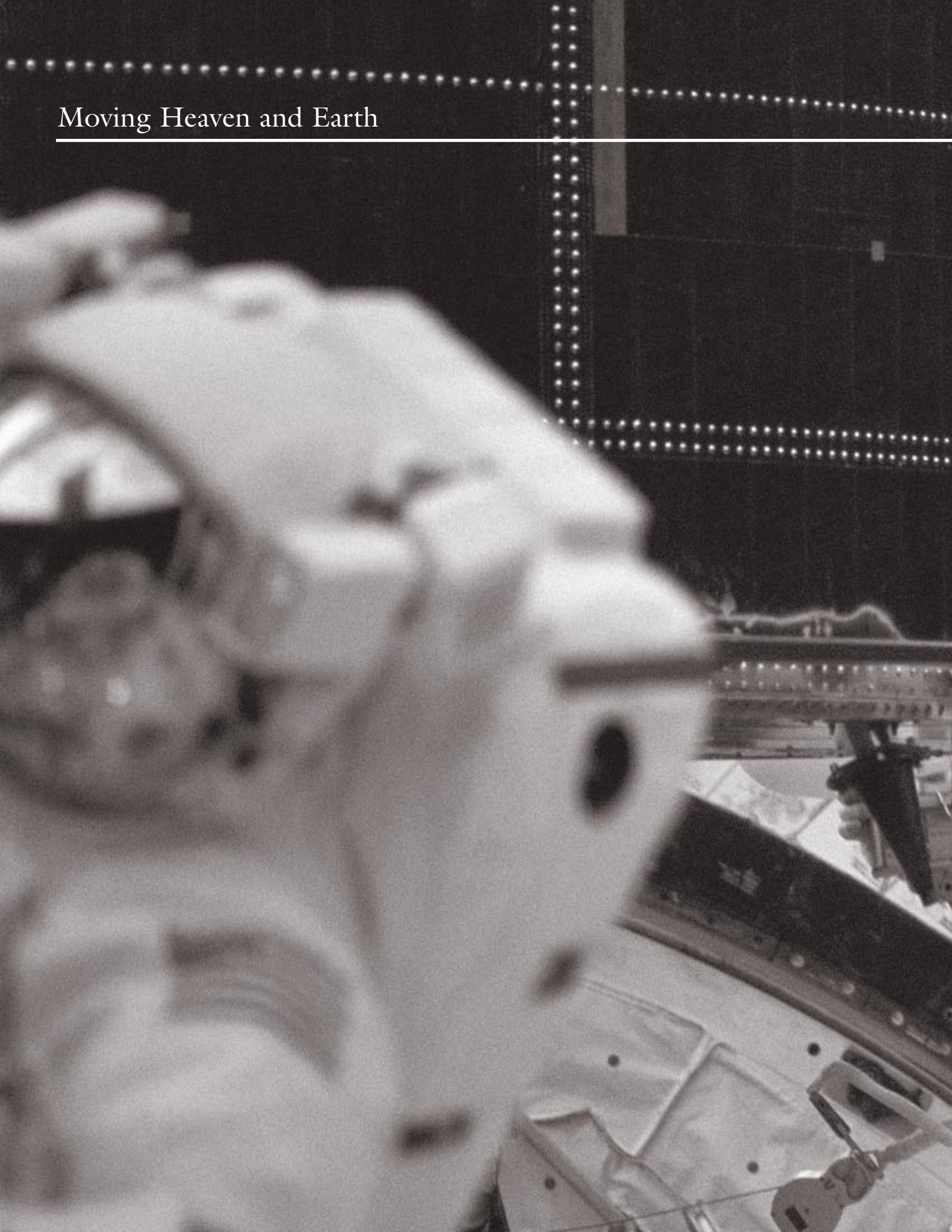
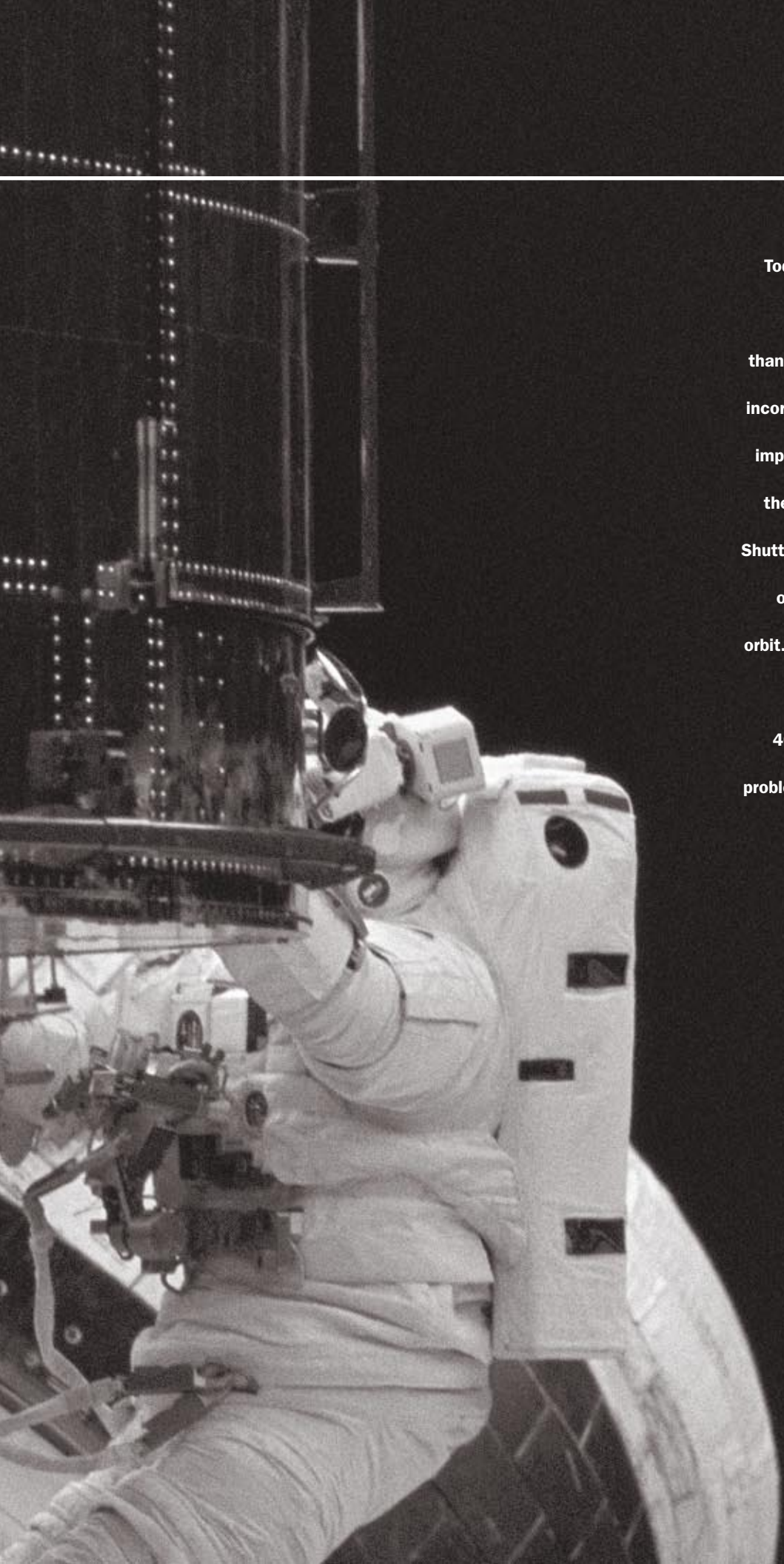
Moving Heaven and Earth





Today's Space Shuttle, is safer, more capable, and less expensive to fly than ever before, thanks to enhancements from new technologies incorporated into the original Shuttle design and improvements to the Shuttle's operation. Since the first flight of *Columbia* in 1981, the Space Shuttle has launched more than 2 million pounds of cargo and more than 500 passengers into orbit. As improvements to the vehicles continue, today's Shuttles are three times safer, cost 40 percent less to operate, have few in-flight problems, and have an additional 16,000 pounds of cargo capacity.

"That Shuttle is a fantastic, amazing, tremendous, reliable flying machine." Commander Eileen Collins

America's Space Shuttles undergo performance evaluations, testing, repairs, and improvements on a continuous basis, but this year included extensive upgrades. Early in the year, *Atlantis* returned to Florida after 130 modifications and improvements. The most apparent is the glass cockpit, similar to systems common in commercial airliners, which weighs less, uses less power, and has greater capabilities. All of the Space Shuttles will be upgraded with the glass cockpit, enabling future upgrades to a smart cockpit that will reduce pilot workload during normal flights and emergency situations.

The Space Shuttle remains the most advanced human spacecraft in the world. The Shuttles are the workhorses that will enable us to build and maintain the International Space Station, the foundation for future exploration beyond Earth's orbit.

Shuttle mission STS-88, launched from Kennedy Space Center on December 4, 1998, was the first of more than 35 planned Shuttle flights to assemble the Space Station. The Space Shuttle *Endeavour,* with a crew of five Americans and one Russian, carried the *Unity* module, a six-sided connector for future Station components. The crew rendezvoused with the orbiting *Zarya* module and, using the Shuttle's Canadian-built robotic arm, docked it to *Unity* on December 6, 1998. The crew finished the connections between the two spacecraft during three spacewalks. They entered the interior of *Unity* and *Zarya* to install communications equipment and complete other assembly work. The crew returned home after 12 days.

Discovery launched on May 27, 1999, and performed the first docking with the new Space Station on May 29. *Discovery*'s international crew included one Canadian, one Russian, and five Americans. The STS-96 crew delivered almost 2 tons of supplies and equipment for the Station, including clothing, laptop computers, water for the first resident station crew, and spare parts.

The crew also performed one spacewalk to install a U.S.-developed spacewalker's crane, the base of a Russian-developed crane, and other spacewalking tools on the Station's exterior for use by future Station assembly crews. *Discovery* fired its thrusters to reboost the Space Station's orbit, undocked, and then landed on June 6.

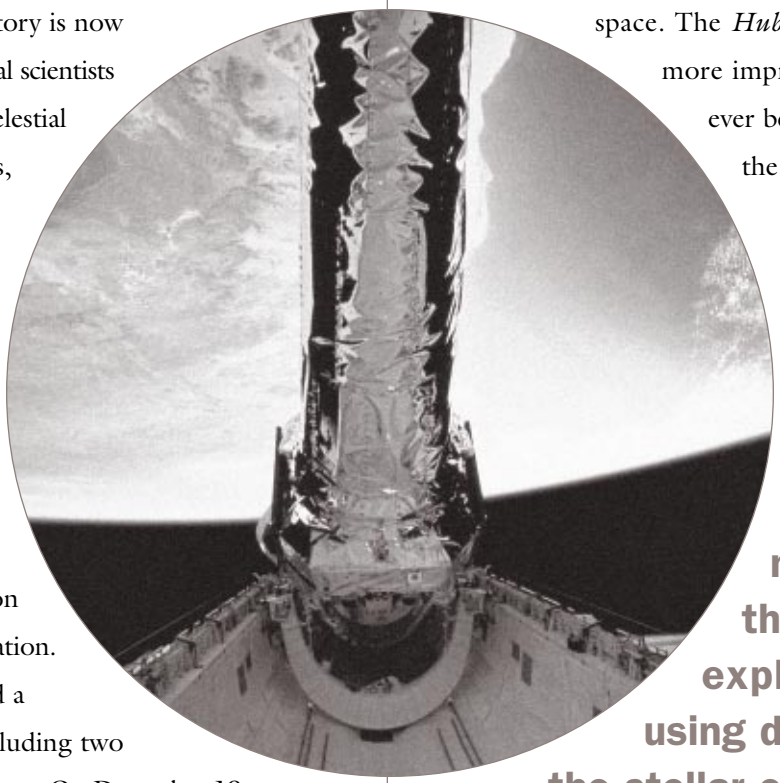
STS-93 First Female Commander
Col. Eileen Collins made news — and history — in 1999 as the first female Space Shuttle commander. Selected as an astronaut in 1990, she has logged more than 500 hours in space.

The STS-93 mission made news for several reasons: it launched NASA's third "Great Observatory," the *Chandra* X-ray Observatory; it was commanded by Eileen Collins, the first woman to command a Shuttle mission; and it carried the heaviest payload ever. This landmark mission was launched on July 22, 1999. Approximately 7 hours into the flight, the crew successfully deployed the *Chandra,* a 5-ton, 57-foot spacecraft, from *Columbia*. This advanced x-ray observatory is now enabling U.S. and international scientists to determine the nature of celestial objects, such as stars, quasars, exploding stars, and galactic collisions, and, in general, understand the history and evolution of the universe.

In December 1999, the STS-103 crew serviced the *Hubble* Space Telescope, upgrading its systems and extending its scientific mission into a second decade of operation. Commander Curt Brown led a crew of seven astronauts, including two from the European Space Agency. On December 19, 2 days into the flight, the crew reached the *Hubble* Space Telescope, which orbits at approximately 350 miles above the Earth, nearly the highest point attainable by the Shuttle. Brown flew *Discovery* in for a manual approach within 35 feet of the *Hubble* — just close enough to reach it with the robotic arm.

The crew replaced all six gyroscopes and a fine-guidance sensor and installed a much more advanced computer. They also installed a new transmitter, a solid-state recorder, and thermal insulation blankets on the "hot" side of the telescope.

After servicing and upgrading the *Hubble,* the crew put the telescope back into orbit and returned home to Florida for a safe landing after almost 8 days in space. The *Hubble* is now sending back more impressive observations than ever before to astronomers around the world.

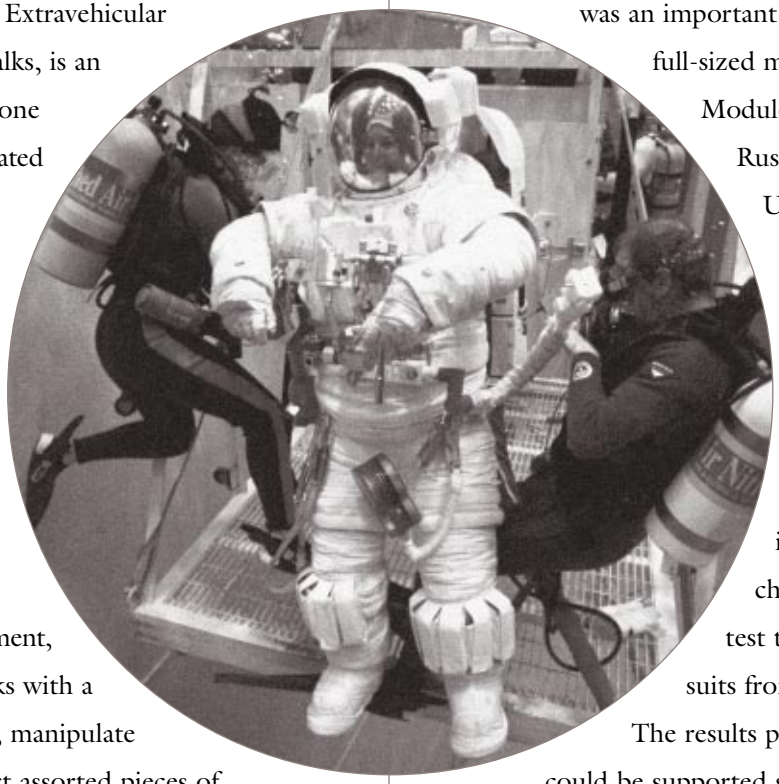


The *Chandra* X-ray Observatory is the third of NASA's "Great Observatories" now in orbit. The three observatories explore our universe using different parts of the stellar energy spectrum. *Hubble* Space Telescope detects light, *Chandra* X-ray Observatory detects x-rays, and the *Compton* Gamma Ray Observatory detects higher energy gamma rays.

***Chandra* X-ray Observatory**
The *Chandra*, the third of NASA's "Great Observatories," and the world's most powerful x-ray telescope, was deployed July 23, 1999, and continues to send us new information about the evolution of the universe.

Imagine doing construction work with an international crew, some 250 miles above the Earth, in the airless reaches of space, where conditions alternate between searing and freezing, while you're orbiting the Earth at 17,500 mph.

Astronauts made it look easy as they assembled the first components of the International Space Station, placed tools and equipment on board for use by future crews, and did the precise and delicate job of servicing the *Hubble* Space Telescope. But each of these Extravehicular Activities (EVAs), or spacewalks, is an entire mini-mission in itself, one that takes decades of accumulated knowledge and training, as well as ongoing research, development, preparation, and coordination. To perform spacewalks, the astronauts have to function within their own private "spaceships" — Extravehicular Maneuvering Units. In this unique environment, they have to do complex tasks with a variety of sophisticated tools, manipulate large equipment, and connect assorted pieces of space hardware.



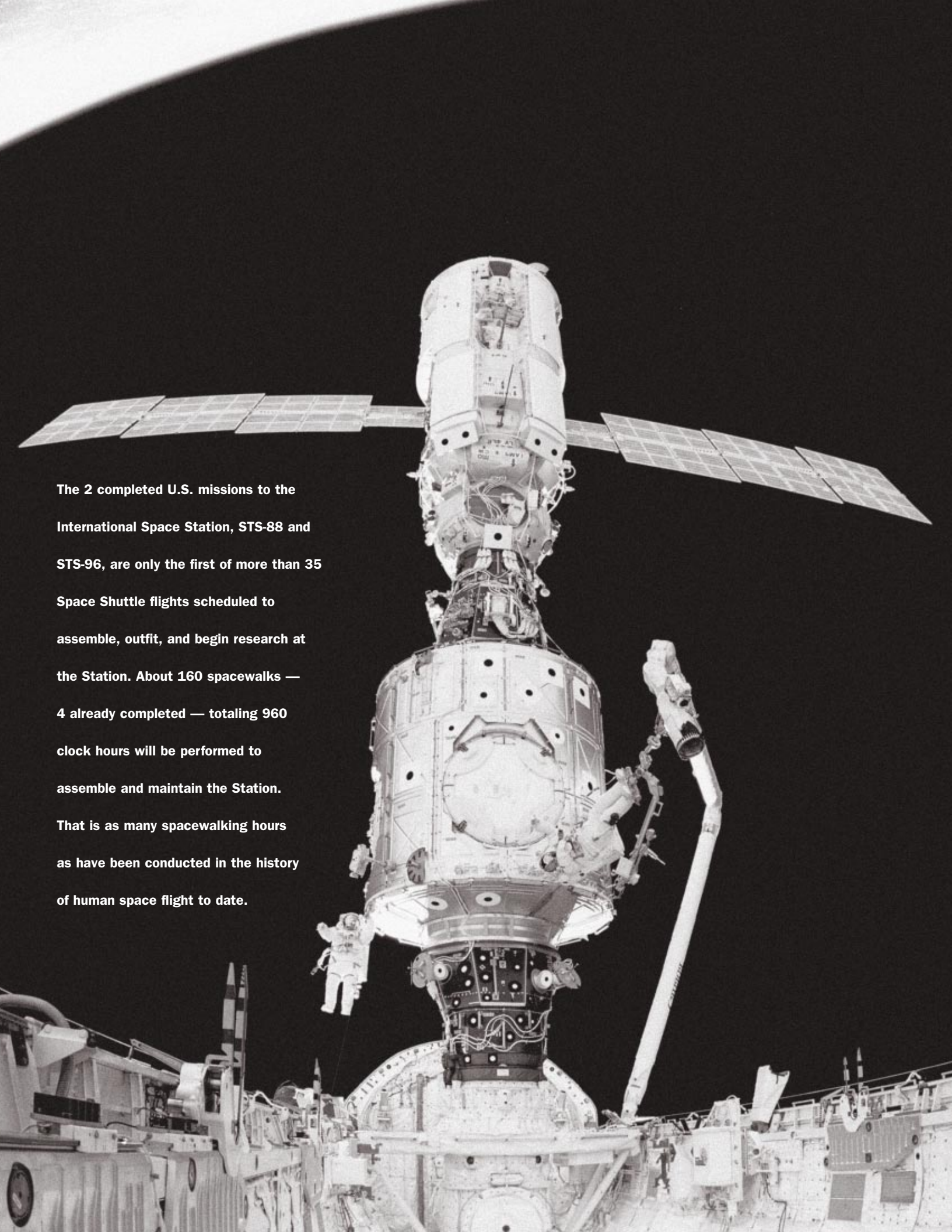
The EVA Project Office is NASA's focal point for spacewalks. EVA activities include those from the Space Shuttle, the Space Station, and other human-tended spacecraft, and perhaps for lunar and Mars surface operations.

Much of the training for U.S. and international spacewalkers takes place in the award-winning Neutral Buoyancy Lab at the Sonny Carter Training Facility. Training also takes place in the Russian equivalent, the Hydrolab, located at the Gagarin Cosmonaut Training Center in Star City.

This year, two important events took place that will allow us to expand our astronaut training capabilities in this area. After 2 years of cooperation, two U.S. spacesuits were successfully tested underwater at the Hydrolab, opening the door to additional U.S. crew training in Russia. This was an important development because a full-sized model of the ISS Service Module is now available only in Russia at the Hydrolab. Also, a U.S. spacesuit and a Russian Orlan spacesuit were tested together in the Space Station Airlock Test Article at JSC. It was the first time that a Russian spacesuit had been tested in an American vacuum chamber, and it was the first test that combined astronauts in suits from two different countries. The results proved that the two suits could be supported simultaneously by hardware components designed for the new Space Station's airlock.

JSC's Advanced Technology Spacesuit Project team is evaluating prototypes for the next generation of spacesuits. The new suits and life-support systems promise to be lighter, more mobile, and capable of being maintained and serviced in space by astronauts themselves.

Spacesuit Test Team
There's no such thing as being over prepared for a spacewalk. Many hours are spent in JSC's Neutral Buoyancy Lab training with such elements as the Extravehicular Maneuvering Unit.



The 2 completed U.S. missions to the International Space Station, STS-88 and STS-96, are only the first of more than 35 Space Shuttle flights scheduled to assemble, outfit, and begin research at the Station. About 160 spacewalks — 4 already completed — totaling 960 clock hours will be performed to assemble and maintain the Station. That is as many spacewalking hours as have been conducted in the history of human space flight to date.