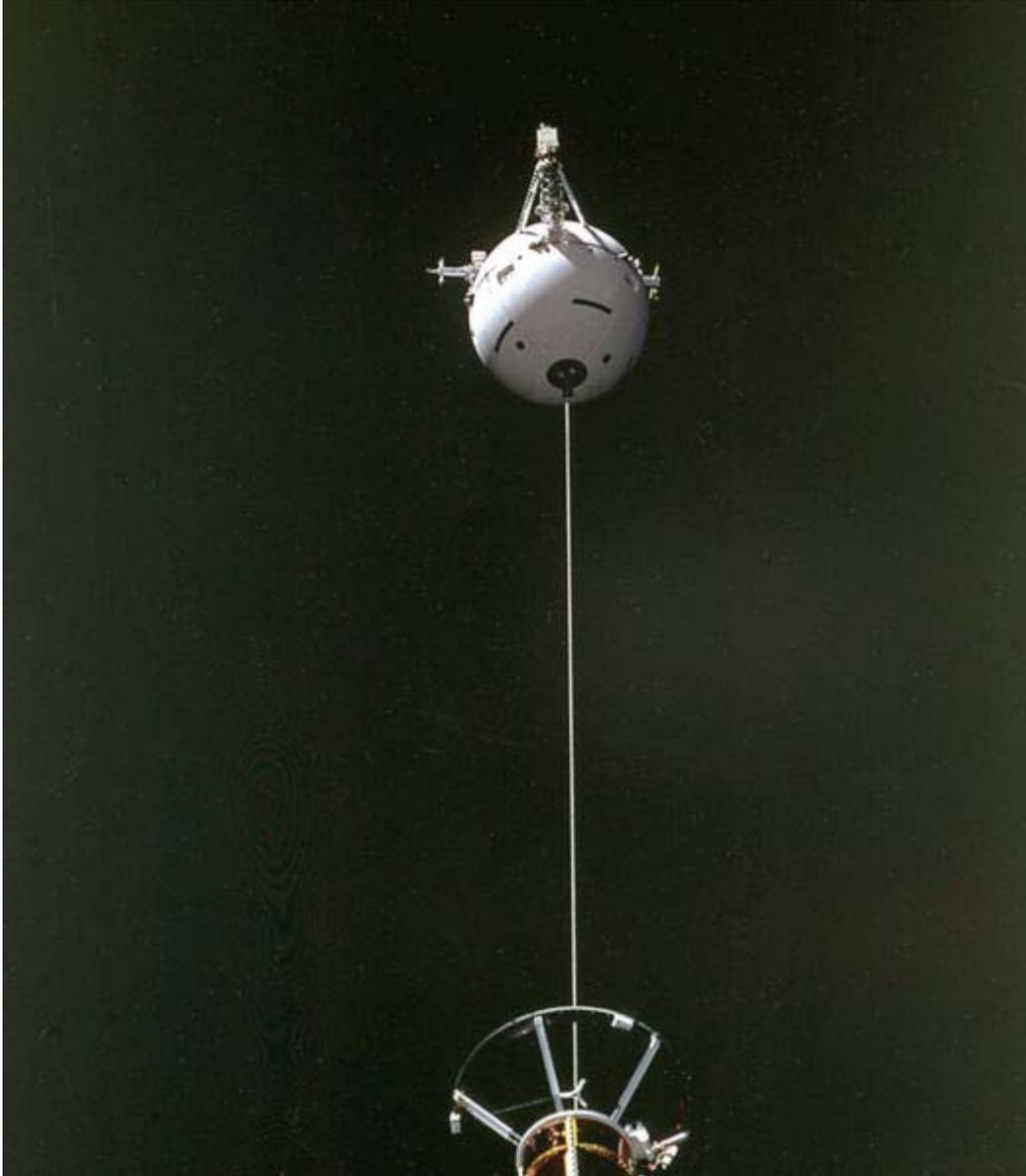
Co-operation and consolidation

As one of the earliest countries to be engaged in space exploration, Italy became a founder and key partner in the European Launcher Development Organisation (ELDO) and the European Space Research Organisation (ESRO), established on March 29 and June 14, 1962 respectively. Both of these would later merge to form the European Space Agency on April 30, 1975.

Further work would continue under the direction of the National Research Council including the launch of an indigenous telecoms/research satellite called SIRIO-1 in 1977. A planned follow-up mission SIRIO-2 was destroyed in the Ariane 1 L-05 launch failure. During the 1980s it became clear of the need to rationalise and strengthen Italy’s position in space research and so the decision was made to create the Italian Space Agency to further coordinate the nation's space activities.

Programmes

Robotic exploration



TSS-1, a tethered satellite, being deployed on STS-46

ASI's first large scientific satellite mission was BeppoSAX, developed in collaboration with the Netherlands and launched in 1996. Named after Giuseppe "Beppo" Occhialini, an important figure in Italian high-energy physics, the satellite was a mission to study the universe in the X-ray part of the spectrum.

Following on from this ASI developed another high-energy astronomical satellite, AGILE for gamma ray astronomy, launched by the Indian Space Research Organisation

(ISRO) in 2007. A particular innovation was the use of a single instrument to measure both Gamma rays and hard X-rays.

ASI also has collaborated on many major international space exploration missions including;

- Cassini-Huygens, a joint NASA/ESA/ASI mission to the Saturn system launched in 1997. The mission has made many new discoveries and increased understanding of the gas giant's environment, particularly Saturn's varied moons. ASI supplied Cassini's large high-gain antenna and radar package as well as involvement in other instruments.
- INTEGRAL, ESA's advanced gamma ray observatory launched in 2002.
- Mars Express, the first Western European mission to Mars launched in 2003. Through ASI, Italy provided two important instruments for the mission; MARSIS a radar altimeter and the Planetary Fourier Spectrometer which discovered concentrations of methane in the Martian atmosphere.
- Rosetta, an ambitious ESA mission to orbit and for the first time in history land a probe on a comet, 67P/Churyumov-Gerasimenko, to study it in detail as it enters the inner solar system. This long duration mission was launched in 2004 and will not arrive at its destination until 2014. Rosetta carries the Italian-built VIRTIS instrument while the Philae Lander's sampling/drilling system, SD2, is another major Italian contribution.
- Swift Gamma-Ray Burst Mission, a NASA-led international mission to provide rapid detection of short-lived Gamma-ray Bursts. ASI provides the use of the ground station facility as the San Marco spaceport.
- Mars Reconnaissance Orbiter, a NASA mission to Mars launched in 2005. The SHARAD radar was supplied by Italy using experience from MARSIS.
- Venus Express, the sister-probe to Mars Express built using the same spacecraft bus and the first Western European mission to Venus. Launched in 2005, ASI contributed a version of VIRTIS spectrometer.
- Dawn, a 2007 NASA mission that will study the largest of the Asteroid Belt's objects, the asteroid Vesta and the dwarf planet Ceres. Italy has provided VIR-MS, another evolution of the VIRTIS instrument.

Italy's space industry has also been involved in many other scientific missions such as SOHO, Cluster II, ISO, XMM-Newton and Planck.

The technology experiments TSS-1 and TSS-1R were also conducted in partnership with NASA.

Launcher development

Currently ASI is a partner in the Ariane 5 launcher programme and more recently is the major (65%) backer of the ESA Vega small launcher, capable of putting a payload of 1500 kg to low Earth orbit.

Earth observation

ASI is a participant in many of ESA's programmes in the field of Earth Observation such as ERS-1, ERS-2, ENVISAT, the Meteosat series and the Galileo satellite navigation system. The agency has also collaborated with other European and international partners such as the Shuttle Radar Topography Mission with NASA.

In October 1992 NASA launched LAGEOS-2 (following LAGEOS-1 launched in 1976) in cooperation with ASI. A passive satellite, it is a sphere of aluminium covered with retroreflectors to reflect laser ranging beams emitted from ground stations on Earth. The primary mission goals were to determine accurately Earth's Geoid and to measure Tectonic plate movement. In 2010 ASI's own satellite, LARES, will be launched using the Vega rocket. The mission is designed to carry out similar studies to that of LAGEOS 2 but with much greater precision.

The Italian Space Agency, under direction of both the MUIR and the Ministry of Defence plans to develop COSMO-SkyMed constellation of satellites for both military and civilian use in a broad range of areas.

Human spaceflight



Raffaello, upper left, docked with the International Space Station during STS-114

Through ASI, the Italian space industry is an active player in human spaceflight activities.

The three Shuttle MPLM cargo containers *Leonardo*, *Raffaello* and *Donatello*, were built for NASA in Turin, Italy by Alcatel Alenia Space, now Thales Alenia Space. They provide a key function in storing equipment and parts for transfer to the International Space Station.

A number of ISS modules have also been built in Italy. As part of ESA's contribution to the costs of the International Space Station, Alcatel Alenia Space built Tranquility, Harmony as well as the Cupola observation deck for NASA.

ESA's Columbus module, Western Europe's primary scientific lab on board the ISS, was again built in Turin based on Italy's previous experience in space station module construction.

Italian astronauts



Harmony, itself built in Italy on contract, was accompanied by Nespoli who acted as mission specialist. It is shown here being moved to its final docking port later the same year

As an ESA member heavily involved in human spaceflight, ASI sponsors a select few Italian citizens to train at ESA's European Astronaut Corps (EAC) to represent the country on missions. Italians to have flown in space are:

- Franco Malerba, Italy's first astronaut and the only one not to fly as a member of the EAC. He flew on STS-46 (July 31 to August 7, 1992) as payload specialist on the first Tethered Satellite System mission.
- Umberto Guidoni, flew on STS-75 (February 22 to March 9, 1996) as payload specialist on the second Tethered Satellite System mission - TSS-1R. He became the first Italian and European on the International Space Station during STS-100 (April 19 to May 1, 2001).
- Maurizio Cheli, flew with Umberto Guidoni as a mission specialist on STS-75.
- Roberto Vittori, has flown on multiple Soyuz missions to the ISS: Soyuz TM-33, Soyuz TM-34, Soyuz TMA-5, Soyuz TMA-6.
- Paolo A. Nespoli, flew on STS-120 (October 23 to November 7, 2007).

Samantha Cristoforetti and Luca Parmitano are Italy's newest astronaut candidates, being selected in 2009, and have yet to fly.