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Chandra

In July 1999, NASA launched Chandra, the world's most powerful x-ray telescope—packed with the strength and accuracy to read a newspaper from one-half a mile away or see the letters of a stop sign from 12 miles. A month later Chandra, a member of NASA's family of Great Observatories, released its spectacular first celestial images.

The journey from Chandra's program inception to initial image was a challenging one. Along the way, the Marshall-managed program focused on precision engineering and attention to detail.

Launched by the Space Shuttle, the observatory travels one-third of the way to the Moon during its orbit around the Earth every 64 hours. At its highest point, Chandra's highly elliptical, or egg-shaped, orbit is 200 times higher than that of its visible-light-gathering sister, the Hubble Space Telescope.

With its combination of large mirror area, accurate alignment, and efficient x-ray detectors, Chandra has 10 times greater resolution and is 50 to 100 times more sensitive than any previous x-ray telescope.

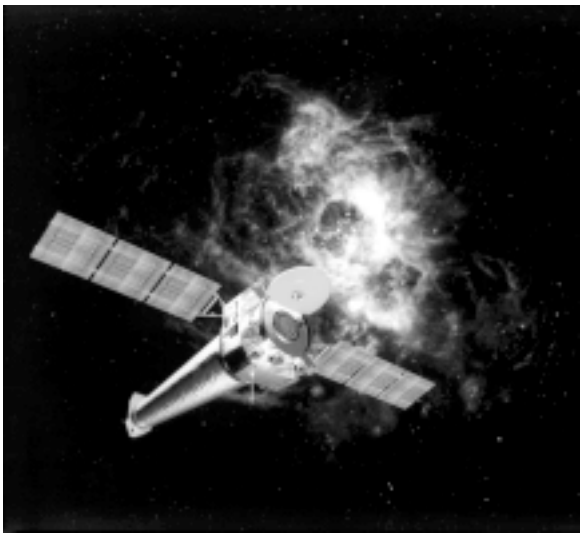
Chandra's mirrors are the smoothest ever created. If the surface of the state of Colorado were as relatively smooth, Pike's Peak would be less than 1-inch tall.

The Chandra team not only produced and polished the mirrors, but also created the systems to put them together. The team also had to align all the components to within miniscule tolerances, assemble them into a spacecraft that could survive the rigors of launch and space, then test them and validate their performance.

In many instances, the Chandra team had to come up with new processes for things that had never been done before. They developed, built and validated a measurement system that was used to make sure the cylindrical mirrors were ground correctly and polished to the right shape. The eight mirrors are the largest of their kind—the biggest is 4 feet in diameter and 3 feet long. The mirror group weighs more than 1 ton.

The team created and executed a system to carefully assemble the mirrors into a total package that could survive the rigors of a rocket ride, weightlessness, and the temperature extremes of space. The spacecraft is made of graphite epoxy to meet stringent weight requirements, and yet Chandra is the largest and heaviest payload ever deployed from the Space Shuttle. Fully fueled, Chandra weighed 12,930 pounds. With the Inertial Upper Stage set of boosters added to the craft, the assembly totaled

This is the Chandra X-ray Observatory, NASA's newest space telescope, which will provide unique and crucial new information about the structure and evolution of our universe. Marshall Space Flight Center manages the Chandra program.



50,162 pounds and measured 45.3 feet long by 64 feet wide with its solar arrays deployed.

On the other end of the size spectrum, microtechnology was used in manufacturing processes to make components for Chandra's imaging systems. Spectrographic transmission gratings, used to precisely determine the energies of incoming x-rays, had never been built before. The gratings include tiny gold bars that are closer together than a wavelength of visible light. It would take hundreds of the bars to equal the thickness of a sheet of paper. Plastic membranes, thin as a soap bubble, support the bars.

While all of these incredibly small and large items were being designed and built, the team also had to make sure that they all came together to form the very best overall system. The spacecraft had to be precise and reliable. Also, the ground control system and its operating staff had to be able to efficiently and safely operate Chandra for 5 years or more. The team tested, tested and re-tested the spacecraft and ground system together to make sure they were compatible. On the optics system testing they made sure that they had at least two ways to crosscheck all results. In some instances the team had even more checks.

Calibrating and validating the telescope's scientific operation proved to be another challenge. Unlike optical astronomy, where there are established, well-known targets in the universe that can be used for calibration purposes, there aren't any for x-ray images. A new world-class X-Ray Calibration Facility was built at the Marshall Center to precisely calibrate Chandra's x-ray optics. The facility also provided opportunities for additional crosschecks of the total optical system and for an independent check of Chandra's optical performance.

From x-rays entering the optics to the quality of the images produced by the science instruments, the testing verified the exceptional accuracy of Chandra's optics. Chandra is so finely tuned it can detect objects separated by one-half arc second. That is like identifying two dimes side-by-side from 2 miles away.