NGST: The Early Days of *JWST*

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Nearly thirty years ago Riccardo Giacconi, then the Institute Director, challenged Peter Stockman (Research Branch Head) and me (Deputy Director) to "think about the next major mission beyond *Hubble*." This was still several years before the launch of the *Hubble Space Telescope*, during the period after the *Challenger* accident when the future looked unclear. Riccardo was concerned that major missions take a very long time between inception and commissioning, longer typically than the then-expected 15-year life for *Hubble*. While I cannot remember the details of exactly when this took place, I can remember thinking that this was somewhat crazy given the work remaining on *Hubble*. But resisting Riccardo without well-formulated arguments was not likely to be successful—especially on this topic, given that Riccardo was one of the few people at that time to have done major space science missions.

Together with a very imaginative engineer, Pierre Bely, Peter and I took the challenge to grow the seed planted by Riccardo into a mission. Peter, Pierre, and I began to think about what might be a worthy scientific successor to *Hubble*. Fortunately, Pierre had already been working in 1986 on a game-changing approach for a large optical-IR telescope. This was passive cooling, which allowed structures shielded from solar heating to reach very low temperatures by radiating to space, thereby eliminating the huge thermal background. Angel, Cheng, and Wolff (1986) had also espoused a similar approach for a 16-m space telescope in their effort to find earth-like exoplanets. A paper led by Pierre (Bely et al. 1987) at the SPIE meeting in Los Angeles in January 1987 discussed a passively cooled 10-m telescope that would operate at ~130 K.

While the core of the group that led the development of the *Next Generation Space Telescope* (*NGST*) mission concept at that time was Pierre Bely, Peter Stockman and me, we were extremely lucky to have Riccardo's continuing support and encouragement, and an extraordinarily talented and imaginative group of engineers and scientists at the Institute—including James Crocker, Mark Rafal, and Chris Burrows—who worked with us on many aspects of the concept development.

Given the modest beginnings to this effort, it was striking that it rapidly gained in visibility and interest. I gave a talk at the 20th IAU in Baltimore in August of 1988 titled The Next Generation: An 8–16 m Space Telescope (Illingworth 1990). This talk discussed the progress on a concept for an 8-m filled-aperture, passively cooled, wide-band UV-Visible-IR telescope in high earth orbit and outlined its extraordinary science capabilities (e.g., distant galaxies; resolving nearby galaxies; earth-like planets). The 8–16-m telescope was endorsed in the 1988 study Space Science in the Twenty-First Century: Imperatives for the Decades 1995–2015 by the National Academies, and was one of the two long-term programs highlighted in the 1990 UV-Visible Management Operations Working Group Strategy Report.

The most important activity for the development of a mission concept, however, was a workshop that was held at STScI the following year, 13–15 September 1989. This workshop, organized as The Next Generation: A 10 m Class UV-Visible-IR Successor to *HST*, covered the scientific opportunities that would come from a cold, diffraction-limited UV-optical-IR 10-m space telescope, as well as the technological challenges that would arise for such an ambitious project. This workshop built on Pierre's 1987 paper and the work done by the group. Ed Weiler, the Chief of the Ultraviolet/Visible and Gravitational Astrophysics Division (and *Hubble* Program Scientist) at NASA HQ, agreed to support the workshop. We greatly appreciated Ed's support since the linkage with NASA was crucial in a development of this nature. A significant number of the participants were from NASA Centers (GSFC, JPL, MSFC), as well as from industry and NASA contractors, who also brought unique experience to the table. A collaboration with ESA, as was being done for *Hubble*, was also discussed. The scientific, technical, and political value of such international collaboration for very large projects was recognized (as noted in the "Sage Advice" by John Bahcall). The conference proceedings and discussion were published in 1990, edited by Bely, Burrows, and Illingworth, highlighting the joint sponsorship of NASA and STScI.

Just two months before the 1989 meeting, then President George H. W. Bush proposed a major lunar initiative. NASA asked us to include a potential lunar siting in the discussions. This was already of interest to some of the participants, and so we quickly put a 16-m lunar-based telescope into the baseline discussion. But for most participants the focus was on the 10-m *Next Generation Space Telescope*. The efforts on a lunar-based 16-m continued for a few years during President Bush's tenure, but died away in the early 1990s with the change of leadership and the financial challenges of the 1991–92 recession.

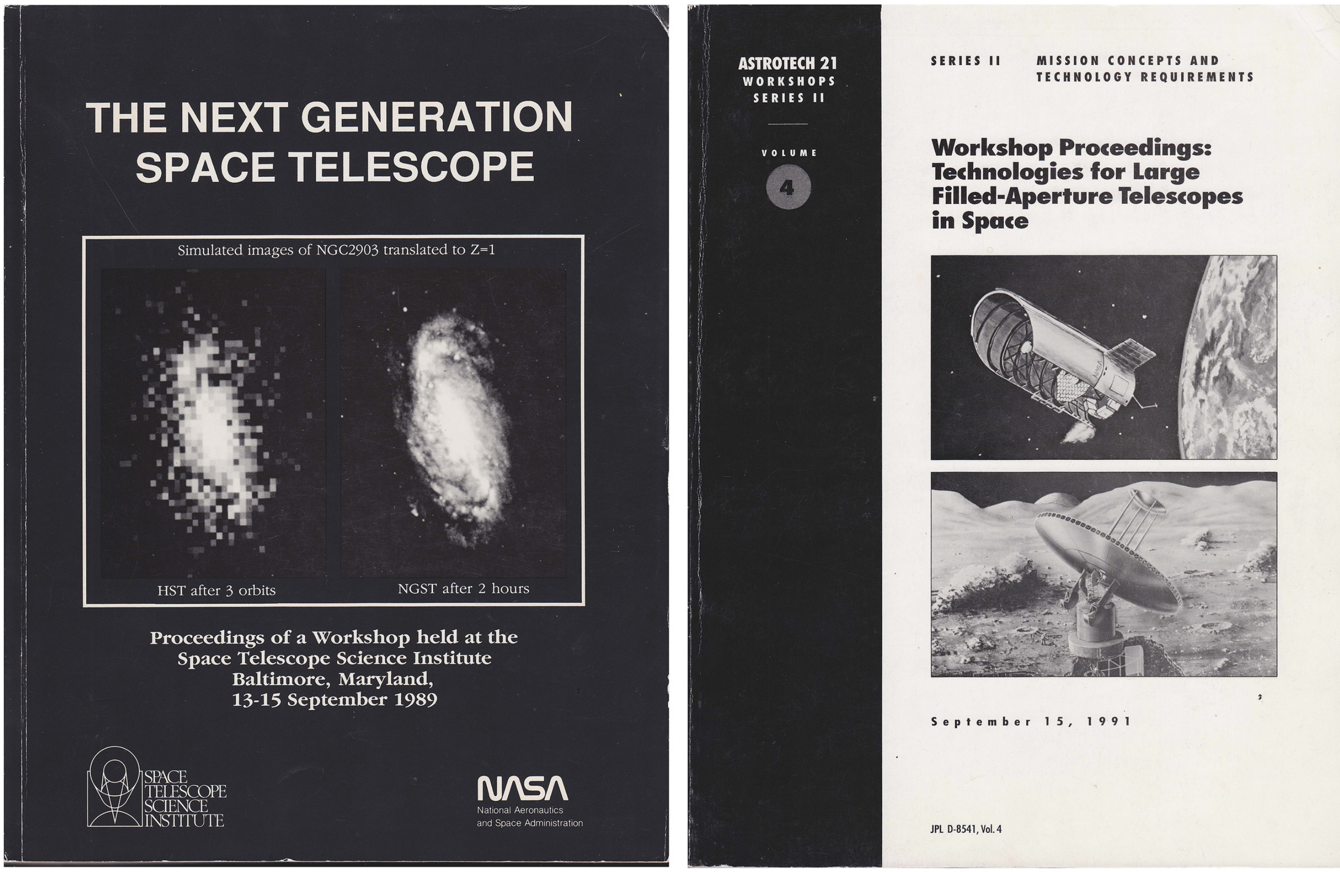

Figure 1: The *Next Generation Space Telescope* workshop in 1989 and the Astrotech 21 workshop in 1991. These, along with the work done for the UV-Optical in Space panel of the 1990 Decadal Survey, were some of the key activities in the early development of *NGST*.

A major step forward occurred with the UV-Optical in Space Panel of the 1990 Decadal Survey (led by John Bahcall). The Panel made a number of recommendations, of which one was for a 6-m cooled space telescope as a successor to *Hubble*. This was called the *Large Space Telescope* in the report. The Panel noted, “The scientific case for enhanced Observatory-class capability in the UV-IR region is overwhelming. The panel strongly recommends that a 6 m-class telescope be launched in the first decade of the next century.” It was essentially the 10-m *NGST* that had been discussed in the 1989 STScI workshop scaled to 6 m (anything less was only a modest gain over *Hubble* and gave low resolution in the mid-IR).

The *NGST* team developed an estimate of the cost. The UV-O-IR 6-m concept presented to the panel was costed at $2B in 1990 dollars with a project start in 1998 and launch in 2009. Given other goals, the full Decadal committee did not accept the Panel recommendation. It is interesting to compare the 1990 Decadal *NGST* cost estimate of $2B with the $1B cost estimate in the 2000 Decadal Survey. Inflating the 1990 $2B estimate to 2000 dollars gives $2.6B. As events have shown, this would have been a better starting cost estimate for *NGST* in the 2000 Decadal, but given the political environment at that time such a figure could well have killed *NGST*/*JWST* before it got started.

While the Decadal Panel recommended 6 m, this size was not carried forward in subsequent discussions. The size of the high-earth-orbit *NGST* mission concept settled down to around 8 m in the early 1990s as the “sweet spot” for this mission. The issue of cost also framed much of the developments and discussions about technology over the next few years. Illingworth (1991) enunciated some of the reasons why *NGST* was expected to cost less than expected from that predicted from the *Hubble* cost-curve (e.g., over 20 years of technological development; weight that was comparable to or less than *Hubble*).

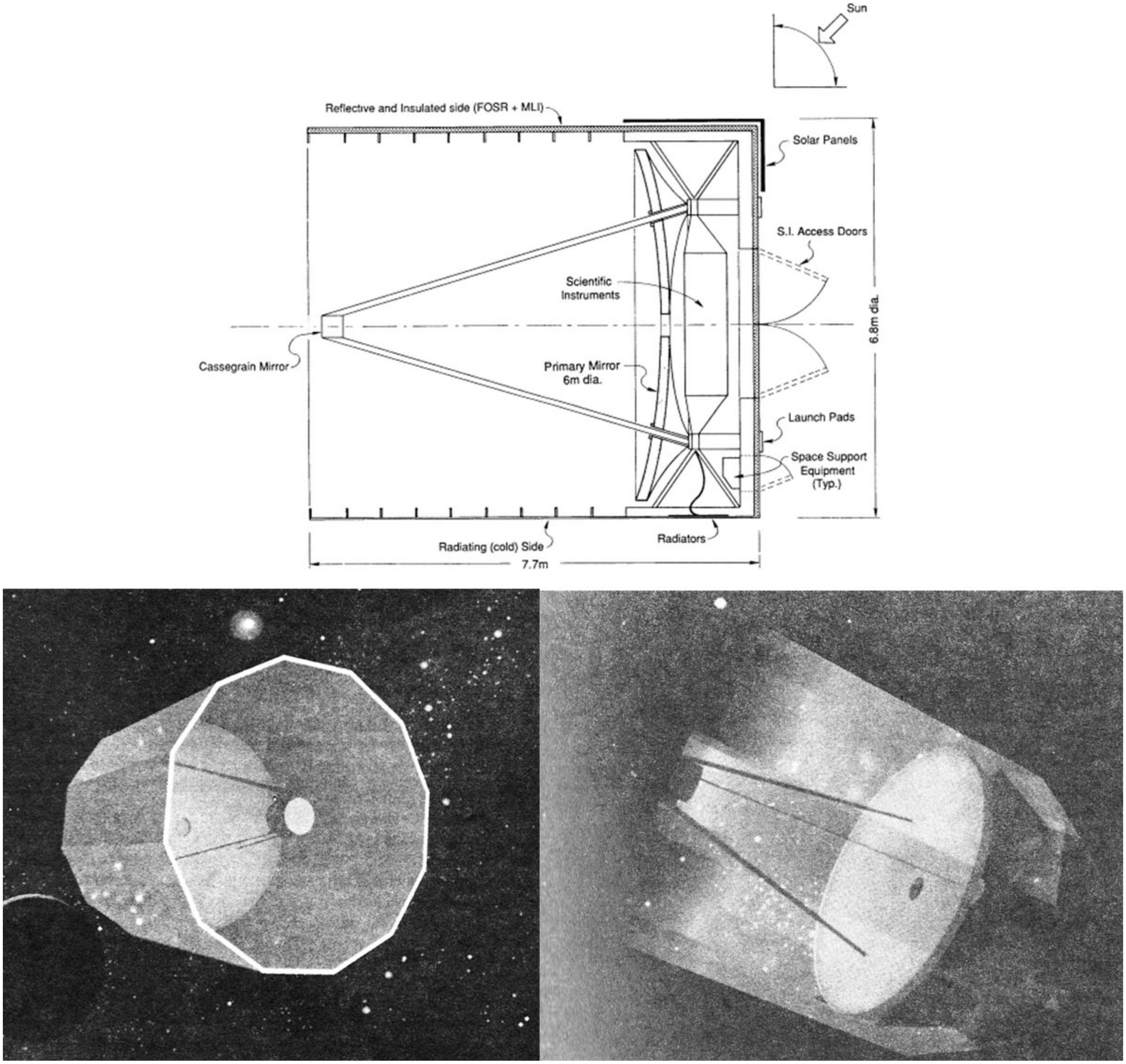

Figure 2: The *NGST* concept layout discussed by the UV-Optical in Space panel of the 1990 Decadal Survey, along with a couple of renditions. *JWST* looks very different from this early concept!

A key activity in 1989–1992 was the inclusion of *NGST* into the Astrotech 21 program that was implemented to identify needed technologies for future programs. This was a joint initiative from NASA HQ Astrophysics and the Advanced Technology program, with planning support from JPL. Key people in this initiative were Mike Kaplan, the Chief of the Advanced Programs Branch in Astrophysics at HQ, Max Nein at Marshall Space Flight Center, where many studies were carried out, and Jim Cutts, the Astrotech 21 manager at JPL.

There were a number of workshops organized under the Astrotech 21 program. The *NGST* workshop was organized by the Astrotech 21 office at JPL and was held in Pasadena March 4–5 1991 to develop recommendations and priorities for input to Astrotech 21. The mission concept workshops were designed to flow requirements down into workshops focused on needed technological capabilities. What was increasingly becoming clear was that *NGST*'s cold optics would become contaminated by outgassed material that would greatly impact the UV throughput. If *NGST* was to meet its IR objectives through cooling to 100 K or less, it would become extremely difficult to have UV capability (the challenges of building diffraction-limited optics in the UV were also a factor). The baseline for *NGST* became optical-IR. Around this time a concept that also used passive cooling, the 1.7-m Edison telescope, was proposed in Europe (but not selected, unfortunately).

A series of events then occurred that had a major impact on the funding and the development efforts for *NGST*—the recession of 1991–1992, *HST*'s problems with spherical aberration, and the change of Administration. Little was done on *NGST* for several years. It was not until 1995 and 1996 that *NGST* activities resumed. They did so vigorously. A key step was taken when Ed Weiler had an opportunity to fund a modest development effort on *NGST* starting in the early fall of 1995. Ed enlisted John Mather and Bernie Seery at GSFC to lead a small team to advance the *NGST* mission concept, with the support of John Campbell, the *HST* Project Director, as well as Peter Stockman and Pierre Bely. John Mather is with *JWST* still as the Senior Project Scientist. Eric Smith, the current *JWST* Program Director at NASA HQ, also joined the activity early in 1996. This development effort was a crucial step in reinvigorating *NGST*.

The report of the AURA *HST* and Beyond study (Dressler 1996) was also moving towards completion at that time. This committee had been formed late in 1993 by AURA with Alan Dressler as Chair to begin a broad study of possible future missions for UVOIR astronomy. This large committee had a broad remit. Its report was published in May of 1996 after 2.5 years of substantial effort on a complex and multi-faceted topic. One of their recommendations was that "NASA should develop a space observatory of aperture 4 m or larger, optimized for imaging and spectroscopy over the wavelength range 1–5 μm."

The endorsement of the *NGST* approach was appreciated, but those who had worked on *NGST* for many years saw the 4 m as a rather incremental step over the 2.4-m *Hubble*. Fortunately, in his talk at the January 1996 AAS meeting, then NASA Administrator Dan Goldin expanded the *HST* and Beyond recommendation to a larger telescope with "I see Alan Dressler here. All he wants is a four-meter optic that goes from a half micron to 20 microns. And I said to him, 'Why do you ask for such a modest thing? Why not go after six or seven meters?'" Subsequently, 8 m actually became Dan Goldin's preferred size for *NGST*.

NGST had entered a new era. With support from Ed Weiler, who was then the Origins Theme Director at NASA HQ, several concept studies were initiated, fortunately at the 6–8-m level. The publication of these studies into a single volume edited by Peter Stockman (Stockman 1997) marked a key step that set *NGST* on a path to a fully-fledged mission. The story of that time remains for a future article, but the NASA start occurred when the Office of Space Science AA Ed Weiler signed the Formulation Authorization on March 8, 1999, followed by the first-ranked recommendation for an 8-m *NGST* by the 2000 Decadal Survey committee. *NGST* was re-scaled to 6.5 m in early 2001, and the name changed from *NGST* to *JWST* in September 2002.

This is clearly a short vignette of a remarkable period when much was done that set *NGST* onto the path that led to *JWST*. An excellent and comprehensive discussion can be found in Chapter 2 of the 2007 workshop Astrophysics in the Next Decade (Smith & McCray 2009; including a detailed list of references). *NGST* arose from a team effort that involved numerous imaginative and enthusiastic scientists, engineers and managers from across NASA, industry and academia.[1]

Yet all such efforts begin somewhere—30 years ago it was the challenge that Riccardo Giacconi made to us (Peter, Pierre and me) at the Institute to “think about the next mission” that set *NGST* on a path to *JWST*, now just a couple of years away from launch.

References

Angel, J. R. P., Cheng, A. Y. S., & Woolf, N. J. 1986, Nature, 322, 341

Astrotech 21 Workshop Proceedings: Technologies for Large Filled-Aperture Telescopes in Space (JPI 1991)

Bely, P. Y., Bolton, J. F., Neeck, S. P., & Tulkoff, P. J. 1987, in Reflective Optics (Bellingham, WA: SPII p. 29

Bely, P. Y., Burrows, C. J., & Illingworth, G. J. (Eds.), *The Next Generation Space Telescope* (Baltimoı MD: STScI)

(*The*) *Decade of Discovery in Astronomy and Astrophysics, Working Papers:* Astronomy and Astrophysics Panel Reports, Astronomy and Astrophysics Survey Committee, Board on Physics anı Astronomy (National Research Council) 1991, page 72; **http://www.nap.edu/catalog/1635/working-papers-astronomy-and-astrophysics-panel-reports**

Dressler, A. (Ed.) 1996, *Exploration and the Search for Origins: A Vision for Ultraviolet-Optical-Infrared Space Astronomy; Report of the "*HST *& Beyond" Committee* (Washington, DC: AURA)

Illingworth, G. D. 1990, in *Proceedings of the 20th General Assembly* (Ed.) D. McNally (Kluwer Academic Publishers)

Illingworth, G. D. 1991, *Next-Generation Space Telescope: A Large UV-IR Successor to* HST (Proc

SPIE: 1494) p. 86

Smith, R. W. & McCray, W. P. 2009, "Beyond the Hubble Space Telescope: Early Development of the Next Generation Space Telescope" in *Astrophysics for the Next Decade* (Springer: 2009) p. 31

Stockman, P. (Ed.) 1997, *The Next Generation Space Telescope. Visiting a Time when Galaxies Were Young* (Baltimore, MD: STScI and Washington, DC: AURA)

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[1] Many of those involved are named here, but many could not be listed because of space limitations. I apologize for any omissions. The development of *NGST* will certainly be the subject of more extensive and thorough expositions in the future.