NASA Facts

National Aeronautics and
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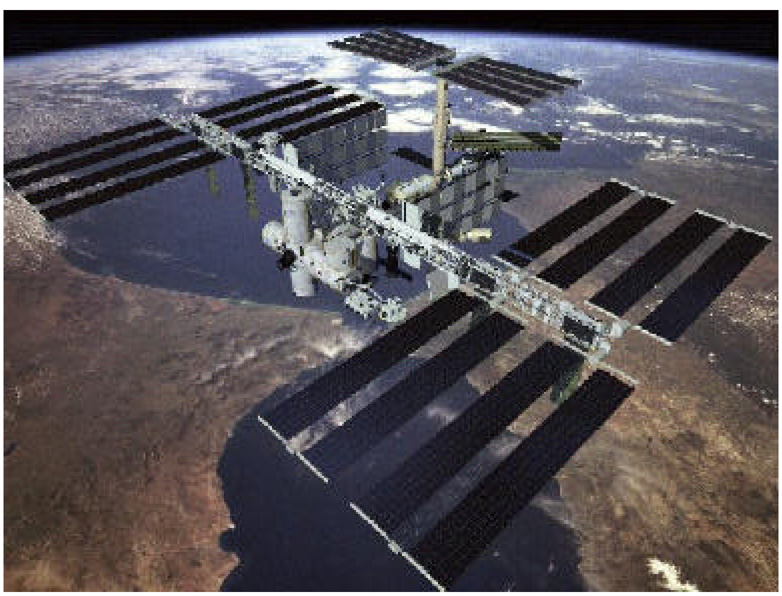
International Space Station **June 1999**

The International Space Station: An Overview

The International Space Station is the largest and most complex international scientific project in history. The station represents a move of unprecedented scale off the home planet that began in 1998 with the launch of the first two components, the Unity and Zarya modules. Led by the United States, the International Space Station draws upon the scientific and technological resources of 16 nations: Canada, Japan, Russia, 11 nations of the European Space Agency and Brazil.

More than four times as large as the Russian Mir space station, the completed International Space Station will have a mass of about 1 million pounds. It will measure about 360 feet across and 290 feet long, with almost an acre of solar panels to provide electrical power to six state-of-the-art laboratories. The first two station modules, the Russian-launched Zarya control module and U.S.-launched Unity connecting module, were assembled in orbit in late 1998.



Artist's concept of the completed International Space Station

The station is in an orbit with an altitude of 250 statute miles with an inclination of 51.6 degrees. This orbit allows the station to be reached by the launch vehicles of all the international partners to provide a robust capability for the delivery of crews and supplies. The orbit also provides excellent Earth observations with coverage of 85 percent of the globe and over flight of 95 percent of the population. Already, about 500,000 pounds of station components have been built at factories around the world. The two-module complex now in orbit has a mass of more than 74,000 pounds and measures 76 feet long with a 78-foot wingspan tip to tip of the solar arrays. The current station's internal pressurized volume is 4,635 cubic feet. The Space Shuttle Discovery peformed the first docking with the new station in May 1999 on mission STS-96, delivering almost two tons of internal and external supplies.

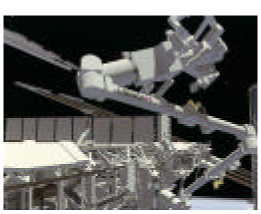
Unity (top) and Zarya in orbit

The United States has the responsibility for developing and ultimately operating major elements and systems aboard the station. The U.S. elements include three connecting modules, or nodes; a laboratory module; truss segments; four solar arrays; a habitation module; three mating adapters; a cupola; an unpressurized logistics carrier and a centrifuge module. The various systems being developed by the U.S. include thermal control; life support; guidance, navigation and control; data handling; power systems; communications and tracking; ground operations facilities and launch-site processing facilities.

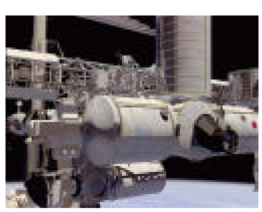
The international partners, Canada, Japan, the European Space Agency, and Russia, will contribute the following key elements to the International Space Station:

- Canada is providing a 55-foot-long robotic arm to be used for assembly and maintenance tasks on the Space Station.
- The European Space Agency is building a pressurized laboratory to be launched on the Space Shuttle and logistics transport vehicles to be launched on the Ariane 5 launch vehicle.
- Japan is building a laboratory with an attached exposed exterior platform for experiments as well as logistics transport vehicles.
- Russia is providing two research modules; an early living quarters called the Service Module with its own life support and habitation systems; a science power platform of solar arrays that can supply about 20 kilowatts of electrical power; logistics transport vehicles; and Soyuz spacecraft for crew return and transfer.

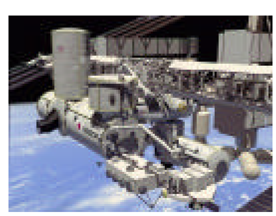
In addition, Brazil and Italy are contributing some equipment to the station through agreements with the United States.



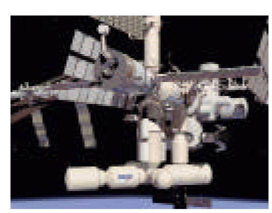
Canadian Robotics



ESA Columbus Lab



Japanese Lab



Russian Segment

The Shuttle-Mir Program

The first phase of the International Space Station, the Shuttle-Mir Program, began in 1995 and involved more than two years of continuous stays by astronauts aboard the Russian Mir Space Station and nine Shuttle-Mir docking missions. Knowledge was gained in technology, international space operations and scientific research.

Seven U.S. astronauts spent a cumulative total of 32 months aboard Mir with 28 months of continuous occupancy since March 1996. By contrast, it took the U.S. Space Shuttle fleet more than a dozen years and 60 flights to achieve an accumulated one year in orbit. Many of the research programs planned for the International Space Station benefit from longer stay times in space. The U.S. science program aboard the Mir was a pathfinder for more ambitious experiments planned for the new station.

For less than two percent of the total cost of the International Space Station program, NASA gained knowledge and experience through Shuttle-Mir that could not be achieved any other way. That included valuable experience in international crew training activities; the operation of an international space program; and the challenges of long duration spaceflight for astronauts and ground controllers. Dealing with the real-time challenges experienced during Shuttle-Mir missions also has resulted in an unprecedented cooperation and trust between the U.S. and Russian space programs, and that cooperation and trust has enhanced the development of the International Space Station.

Research on the International Space Station

The International Space Station will establish an unprecedented state-of-the-art laboratory complex in orbit, more than four times the size and with almost 60 times the electrical power for experiments — critical for research capability — of Russia's Mir. Research in the station's six laboratories will lead to discoveries in medicine, materials and fundamental science that will benefit people all over the world. Through its research and technology, the station also will serve as an indispensable step in preparation for future human space exploration. Examples of the types of U.S. research that will be performed aboard the station include:

- **Protein crystal studies:** More pure protein crystals may be grown in space than on Earth. Analysis of these crystals helps scientists better understand the nature of proteins, enzymes and viruses, perhaps leading to the development of new drugs and a better understanding of the fundamental building blocks of life. Similar experiments have been conducted on the Space Shuttle, although they are limited by the short duration of Shuttle flights. This type of research could lead to the study of possible treatments for cancer, diabetes, emphysema and immune system disorders, among other research.

- **Tissue culture:** Living cells can be grown in a laboratory environment in space where they are not distorted by gravity. NASA already has developed a Bioreactor device that is used on Earth to simulate, for such cultures, the effect of reduced gravity. Still, these devices are limited by gravity. Growing cultures for long periods aboard the station will further advance this research. Such cultures can be used to test new treatments for cancer without risking harm to patients, among other uses.

- **Life in low gravity:** The effects of long-term exposure to reduced gravity on humans – weakening muscles*;* changes in how the heart, arteries and veins work; and the loss of bone density, among others – will be studied aboard the station. Studies of these effects may lead to a better understanding of the body's systems and similar ailments on Earth. A thorough understanding of such effects and possible methods of counteracting them is needed to prepare for future long-term human exploration of the solar system. In addition, studies of the gravitational effects on plants, animals and the function of living cells will be conducted aboard the station. A centrifuge, located in the Centrifuge Accommodation Module, will use centrifugal force to generate simulated gravity ranging from almost zero to twice that of Earth. This facility will imitate Earth's gravity for comparison purposes; eliminate variables in experiments; and simulate the gravity on the Moon or Mars for experiments that can provide information useful for future space travels.

Astronaut Shannon Lucid checks wheat plants grown aboard the Russian Mir Space Station in 1996. More advanced studies on the International Space Station will analyze the effects of weightlessness on humans, plants and animals.

- **Flames, fluids and metal in space:** Fluids, flames, molten metal and other materials will be the subject of basic research on the station. Even flames burn differently without gravity. Reduced gravity reduces convection currents, the currents that cause warm air or fluid to rise and cool air or fluid to sink on Earth. This absence of convection alters the flame shape in orbit and allows studies of the combustion process that are impossible on Earth, a research field called Combustion Science. The absence of convection allows molten metals or other materials to be mixed more thoroughly in orbit than on Earth. Scientists plan to study this field, called Materials Science, to create better metal alloys and more perfect materials for applications such as computer chips. The study of all of these areas may lead to developments that can enhance many industries on Earth.

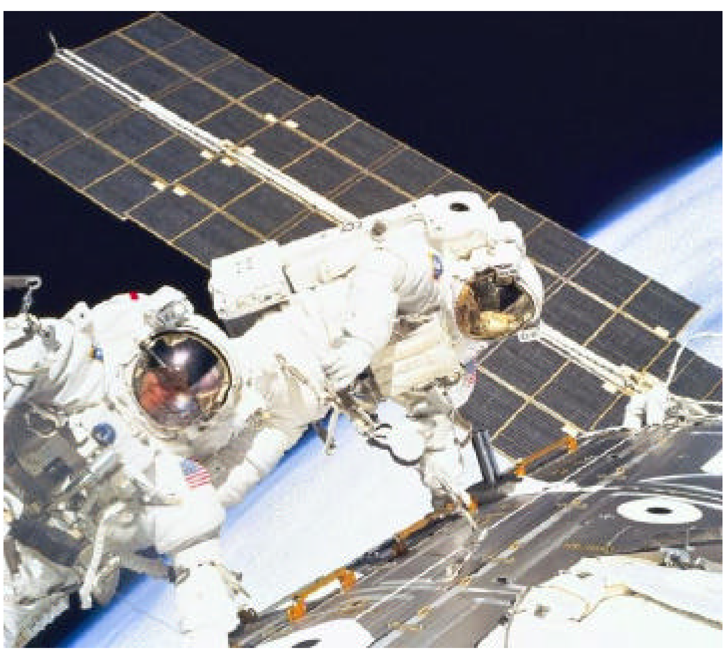
- **The nature of space:** Some experiments aboard the station will take place on the exterior of the station modules. Such exterior experiments can study the space environment and how long-term exposure to space, the vacuum and the debris, affects materials. This research can provide future spacecraft designers and scientists a better understanding of the nature of space and enhance spacecraft design. Some experiments will study the basic forces of nature, a field called Fundamental Physics, where experiments take advantage of weightlessness to study forces that are weak and difficult to study when subject to gravity on Earth. Experiments in this field may help explain how the universe developed. Investigations that use lasers to cool atoms to near absolute zero may help us understand gravity itself. In addition to investigating basic questions about nature, this research could lead to down-to-Earth developments that may include clocks a thousand times more accurate than today's atomic clocks; better weather forecasting; and stronger materials.

- **Watching the Earth:** Observations of the Earth from orbit help the study of large-scale, long-term changes in the environment. Studies in this field can increase understanding of the forests, oceans and mountains. The effects of volcanoes, ancient meteorite impacts, hurricanes and typhoons can be studied. In addition, changes to the Earth that are caused by the human race can be observed. The effects of air pollution, such as smog over cities; of deforestation, the cutting and burning of forests; and of water pollution, such as oil spills, are visible from space and can be captured in images that provide a global perspective unavailable from the ground.

- **Commercialization:** As part of the Commercialization of space research on the station, industries will participate in research by conducting experiments and studies aimed at developing new products and services. The results may benefit those on Earth not only by providing innovative new products as a result, but also by creating new jobs to make the products.

Assembly in Orbit

Assembly in orbit of the International Space Station began with the launch of the U.S.-owned, Russian-built Zarya control module on a Russian Proton Rocket Nov. 20, 1998, from the Baikonur Cosmodrome, Kazakstan. The launch of the Space Shuttle Endeavour



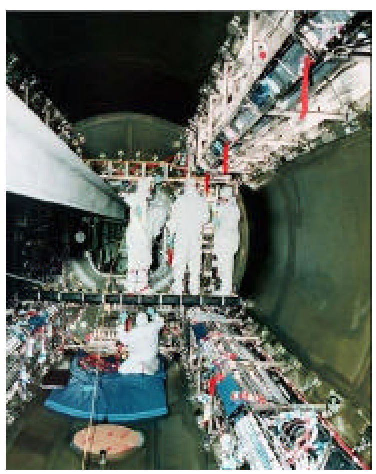
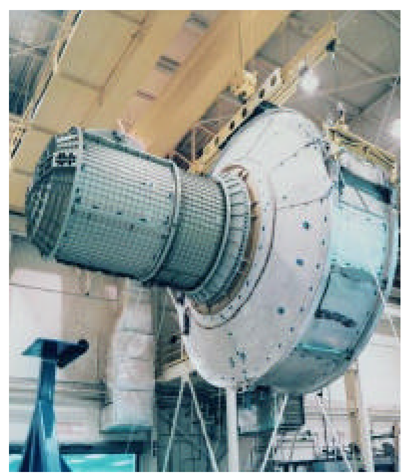
Astronauts Jerry Ross and Jim Newman performed three spacewalks on the first Shuttle assembly mission for the station to finalize connections between the first modules. About 160 spacewalks will be performed in total during the years of station assembly in orbit, turning space into an ever-changing construction site.

from the Kennedy Space Center, Fla., followed on Dec. 4, 1998, carrying the U.S.-built Unity connecting module. Endeavour's crew attached Unity and Zarya during a 12-day mission to begin the station's orbital construction. Discovery next docked with the new outpost in May 1999, with the crew unloading almost two tons of equipment to store aboard the station in preparation for the arrival of the first crew in March 2000.

The components required for the next five Space Shuttle missions to assemble the International Space Station are now undergoing pre-launch testing and preparations at Kennedy, and one more Shuttle is planned to visit the station in 1999. The first fully Russian contribution to the station, the Service Module, an early crew quarters, was shipped from its Moscow factory to the Russian launch site in Kazakstan in February 1999 and will be launched to the station in November 1999.

The orbital assembly of the International Space Station begins a new era of hands-on work in space, involving more spacewalks than ever before and a new generation of space robotics. About 160 U.S. and Russian spacewalks – totalling 960 clock hours -- will be required over five years to maintain and assemble the station. The Space Shuttle and two types of Russian launch vehicles will launch a total of 46 assembly missions – 37 by the Space Shuttle and nine by Russian rockets. Three assembly missions – one Russian launch and two Shuttle flights have been completed so far. In addition, Progress resupply missions and changeouts of Soyuz crew return spacecraft will be launched regularly.

The first crew to live aboard the International Space Station, commanded by U.S. astronaut Bill Shepherd and including Russian cosomonauts Yuri Gidzenko as Soyuz Commander and Sergei Krikalev as Flight Engineer, will be launched in March 2000 on a Russian Soyuz spacecraft. They, along with the crews of the next five assembly missions, are now in training. In all, over 100 different components will be joined together in orbit to construct the International Space Station. Assembly is planned to be finished in 2004.

U.S. components near complete, from left: truss section; interior of laboratory; airlock