Space Telescope Institute: Inside the Black Box

SOURCE: STSCI ILLUSTRATION: C. FABER SMITH

Astronomers using the Hubble Space Telescope miss out on some of the romance of traditional astronomy: the lonely nights on a mountaintop, adjusting and angling a big telescope to zero in on a suddenly interesting nebula or galaxy. Instead, they observe without leaving their offices. First, they fill out paperwork more complex than income tax forms and send it off; then they settle in for a wait of weeks or months; finally, they receive in the mail a tape bearing their data.

Between the astronomer and the instrument is a place that can appear as a black box: the Space Telescope Science Institute in Baltimore, Maryland. This 400-person operation, with an annual budget of $36.6 million, is where the proposals go and where the magnetic tapes originate. It's the gatekeeper for research on the Space Telescope, scheduling observations on as many as 100 projects a week, controlling the telescope, and turning the 0s and 1s it sends back to Earth into images, spectra, and other forms of astronomer-friendly data. It's also a focus of grumbling within the astronomy community.

It's bad enough that the telescope's primary mirror has a case of myopia, but astronomers are finding that the instrument's defects are not the only cause for complaint. Working through an intermediary can be disorienting. "Normally, observing is a craft," says Robert Kirshner of the Harvard-Smithsonian Astrophysical Observatory. "The way you learn is through trials," he says. You figure out what you did wrong and try again. "With the Space Telescope you don't get any trials," he says. If an observation goes wrong, an astronomer may have to wait months for a second chance.

Long waits may be inevitable, given the number of astronomers vying for time on the telescope. But tedious paperwork and bureaucracy, which Kirshner describes as operating at a "snail's pace," also make the institute slow to respond to observers' demands. Slowing the process still further, say some outsiders, is the fact that the researchers who helped design the telescope's five instruments get first crack at observing time, and the institute staff, many of whom are themselves astronomers, devote part of their time to their own observations. "It takes so long from proposal to observations," Kirshner says. "It may be sacrilegious to say so, but it's possible to lose interest."

Those comments outline some of the challenges facing the new director, Robert Williams, when he arrives in August to replace Riccardo Giacconi, who has left to head up the European Southern Observatory (see box). But whether Williams, the former director of the Cerro Tololo Inter-American Observatory in Chile, will be able to make the institute more open and responsive than his predecessor could is an open question. Institute employees say they have been distracted by software problems and the mechanical failings of the telescope. What's more, they say, bureaucracy and scheduling difficulties may simply come with the territory when you are running such a complex and oversubscribed instrument.

The institute's goal is to "get the best science out of the Hubble," says acting director Peter Stockman, who is filling in until Williams arrives. To do that the staff has to cram as many projects as possible into the schedule. More than 500 proposals come to the institute each year. After institute staff evaluate them for technical feasibility, they get a sort of peer review and are ranked from best to worst by an independent panel of astronomers known as the Time Advisory Committee. The winners—about 10% of the proposals—get another 150 pages of instructions and 15-20 pages of paperwork to fill out, requesting details about the instruments needed, filters, and exposure time. "It's like doing your taxes," says Harvard's Kirshner. "It's very painful." That's the nature of the beast, though, says astronomer James Westphal of the California Institute of Technology. The telescope "is more complex than any of us dreamed," he says. "It's like learning to use your VCR."

A packed schedule. When the projects for a given year have been approved, institute researchers assemble the elaborate jigsaw puzzle of a schedule. The schedule-makers use special computer programs to create schedules in 24-day chunks, says operations manager James Etchison. "We have to pack each week with as many projects as possible." They have to satisfy a variety of constraints, says institute scientist Rodger Doxsey, who develops scheduling software. First, he says, the telescope can't observe most objects for longer than about 45 minutes at a stretch because Earth keeps blocking the target as the telescope makes its 96-minute orbits. And each observation has to be timed so that the telescope never points too close to the sun, moon, or Earth, for fear of burning out the delicate instruments. To top it all, some observations can't be scheduled back to back, because the telescope's instruments can interfere with one another and because the telescope moves slower than a clock's minute hand when shifting to a new target.

Once all these conflicting demands have been weighed and the most efficient schedule developed, it is turned into instructions that go by cable to the National Aeronautics and Space Administration (NASA)-Goddard Space Flight Center in Greenbelt, Maryland, then bounced to the telescope via a satellite known as the Tracking and Data Relay Satellite System. Data from the telescope follow the same route in reverse. Within 48 hours, institute scientists calibrate the data and estimate errors. The processed data then go onto the tapes sent to the astronomers.

Astronomers can look on in the institute's control room as technicians monitor the telescope. But few actually do so, because it's an entirely passive role, says Westphal. "No one would dare let me sit by the console and say, 'Move the space telescope over here,'" he says. Even more discouraging for would-be kibitzers, a single observing program may get

divided up in the schedule so that it takes place in small bits over a period of weeks.

And if something goes wrong, there's little an astronomer can do anyway, says NASA-Goddard astronomer Steve Shore: The telescope is often too tightly scheduled to take another look. Shore says he is still smarting from his experience of jumping through all the paperwork hoops to get time on the telescope for his studies of the stellar explosions called novae, only to lose much of his time through a glitch that wasn't his fault. "They failed to find a guide-star," he says, which is needed to keep the telescope locked on its target. "I never got any explanation," he says.

Harvard's Kirshner, too, has suffered from the rigidity of the scheduling. For one project, he recalls, he had won approval to have the telescope make an observation every 120 days, but on the second cycle, the telescope wasn't working, and he got bumped out of the queue. "You would prefer them to just use day 115, or 125, but instead they throw it right out of the schedule." Now, he says, he's more careful in wording his proposals to include a margin of error. The institute's Doxsey responds that institute staff try to reschedule canceled observations within 2 months, but sometimes the carefully constructed schedule simply doesn't allow it.

Attention, please. To Kirshner and some other outside users of the telescope, however, the lack of flexibility in scheduling observations is symptomatic of a wider lack of individual attention from institute staff. Kirshner belongs to a group of astronomers known as the users' committee, which meets to discuss ways of avoiding such problems. One suggestion that has come out of those meetings, he says, is that the institute assign each outside observer a kind of caretaker and guide. "We need a person at the institute responsible not only for the bureaucratic paper maze but also the meaning of the observations," says Kirshner—someone who understands the ultimate goal of a project and makes sure the researchers get the data they need.

One reason that kind of attention is lacking so far, say outsiders, including NASA-Goddard's Shore, is that institute astronomers are entitled to spend half their time doing observations of their own. That system has its roots in 1976, when the National Academy of Sciences recommended that an independent institution run the space telescope research. The institute would get the best science possible from the telescope, the group said, if it were made up of active research astronomers—who could only be kept on board by giving them a chance to pursue their own astronomical interests. (Staffers do not, however, get priority on the telescope.)

But acting director Stockman says the real distraction has been a stream of technical glitches. As a case in point, he says, NASA originally supplied the institute with computer software for creating the schedules, but the program was so slow that it took more than 3 days to schedule a day of observations. "We would have ended up with a backlog," recalls Stockman. So the institute scientists had to create new, faster software. "If we could have served the users more instead of building systems that are missing," says Stockman.

STSCI

Ground control. Technicians monitor the telescope.

And then there's the deterioration of the telescope itself, adds institute scientist Bruce Gillespie. So far the solar panels, gyros, one of the fine guidance sensors that keep the telescope on target, and the electronic system that reorients the solar panels as the telescope moves have all suffered damage. And each new failure limits the telescope's range of targets, forcing institute staff to spend time rescheduling observations.

In 3 months, Robert Williams will inherit these frustrations—and more, says acting director Stockman. The Clinton Administration will almost certainly reduce NASA's budget. Then there's the anxiety of the repair mission planned for late this year. The current heavy demand for the telescope is a challenge for the institute staff, but it's what Williams considers a good problem. "A bad problem would be to have an expensive thing that doesn't work."

–Faye Flam

A New Director Promises to Focus on Service

When Robert Williams was in grade school, he became entranced with a photograph of Mars in a classroom magazine. He says he came back the next day with his magnifying glass to get a better look. It was a disappointment—nothing but graininess. Now Williams has gotten perhaps the best possible equipment for examining astronomical objects. After 6 years as director of the Cerro Tololo Inter-American Observatory in Chile, Williams has been appointed the next director of the Space Telescope Science Institute, where the instrument—in spite of its flawed mirror—is unmatched, but so are the potential pitfalls.

One source of uncertainty is the planned repair of the telescope's optics and other failed components at the end of this year. "In 9 months, I may have the project coming down around me in pieces," says Williams. But even if the repair goes well, Williams will face one of the biggest bureaucracies ever to surround a single scientific endeavor, a threat from NASA to cut the institute's budget by as much as 5% to 10% in the coming years, and a community of users clamoring for more attention (see main text).

That's a different set of demands from those that faced his predecessor, Riccardo Giacconi, who built up the institute from a shoebox to a 400-person operation and saw the project through the mirror debacle. Says veteran institute astronomer Barry Lasker: "Giacconi had a very clear sense of mission, which was important in the early years of the institute." Now, say staffers and outside users, the institute needs to cope with one consequence of that growth: a bureaucracy that, to some users, has become cumbersome and unresponsive. Williams says he'd like to do what he can to dispel that perception. "We should be basically a service organization," he says. "The institute exists primarily to help others get good science out of their projects."

To meet that goal, he says, "I plan to make sure the institute is extremely responsive to the user community." Williams' own style may help foster change. Says institute astronomer Marc Postman, "One criticism of Giacconi is that he was aloof with a good majority of the staff people. My impression with Bob is he's quite the opposite. At Cerro Tololo his door was always open and you could come in and chat with him."

But one thing Williams says he won't change is the opportunity for institute scientists to spend time on their own research. He even plans to try to squeeze in a little research on his own passion, the stellar explosions known as novae. That may be a stretch, considering the challenges Williams is facing. "The prospects are daunting," he admits, but "someone has to do it."

–F.F.