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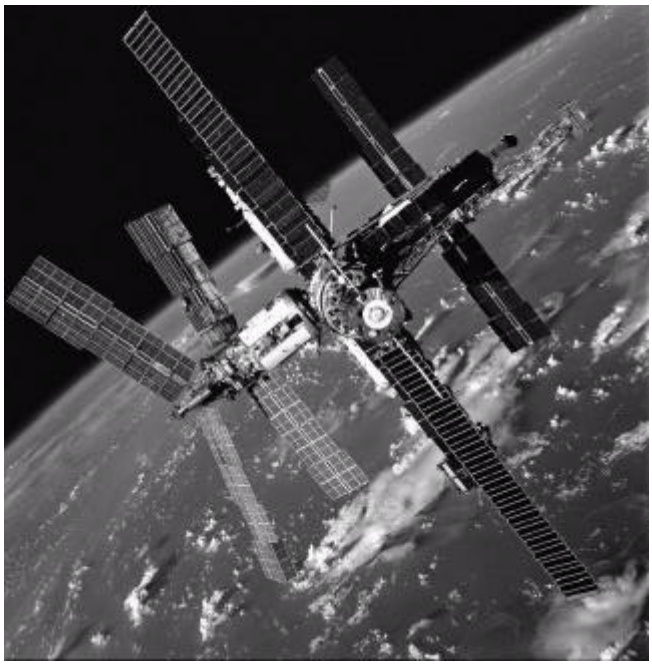
International Space Station **August 1998**

The International Space Station: Benefits from the Shuttle-Mir Program



Mir seen from shuttle Atlantis in October 1997

When construction of the International Space Station begins in the fall of 1998, it will be history's largest peacetime scientific and engineering project. Just as crucial hands-on experience during Projects Mercury and Gemini formed stepping stones to the first lunar landing, the Shuttle-Mir program is returning valuable lessons for extended stays on the high frontier. Those lessons already are proving valuable as NASA and 15 other nations prepare for a new era in space exploration aboard the international station.

One of the most important commodities of space flight is time in orbit. At the conclusion of astronaut David Wolf's stay in January 1998, the total U.S. astronaut time spent aboard Mir was 26 months -- with 22 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 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 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 operaton 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.

Hands-On Experience in an Unforgiving Environment

A primary goal of the Shuttle-Mir program was to give the United States valuable experience in operating a space station for long periods of time. Through Shuttle-Mir, NASA gained valuable experience in rendezvous and docking, spacewalks, and long-duration operation of large-scale systems. Studies on promoting human health and welfare in space have validated old concepts and established new ones. Specific design enhancements and modifications of the Space Station and other new knowledge based on Shuttle-Mir experience include:

- Having studied rendezvous and docking techniques with the Mir, NASA is placing additional lighting on the Space Station to enable use of the Shuttle's star trackers during proximity operations.

- The European proximity operations sensor proved the value of a new tool for sensing object distances, speeds and closure rates.

- Astronauts on Mir have demonstrated the reliability of a wireless communications system. Use of this system aboard the Space Station will save millions of dollars by reducing the need for additional data cables.

- Spacewalks from Mir verified designs for movable foot restraints and the equipment that will be used to transfer replacement hardware on the Space Station. Other lessons from Mir spacewalks resulted in additional modifications to hardware, tools and procedures for future spacewalks.

- A rack system designed to isolate experiments from jostling and other vibrations aboard the Space Station was validated aboard the Mir. This will help ensure useful results from much more ambitious microgravity experiments in the future.

- Experience with flights to the Mir allowed U.S. planners to refine techniques for transporting large amounts of equipment and supplies between docked spacecraft. To date, more than 12,000 pounds of hardware have been transferred from visiting Space Shuttles to the Mir.

- A study of contamination in the vicinity of the Mir due to fluid and waste purging led to changes in propellant venting planned for the Space Station.

- The U.S. approach to crew training and to the scheduling of crew members aboard the Space Station is being modified thanks to experience aboard the Mir, which has shown that training for Station crew members should emphasize generic skills rather than specific experiment-related tasks. This will allow the astronauts to better deal with a wide range of potential circumstances. NASA also observed that Russian timeline planners use a more flexible approach than their American counterparts -- certain aspects of this will be adopted for Space Station operations.

Results from Science Experiments

To date, approximately 120 investigations have been conducted aboard Mir, including those of leading scientists from the United States, Russia, Canada, France, Germany, Hungary and Japan. Many of these investigators have flown experiments on Shuttle and Spacelab missions, and in many cases their goal was to conduct similar experiments on Mir to compare the results from short-duration and long-duration space flights.

A central theme of science investigations aboard the Mir was the study of the crew members themselves and their responses to long periods in weightlessness. Researchers are able to better characterize human physiology and psychology in space, in particular, changes in bones and muscles, in the neurovestibular system, and changes in the interactions among crew members and their ground support teams during a long mission.

Highlights of the scientific investigations aboard the Mir included:

- NASA doctors have been able to study in much greater detail the countermeasures developed by the Russians over the past quarter century to minimize the effects of long-term weightlessness. These countermeasures appear to be effective.

- Learning from the Russians, U.S. researchers found that targeting specific muscles for exercise can help offset the long-term effects of weightlessness. Exercising the neck muscles, for example, is very important.

- Researchers found that the rate of bone loss on the Mir, a chronic problem for space explorers, does not lessen over time as previously thought. Astronauts average a ten-fold greater loss in the lower hips and spine per month than when living on Earth. This has helped focus researchers on developing specific countermeasures.

- On the Space Shuttle, a series of experiments has been conducted in growing tissue just as the human body does it. Due to the effects of gravity, this type of research cannot be done on Earth. With access to Mir, the tissue growth work was extended from 10 days to four months with the successful culturing of cartilage cells in a device known as the bioreactor. The cartilage cells grew into a three-dimensional spherical structure more like tissue would grow in a living organism. This research holds tremendous promise in the future aboard the International Space Station, and the value of long-duration growth was validated aboard the Mir.

- For the first time in history, a complete natural cycle of plant growth has been accomplished in space. Seeds harvested from plants grown aboard Mir were in turn germinated and produced new plants -- the first "seed-to-seed" experiment of the Space Age.

- Benefiting from increased time aloft and using new cutting-edge techniques, U.S. astronauts have dramatically increased the number of protein crystals grown in space -- 30 times more than using conventional techniques. The crystals form the basis for improved drug design for a wide variety of illnesses.