Project Manager's Report

Roger Brissenden

***Chandra* marked over twelve years of successful mis**sion operations with continued excellent operational and scientific performance. Telescope time remained in high demand, with significant oversubscription in the Cycle 13 peer review held in June. In the Fall the observing program transitioned from Cycle 12 to Cycle 13. We released the Call for Proposals for Cycle 14 in December, and look forward to the Cycle 14 peer review in June 2012.

The team worked hard to prepare for NASA's 2012 Senior Review of operating missions. The CXC submitted our proposal in January 2012 (with the Education and Public Outreach proposal submitted separately in December, 2011), and will participate in an oral presentation to the Senior Review committee at the end of February 2012.

The CXC conducted several workshops and symposia during 2011. We celebrated *Chandra*'s 12th anniversary with the symposium "12 Years of Science with *Chandra*," part of the American Astronomical Society meeting held in Boston in May. In July we conducted the workshop "Structure of Clusters and Groups of Galaxies in the *Chandra* Era," and in August held the 2011 5-day X-ray Astronomy School, followed by a workshop for users of the CXC's CIAO data analysis software system. As part of the CXC's regular reviews and consultations with outside organizations, NASA reviewed the CXC's operations in March and September, and the *Chandra* Users' Committee met at the CXC in October.

The CXC mission planning staff continued to maximize observing efficiency in spite of temperature constraints on spacecraft pointing. Competing thermal constraints continue to require that some longer observations be split into multiple short duration segments, to allow the spacecraft to cool at preferred attitudes. The total time available for observing has been increasing gradually over the past few years as *Chandra*'s orbit evolves and the spacecraft spends less time in Earth's radiation belts. The overall observing efficiency during 2011 was 75%, compared with 74% in 2010 and an average of 68% over the mission. In the next several years we expect potential
observing time to increase slightly, but actual observing to be limited by radiation due to increasing solar activity.

Operational highlights over the past year included five approved requests to observe targets of opportunity that required the mission planning and flight teams to interrupt and revise on-board command loads. After several years of very low solar radiation, the sun has become more active, causing the team to interrupt *Chandra* observing three times during the year to protect the instruments from solar particles. *Chandra* passed through the 2011 summer and winter eclipse seasons, as well as a brief lunar eclipse in June, with nominal power and thermal performance.

Chandra's first full safe mode event in over 11 years—ultimately shown to have no hardware cause—occurred in July. On-board software detected an anomalous change in the spacecraft's angular momentum, triggering an autonomous transition to safe mode and a resulting swap to redundant hardware. The swap went flawlessly and all of the redundant systems performed as expected. The CXC's flight and science staff changed immediately to 24-hour operations and scheduled extra telemetry contacts with the spacecraft. Analysis of spacecraft data and orbital dynamics revealed that the safe mode transition resulted from a complex interaction of gravity-gradient torques, commanding in the science loads, and flight software timing. No hardware failures were involved and no harm was caused to the Observatory. The staff returned *Chandra* to nominal observing five days after the anomaly occurred, with a loss of 370 ks of observing time. The event demonstrated the training, effectiveness and seamless cooperation of all elements of the *Chandra* X-ray Observatory team.

In October, the spacecraft transitioned to normal sun mode when an electronic circuit reset, believed to be due to a single event upset, in which radiation or ions interrupt a component in the on-board electronics. The operations teams returned the spacecraft to normal status within two days with no adverse consequences, but the loss of 154 ks of observing time.

As part of an on-going risk reduction program, the CXC flight team identified a method to improve *Chandra*'s response to high radiation as the sun becomes more active. The new process maintains the science instruments in a radiation-safe condition while allowing controllers to continue spacecraft management activities such as eclipse response, attitude control, and thermal and momentum management. The new safing approach reduces risk to the spacecraft and minimizes the time and effort required to resume observations after a high radiation event. Following software development and extensive ground testing, the new method was fully implemented on 1 December 2011 and first came into action during a radiation safing in January, 2012.

Both focal plane instruments, the Advanced CCD Imaging Spectrometer and the High Resolution Camera, have continued to operate well and have had no significant problems. ACIS, along with the overall spacecraft, has continued to warm gradually.

All systems at the *Chandra* Operations Control Center continued to perform well in supporting flight operations.

Chandra data processing and distribution to ob-

servers continued smoothly, with the average time from observation to delivery of data averaging roughly 30 hours. The *Chandra* archive holdings grew by 0.5 TB to 8.8 TB and now contain 32.7 million files. *Chandra* Source Catalog data products represent 1.8 TB of the archive.

The Data System team released software updates to support the submission deadline for Cycle 13 observations proposals (March 2011), the Cycle 13 Peer Review (June) and the Cycle 14 Call for Proposals (December 2011). Software upgrades supported the multi-cycle observing proposals that were solicited beginning in Cycle 13.

In addition, several enhancements to instrument algorithms have been incorporated into standard data processing and also released in CIAO 4.4 (December), including a new ACIS afterglow/hot pixel determination tool. Work is progressing on a new version of the *Chandra* Source Catalog (CSC) that will increase the number of detected X-ray sources. The new CSC version will extend the catalog to fainter limits by combining multiple observations and by using new algorithms to allow point sources as faint as ~5 counts to be detected on-axis, resulting in a ~2.5 times increase in the number of X-ray sources included in the catalog.

The CXC Education and Public Outreach (EPO) group in 2011 created 15 science press releases, a press release posting and 12 image releases, and produced 22 60 second High Definition podcasts on astrophysics and *Chandra* results. Two of the group's animated videos earned platinum-level Pixie awards from the American Pixel Academy. CXC staff created 75 blog entries, and initiated live tweets from such venues as the AAS meeting, science fairs and the NASA press conference.

EPO personnel presented 26 workshops at conferences and clinics sponsored by the National Science Teacher Association, National Science Olympiad, American Association of Physics Teachers, and the Astronomy Society of the Pacific. EPO staff presented an invited talk on public science at the October conference Communicating Astronomy with the Public, sponsored by the International Astronomical Union.

The EPO group was awarded a grant to support NASA's Year of the Solar System initiative by developing the exhibit From Earth to the Solar System, modeled on the EPO-created exhibit From Earth to the Universe (FETTU). The Braille panels developed for FETTU were donated to the National Federation for the Blind for permanent exhibit at its Jernigan Institute.

We look forward to a new year of continued smooth operations and exciting science results. Please join us for the workshop "X-ray Binaries, 50 Years Since the Discovery of Sco X-1", to be held in Boston July 10–12, 2012.