Personal Recollections of Institute and Hubble Pre-History

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My involvement with the no longer Large—but not yet Hubble—Space Telescope began in November 1979, when I was seconded to the corporate office of the Association of Universities for Research in Astronomy (AURA) from the Cerro Tololo Inter-American Observatory (CTIO) to help write our proposal to NASA to manage the Space Telescope Science Institute. I recall arriving at Dulles Airport, which had seemed near enough to Baltimore to a Tucson travel agent, with my family and no credit card, which meant no rental car and a $50 cab fare to the Homewood Campus of Johns Hopkins University (JHU). Fortunately, such an expense was covered!

I joined my senior CTIO colleague Barry Lasker, sharing an office in Rowland Hall. We interacted most intensively with JHU astronomers Art Davidsen and Bill Fastie, and I recall many work or social occasions with them. Now I'm the sole survivor of those four musketeers, so I had better write these memoirs before it is too late.

I rapidly lost my prior innocence of NASA proposing, faced with a voluminous Request for Proposals (RFP) outlining the requirements for several massive volumes in response, including scientific, technical, administrative, cost, and staffing plans, or some combinations of those and perhaps others.

Barry and I attacked the scientific proposal, with input from Art and Bill based on their considerable experience with NASA. Specifically, I wrote "Section 2.1, Science Management," expounding AURA's rationale for an excellent scientific staff at a national research center, namely that superior facilities and services for the community would arise naturally from the enlightened self-interest of a competent staff using the observatory for its own research. I had become convinced by this philosophy from my experiences at Kitt Peak and Cerro Tololo. Nevertheless, my closest experience to this writing activity was conjuring themes largely from thin air in freshman English. It was far from my subsequent writing of research reports and seemed rather surrealistic at first.

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A vignette from this period sticks in my memory. One day I encountered on a corridor bulletin board a *Baltimore Sun* article about a local optical genius, who was polishing the mirror for another JHU project in his home laboratory. There was a picture of his desk heaped with papers and materials, and a prominent sign proclaiming, "A neat desk is a sign of a sick mind!" So, I went back and stared at my neat desk for a while, feeling oppressed. Then, some time later, I heard that this person had applied the correction to the sphere with the wrong sign, and the top of the telescope had had to be sawed off so it could be focused. I thought that if his desk had been neater, perhaps that might not have happened, and I felt considerably better!

Prior to this proposal writing stage, AURA had selected JHU from among six universities vying to be the site of the Institute. In addition to its astronomers' experience in space projects, JHU offered the considerable expertise and resources of its Applied Physics Laboratory for the proposal effort. Also, AURA had selected Computer Sciences Corporation (CSC)—of International Ultraviolet Explorer fame—as an operations subcontractor. Thus, we had assembled a strong team with diverse and complementary experience.

Nevertheless, I wish I had $5 for every time during this period I heard, "You're wasting your time—it will obviously go to Princeton!" (I could at least treat myself to a fine meal at the Polo Grill.) That sentiment was not entirely unreasonable, Princeton being the home of Lyman Spitzer, the intellectual father of the Space Telescope, and of several others, such as John Bahcall, whose high levels of scientific and political expertise had initiated and then more than once rescued the project in Washington. There were said to be five competing proposals to manage the Institute, some of which named Princeton as the site.

Our proposal captain was John Teem, the AURA President, who came to Baltimore from his office in Tucson. I think John is the unsung hero of the AURA effort. He brought together the floundering administrative and logistical parts of the proposal, personally doing the cost and staffing plans—and landing in the hospital directly after the proposal due date. By the way, it is amusing to recall that our full staff plan for STScI contained a total of 160 people. Little did we or NASA know what lay ahead!

I took my family back to Chile for the holidays and then returned to Baltimore alone in January, promptly landing in bed with a severe flu no doubt brought on by the extreme climate changes. During this second period, we spent time at the CSC building in Silver Spring producing the final volumes. The firm proposal due date was March 31, 1980. And remember this: we were proposing toward a firm launch date of December 13, 1983! All intervening milestones were carefully laid out, including a NASA decision on the proposals six months after the due date. Slippages began almost immediately, and the decision was finally announced about a year after the deadline.

Rumors, rumors! In view of the delay, AURA decided to pre-select a Director and Deputy Director, who would then be in place already if AURA were the winner. Job announcements were duly posted. Back at CTIO, a northern visitor read these announcements on the bulletin board in La Serena, inferred from them that AURA had won, and then went up the mountain spreading the information without commenting on his source. Excited CTIO staff immediately called down to La Serena with the 'news' from the recent arrival!

Eventually, NASA announced that AURA was indeed the winner. I heard that one of the winning points of the AURA proposal was the Science Management section, which gave me a warm feeling, although I never received any personal comment about it.

Ironically, I was hired to the Institute scientific staff by Princeton astronomer Neta Bahcall, the original chief of the General Observer Support Branch, in January 1984. Those were lean years in space astronomy. I well recall the annual one-year-till-launch parties—suspended for two following the Challenger accident—and one wag's dictum, "The Space Telescope Science Institute: no space, no telescope, and no science!" But then we got 'bookend' additions to the Institute building and finally a launch.

Due either to a clerical error or to unexpectedly warm regard at high

levels of NASA for my efforts to resolve the numerous and vehement conflict complaints by the original Guaranteed Time Observers (GTOs), I received one of only four Institute invitations to fly down to the Hubble launch onboard a NASA airplane. However, since I wanted to take my family along, I flew commercial for the April 10, 1990, event. I was even able to get them into the VIP viewing area three miles from the launch pad. Then the excitement was abruptly replaced by the crushing disappointment of a scrub at T minus four minutes due to the failure of a redundant auxiliary power unit aboard the shuttle. This the family accurately perceived as the loss of a once-in-a-lifetime opportunity. I took up the NASA invitation for the second attempt on April 24, flying out of Andrews Air Force Base at 4 AM and directly into the Space Center before dawn, with the floodlit shuttle standing on the pad below, an awesome sight. This time the launch went off flawlessly—and I was back in my office by 2 PM the same day!

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Institute staff member Chris Burrows diagnosed spherical aberration just about two months later. I was on an extended trip to conferences in Bali and Sydney, still riding the euphoria of launch, when I first heard confused remarks about a 'problem' from participants at the second conference. Then I read incomprehensible reports of 'myopia' in the Australian press. Surrealism had returned. However, I recall one of those articles concluding prophetically, "The Americans will fix it—their national pride depends on it!"

Here is a brief account of the 'problem', in case you haven't heard it or don't remember the details. At the Perkin-Elmer Corporation, the reflective null corrector—an optical device used to test and monitor the primary mirror during polishing—had been incorrectly assembled because of a laser measurement error, resulting in a field lens being 1.2 mm out of position. During assembly, the screws designed to hold the lens were found to have the wrong length (because of the incorrect position), so washers were arbitrarily added to compensate! (Can you imagine adding unspecified macroscopic spacers to a precision optical device without investigating the reason they seemed to be needed?) Consequently, the primary mirror was exquisitely polished to the wrong figure to compensate the error in the corrector. The result was a 0.002 mm excess downturn at the edges of the mirror, producing a 40 mm difference between the focal points of its inner and outer parts—spherical aberration.

To add insult to injury, at least a half dozen independent indications of the error were uncovered by the subsequent investigation. In addition to the unheeded screw/washer warning, I recall a check with a less accurate refractive null corrector that detected the aberration, an inverse null test of the reflective corrector that showed it, records of excessive weight of material removed during the figuring, and a crude knife-edge or similar test that also showed the huge error. If such an array of correlated evidence were shown to any competent astronomer, there would be scorched earth all around. Incredibly, the technicians involved were evidently able to discount or conceal all of it.

The Hubble mirror was finished by 1980 and sat in storage until final assembly of the telescope, its horrendous flaw not to be discovered until it was in orbit, over a decade later. Ironically, you can read an article in the April 1990 *Physics Today* about the unprecedented perfection of the mirror, based, of course, on the circular reflective null corrector results. Some of the best astronomical optics experts in the world were involved in the oversight committees, including Bill Fastie, but none ever received a hint of the flaw from what they were shown.

I won't go into the mood in late summer and early fall 1990 at the Institute, in the astronomical community, and in the Congress which came within 0.002 mm of cutting Hubble off. (Interestingly, a lousy, aberrated image of one of my favorite objects, R136 in 30 Doradus, contributed to saving it for the moment!) Instead, let me move on to a small meeting of the Institute senior scientific staff in the Director's Office, at which I saw Hubble rescued before my very eyes. Holland Ford placed on the table a proposition that *we—the Institute*— should fix Hubble! (Holland was a Faint Object Spectrograph GTO with an intense desire to do his science. At that moment he exemplified the AURA rationale for a scientific staff described above.) Our taking the lead sounded like a crazy idea to my naive ears, but I saw Riccardo Giacconi's eyes light up instantly—and later Bob Brown's and Jim Crocker's. The contributions of those four people were essential to Hubble's rescue. Of course, WFPC2 was corrected independently by its team under John Trauger. However, the Institute's Corrective Optics Space Telescope Axial Replacement (COSTAR) brilliantly fixed the spectrographs and ESA's Faint Object Camera. Selected from among thirty solutions proposed by the Strategy Panel convened by the Institute, COSTAR used only standard Hubble refurbishment procedures and deployed independent, fail-safe optical correctors for each of the three instruments. Moreover, the incredibly stringent constraints on the optical prescriptions and positioning of the tiny corrective mirrors in both COSTAR and WFPC2 were met.

Thus, Hubble began to perform as designed following the successful installation of COSTAR and WFPC2 by the astronauts during the first servicing mission, in December 1993, exactly 10 years after the launch date addressed by the AURA proposal—remember? The rest is history. By now we are accustomed to Hubble consistently pushing the envelope of astronomical knowledge, but we should not forget the sobering lessons its pre-history could hold for the future. Ω