

# One Last Ride to the Hubble

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Correction Appended

GREENBELT, Md. — It's the last roundup for the People's Telescope.

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Photographs by NASA

John Grunsfeld, top, one of the astronauts who will ride to the Hubble Space Telescope in August aboard the space shuttle Atlantis, practiced repairs on a model at the Johnson Space Center. The telescope, center, has been orbiting 350 miles above Earth since 1990, capturing images like the death of a star, shown below casting off its outer layers of gas.

Next August, after 20 years of hype, disappointment, blunders, triumphs and peerless glittering vistas of space and time, and four years after [NASA](#) decided to leave the Hubble Space Telescope to die in orbit, setting off public and Congressional outrage, a group of astronauts will ride to the telescope aboard the space shuttle Atlantis with wrenches in hand.

That, at least, is the plan.

“It’s been a roller coaster ride from hell,” Preston Burch, the space telescope’s project manager, said in his office here at the Goddard Space Flight Center of the controversy and uncertainty.

In a nearby building, the Hubble’s astronaut knights — dressed as if for surgery, in white gowns, hoods and masks — swarmed through a giant clean room to kick the tires, so to speak, of new instruments destined for the Hubble and to try out techniques and tools under the watchful eye of the Goddard engineers. They practiced sliding a new wide-field camera 3, suspended in air like a magician’s grand piano, in and out of its slot on a replica of the telescope that is mechanically and electrically exact down to the tape around the doors. “We have to train their minds and bodies,” said Michael Weiss, the deputy project manager of Hubble, adding that when the astronauts see the real telescope in orbit, “they say they’ve seen it before.”

Spacewalking astronauts have refurbished the Hubble four times in the last two decades; but the trip planned for August, almost everybody agrees, really will be the last service call. The shuttles are scheduled to stop flying in 2010, and without periodic maintenance, the telescope’s gyroscopes and batteries are expected die within about five years.

Astronauts, engineers and scientists here say they are resolved to pull off the most spectacular rejuvenation of the telescope yet, one, they say, that will leave it operating at the apex of its abilities well into the next decade so that it can go out in a blaze of glory.

“It will be a brand new telescope, practically,” said Matt Mountain, director of the Space Telescope Science Institute on the Johns Hopkins campus in Baltimore. He added, “We want to return crackerjack science we can be proud of.”

The last visit, Dr. Mountain explained, is unique. “You don’t have to do routine maintenance,” he said. “It’s like a car you’re only going to keep another 20,000 miles. You don’t buy new tires.”

Engineers and project managers are busy mapping out five days of spacewalks.

If all goes well — never a given 350 miles above Earth — the astronauts will install a new camera and spectrograph and change out all the gyroscopes that keep it properly pointed and the batteries that keep it running. They are also planning to repair a broken spectrograph and the Hubble’s workhorse, the Advanced Camera for Surveys, which had a severe short-circuit last winter and was pronounced at the time probably beyond repair.

Dramatic turnabouts have characterized the history of the Hubble telescope, which was hailed before its launching in April 1990 as the greatest advance in astronomy since Galileo invented the telescope.

In space, the Hubble would be able to discern details blurred by the turbulent murky atmosphere. But its 94-inch diameter mirror turned out to have been polished to the wrong shape, leaving it with what astronomers call a spherical aberration. The Hubble became branded as a “technoturkey.”

In 1993, astronauts fitted the telescope with corrective lenses (at the cost of removing one of its five main instruments, a photometer), and the cosmos snapped into razorlike focus.

Three more visits by astronauts kept the Hubble running and, by replacing old instruments, actually made it more powerful. Along the way, the astronauts graduated from yanking equipment fitted with large astronaut-friendly handles to operating on instruments never meant to be repaired by people wearing the equivalent of boxing gloves in space.

In 2002, after an infrared camera named Nicmos unexpectedly ran out of coolant, the astronauts attached a mechanical refrigerator to run coolant through its pipes. A year later, the Hubble's astronomers used the rejuvenated camera along with the advanced survey camera to record the deepest telescopic views ever obtained of the universe. The images captured galaxies as they existed a few hundred million years after the beginning of time.

“When you have an instrument that reaches so far beyond what you've ever had before, you make discoveries that nobody ever thought of before,” said John Grunsfeld, who will be the payload commander on the Atlantis mission. “And we see things that nobody ever saw before. As a result, you know, Hubble became not just an observatory, but an icon for all of science. And Hubble has become part of our culture.”

That status did not come cheaply.

Edward Weiler, director of the Goddard center and formerly associate administrator for science at NASA, estimated that over the years the Hubble had cost \$9 billion. “There are few people, especially Americans, who won't say it was worth it,” he said.

All this seemed doomed to a premature end after the shuttle Columbia disaster in 2003 that killed its crew of seven. [Sean O'Keefe](#), who was then the NASA administrator, declared that a shuttle flight to the telescope was too risky because, unlike the space station, it offered no safe haven if anything went wrong with the shuttle. The public was appalled. Schoolchildren even offered to send their pennies to NASA to keep the telescope going.

Some astronomers and engineers challenged the reasoning of Mr. O'Keefe, whose background was in public administration, and not engineering. Others in the space science community, noting that the science budget was being squeezed by President Bush's Moon-Mars initiative, suggested that it was time to move on and that the Hubble repair money might be better spent on other science projects.

“Everybody could see where he was coming from,” David Leckrone of Goddard, the Hubble's project scientist, said, referring to Mr. O'Keefe's distress about the Columbia and a mandate for increased emphasis on safety. But, he added, “It seemed so un-NASA-like. We would never have sent anybody to the Moon if we were so risk averse.”

“I thought we were dead,” Dr. Leckrone said. “As long as he was administrator, it stuck.”

In February 2005, however, Mr. O'Keefe resigned to become chancellor at Louisiana State University in Baton Rouge. His successor, Michael Griffin, who has a Ph.D. in aerospace engineering, instituted a rigorous risk analysis, culminating in a two-day meeting of experts that concluded it was no riskier to fly to the telescope than to go to the space station. In fall 2006, after the shuttles had begun flying again, Dr. Griffin approved the Hubble mission to a standing ovation from scientists and engineers.

“We all agree the risks are acceptable,” Dr. Leckrone said. “Griffin led us through that process with a good deal of intellectual vigor. He didn't fake it.”

As a backup, NASA will have the shuttle Endeavor, which is scheduled for a September mission to the space station, prepped for a quick launching if a rescue is needed.

In the meantime, engineers, challenged by Mr. O'Keefe to keep the Hubble going as long as possible, learned to run it on a kind of austerity program, using two gyroscopes to keep the telescope pointed instead of the usual three (one for each dimension in space). They also learned how to preserve the batteries, which derive power from solar panels in the sunlit part of each orbit and provide electricity in the dark part. As a result, the batteries, which degraded rapidly for years, are now actually slightly stronger than before, the engineers say, and the Hubble has a healthy gyroscope in reserve in case one fails.

“If it weren't for two-gyro science,” Mr. Weiss, the deputy project manager, said, “the next gyro failure would take us out of science.”

Besides Dr. Grunsfeld, who has been to Hubble twice, the crew includes Cmdr. Scott Altman, who led a Hubble mission in 2002; the pilot, Gregory Johnson; and the mission specialists, Andrew J. Feustel, Megan McArthur, Col. Mike T. Good and Michael J. Massimino, who also worked on the Hubble in 2002 and performed two spacewalks.

The new wide-field camera was designed to extend the Hubble's vision into the ultraviolet wavelengths characteristic of the hottest stars and into the longer infrared wavelengths characteristic of cool stars, complementing the abilities of the advanced survey camera. It will replace the wide-field planetary camera 2, which has been in the telescope since 1993 and has been its only visible-light camera for the last year.

When the old camera is slid out, perhaps as early as the first spacewalk, will be “a heart-stopping moment,” Dr. Mountain said.

Dr. Grunsfeld's crew will install another new instrument, the Cosmic Origins Spectrograph, into the slot now occupied by an old corrective optics package known as Costar that is no longer needed.

The instruments installed on the Hubble since the 1993 repair were built taking the mirror's aberration into account. The new spectrograph is also designed to be sensitive to invisible ultraviolet light. Astronomers hope to use it to map a so-called “cosmic web,” stretching through

intergalactic space, in which two-thirds of atoms in the universe are thought to be drifting and hiding.

Those tasks will be the easier parts.

One of the bigger challenges of the mission will be surgery on the Space Telescope Imaging Spectrograph, which can take pictures of things and break down their light to analyze their composition. The spectrograph had an electrical failure in 2004. To get inside the spectrograph, 111 screws that were never meant to be removed in space have to be unscrewed and kept from floating off. The plan is to clamp a plate over them beforehand and unscrew them through tiny holes.

No such option exists for the Advanced Camera, the choice for 70 percent of Hubble's prospective users and the chief dark-energy-hunting instrument on or off the planet. It suffered a huge short-circuit in its power supply last winter.

In a task that could be spread over two spacewalks, the astronauts will clamp a new power supply to the outside of the camera. From there, according to ground tests, power can be fed back inside to the other parts of the camera through existing wires, unless they were damaged in the short-circuit.

In one additional piece of business, the astronauts will attach a grapple fixture to the bottom of the telescope so that a robot spacecraft could grab it and attach a rocket module in the future. The rocket would then drop the telescope into the ocean.

But that time is not yet. The telescope's orbit will be stable through 2024, according to recent calculations.

All of this work could, in principle, be performed in the allotted five days of spacewalks. In that case, when the Atlantis pulls away and human eyes glimpse the Hubble for the last time in person, the telescope would have its full complement of instruments to dissect the light from the cosmos for the first time since 1993.

Running down a list of subjects like planets around other stars, dark energy and the structure of the universe, Dr. Leckrone called the telescope a toolkit for discovery. Noting that any astronomer in the world could propose to use it, he said: "A lot of brain power comes to Hubble. It's mouthwatering to think of what they will do with it."

Asked whether the astronomers were tempted to run the rejuvenated instrument frugally to prolong its life beyond its anticipated 2013 demise, Dr. Mountain said the idea was to go for broke.

"We don't want to trade science for false longevity," he said.

Correction: December 5, 2007

An article in Science Times yesterday about a repair mission to the Hubble Space Telescope misstated the year of a previous mission. Cmdr. Scott Altman and Michael J. Massimino were on a Hubble mission in 2002, not 2003.