



# NASA HISTORY NEWS & NOTES

Volume 41, Number 2

Summer 2024

## X·RAY VISION

### THE CHANDRA X-RAY OBSERVATORY'S 25 YEARS IN SPACE

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➤ This image of Eta Carinae, a volatile system containing two massive stars that closely orbit each other, has three types of light: optical data from Hubble (appearing as white), ultraviolet from Hubble (appearing as cyan), and x rays from Chandra (appearing as purple emission). The previous eruptions of this star have resulted in a ring of hot, x-ray-emitting gas about 2.3 light-years in diameter surrounding these two stars. (Credit: x ray: NASA/Chandra X-ray Center; ultraviolet/optical: NASA/Space Telescope Science Institute; combined image: NASA/European Space Agency/N. Smith [University of Arizona], J. Morse [BoldlyGo Institute] and A. Pagan)



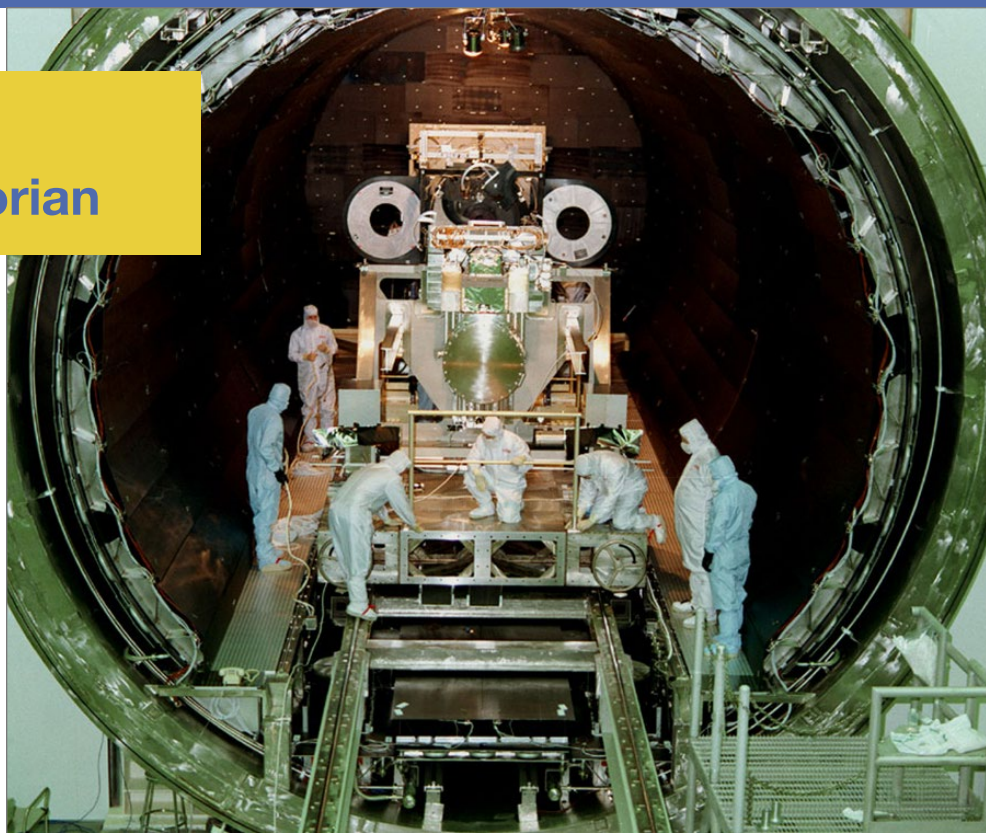


## From the Chief Historian

**WHEN I BEGAN** working in the NASA Marshall Space Flight Center's history office, I expected the research to be dominated largely by investigation of the Saturn V, Space Shuttle, and various other propulsion projects. Apollo and Shuttle certainly occupied a prominent position at the center. The surrounding community in Huntsville reflected as much, with “big propulsion” represented everywhere you looked.

But diving just beneath the surface of this history revealed something else of significance—the world of high-energy astronomy. It turns out that while some science had been there from the beginning, high-energy astronomy was an intentional development sought in the austerity of post-Apollo planning. Serving as the lead center for Skylab's Apollo Telescope Mount had brought Marshall scientists, engineers, and managers into contact with scientists around the country. And as solar physics was a primary emphasis for Skylab, high-energy studies became the dominant focus.

Work on Skylab created a team dynamic between Marshall engineers and scientists that hadn't existed during the heady years of Apollo. Bill Snoddy of Marshall's Space Sciences Laboratory noted that it was during this work that engineers began to see cultivating a positive relationship with



↑ In March 1997, the Chandra X-ray Observatory's High Resolution Camera was integrated with the High Resolution Mirror Assembly in the 24-foot vacuum chamber at NASA's Marshall Space Flight Center's X-ray and Cryogenic Facility. (Photo credit: NASA)

center scientists in a new light. Snoddy pointed out that it was then that those engineers stopped referring to them as the “hobby shop” and started to think of them as a useful conduit to the larger scientific community.<sup>1</sup>

As I found out when reading through the pages of the Marshall history *Power to Explore*, the trick came when center leadership leveraged those connections into a sustainable portfolio of new work. A new organization known as the Program Development Directorate emerged and was charged with developing new ideas into work. During the 1970s, that work encompassed a wide range of programs, including the Laser Geodynamic Satellite and Gravity Probes A and B. But it was in high-energy astronomy that these lessons really began to pay dividends.

Work for the three High Energy Astronomy Observatories (HEAO) missions cemented this new direction with a core focus on cosmic rays, x rays, and gamma rays. Long-time employees like Ernst Stuhlinger, Fred Speer, and Thomas Parnell worked to link Marshall with science coalitions from the Massachusetts Institute of Technology, the Harvard-Smithsonian Center for Astrophysics, the Naval Research Laboratory, and others, and to bring in new blood like Martin Weisskopf and Jerry Fishman to work on upcoming programs. Marshall also developed new facilities, including the X-ray Calibration Facility for development and testing.<sup>2</sup> Management proved prescient when new personnel, links with scientists of the caliber of Riccardo Giacconi and Harvey Tannenbaum, and center capability

From the Chief Historian (continued)

secured Marshall a leadership role in developing what became the Chandra X-ray Observatory.

As I went about this research, reading back from Chandra to Apollo, many key points began to stand out. First, the evolution of Marshall into a center of excellence in high-energy astronomy did not happen by accident. Individuals from the top to the bottom of the center worked with remarkable skill and determination to secure these new programs. Second, a major sustained part of the effort involved the creation of a vibrant interface between scientists at Marshall and the larger scientific community. While work on the Hubble Space Telescope provided a wealth of valuable lessons, it was in the field of high-energy astronomy that these connections became more central to securing and sustaining work.

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Finally, I learned that the most crucial relationship had been among center engineers, scientists, and managers. Lessons learned by engineers on one program bore fruit as those lessons were transmitted to new ones. Engineers and managers coming fresh from work on Hubble, including Fred Wojtalik, Jean Olivier, and Keith Hefner, brought to the Chandra program significant insights about what had gone right (and wrong) on that program. These insights, combined with the clean



↑ Marshall's Dr. Gerald Fishman, a principal investigator of the Compton Gamma-Ray Observatory's instrument, the Burst and Transient Source Experiment, and Dr. Chryssa Kouveliotou of Universities Space Research Associates review data in 1996. (Photo credit: NASA)

interface with the science community, made and continue to make Chandra a success by any metric.

Since I started this research, something else important happened. That high-energy workforce became much more inclusive. Martin Weisskopf and others mentored a new, diverse generation of experimental astrophysicists. Marshall's National Space Science and Technology Center includes women in many key positions. Several have become leaders in the field themselves, including Jessica Gaskin, manager of the X-ray Astronomy Group at Marshall.

The marking of 25 years of breakthrough science by the Chandra X-ray Observatory offers a unique opportunity to reflect on why this has been the case. Individuals, working in real time, made key decisions, took audacious moves, and contributed their subject

matter expertise to bear on an organization that recognized and rewarded their intellect, hard work, and daring. The result has been amazing breakthroughs that have redefined our understanding of the universe. Take a bow, Chandra team—you've earned it! ■

**Brian C. Odom**  
Chief Historian

#### Endnotes

- 1 Andrew J. Dunar and Stephen P. Waring, *Power to Explore: A History of Marshall Space Flight Center, 1960–1990* (Washington, DC: NASA SP-4313, 1999), pp. 233–234.
- 2 Dunar and Waring, *Power to Explore*, pp. 241–249.

# Martin Weisskopf's Lessons Learned from Chandra

» By Jennifer Ross-Nazzal,  
NASA Historian

**I**N 1999, the five crewmembers aboard the Space Shuttle Columbia deployed the Chandra X-ray Observatory. Chandra was one of four Great Observatories launched by NASA between 1990 and 2003, and its development, design, testing, and restructuring offer important lessons learned for scientists, engineers, and managers working on similar projects. Chandra succeeded because the people involved built upon earlier scientific programs, including the High Energy Astronomy Observatory (HEAO). Additionally, the team proactively managed risk and developed what Chandra Program Manager Keith Hefner called a “high-performance culture” that “fully integrated” the scientific community.<sup>1</sup> This effort was so successful that Chandra Project Scientist Martin Weisskopf called the telescope “an outstanding example of the power of the science-driven approach.”<sup>2</sup> Weisskopf’s career exemplifies the importance of Chandra’s inclusive strategy as well as the value of teamwork, mutual respect, friendship, and understanding that led to a mission that came in at cost and on schedule.<sup>3</sup>

» Dr. Martin Weisskopf,  
Chandra project scientist.



Weisskopf came to NASA’s Marshall Space Flight Center (MSFC) from the Columbia Astrophysics Laboratory in New York. He accepted a position with Columbia in 1969, and his first few days there were memorable. Only a few days after he arrived, demonstrators tried to take over the Pupin Building, which was home to the departments of physics and astronomy. Protesters were upset that university scientists were working with a military think tank. He and other faculty members spent many hours listening to their concerns and tried to dissuade them from taking over the building.<sup>4</sup>

Around that same time, Rob Novick, then co-director of the Astrophysics Lab, and his colleagues learned that the rocket

containing their x-ray concentrator had blown up during liftoff. Weisskopf, who had only recently arrived, recalled that the event “taught me (and the rest of us) an important lesson that influenced my approach to interacting with NASA and especially my approach to Chandra.” He came to realize that the scientists “hadn’t paid enough attention to...the entire system. When the rocket failed,” he concluded, it was the “scientists [who] paid the biggest price.”<sup>5</sup> They lost the opportunity to conduct vital cosmological research. Over the years, that failure stuck with Weisskopf, and when he started working on Chandra, he was determined not to be so focused on the scientific objectives that he lost sight of other items that could result in mission failure.

Martin Weisskopf's Lessons Learned from Chandra (continued)

**Over the years, that failure stuck with Weisskopf, and when he started working on Chandra, he was determined not to be so focused on the scientific objectives that he lost sight of other items that could result in mission failure.**

In the early 1970s, NASA began launching its first x-ray satellites into orbit and planned to send the larger HEAO missions later that decade, but instead canceled the program without warning, leaving astronomers in shock. A much less ambitious HEAO Program reappeared rather quickly, but Weisskopf believed that endeavor “did not completely encompass the best science.” (Budgetary cuts resulted in the brief cancellation.) Politics, he believed, tended “to place science second in lieu of an assumed expediency.” Nonetheless, witnessing the program’s cancellation and resurrection was invaluable, because Weisskopf came to recognize the impact such decisions could have on the state of x-ray astronomy. “Can you imagine,” he asked, what the progression of the field might have been if “the original HEAO series had been performed in the 1970s?”<sup>6</sup>

NASA launched the first HEAO satellite, HEAO-1, in 1977, and the following year sent the second, known as HEAO-2, into orbit. Named in

honor of Albert Einstein, HEAO-2 (the Einstein Observatory) had an “astounding impact on astronomy and astrophysics.”<sup>7</sup> The observatory was more than a thousand times more sensitive than the Uhuru X-ray Explorer Satellite, which surveyed the skies for x-ray sources from 1970 to 1973.<sup>8</sup> After more than five thousand observations during the mission, researchers learned that comets and quasars emit x rays and are x-ray sources. Perhaps most importantly, the Einstein Observatory “firmly established the place of X-ray observations alongside those in the topical and radio [fields of astronomy].” X-ray astronomy was now “a vital part of man’s equipment for probing the heavens, in his oldest and most enduring intellectual quest, to understand the nature of the universe.”<sup>9</sup>

A year before the launch of HEAO-2, Weisskopf accepted a position as project scientist for what was then called the Advanced X-ray Astrophysics Facility (AXAF), which eventually became the Chandra Observatory, at MSFC in Huntsville, Alabama.<sup>10</sup> He and other scientists brought with them the lessons they had learned from the Einstein Observatory and suggested a different approach to AXAF science. In HEAO, the project manager and project scientist were not located at the same NASA center; the manager was at Marshall, while the project scientist worked in Maryland at Goddard

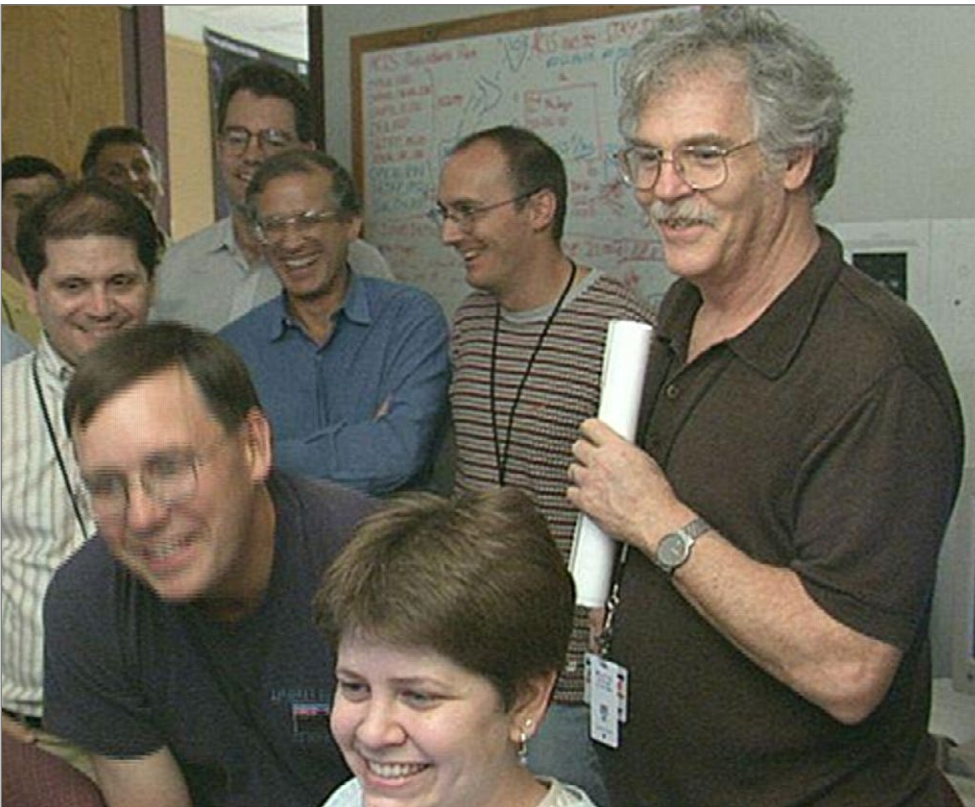
Space Flight Center. Weisskopf and others found “long distance” project science ineffective and demanded an “on-site” project scientist for the new observatory to avoid the challenges they faced with HEAO-2. Being separated by long distances was an obstacle for the scientific community. Regarding his selection as the project scientist, Weisskopf insisted, “despite appearing immodest...this decision was a major, if not the key, factor in the ultimate programmatic, technical, and scientific success of Chandra.”<sup>11</sup>

Another critical element of Chandra’s success was the incorporation and involvement of the scientific community throughout the design, development, testing, calibration, and eventual operation of the telescope. Over the years, members of Chandra’s Science Working Group as well as scientists from Marshall and the Smithsonian Astrophysical Observatory weighed in on decisions to maintain the mission’s

→ NASA’s Martin Weisskopf and colleagues from Columbia University in 1971 pose with the Aerobee-350 sounding rocket they used to detect x-ray polarization from a celestial object—the Crab Nebula—for the first time. From left to right are Robert Novick, Gabriel Epstein, Weisskopf, Richard Wolff, and Richard Linke. (Credit: NASA)



## Martin Weisskopf's Lessons Learned from Chandra (continued)



↑ Observing from the control center, the team witnesses Chandra X-ray Observatory's official first light on 19 August 1999. Martin Weisskopf appears on the right.

scientific integrity.<sup>12</sup> Their support proved to be invaluable because everyone brought what they had learned from other satellite missions to this project. Many were friends who had worked together on Einstein and other projects, and all respected their project scientist. All the scientists had real-life hardware experience and previously “built instruments, sometimes making last minute repairs while the rocket was mounted in the launch tower.” They also recalled “the agonies of cancellation,” but most importantly, they were seasoned veterans who “knew what [they] were doing!”<sup>13</sup> The Hubble Space Telescope, by contrast, did not have such staff, and the program was later criticized for its lack of experienced scientists to monitor the telescope’s mirror,

which ended up being flawed, causing the images to be blurry.<sup>14</sup> Eventually, the telescope had to be serviced and repaired more than three years later by the STS-61 crew.

The organizational structure of the Hubble team also differed from that of AXAF. Their science team consisted solely of one project scientist and a deputy. Weisskopf noted that this approach reflected “a different way of doing business and a lot of naivete.” When it came to requirements, scientists refused to budge.<sup>15</sup>

By contrast, the Chandra team demonstrated flexibility. When a subcontractor announced that they had found a problem with the High Resolution

Mirror Assembly thermal baffles and came up with a solution that would cost \$282,000 but not result in any schedule delays or impact to the mission, a scientist immediately described the baffle violation as insignificant. He publicly stood up and said, “That is the stupidest thing I’ve ever heard.” Fixing the hardware would be a waste of money. He suggested that the team save the funds and do nothing. Other scientists studied the issue, concurred with their colleague, and agreed the best course of action was to take no further action. This was one example of how unique Chandra’s team was. In other programs, “no scientist would yield on a requirement affecting performance, no matter how trivial.” Hefner credited the scientific “culture of skeptical inquiry with a focus on mission utility” with their ability to form an integrated team that ultimately led to the success of the mission.<sup>16</sup> Others appreciated the team bond “forged through trial by fire.”<sup>17</sup> When it came to Chandra, team members questioned everything. “Science,” as Weisskopf explained, “is a full-contact intellectual sport. You’ve got to plan ahead but think fast on your feet.”<sup>18</sup>

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**“Science is a full-contact intellectual sport. You’ve got to plan ahead but think fast on your feet.”**

—Martin Weisskopf

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AXAF scientists quickly coalesced around the requirements laid out in a 1976 proposal submitted by Riccardo Giacconi and Harvey Tananbaum

## Martin Weisskopf's Lessons Learned from Chandra (continued)

to build a subarc-second telescope. Weisskopf was particularly proud that the science team held firm and “saw to it that there was essentially no ‘requirements creep’ (i.e., the requirements stayed constant) throughout the lengthy development of the mission,” which stretched from 1977 to 1999, when Chandra was finally deployed.<sup>19</sup> Even the engineering and management team for Chandra agreed to follow the scientists’ lead on this endeavor, which was not often the case at NASA. More often than not, as Weisskopf noted, scientists were forced to use existing technology, which did not often meet the scientific requirements of the mission.<sup>20</sup>

When NASA restructured Chandra in 1992, due to budgetary pressure, the entire team, which included the scientists, came up with a less expensive mission. Working together, the team came up with a new concept: they dropped the servicing requirement and two focal plane instruments. The observatory would be placed into a higher orbit, which would increase observing time, thereby still meeting the scientific objectives of the flight. But it could no longer be repaired by astronauts. Chandra’s performance was improved by using an iridium mirror coating. In all, the redesign saved taxpayers \$3.6 billion.

Today, the Chandra X-ray Observatory is one of NASA’s most successful space-flight missions. The telescope gave x-ray astronomers front-row access to “phenomena light years away, such as exotic celestial objects, matter falling into black holes, and stellar explosions.”<sup>21</sup> Expected to operate for 5 years, Chandra has exceeded all expectations and remains in operation to this day, 25 years after astronauts deployed the

observatory from Columbia during the STS-93 mission. Looking back on this program, Weisskopf believes “one of the principal reasons for this success was the heavy involvement of experimental X-ray astronomers in all phases of the program.”<sup>22</sup> ■

## Endnotes

- 1 Keith Hefner, “[Performance as Promised: Chandra X-ray Observatory](#),” *ASK Magazine* (fall 2006): 41–42 (accessed 22 May 2024).
- 2 Martin C. Weisskopf, “The Making of the Chandra X-ray Observatory: The Project Scientist’s Perspective,” *PNAS* 107, no. 16 (2010): 7135, doi/10.1073/pnas.0913067107 (accessed 26 March 2024).
- 3 Helen Cole and Martin Weisskopf, “[15: 20 Years of Chandra Discoveries](#),” in *Small Steps, Giant Leaps*, produced by NASA, podcast, transcript (accessed 22 May 2024).
- 4 Martin C. Weisskopf, “[From a Sounding Rocket per Year to an Observatory per Lifetime](#),” last updated 15 March 2013, p. 1 (accessed 22 May 2024).
- 5 *Ibid.*, p. 2.
- 6 *Ibid.*, p. 3.
- 7 Weisskopf notes the date of launch as 1979, but NASA sources identify the date a year earlier. Weisskopf, “The Making of the Chandra X-Ray Observatory,” p. 7136.
- 8 Martin C. Weisskopf, “[The Advanced X-Ray Astrophysics Facility](#),” *Journal of the Washington Academy of Sciences* 71, no. 2 (1981): 69 (accessed 22 May 2024).
- 9 Program Development Directorate, “Advanced X-Ray Astrophysics Facility (AXAF)—Science Working Group Report,” NASA TM-78285, May 1980, p. v.
- 10 The project’s original name was the brainchild of a NASA associate administrator who wanted to avoid the project’s being scrapped. Earlier that year, Congress had approved the Large Space Telescope, which became the Hubble Space Telescope, and he believed the august body would not support a second telescope so soon after it had already voted to provide funding for the first space telescope. Weisskopf, “The Making of the Chandra X-ray Observatory,” p. 7136.
- 11 Weisskopf, “From a Sounding Rocket,” p. 4.
- 12 Stephen L. O’Dell and Martin C. Weisskopf, “[The Role of Project Science in the Chandra X-ray Observatory](#),” *Proceedings of SPIE*, vol. 6271: *Modeling, Systems Engineering, and Project Management of Astronomy II* (2006): 7–8 (accessed 22 May 2024).
- 13 Weisskopf, “From a Sounding Rocket,” p. 5.
- 14 Wallace Tucker and Karen Tucker, *Revealing the Universe: The Making of the Chandra X-ray Observatory* (Cambridge: Harvard University Press, 2001), pp. 62–64.
- 15 *Ibid.*, p. 65.
- 16 Hefner, “Performance as Promised,” p. 42.
- 17 Kimberly Arcand, Grant Tremblay, Megan Watzke, Martin C. Weisskopf, and Belinda J. Wilkes, *Light from the Void: Twenty Years of Discovery with NASA’s Chandra X-ray Observatory* (Washington, DC: Smithsonian Books, 2019), p. 199.
- 18 Lee Mohon, “[50 Years of X-ray Vision: Scientist Leads NASA’s Next Step in X-ray Astronomy](#),” 3 December 2021 (accessed 22 May 2024).
- 19 Martin C. Weisskopf et al., “[Fifteen Years of Chandra Operation: Scientific Highlights and Lessons Learned](#),” *Proceedings of SPIE*, vol. 9144: *Space Telescopes and Instrumentation Ultraviolet to Gamma Ray* (2014): 6 (accessed 22 May 2024).
- 20 Weisskopf, “The Making of the Chandra,” p. 7135; Jonathan Arenberg et al., “[Lessons We Learned Designing and Building the Chandra Telescope](#),” *Proceedings of SPIE*, vol. 9144: *Space Telescopes and Instrumentation, Ultraviolet to Gamma Ray* (2014): 3 (accessed 22 May 2024).
- 21 NASA Press Release, “[NASA Awards Chandra X-ray Observatory Follow-On Contract](#),” 26 August 2003 (accessed 22 May 2024).
- 22 Weisskopf, “From a Sounding Rocket,” p. 7.

# Chandra's Rocky Ride into Space



After a year of delays, on 23 July 1999, Space Shuttle Columbia lifted off from Launch Pad 39B with the heaviest Shuttle payload ever launched, the Chandra X-ray Observatory. (Credit: NASA)

» By Robert Arrighi, NASA Historian

**A** **T 7:47 A.M. EDT** on 23 July 1999, STS-93 mission specialist Cady Coleman released the Chandra X-ray Observatory and its Inertial Upper Stage (IUS) booster from Columbia's payload bay into space. An hour later, the IUS's two solid rockets fired in succession, propelling Chandra into a

transfer orbit, where it separated from the IUS and deployed its solar arrays. After more than 20 years of development and a series of last-minute hurdles, NASA's latest Great Observatory commenced its groundbreaking x-ray astronomy mission.

Chandra's size and sophistication complicated the launch for the mission planners. At nearly 50,000 pounds when paired with the IUS, Chandra was the heaviest payload ever launched by a Shuttle, and Columbia was the heaviest orbiter in the fleet. This unprecedented load increased the number of "black zones," where the orbiter would be unable to return to the launch site in the event of an aborted launch.

"The black zones would be the areas where it's most likely you're not going to survive," explained Lisa Reed, a NASA training lead. "So, there's more opportunities of that [on STS-93], simply because Chandra was so big. So, it made the flight control team and the flight planners, the trajectory officers, work a little harder to come up with that profile."<sup>1</sup>

Chandra's complex navigation and guidance systems required the prompt activation of its solar arrays upon orbital insertion. This necessity, coupled with NASA's desire to deploy the observatory early in the mission, limited the launch windows.

Chandra was originally slated to be launched in the summer of 1998 but was delayed several months by a failed vacuum door and compromised wiring boards. In January 1999, an issue with the observatory's circuit boards pushed back Chandra's launch readiness by another five weeks.

Finally, after months of preparation at Kennedy Space Center, Commander Eileen Collins and the STS-93 crew boarded Columbia on July 20—the 30th anniversary of the Apollo 11



## Chandra's Rocky Ride into Space (continued)

Moon landing—and prepared to launch. The countdown was paused when hydrogen was detected in the rear engine compartment. NASA engineers determined that it was a false reading, reset the sensor, and proceeded with the countdown. Just 7 seconds before igniting the orbiter's main engines, the launch was scrubbed because they would overshoot the launch window by less than 1 second. The next window was two days later and only about 45 minutes long.

Despite forecasts for clear skies on that day, thunderstorms began forming offshore as the countdown proceeded. Frustrated at another potential scrub, the launch management team conferred with those managing the IUS and observatory. In hopes that the weather would pass, they agreed to eliminate a tertiary deployment option, extending the window by 10 minutes. The storm increased, however, and additional time was needed. The launch team again conferred with the other stakeholders

to discuss additional options. Despite growing concern regarding the dwindling backup deployment options, it was agreed to eliminate another deployment alternative to add 7 more minutes to the launch window. The storm continued to grow, however, and the team had no choice but to scrub the launch.<sup>2</sup>

The next day, the STS-93 crew boarded Columbia a third time. An issue with the tracking station communications system delayed the countdown for 7 minutes, but at 12:31 a.m. EDT on 23 July 1999, Columbia lifted off with Chandra. “Right at liftoff, I could see a flash on the caution and warning panel, and a light came on and went off,” recalled mission specialist Stephen Hawley.<sup>3</sup> A voltage drop in one of the vehicle's electric buses caused the controllers for two of the main engines to shut down. An automatic switch to the redundant controllers prevented any interruption in performance, but a failure of the backup controller would have forced Collins to attempt the Shuttle's first-ever return-to-launch-site maneuver and do it with the heaviest Shuttle payload ever.

Also, unbeknownst to Mission Control or the crew, a pin in the right main engine's liquid oxygen injector came loose during launch, causing minor damage to three cooling channels in the engine's

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converging nozzle. Fortunately, the event did not send the liquid oxygen into the space where the hydrogen was introduced or cause the regeneratively cooled nozzle to fail. Either scenario could have critically damaged the orbiter.

The breach, however, caused 3.5 pounds of liquid hydrogen to leak each second, which prompted the hydrogen pump to increase its feed rate. Since the leak was downstream of the flowmeter, there was no indication that the hydrogen was leaking. The engine controller assumed that the hydrogen was being burned, so it increased the oxygen flow to maintain proper mixture. The depletion of the oxygen led to a premature shutdown of the main engines at an orbit 7 miles lower than intended. Nonetheless, the spacecraft's Orbital Maneuvering System was used to propel Columbia to the proper altitude to proceed with Chandra's deployment.

Following that successful deployment, Collins moved the Shuttle to an orbit a safe distance from the observatory. The STS-93 crew conducted several



← The STS-93 crew walks out of the Operations and Checkout Building for the second time on their way to the awaiting Space Shuttle Columbia at Pad 39B. A storm would result in a scrub of the launch that day. (Credit: NASA)

Chandra's Rocky Ride into Space (continued)

secondary experiments over the next few days before safely returning to Kennedy Space Center at 11:20 p.m. EDT on 27 July 1999.

Post-mission inspections found that the power reduction during launch was likely caused by a small stretch of wiring in the payload bay whose insulation had worn away over time. The issue, along with loose wiring to a pressure sensor, led to a grounding of the Shuttle fleet for five months to conduct intensive electrical inspections. In addition, the source of the hydrogen leak was identified, and new procedures were implemented that required failed injector posts to be removed rather than plugged with pins. ■

Endnotes

- 1 [Lisa M. Reed](#), interview by Jennifer Ross-Nazzari, 15 May 2015 (accessed 23 May 2024).
- 2 Wayne Hale, “[STS-93: We Don’t Need Any More of Those,](#)” Wayne Hale’s Blog, 26 October 2014 (accessed 28 May 2024).
- 3 [Steven A. Hawley](#), interview by Sandra Johnson, 14 January 2003 (accessed 23 May 2024).

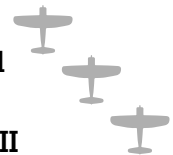


↑ The 50,162-pound Chandra X-ray Observatory is seen in Columbia’s payload bay just before it is deployed on 23 July 1999. (Credit: NASA)

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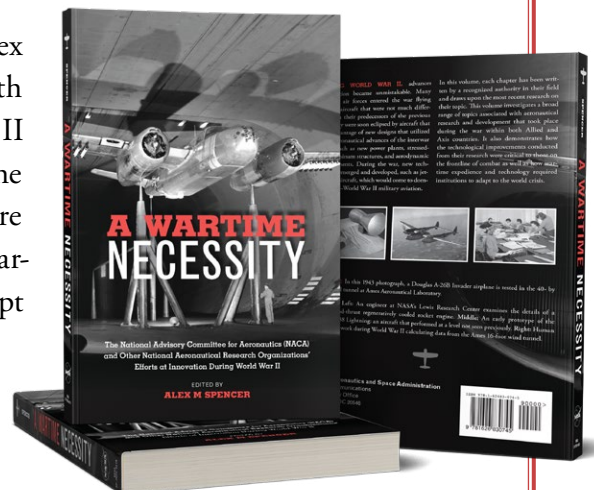
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# Arcus: Evolution of a Proposal

» By **James Anderson**, NASA Historian

**EVERY MISSION BEGINS** its life as a proposal. The collaboration required for developing a proposal includes much more than simply documenting plans and describing the concept behind a proposed mission. The investment in time is significant. Team dynamics take shape as the core members—often coming from different institutions across government, academia, and industry—address the challenges that arise throughout development. Proposals must demonstrate that a team can realistically achieve its scientific goals while staying within parameters set for cost, schedule, and risk. Many team members work on multiple and even competing proposals, hoping for at least one to be funded. Missions selected for flight can define careers and shape the future of scientific fields. Most proposals are not selected for flight, yet every proposal has its own developmental history. Those

histories represent a fuller scope of the work involved in scientific fields like high-energy astrophysics.

For Randall Smith and Jay Bookbinder, their professional collaboration began almost 20 years ago on Constellation-X, a mission concept that later merged with related European Space Agency and Japan Aerospace Exploration Agency work to become the International X-ray Observatory (IXO) mission concept. Smith, then working at Goddard Space Flight Center, approached Bookbinder after a meeting and told him that the resolution for the grating spectrometer on Constellation-X “was totally inadequate.”<sup>1</sup> Bookbinder challenged Smith to demonstrate that the tenfold increase in resolution that Smith claimed was needed was also achievable. Bookbinder was at the Smithsonian Astrophysical Observatory (SAO) at the time and did not expect Smith to voluntarily prepare

↑ In this composite image of the central region of the Milky Way galaxy, x rays detected by Chandra show high-energy features around the active galactic core. Pink represents lower-energy x rays, and blue indicates higher-energy x rays. Data from two other NASA Great Observatories, Hubble and Spitzer, are included. The current Decadal Survey states that “higher sensitivity and spectral resolution optical-UV and X-ray spectroscopy” will be key to understanding active galactic nuclei. (Credit: NASA/Jet Propulsion Laboratory–Caltech/European Space Agency/Chandra X-ray Center/Space Telescope Science Institute)

a set of charts making his case. Smith did so, and the charts so impressed Bookbinder that he recruited Smith away from NASA to SAO.

By 2012, Smith and Bookbinder were having lunch together a few times a week at a Chinese restaurant near SAO. Smith would carry note cards in his wallet, and at one of those lunches, Bookbinder asked him to take out a blank note card and write down the names of 10 people that Smith wanted to work with. Bookbinder wrote down his own list of 10 names; then they

Arcus: Evolution of a Proposal (continued)

compared lists. The 2010 Decadal Survey had been published, which called for a descope of the IXO, and the two astrophysicists were contemplating what to propose for an eventual Astrophysics Medium Explorer, or MIDE X, Announcement of Opportunity (AO) from NASA in light of the Decadal Survey. They did not start the mission proposal process with a particular instrument, or capability, or even a specific scientific question in mind. They started with a core team of people that they had in common on those two note cards.<sup>2</sup>

Meetings followed. In an era when videoconferencing was possible but not omnipresent, phone calls and in-person meetings were the modes of communication that connected the team members. Open communication has been a fundamental approach to how Smith and Bookbinder have conducted their work. Knowing that even the proposal process itself is stressful, with its intensive reviews and its tight turnaround times, the emphasis on building a team with people who will collaborate well, will speak up, and will support other team members without focusing on blame when something goes wrong are crucial to a team's cohesion and success.

That cohesion was tested shortly before the team's first MIDE X proposal. The specific technologies available for x-ray gratings were evolving. The two main types of gratings were in-plane gratings and the newer off-plane gratings. A third, even more recent type, critical angle transmission gratings, were not on the scene yet. Off-plane gratings offered higher resolution, but the technology was new, so it lacked widespread confidence in its capability and reliability. With the IXO mission

off the table, Smith and Bookbinder got together with Randall McEntaffer and developed what amounted to an updated version of Constellation-X, but with a newer off-plane grating spectrometer. That initial proposal, before the MIDE X submission, received a Category II rating from NASA, which meant the approach was plausible, but not developed enough to be selected. They persisted, and, in advance of the Explorer proposal, two groups within the team performed tests at Marshall Space Flight Center of their respective off-plane gratings and the newer option now available, the critical angle transmission gratings. As it turned out, the manufacturing of the off-plane gratings led to much lower resolutions than expected, while the critical angle gratings performed even better than expected. With only a few months to go before the deadline for the 2016 MIDE X proposal, the team switched to critical angle transmission gratings.

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**With only a few months to go before the deadline...the team switched to critical angle transmission gratings.**

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The decision was not trivial, and there were plenty of doubts within the team and from management. As one sign of team cohesion and collaboration, McEntaffer remained an active participant on the mission, called Arcus, even though the team switched to another member's approach. Arcus was one of three missions selected in 2017 for

Phase A funding, but it was not selected for subsequent flight. In the meantime, the off-plane grating manufacturing issue was resolved, and the critical angle gratings gained wider acceptance in their capabilities. In its current configuration, Arcus Probe has added an ultraviolet (UV) spectrometer working in tandem with its high-resolution soft x-ray spectrometer.

In November 2021, the National Academies released the most recent Decadal Survey for astronomy and astrophysics. In response to one of its recommendations, NASA initiated a new Astrophysics Probe Explorer (APEX) program. This new probe-class mission line has a cost cap of \$1 billion in FY 2023 dollars, not including the launch vehicle and launch services. APEX is intended to provide a flight opportunity that falls between the MIDE X-class and a flagship-class mission. This is the first AO for APEX. Two or three missions will be chosen for funded Phase A studies, with an anticipated launch in 2032 for the mission eventually selected for flight.

Arcus Probe is one of eight missions under consideration for Phase A selection. ■

#### Endnotes

- 1 Randall Smith (Principal Investigator for the Arcus high-energy probe mission proposal and Associate Director for Science at the Harvard-Smithsonian Center for Astrophysics) and Jay Bookbinder (Director of Programs and Projects at NASA's Ames Research Center) in discussion with the author, 3 May 2024.
- 2 The note cards, unfortunately, were not saved, leaving only the recollection of this particular lunch meeting.

# News from Around NASA

## A HEARTFELT FAREWELL TO HISTORIAN STEVE GARBER

After roughly 30 years of service at NASA, beloved colleague Steve Garber has moved on to a new position with the Department of Defense supporting the Space Force. Steve first came on board at NASA Headquarters as a Presidential Management Intern in 1993 and was subsequently hired by then-Chief Historian Roger Launius. Over the next 28 years, he racked up an enviable list of significant contributions to the program. Of his many accomplishments, he helped shepherd many publications in the NASA History Series through to completion. With Glen Asner, he also coauthored the award-winning book *Origins of 21st-Century Space Travel: A History of NASA's Decadal Planning Team and Vision for Space Exploration, 1999–2004*. Additionally, his work managing and developing the NASA history website, one of the best history resource websites in the U.S. government, is particularly notable. The site also benefited from his ongoing collaboration with the editors of the *Apollo Flight Journal* and *Apollo Lunar Surface Journal* websites.

Steve's professionalism, generosity with his time, support of interns and fellows, and kindness to all he worked with touched the lives of so many of his NASA coworkers. Similarly, his tireless work as a resource to offices across NASA Headquarters will be difficult to match. As Steve said in his parting words, "It's all about taking care of your people." We wish him the utmost success in his ongoing work in space policy. Godspeed!



↑ Steve Garber. (Courtesy of Steve Garber)

## Sendoff for NASA Archivists Sarah Jenkins and Jess Deibert

In May, the NASA History and Archives Branch said farewell to two of its archivists. **Sarah Jenkins**, an archivist working at NASA Headquarters for the last three years, departed NASA for a position at the Architect of the Capitol. We will dearly miss her sharp wit, deep knowledge of the Headquarters archival collection, and vast expertise that she is always willing to share.

**Jess Deibert** started work at Goddard Space Flight Center (GSFC) as an Archives Pathways Intern in 2018. After a one-year detail with NASA's Office of the Chief Information Officer, she has taken a position with their artificial intelligence (AI) team. Jess's enthusiasm, dedication, and know-how have been a boon to the GSFC archival team over the last half decade. She will be very missed.

## The History Office Welcomes Three New Historians

In recent months, the NASA History Office welcomed three new historians to their ranks, Lois Rosson and Brad Massey, and Bradley Coleman.

### Dr. Lois Rosson

**Lois Rosson** joins the NASA History Office after completing a doctorate in history at the University of California, Berkeley. Her dissertation focused on art and image-making in 20th-century astronomy, and she invites all conversation related (but not limited) to James Nasmyth, Chesley Bonestell, Wernher von Braun, Disney's Tomorrowland, the NASA Artist's Cooperation Program, the TV show *Cosmos: A Personal Voyage*,



↑ Dr. Lois Rosson (Photo courtesy of Lois Rosson)

News from Around NASA (continued)

lunar mapping, Mars Hill in Death Valley, Southern California aerospace, and plein-air painting. She is a dedicated science fiction nerd and recently completed the Octavia E. Butler Fellowship at the Huntington Library. Before starting graduate school, Lois interned at Ames Research Center for two years and was a Guggenheim Predoctoral Fellow at the Smithsonian’s National Air and Space Museum from 2018 to 2019. She has also held fellowships at Lawrence Livermore National Laboratory and the University of Southern California.

As NASA’s incoming historian in Southern California, she is working on an overview of the Stratospheric Observatory for Infrared Astronomy (SOFIA) mission. Lois is a native of Southern California’s Inland Empire and currently lives in Pasadena.



↑ Dr. Brad Massey. (Photo courtesy of Brad Massey)

**Dr. Brad Massey**

Historian **Brad Massey**, stationed at Kennedy Space Center, has experience as a professor of history and a museum curator. At the Tampa Bay History

Center, he curated more than 10 exhibitions, including the award-winning *Cuban Pathways*. He has a Ph.D. in history from the University of Florida and specializes in Florida history. Brad is currently completing a book entitled *State of Change: A Technological History of Florida*. In his new role at NASA, Brad will be focusing on the history of Kennedy Space Center as well as leading the development of new historical content for the NASA website.



↑ Bradley Coleman. (Photo courtesy of Bradley Coleman)

**Bradley Coleman**

Historian **Bradley Lynn Coleman** is a graduate of the Virginia Military Institute (VMI), Temple University, and the University of Georgia. Between 2001 and 2012, he served as a historian at the Department of State and Department of Defense (DOD), including six years as combatant command historian for the U.S. Southern Command, the DOD headquarters for U.S. forces in Latin America and the Caribbean. He later worked as professor of history and director of the John A. Adams ’71 Center for Military History and Strategic Analysis at VMI. He is particularly interested in

the utility of history in the design and implementation of national security, foreign, and public policy. In his spare time, he is writing a book on George C. Marshall, William S. McCauley, and the Virginia Military Institute during the World War II era. He currently lives in Marietta, Georgia, with his wife Keri-Lyn and their three teenage children. At NASA, Bradley will focus on the history of the DC-8 Airborne Science Laboratory.

**New Archivist at NASA Headquarters**

**Alan Arellano** joins us from the Smithsonian’s National Museum of the American Indian, where he worked as a Digital Archivist, providing support for departments across the museum, with a focus on Digital Asset Management. He has worked in libraries



↑ Alan Arellano. (Photo courtesy of Alan Arellano)

and archives for over five years, having worked for the Commonwealth of Virginia and the University of Maryland, where he received a master’s degree in library science as well as a master’s degree in history. Alan is originally from the Northern Virginia area, with proud Peruvian roots, but he has spent many years in the border town of El Paso, Texas, where he will be marrying his fiancée Mireya later this year. In his free time, he can be found at the beach, in Audi Field watching DC United play, or playing with his one-year-old tuxedo cat, Sox, and kicking the ball around in his local recreational soccer league. ■

# Other Aerospace History News

## 2024–25 Fellowships in Aerospace History Announced

» American Historical Association

The American Historical Association (AHA) is pleased to announce the recipients of 2024–25 Fellowships in Aerospace History.

The Fellowships in Aerospace History, awarded annually, are supported by NASA and administered by the AHA, the History of Science Society (HSS), and the Society for the History of Technology. The fellowships provide funding to scholars undertaking

advanced research projects in all aspects of aerospace history, including cultural and intellectual history; economic history; the history of law and public policy; and the history of science, engineering, and management.

The 2024–25 AHA Fellowship in Aerospace History has been awarded to **Reynolds Hahamovitch**, a Ph.D. candidate at the University of Michigan, Ann Arbor, who will be conducting

research for his dissertation, “The Space Age: Horizons of the Future in the Cold War United States.”

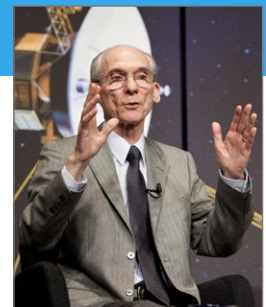
The 2024–25 AHA Fellowship in the History of Space Technology has been awarded to **Breanna Lohman**, a Ph.D. candidate at the University of Toronto, to work on her dissertation, “The Ends of the World: An Environmental History of the SAGE Air Defense System and the American National Security Regime.”

The 2024–25 HSS Fellowship in Aerospace History has been awarded to **Christina Roberts**, a Ph.D. candidate at the University of California, Santa Barbara, who will be working on her dissertation, “Spacemobile: NASA Stakes Its Claim on American Science Education, 1961–2014.” ■

# In Memoriam

With heavy hearts, we say farewell to NASA leaders and legends who have left us in recent weeks.

*Ad astra*



Thomas P. Stafford  
NASA Astronaut  
1930–2024

George W. S. Abbey  
NASA Johnson Space  
Center Director  
1932–2024

James D. Dean  
Founder of NASA Art  
Program  
1931–2024

William A. Anders  
NASA Astronaut  
1933–2024

Edward C. Stone  
Jet Propulsion  
Laboratory Director  
and Voyager Project  
Scientist  
1936–2024

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## Upcoming Meetings

**9–11 JULY 2024**

**International Conference on Transdisciplinary Engineering 2024**  
London, England  
<https://www.te2024.org.uk/>

**9–14 JULY 2024**

**Society for the History of Technology (SHOT) Annual Meeting**  
Viña del Mar, Chile  
<https://www.historyoftechnology.org/annual-meeting/2024-joint-icohtec-shot-annual-meeting/>

**15–17 JULY 2024**

**American Astronautical Society's John Glenn Memorial Symposium**  
Cleveland, Ohio  
<https://astronautical.org/events/john-glenn-memorial-symposium/>

**16–19 JULY 2024**

**2024 National Association of Government Archives and Records Administrators (NAGARA) Annual Conference**  
Atlanta, Georgia  
<https://nagara.org/annualconference>

**16–19 JULY 2024**

**European Association for the Study of Science and Technology (EASST)—Society for Social Studies of Science (4S) Joint Conference 2024**  
Amsterdam, Netherlands  
<https://www.4sonline.org/meeting.php>

**22–28 JULY 2024**

**Experimental Aircraft Association (EAA) AirVenture**  
Oshkosh, Wisconsin  
<https://www.eaa.org/airventure/>

**29 JULY–2 AUGUST 2024**

**2024 American Institute of Aeronautics and Astronautics (AIAA) Aviation Forum and Exposition**  
Las Vegas, Nevada  
<https://www.aiaa.org/aviation>

**15–17 AUGUST 2024**

**ARCHIVES \* RECORDS 2024 (88th Annual Meeting of the Society of American Archivists)**  
Chicago, Illinois  
<https://www2.archivists.org/conference>

**21–22 AUGUST 2024**

**Contributions of the DC-8 to Earth System Science at NASA: A Workshop**  
Washington, DC  
<https://www.nasa.gov/history/contributions-of-the-dc-8-to-earth-system-science-at-nasa-a-workshop/>

**17–19 SEPTEMBER 2024**

**2024 Forum on Philosophy, Engineering, and Technology Meeting**  
Karlsruhe, Germany  
<https://www.fpet2024.org>

**18–19 SEPTEMBER 2024**

**NASA and Archaeology from Space: A Symposium in Honor of Dr. Thomas L. Sever**  
Huntsville, Alabama  
<https://www.nasa.gov/history/nasa-and-archaeology-from-space/>

**14–18 OCTOBER 2024**

**International Astronautical Congress**  
Milan, Italy  
<https://www.iafastro.org/events/iac/international-astronautical-congress-2024/>

**30 OCTOBER–2 NOVEMBER 2024**

**Oral History Association (OHA) Annual Meeting**  
Cincinnati, Ohio  
<https://oralhistory.org/annual-meeting/>

**7–10 NOVEMBER 2024**

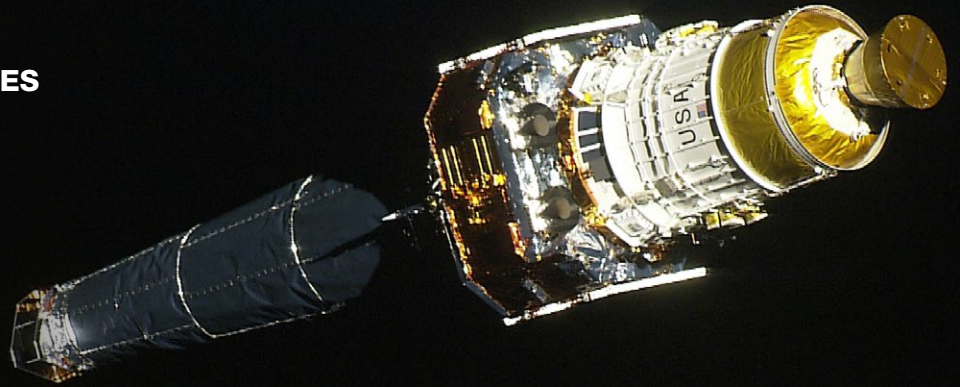
**History of Science Society (HSS) Annual Meeting**  
Mérida, Mexico  
<https://hssonline.org/page/HSS24>



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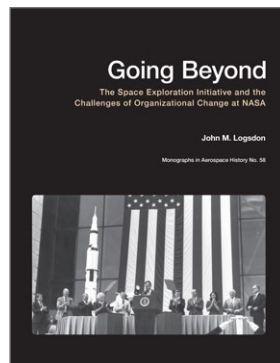


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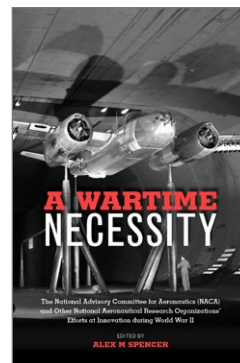
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↑ The crew of STS-93 captured this image from a video of the Chandra X-ray Observatory and its upper stage being deployed from Space Shuttle Columbia. (Credit: NASA)

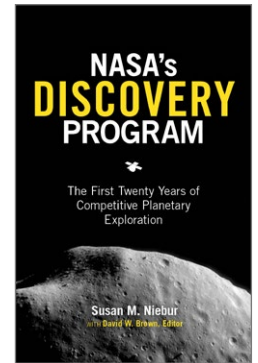
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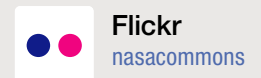
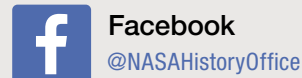
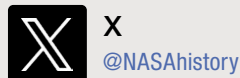


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