by Bob Pickard

One Stellar Obse

Once considered the Rodney Dangerfield of space science, the Hubble Space Telescope is now a national treasure.

Orbiting 365 miles above Earth and carrying the largest scientific telescope put into space, the Hubble Space Telescope is the premier observatory in astronomy. Scientists around the world compete for a chance to use it, and NASA's Hubble web site gets 100,000 hits a day from people who want to see its latest color photos of exploded stars and newly discovered galaxies.

But until a few years ago, the space telescope was the target of jokes in everything from "The Tonight Show" to the movie "Naked Gun 2½." Weeks after its much-postponed launch in April 1990, the $3 billion observatory, once touted as the "eighth wonder of the world," was found to be flawed. The surface of its eight-foot primary mirror, the heart of the telescope, had been incorrectly ground. It was only two microns off – 1/50th the width of a human hair – but that was enough to prevent precise focusing of the light entering the bus-sized spacecraft.

NASA pointed out that even a handicapped Hubble was more powerful than other science satellites, but the press wasn't listening. The telescope that was supposed to peer to the edges of the universe and help discover its origins was now likened to the myopic Mr. Magoo. Headlines blared "Hubble Trouble," and the space telescope became a symbol of bureaucratic bungling.

The Hubble Space Telescope can see objects that are fainter and farther away than any other observatory. CSC's Mike Crenshaw has worked on two of the observatory's instruments.

It was a tough time for members of the Hubble program, including CSC, which joined the project in 1981 and provides support ranging from scheduling observations to developing Hubble's stunning photos.

Early on, CSC was tapped by the Association of Universities for Research in Astronomy (AURA) to help set up the Space Telescope Science Institute, based at Johns Hopkins University in Baltimore, which oversees Hubble's scientific operations for NASA. Today, about 200 CSC employees work on the program, ranging from engineers who keep the spacecraft flying to astronomers who use the telescope to conduct their own explorations.

For some CSC staff members who put in 80-hour weeks for two years preceding the launch, the mockery was especially hard to take. "It was devastating," recalls CSC scientist Olivia Lupie, a 13-year veteran of the program. "Thousands of us worked so hard for so long on Hubble, and our expectations were high. To hear stuff like 'Hubble trouble' was incredibly depressing."

For two years, thousands of Hubble project members scrambled to produce as much science as possible, rescheduling observations and using image-enhancing software to compensate for the flaw while waiting for a repair mission. "A lot of AURA and CSC people were heroes during that time," says AURA's Rodger Doxsey, director of science and engineering systems. "They kept things going and were getting good data even with the aberration."

Redemption finally came in December 1993, when shuttle astronauts conducted a flawless nine-day servicing mission, which required a record-breaking five six-hour spacewalks. They installed a new camera and an ingenious device that moved small mirrors into place to correct the flow of light to the instruments. The result? Cameras that once turned out blurry images now produce sharp, beautiful pictures of everything from the surface of Pluto to massive galaxies millions of light years away.

These days, Lupie and her co-workers are proud to work on Hubble. "The science it's doing is astonishing," she says. "It's working even better than it was designed to."

"We used to be Rodney Dangerfields of space science," says Ray Villard, public information manager for the Space Telescope Science Institute, "but Hubble has turned into one of those great American comeback stories."

Getting the Science

As AURA's major subcontractor, CSC is involved in every phase of carrying out observations on Hubble. That process begins with selecting which proposals will win time on the telescope.

There's fierce competition for it. "Astronomers ask for four times the amount of observing time we have available," says Doxsey. Each year, CSC assists several panels of world-class astronomers who review thousands of proposed observations that come from around the world. This year, 1,300 proposals were submitted, and the panels will approve 300-to-400 of them to run on Hubble in 1998.

Once the proposals have been selected, CSC plays a leading role in scheduling them on the telescope, an effort led by Wayne Kinzel. They create detailed timelines of each step the instruments and telescope should take during an observation. Efficiency is crucial. "We try to schedule observations to minimize telescope motion and the amount of time the spacecraft isn't doing anything," says CSC's Merle Reinhart, an 11-year Hubble veteran.

Operating around the clock, Hubble makes 15,000 to 18,000 observations a year. Scheduling has to balance many factors – the scientific demands of the observation, the

An Instrument Worthy of its Name

Named for American astronomer Edwin Hubble (1889-1953), whose discoveries of distant galaxies expanded our knowledge of the universe, the Hubble Space Telescope is the largest, most complex and most powerful observatory ever sent into space. Hubble proved the existence of other galaxies besides our own Milky Way, which greatly multiplied the known volume of the universe. He classified these new-found galaxies by their characteristics and measured their distance from the Earth. His groundbreaking research showed that the universe is expanding.

Big as a City Bus

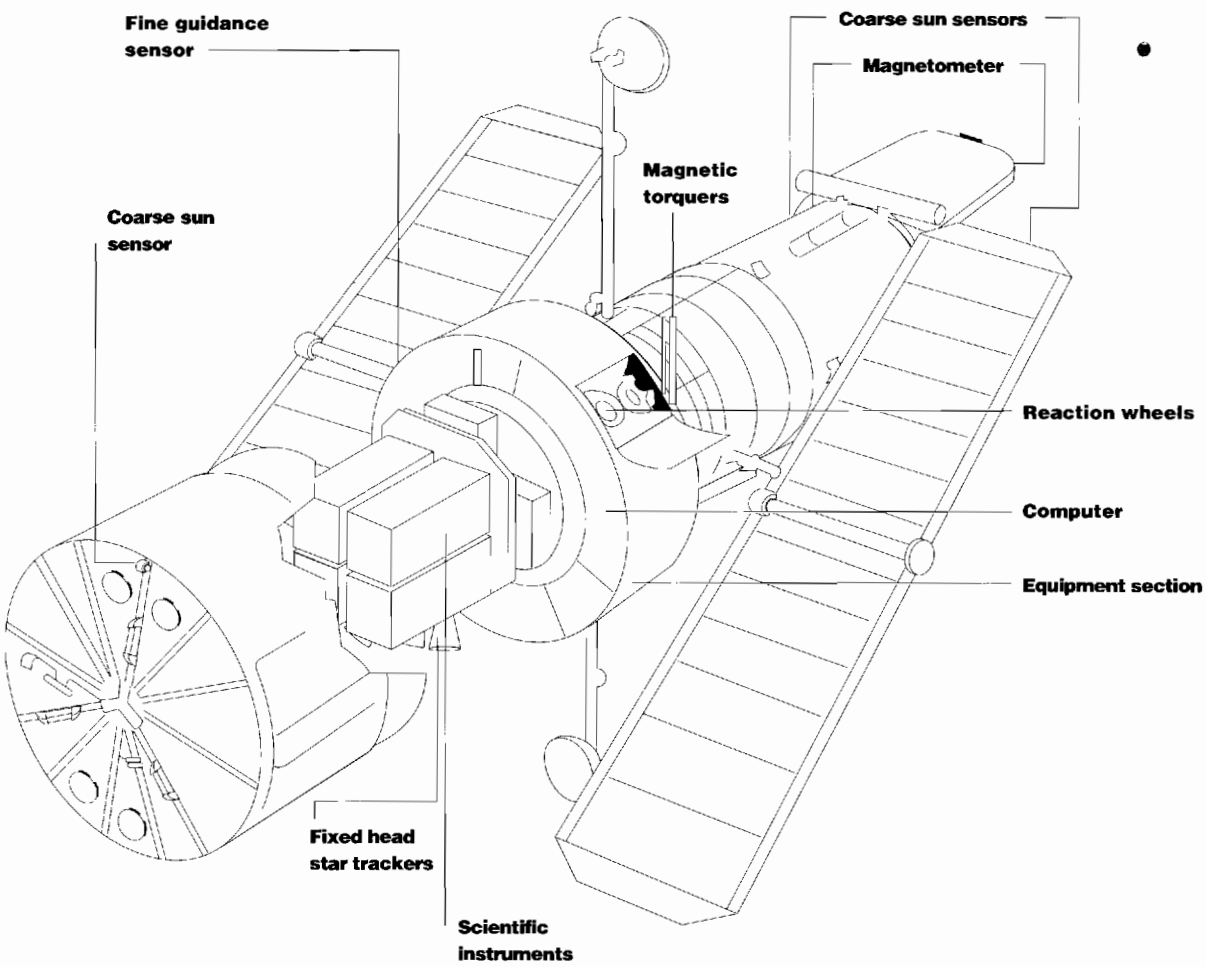
Roughly the size and shape of a railroad tank car, the space telescope is 43 feet long, 14 feet in diameter (not counting its two large solar panels) and weighs 12.5 tons. It's made of more than 400,000 parts and 26,000 miles of electrical wiring. Five phone booth-sized instruments sit at the rear of the tube-shaped craft to catch and analyze incoming light. They include two cameras, two spectrographs and a set of fine guidance sensors that pinpoint the position of stars in the sky to accurately aim the telescope. Directed by a stream of software commands from the ground, Hubble makes its observations and beams them back to Earth.

Extremely Light-Sensitive

Astronomy is a science based on collecting light and decoding its secrets, and Hubble is a great "light bucket." From its orbit 365 miles above the Earth, it doesn't have to look through the murky atmosphere, which obscures the view of ground-based telescopes. Hubble's resolution is 10 times greater than the best ground-based instruments, and its sensitivity to faint light is unprecedented. If the telescope were placed in Washington, D.C., it could see a firefly in Tokyo, halfway around the world. In fact, it could pick out two of them just 10 feet apart. Hubble could see a candle burning 10,000 miles away.

Peering Back into Time

Hubble is often called a time machine, because it can see things so much farther away – and therefore younger, since their light can take millions of years to get here – than other telescopes. The clarity and detail of its vision is blazing new paths in our understanding of the universe. Hubble's images of distant galaxies show what they looked like long ago and have proved that their shape and structure evolve over time. And it's measuring distances into deep space more precisely than ever. That will help determine the rate of expansion of the universe, which is a key to determining its age – a question that intrigued Edwin Hubble himself.



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capabilities of the instruments and natural constraints. For instance, Hubble can't point within 50 degrees of the sun, and the Earth blocks its view half of every 97-minute orbit. Each observation brings unique challenges. Some require just five minutes of viewing every 24 hours; others are longer, like the historic Hubble Deep Field observation where the telescope stared intently at a narrow strip of deep space for 10 days.

Scheduling is a complicated process that calls on several software systems, many of them developed, enhanced or maintained by CSC. For instance, a group of 13 programmers headed by Vicki Balzano writes programs that help translate astronomers' proposals into software instructions that Hubble's computers can understand. To keep Hubble precisely pointed at its celestial targets, guide stars are selected for every observation. They are chosen from a catalog of 15 million stars compiled by AURA and CSC.

Hubble is a valuable scientific resource with a limited lifespan, so operators strive to keep failed and postponed observations at a minimum. The pre-launch goal was for Hubble to make observations 35 percent of its time on orbit. The AURA-CSC team has increased it to more than 50 percent. That efficiency is paying off. Last July, Hubble made its 100,000th observation years before mission planners thought it would.

Once the scientific command load is created, it's blended with engineering commands that keep the spacecraft running smoothly. Those tens of thousands of commands are merged into a single load sent to Hubble every 48 hours using a system built by CSC at NASA's Goddard Space Flight Center. Goddard is also the site of a CSC engineering team headed by Betty Colhoun that monitors batteries, solar arrays, tape recorders and other machinery aboard Hubble.

"The science people bring down the pretty pictures," she says. "We keep Hubble operating." And they monitor operations to a very fine detail. One CSC-built engineering system has kept track of 1,300 engineering points since the 1990 launch and built a database that helps operators flag and then solve mechanical problems. When one of Hubble's fine guidance sensors malfunctioned, engineers used that database to analyze the sensor's workings right down to individual ball bearings.

After Hubble sends its scientific data back to Earth, the CSC staff handles the initial processing. They preview the data to check that the instruments are performing properly and to correct data errors. The data is stored in an archive, and when scientists need it, they use a software system developed by CSC and AURA to convert it to more familiar formats.

And those awesome photos? They're developed in a lab run by CSC's John Bedke, who has produced images from some of the world's best ground-based telescopes. "Hubble is by far the best telescope ever," he says. "We keep producing more and more interesting photographs from it. The source isn't drying up, it's growing."

Keeping it Flying

Hubble was designed to be serviced on orbit every few years, and the next mission is scheduled for February 1997. At that time, its two spectrographs will be removed and replaced with new instruments that will expand Hubble's view: a more powerful spectrograph, capable of picking out dim objects near brighter ones, which may produce the first images of a planet orbiting another star in our galaxy; and an infrared detector, which astronomers hope will let them peer through the clouds of interstellar dust that obscure the creation of stars, planets and galaxies from view.

Years of preparation go into each servicing mission. Each step must be rehearsed, and every contingency prepared for. CSC helps test the new instruments, run simulated

observations, prepare ground systems and schedule lengthy checkout procedures. "My group is already worrying about the 1999 service mission," says Vicki Balzano. "It's coming up pretty quickly."

CSC's Steve Kraemer plays a unique double role on Hubble's new spectrograph. On the technical side, he checks out its flight and operations software; on the science side, he'll use the instrument to observe the nuclei of galaxies 30 million light years away. Once the spectrograph is released from the shuttle, he'll conduct four months of intense testing on every part of the instrument. Then he'll don his astronomer's cap and begin his research. "It could be a once-in-a-lifetime experience," he says.

CSC plays a key role in another vital Hubble project called Vision 2000, where CSC and other NASA contractors are reengineering the ground systems and procedures to cut the costs of operating and maintaining the space telescope. CSC's Consulting & Systems Integration unit helped the Hubble team get started with a study of the ground systems' structure and processes.

The Hubble program is scheduled to end in 2005, but if the spacecraft is healthy and operating costs can be reduced, it might run longer. "Our goal is to cut costs and keep Hubble out of the Smithsonian as long as possible," says CSC's Bailey Spence, who oversees 50 CSCers and another 60 subcontractors working on the reengineering project. "We want to keep it flying."

That sense of pride in the mission runs throughout the CSC team on the Hubble project, many of whom worked through its bad old days. "I'm a tiny cog on a big wheel," says Olivia Lupie, "but I feel a part of history working here. All of us do." ■

Hubble Highlights

It has charted weather patterns and immense storms on Neptune, discovered a belt of hundreds of millions of comets encircling the solar system and confirmed black holes truly exist in space, not just in theory. "Hubble's rate of discovery is unprecedented," says Ray Villard of the Space Telescope Science Institute. "It has sent shock waves through the astronomy community." The space telescope has made more than 100,000 separate observations of 10,000 celestial objects. Almost midway through its 15-year design life, here are some of Hubble's highlights:

Jupiter Bombarded

In July 1994, Hubble captured the bombardment of 20 comet fragments smashing into Jupiter. The largest impact struck with a force estimated at 600 times the power of the world's entire nuclear arsenal. "You could see big mushroom clouds erupting from the surface," says CSC's Vicki Balzano, who helped plan the observations and watched some of them in real time.

Stretching the Universe

The Hubble Deep Field, 10 days of observations made during December 1995, provided the deepest, most detailed view of the universe ever taken. Staring at a speck of space about the size of a dime seen from 75 feet away, the Deep Field looked through that keyhole to the visible horizon of the universe. In that narrow view, Hubble uncovered at least 1,500 galaxies in various stages of evolution, including several hundred never seen before. Astronomers can infer the age, distance and composition of galaxies in this view to get clues to the evolution of the universe.

Getting to Know Pluto

In March 1996, Hubble took the first detailed images of the surface of Pluto since its discovery in 1930. The images will allow astronomers to map the frozen planet, two-thirds the size of our Moon, and monitor it for changes. Hubble's observations have taken Pluto from a fuzzy, distant dot of light to a complex planet with almost as much large-scale surface variation as the Earth.