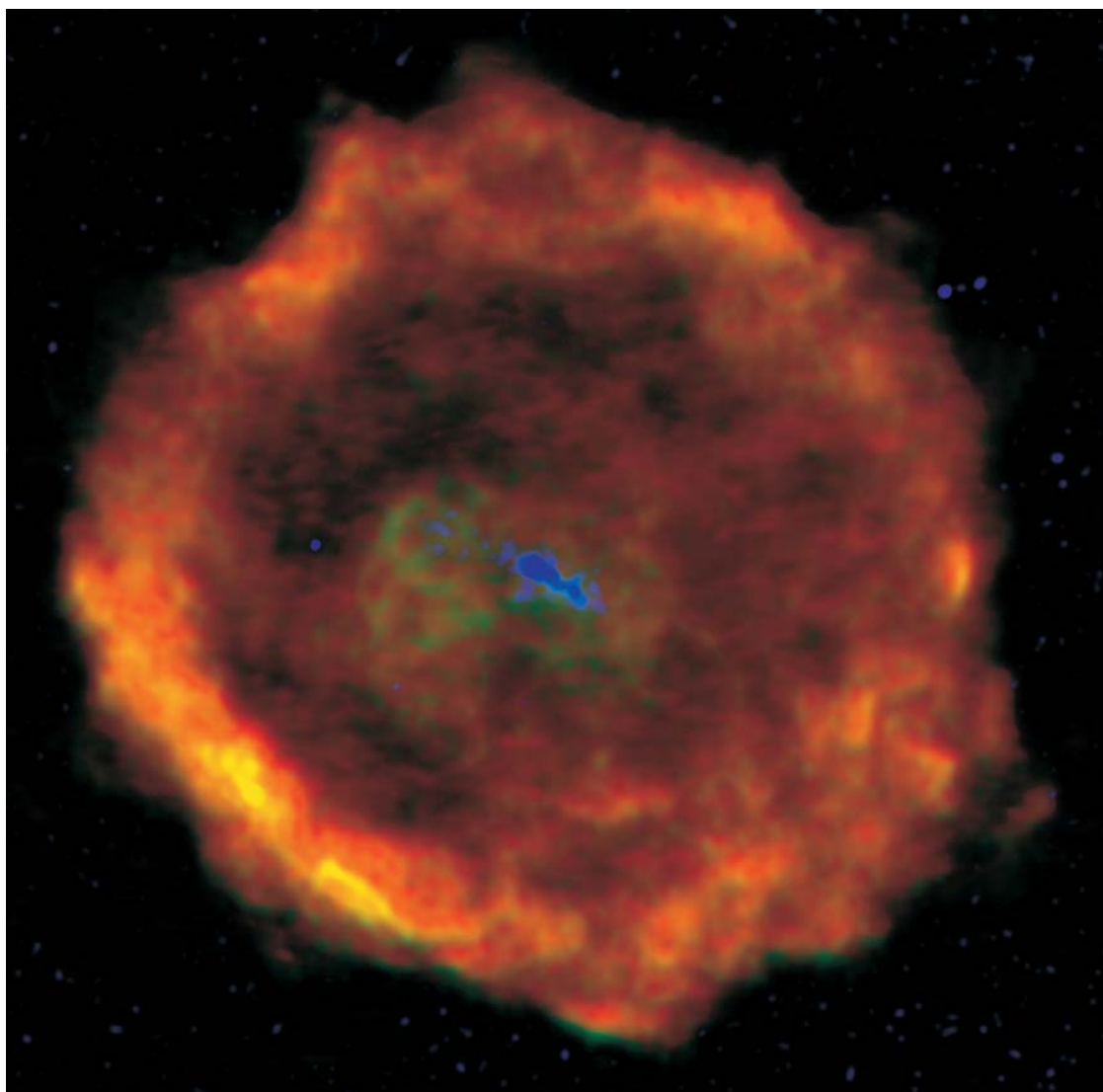


# NATIONAL RADIO ASTRONOMY OBSERVATORY



Quarterly Report



July – September 2008

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## Quarterly Report

July - September 2008



*Cover Image: Composite radio and X-ray image of the Type II supernova remnant of the “guest star” observed by Chinese astronomers in 386 AD. Red and green encode VLA  $\lambda = 20$  cm and  $\lambda = 3.6$  cm continuum emission, and blue indicates X-ray emission observed by Chandra. Winds from the central pulsar create energetic electrons powering the blue center and the larger green area surrounding it.*

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### EXECUTIVE SUMMARY

Four years of GBT observations of the eclipsing double-pulsar binary system J0737–3039A/B have been used to derive geometric parameters that are consistent with the gravitational spin-orbit coupling predicted by general relativity within an uncertainty of only 13%. The double pulsar is the only relativistic binary system that allows a direct constraint on the spin-orbit coupling in theories of gravity. The VLA and VLBA were used to study the first radio-loud quasar found at a redshift greater than 6, the quasar J1427+3312 at  $z = 6.12$ . A recent GBT search for water-maser emission from star-forming regions in four nearby galaxies had a 100% success rate. This implies that there is a population of kilomasers just below the detection limits of other instruments but readily accessible with the GBT.

Seventeen EVLA antennas have been retrofitted and restored to routine service with the VLA. Tests of the prototype WIDAR correlator installed at the VLA site last quarter are continuing successfully, with first fringes obtained in August.

The NAASC is actively searching for new staff in the ramp-up to early operations. The NAASC sponsored its third scientific workshop in Charlottesville, with over 140 participants. The NAASC supported the first public release of the CASA offline software system. The memorandum of understanding (MOU) with our Canadian partners was signed, and the first meeting was held to discuss the Canadian contribution to ALMA core support. An MOU was signed with the University of Virginia Microfabrication Laboratory to manufacture and supply replacement SIS mixer chips for ALMA.

The GBT underwent summer maintenance for two months of inspection, repair, and painting. All GBT scheduling for this quarter was conducted by the beta test version of the new Dynamic Scheduling System, which was largely successful.

In collaboration with the University of Virginia Microfabrication Laboratory, the Central Development Lab is developing sideband-separating and balanced SIS receivers for 385–500 GHz and 780–950 GHz using AlN SIS junctions and NbTiN superconductors. A new type of orthomode transducer was fabricated that has good performance from 78 to 102 GHz and can be scaled to some ALMA bands.

The Office of Science and Academic Affairs (OSAA) created the Undergraduate Student Internship Program (USIP) for students at U.S. universities who are interested in pursuing research in radio astronomy, instrumentation development for radio astronomy, or areas of electrical engineering or computer science that are closely related to radio-astronomical observing techniques or data analysis. Interns will work part-time, usually during the academic year, under the supervision of NRAO staff in Socorro, Green Bank, and Charlottesville.

The U.S. SKA (Square Kilometer Array) Consortium is preparing to develop its final strategy for the U.S. decadal survey, to be based on the forthcoming ground rules for that survey. A draft “Return on Investment” was prepared, regarding the return to NASA from investing in the VLBA. Discussions regarding long-term VLBA support, and the ability of the VLBA to support VSOP-2, are under way with both the Institute of Space and Astronautical Science (ISAS) and the National Observatory of Japan.

## EXECUTIVE SUMMARY

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With a grant from the NSF's education division, the GBT's EPO team and West Virginia University created the Pulsar Search Collaboratory (PSC) to combine the capabilities of the NRAO and WVU to provide a unique opportunity for teachers and students to join in cutting-edge scientific research.

NRAO prepared presentations and hosted the AUI Cooperative Agreement Proposal review panel in Charlottesville on 25-27 August 2008, and similarly for a follow-up site visit at the VLA and in Socorro on 10-12 September 2008. The Annual Progress Report for FY 2008 was prepared and submitted to the NSF. The search was completed and appointments were made for two new Assistant Directors: Carol Lonsdale (ALMA NA Science Center) and Karen O'Neil (Green Bank Operations).

# SCIENCE

## 1. SCIENCE HIGHLIGHTS

### Very Large Array and Very Long Baseline Array (VLBA)

***The Most Distant Radio-Loud Object Known:*** The VLA and VLBA were used to study the first radio-loud quasar found at a redshift greater than 6, the quasar J1427+3312, at  $z = 6.12$ . It is unresolved by the 8.4 GHz VLA observations, but comparison of the flux at this frequency with earlier 1.4 GHz observations shows that the object has a steep spectrum (spectral index  $\alpha = -1.1$ ). The VLBA observations at 1.4 GHz resolve the radio source into two distinct components, suggesting that it is a Compact Symmetric Object with two radio lobes confined by the dense interstellar medium in the host galaxy. Though Keck II optical spectra reveal two strong Mg II absorption systems in the line of sight, the new high-resolution radio image sets strong constraints on any possible gravitational lensing and rule out typical lens systems.

*Collaborators:* E. Momjian (NAIC, NRAO), C. Carilli (NRAO), and I. McGreer (Columbia).

***Electron Diffusion in a Star-Forming Galaxy:*** In a study of the spiral galaxy NGC 3627, VLA radio continuum observations were combined with CO line observations from the Plateau de Bure Interferometer to compare the radio continuum emission, the molecular gas, and dust emission seen at infrared wavelengths. The expectation was that the radio continuum, primarily synchrotron emission from relativistic electrons accelerated by supernovae, would be significantly more diffuse and, at small spatial scales, less correlated with the gas and dust emission. However, the radio emission remained correlated with the dust and gas emission down to linear scales much smaller than expected. The observers concluded that the mechanisms of electron diffusion, loss, and injection must be significantly more complex than previously thought.

*Collaborators:* R. Paladino, M. Murgia, A. Tarchi, and L. Moscadelli (INAF, Italy) and C. Comito (MPIfR).

### Green Bank Telescope (GBT)

***Relativistic Spin Precession in the Double Pulsar:*** The double-pulsar system J0737–3039A/B is extraordinary in several respects: it is the only known binary system containing two neutron stars both of which appear as radio pulsars; the system is quite compact with an orbital period of slightly less than two and one-half hours; and the orbital plane is aligned nearly exactly along our line of sight so that pulsar “A” is eclipsed by the magnetosphere of pulsar “B”. These eclipses allowed a measurement with the GBT of an aspect of the theory of general relativity with unprecedented precision.

Because the spin axis of pulsar “B” is tipped with respect to the orbital axis, it precesses, and the pulsar's donut-shaped magnetosphere traces a complex pattern on the plane of the sky. In certain orientations the magnetosphere occults emission from pulsar “A”, while in other orientations pulsar “A” is clearly seen. From an examination of the amplitude pattern of pulses from “A” during an eclipse, the relativistic spin



## SCIENCE

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### *1. SCIENCE HIGHLIGHTS*

precession of pulsar “B” arising from spin-orbit coupling can be determined with very high accuracy. The double pulsar is the only relativistic binary system that allows a direct constraint on the spin-orbit coupling in theories of gravity. Four years of observation of this system with the GBT have been used to derive geometric parameters that are consistent with the spin-orbit coupling predicted by general relativity within an uncertainty of only 13%.

*Collaborators: R. Breton, V. Kaspi, M. Kramer, M. McLaughlin, M. Lyutikov, S. Ransom, I. Stairs, R. Ferdman, F. Camilo, A. Possenti.*

***Ubiquitous Water Masers in Nearby Star-Forming Galaxies:*** Radio emission from H<sub>2</sub>O masers arises during the early stages of massive star formation and is a marker of ultra-dense HII regions, which can contain the equivalent of a thousand or more embedded O-type stars. Such masers can have luminosities in the H<sub>2</sub>O line of a solar luminosity, and they are typically orders-of-magnitude weaker than the “megamasers” associated with galactic nuclear disks. Although these weaker “kilomasers” can help pinpoint sites of active star formation, there have been few searches with the sensitivity necessary to detect them at extragalactic distances. Previously only six H<sub>2</sub>O kilomasers had been associated with extragalactic regions of star formation, and the most thorough search had a detection rate of about 10%.

In contrast, a recent GBT search for H<sub>2</sub>O masers in star-forming regions in four nearby galaxies had a 100% success rate. This implies that there is a population of kilomasers just below the detection limits of other instruments but readily accessible with the GBT. In comparison with the sample of H<sub>2</sub>O masers known in the Milky Way, all of the newly detected masers are subluminal in the H<sub>2</sub>O line relative to their host galaxies' far-infrared luminosities. The origin of this difference is not known. Sensitive future surveys should produce a greatly expanded sample of these masers and, if some of the spots are bright enough, they could be targets for VLBI astrometry to measure the full space motions of their host galaxies.

*Collaborators: J. Darling, C. Brogan, K. Johnson.*

### *2. Office of Science and Academic Affairs (OSAA)*

#### **2. OFFICE OF SCIENCE AND ACADEMIC AFFAIRS (OSAA)**

During this quarter the OSAA worked on career development for the NRAO scientific staff. These tasks included finding the new Green Bank Assistant Director, drafting agreements with the University of Virginia for joint faculty hires, determining criteria for the next tenure-track hire, creating a new NRAO Undergraduate Internship program, and reviewing appropriate scientific-staff appointment levels and promotions. The OSAA began discussions with the Human Resources divisions at NRAO-US, NRAO-Chile, and ESO to determine the evaluation process for the scientific staff stationed at the Joint ALMA Observatory in Chile.

The OSAA focused on establishing future science directions for the Observatory by defining the roles of the new Observatory Chief Scientist both within the NRAO and with respect to the outside astronomical community, and also participating in Decadal Planning meetings.

The 2008 Jansky Lecture was presented by Arthur M. Wolfe of the University of California, San Diego in Charlottesville and in Green Bank in mid-September. The events were well attended, and Dr. Wolfe's scientific talk entitled "Finding the Gas that Makes Galaxies" received rave reviews from the NRAO scientific staff as well as the faculty and staff at the University of Virginia. The Karl G. Jansky Lectureship is an award established to recognize outstanding contributions to the advancement of radio astronomy.

#### **Historical Archives**

Processing work continued on post-1979 NRAO materials and on the papers of pioneering radio astronomer John D. Kraus.

Preliminary examination and sorting was completed for the Ronald N. Bracewell materials received in the second quarter of 2008. His radio astronomy papers were retained, and other papers were shipped to the Stanford University Archives. A complete bibliography of Bracewell's many publications was prepared with the assistance of Scientist Emeritus A. Richard Thompson and posted on the Web.

After consultation with NRAO staff and with the American Institute of Physics Center for the History of Physics, we began discarding all negatives of figures included in papers published in the open literature from the historical image file of 26,000 black-and-white negatives; these figures were prepared by hand before image-generating software was available. We expect that removing these negatives from the historical image file will reduce its size by at least 50% and greatly reduce Archives storage requirements.

About 3,200 un-indexed 35 mm VLA construction slides were transferred from Socorro to Archives for future identification, organization, and processing. A small collection of family photos from the 1940s that were loaned to the NRAO by the Jansky family were digitized and added to the collection.

Finding aids to the collection and the Archives online catalog are available on the NRAO Archives home page <http://www.nrao.edu/archives/>

### 2. Office of Science and Academic Affairs (OSAA)

#### Library Program

The Library hosted Open Houses at the Socorro, Green Bank, and Charlottesville locations for the rollout of *NRAOPapers*. This is the bibliographic database of NRAO telescope and author publications from 1957 to date. Reception of the *Papers* side of the E2E program has been positive. The system is available to the NRAO staff and the general public via <https://safe.nrao.edu/php/library/search.shtml>

Linking *NRAOPapers* to the Data Vault is the next step in our program to let any user connect from a particular scientific paper to the data and/or original proposal, or from the proposal or data to the resultant papers—a complete e2e system.

“State of the Library” presentations were given at all three locations. Some 2007 numbers include:

- Services provided to NRAO Staff (including reference inquiries, article and book acquisitions, book circulation, and page charges) = 4,373.
- Services provided to the community outside of the NRAO = 327.
- Visits to the NRAO Library Web Page = 22,280.
- Journal Subscription Expenditures only = \$181,304.95.
- Journal Subscriptions plus Page Charge Support (total NRAO expenditure for journals) = \$318,020.69.

#### Scientific Appointments

##### Arrivals/Promotions

- Esteban Araya began his Jansky Fellowship on September 2. This is considered a non-resident Fellowship, as he will be working at the University of New Mexico on cosmic masers, massive star formation, molecular clouds and the interstellar medium, and starburst galaxies and AGN.
- Brian Kent began his Jansky Fellowship in Charlottesville on September 2. His research interests include nearby galaxies and clusters, galaxy dynamics, gas dynamics, extragalactic HI, scientific software, and the Virtual Observatory.
- Violette Impellizzeri, MPIfR, began her NRAO Postdoctoral appointment on the Megamaser Cosmology Project on September 29, working with Jim Braatz in Charlottesville.
- Aaron Evans began his Associate Astronomer/Tenure appointment full time on July 22 and his joint NRAO/UVa faculty position in August. His functional work in the NAASC continues.
- Remy Indebetouw began his full-time Associate Scientist/A, joint NRAO/UVa faculty position in Charlottesville on August 1. Remy's functional work in the NAASC continues.

##### Departures/Extensions

- Poonam Chandra completed her Jansky Fellowship on August 31 and joined the Royal Military College in Ontario, Canada.
- Dave Meier completed his Jansky Fellowship at the end of August and accepted an Assistant Professorship at New Mexico Tech.

### 2. *Office of Science and Academic Affairs (OSAA)*

- Marijke Haverkorn completed her Jansky Fellowship on September 1 and moved to the Netherlands to accept a staff scientist position at ASTRON.

### **Student and Visiting Scientist Programs**

#### **Predocs**

- Urvashi Rao-Venkata (New Mexico Tech) continued working with Frazer Owen in Socorro and Tim Cornwell at the Australia Telescope National Facility; she is investigating parameterized deconvolution in radio synthesis imaging, specifically for high-dynamic-range and multi-frequency imaging with the EVLA, co-supervised by Prof. Jean Eilek at New Mexico Tech.
- Chataili Parashare (University of Virginia) continued working with Richard Bradley at the NRAO Technology Center (NTC) on instrumentation for low frequency radio astronomy arrays.
- Rohit Gawande (University of Virginia) worked with Richard Bradley at the NTC on developing and fabricating ultra-wideband feeds for a variety of radio astronomy applications.
- Katie Mae Chynoweth (Vanderbilt University) completed her graduate internship in August and transferred to a predoctoral position in order to continue working with Glen Langston in Green Bank on HI observations of interacting galaxies with the GBT and VLA.
- Cheng-Yu Kuo (University of Virginia) completed a graduate internship in September and transferred to a predoctoral position to continue working with Jim Braatz in Charlottesville on reducing and analyzing VLBI observations of water-maser emission from galactic nuclei as part of the Megamaser Cosmology Project.

#### **Graduate Interns**

- Ryan Lynch (University of Virginia) completed a graduate internship working with Scott Ransom in Charlottesville on GBT searches for new globular-cluster millisecond pulsars.
- Nimish Sane (University of Maryland) began a graduate internship working with John Ford in Green Bank on digital processing for radio spectroscopy.
- Kristen Thomas (University of Kentucky) visited Charlottesville as a graduate intern to work with Crystal Brogan on VLA Zeeman-effect observations toward the Galactic Center.

#### **Undergraduate Interns**

The OSAA created the Undergraduate Student Internship Program (USIP) for students at U.S. universities who are interested in pursuing research in radio astronomy, instrumentation development for radio astronomy, or areas of electrical engineering or computer science that are closely related to radio-astronomical observing techniques or data analysis. Interns will work part time, usually during the academic year, under the supervision of NRAO staff in Socorro, Green Bank, and Charlottesville.

#### **Visiting Scientists**

- Malcolm Gray (University of Manchester, U.K.) is spending a sabbatical year in Socorro working on theory and computational models associated with astrophysical masers.

## SCIENCE

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### *2. Office of Science and Academic Affairs (OSAA)*

- Maura McLaughlin and Duncan Lorimer (WVU) visited Green Bank to observe rotating radio transients (RRATs) and new pulsars discovered in the GBT 350 MHz drift-scan survey.
- Andrew Harris and Shuvra Battacharyya (University of Maryland) visited Green Bank to work with John Ford on digital processing for radio spectroscopy.
- Pat Palmer (University of Chicago) worked with Miller Goss in Socorro on parallax and proper motion studies of excited-state OH masers in DR21.

### **Support Programs**

#### **Student Observing Support (SOS)**

The NRAO Student Observing Support committee met in April 2008 to discuss the twelve proposals that were submitted during the last trimester. This committee, composed of five faculty from U.S. universities, reviewed the science case and student support application for each proposal and selected four to receive funding. The funded proposals are:

- Jackie Hodges (UC, Berkeley, supervisor: R. Becker) was awarded \$35,000 for work related to the VLA Large proposal AR685 “Deep VLA Observations of SDSS Stripe 82.”
- Stephanie Zonak (U Maryland, supervisor: A. Harris) was awarded \$18,000 for work related to the GBT proposal 08C-070 “Deep Zpectrometer Integration toward the Cloverleaf Galaxy.”
- Loren Anderson (Boston U, supervisor: T. Bania) was awarded \$12,820 for work related to the GBT proposal 08C-007 “How Many HII Regions are in the Milky Way?”
- Ryan Lynch (U Virginia, supervisor: S. Ransom) was awarded \$27,400 for work related to the GBT proposal 08C-076 “Long-Term Timing of 55 Recycled Pulsars in Bulge Globular Clusters.”

Complete information on the Student Observing Support program is available on the NRAO web page <http://wiki.gb.nrao.edu/bin/view/Observing/NRAOStudentSupportProgram>

### 3. TELESCOPE USAGE

The NRAO telescopes were scheduled for research and for maintenance during the third quarter of 2008 as described in the table below. Time lost and actual observing times for the arrays are computed as fractions of the total antenna arrays. For example, losing 27 VLA antennas for one hour counts as 1.0 hours of array time lost, while losing one out of ten VLBA antennas for one hour counts as 0.1 hours of array time lost. Antennas being modified for the EVLA and therefore not available for astronomical observations are counted as lost for observing.

We now schedule approximately 40% of the VLA time dynamically, prototyping our dynamic scheduling process for the EVLA. There are voids in this process creating unscheduled periods because we do not always have programs of the right length in the right range of sidereal times to fill in the gaps in the schedule. This is particularly true during the 6–8 weeks each year when antennas are being moved because the mixed VLA configurations are not useful for the majority of our astronomical observations. In addition, EVLA testing and commissioning now takes priority for dynamic time, especially at short notice. The EVLA testing sometimes fills part of a dynamic scheduling slot in such a way that there is no corresponding astronomical observation available to fill the rest of the slot.

There are three primary factors that create unscheduled periods for the VLBA.

- (1) Both dynamically scheduled and fixed-schedule VLBA projects are typically 10–16 hours in length; with only 10 antennas, the VLBA cannot effectively take snapshots. The lack of scientifically compelling proposals that last for only 2–4 hours means that gaps of this length usually cannot be filled by dynamically scheduled programs, so the VLBA is idle for such periods.
- (2) The VLBA observing rate is limited by the disk module supply, which is sufficient only for a 128 Mbps sustained recording rate with a module turnaround time of about 30 days. Because the best science typically requires more sensitivity, as many as 70% of the VLBA proposals now request 256 Mbps or 512 Mbps data rates; these proposals can be accommodated (and the correlator can keep up!) only if we leave gaps in the schedule.
- (3) We have at least three scheduled 1–2 week maintenance visits per year to a VLBA station. There are significant gaps in the schedule during those periods because most programs require at least nine working antennas to have effective imaging capability. We have neither the personnel nor the hardware available to visit multiple antennas during the same week.

Telescope Usage (hours)			
Activity	VLA	VLBA	GBT
Scheduled Observing	1522.62	857.75	1718.00
Scheduled Maintenance and Equipment Changes	231.50	237.80	414.00
Scheduled Tests and Calibrations	453.88	342.21	100.00
Time Lost	256.44	40.85	86.00
Unscheduled	—	770.25	—
Actual Observing	1266.19	816.90	1633.00

## PROJECTS

### *1. Expanded Very Large Array*

## PROJECTS

### *1. EXPANDED VERY LARGE ARRAY (EVLA)*

EVLA highlights for the quarter include:

- First fringes were recorded with a prototype WIDAR correlator and two EVLA antennas on August 7, 2008.
- A total of 17 antennas have been retrofitted to the EVLA design and account for 62.3% of all antenna hours in scientific observations.
- Installation of the infrastructure for the final WIDAR correlator was completed.
- Four of the new Ka-band receivers were installed on EVLA antennas in the array.
- Production quantities of the 3 bit, 4Gbps digitizers were delivered by the vendor to the NRAO.
- The L-band orthomode transducer was shown to meet project specifications.
- The origin of the long-standing phase instability problem in the EVLA LO/IF system was found in the antenna reference generator module.

**EVLA Milestones**

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
1. Start on-the-sky testing with the 2 station prototype correlator	07/02/08	07/07/08	07/07/08
2. Successful conversion of SDM+BDF to FITS format	07/07/08		07/07/08
3. Start EVLA conversion of antenna 28	07/15/08		07/09/08
4. 1 <sup>st</sup> article 3 bit sampler chip on-board test completed	06/30/08	07/10/08	07/10/08
5. Circuit-board design and prototype for the new DDS completed	07/15/08		07/15/08
6. S-band receiver OMT tests completed	05/13/08	07/21/08	07/21/08
7. Begin lab tests of the 3 bit sampler in DTS module	07/28/08		07/28/08
8. All 16 WIDAR correlator racks delivered	07/30/08		07/30/08
9. Second Ka-band receiver ready to install	07/15/08		08/07/08
10. WIDAR correlator room fire-suppression system activated	08/11/08		08/07/08
11. First Fringes from prototype WIDAR correlator	08/07/08		08/07/08
12. Observation Preparation Tool readiness review for Ka band	07/14/08		08/14/08
13. Hardware acceptance tests completed on Antenna 3	08/04/08		08/22/08
14. Antenna 3 Turnover to Operations	08/08/08		08/25/08
15. Correlator racks and cable installation completed	08/29/08		09/05/08
16. Final training and correlator-room access control implemented	09/09/08		09/10/08

## PROJECTS

### *1. Expanded Very Large Array*

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
17. Start EVLA conversion of Antenna 9	09/16/08		09/16/08
18. Prototype correlator data captured into AIPS	09/18/08		09/18/08
19. Stringent cleaning of new correlator room completed	09/03/08		09/25/08
20. 4 station board correlator installed	07/15/08		09/26/08
21. L-band receiver OMT tests completed	11/15/07	07/31/08	09/29/08
22. Correlator-room access control implemented	12/05/07	09/09/08	09/29/08
23. Science Data Model version 1.00 published	12/31/07	10/30/08	
24. 10 station correlator boards delivered	08/15/08	10/31/08	
25. Four DTS modules with 3 bit samplers assembled	08/18/08	11/03/08	
26. On-the-sky testing of 4 station prototype correlator completed	09/23/08	11/04/08	
27. Limited observing with 10 station board correlator	09/23/08	11/07/08	
28. Complete waveguide-style design of X-band receiver	01/15/08	11/14/08	
29. WIDAR correlator CDR – station-board acceptance	06/10/08	12/02/08	
30. Science Support System software PDR	11/13/07	11/14/08	
31. Hardware acceptance tests completed on Antenna 28	10/09/08		
32. Antenna 28 Turnover to Operations	10/10/08		
33. Hardware acceptance tests completed on Antenna 9	12/05/08		
34. Antenna 9 Turnover to Operations	12/08/08		
35. Prototype S-band receiver RF tests completed	10/23/08		
36. Prototype feed horn dry-air system installed	10/31/08		
37. Four DTS modules with 3 bit samplers installed	11/07/08		
38. Project Data Model drafted	12/01/08		
39. WIDAR correlator CDR – baseline-board acceptance	01/15/09		

## Management

Overall, the EVLA project remains on schedule. The conversion of antennas to the EVLA design is scheduled to be complete in Q3 of CY 2010. The installation of the WIDAR correlator is scheduled for completion in the first quarter of CY 2010. The last EVLA receiver will be installed in late CY 2012.

The WBS cost data sheets for the EVLA project were updated. Project contingency is \$3.16M, or about 19.6% of the estimated cost to complete the project. The percentage contingency remains at historically high levels. However, the contingency is needed to address the many risks that face the project.

The EVLA risk register was also updated during the past quarter. Since the first risk assessment made in December 2006, the total number of risks has been reduced from 79 to 47, the summed financial impact



## **PROJECTS**

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### *1. Expanded Very Large Array*

of the risks has been reduced from \$11.2M to \$7.3M, and the summed weighted impact has been reduced from \$3.3M to \$2.3M. The current project contingency is adequate to cover the weighted financial impact of the risks. The risk-register comparison shows that project risks are actively managed and that progress is being made towards eliminating the risks.

The NSF held a brief review of the EVLA project on September 10, 2008. The review committee's report has yet to be received.

A meeting of the Science Advisory Group for the EVLA (SAGE) is scheduled for mid-December 2008. The meeting will be followed by a science workshop on "The EVLA Vision: Galaxies through Cosmic Time." A meeting of the EVLA Advisory Committee will likely occur in Q1 of CY 2009.

### **Systems Integration**

The conversion of the 17<sup>th</sup> antenna was completed and the antenna was returned to array operations. The 17 EVLA antennas now contribute 62.3% of all antenna hours in scientific observations. The conversion of the 18<sup>th</sup> antenna is nearly complete. It will be returned to operations in October.

A phase instability problem of unknown origin had existed in the EVLA local oscillator (LO) and intermediate frequency (IF) system for some time. The problem was recently located in a crystal oscillator in the L305 antenna reference generator module. A solution for the problem is under development. We located the problem by using a new measurement technique that divides the antenna LO signals down to 512 MHz, transmits them back to the control building, and measures the signals with the recently completed L352 round-trip-phase modules. The same technique is being used to measure a similar, but smaller, effect that is occurring in the first LO of some receiver bands.

The design of the fault-tolerant LO and power supply hardware for the EVLA Central LO system is being completed. The design of the P350/P351 power supplies is complete, and the printed circuit boards (PCBs) for them have been assembled and tested. A distribution board designed to combine two of these power supplies into one fault-tolerant power supply is underway. The board should be complete in the next quarter. Three new modules (L356, L357, and L358) are being designed to provide a redundant, fault-tolerant LO system to the entire array. This system should be ready for installation in about a year.

### **Civil Construction**

The civil construction group helped Electronics Division personnel install the final set of equipment racks for the WIDAR correlator. The rack installation was completed in August. Electricians installed the cable tray and 48V power cables to each of the 16 racks. The FM200 fire-suppression system was armed and activated on August 7. The only work remaining for civil construction is to install control and alarm wiring for the air-conditioning equipment in the correlator shielded room.

### **Antennas**

The mechanical overhaul of the 17<sup>th</sup> and 18<sup>th</sup> EVLA antennas was completed. The mechanical overhaul of the 19<sup>th</sup> antenna is underway.

## PROJECTS

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### *1. Expanded Very Large Array*

Production of the S-band (2–4 GHz) feed horns began in April. Seven horns have been fabricated to date.

#### **Front End**

During the past quarter, the 17<sup>th</sup> and 18<sup>th</sup> EVLA antennas were outfitted with interim L- and X-band receivers as well as fully EVLA-compliant C-, K-, and Q-band systems. The current status of each receiver band is summarized below.

**L band:** Two of the final versions of the L-band (1–2 GHz) orthomode transducer (OMT) were manufactured and delivered to the NRAO. The design of all EVLA OMTs takes into account the straightforward assembly of each device, which is an important issue for their mass production. Tests show that both OMTs easily comply with performance specifications (see Fig. 1 below) without any tuning needed after the original assembly. Cold tests of the OMTs will commence in the coming months after the new L-band dewars are delivered.

**S band:** Cool-down tests of the final version of the S-band (2–4 GHz) OMT indicated that the receiver's refrigerator has the capacity to cool the OMT to the requisite temperature. The OMT is the largest thermal mass in the receiver. Tests of the entire receiver are scheduled for late October.

**C band:** Four of the wideband fully EVLA-compliant C-band (4–8 GHz) receivers have been assembled and tested, and three were installed on antennas in the array. The fourth receiver has passed all of its noise figure and RF gain tests. It will be installed on an antenna in October after its axial-ratio tests are completed.

**X band:** Preparations for fabricating and testing the prototype planar-style OMT for the X-band (8–12 GHz) receiver are underway in Green Bank. Drawings for the OMT have been submitted to the machine shop, and its fabrication is underway. An X-band dewar was assembled in Socorro and sent to Green Bank for the tests. Additional hardware needed for the tests has been designed, and the mechanical drawings for it have been submitted to the machine shop.

An alternative turnstile-junction-style OMT is being designed at the Central Development Laboratory. Its three primary sections (turnstile junction, stepped impedance transformer, and combiner) have been designed. The fabrication of these sections will commence in November.

**Ku band:** The RF and mechanical designs of the Ku-band (12–18 GHz) receiver are complete. Detailed mechanical drawings for the receiver are being prepared. The OMT, phase shifter, and square-to-rectangular waveguide transition were scaled from the design of the K-band receiver. Full production of the Ku-band receivers will start in late 2009.

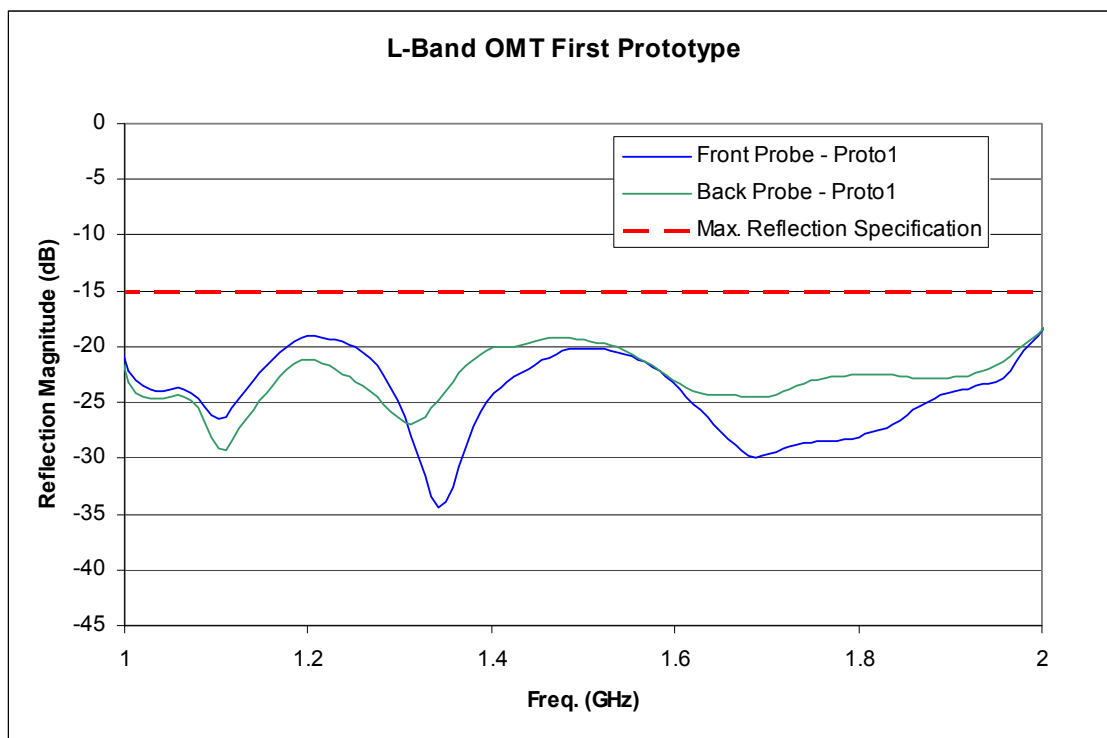
**Ka band:** Four Ka-band (26–40 GHz) receivers have been installed on antennas in the array. The fifth receiver is being assembled and will be installed on an antenna in early November.

**K and Q bands:** Installation of EVLA-compliant K-band (18–22 GHz) and Q-band (40–50 GHz) receivers continues to keep pace with the antenna-retrofitting schedule. Some of the original

## PROJECTS

### *1. Expanded Very Large Array*

versions of the Q-band receiver require new top plates and thermal transition sections. Machining these new components is not expected to affect the receiver production schedule.



*Figure 1. Results from reflection measurements of the L-band OMT*

### **Local Oscillator (LO) and Intermediate Frequency (IF) Systems**

Modules for the LO and IF systems are being built on a slightly accelerated schedule to meet the goal of having all modules finished in FY 2009. Some modules require retrofits for hardware upgrades and RFI considerations. The module retrofits will be made so as not to interrupt the antenna retrofitting schedule. Parts procurement for all LO/IF modules will be complete by the end of CY 2008.

Production of the L352 round-trip-phase module was recently delayed by a phase-wrap error that was discovered in the module. The phase error has since been reduced to the point where it is smaller than the phase instability caused by the atmosphere.

The EVLA antennas currently in the array use the EVLA's narrowband (1 GHz) signal path. The full capability of the EVLA's wideband (2 GHz) signal path cannot be exploited until the completion of the final WIDAR correlator. The first T304 baseband-converter modules to be fully configured with wideband electronics are now being produced. The parts needed for the wideband path, such as the gain-slope equalizers and wideband filters, have been received and are now being included in the regular production build. The wideband upgrade of existing T304 modules is ongoing.

## PROJECTS

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### *1. Expanded Very Large Array*

The main source of the phase instability in the LO/IF system was found to reside in the L305 antenna reference generator. All other modules in the LO/IF system are being investigated for phase instabilities. These problems will be resolved as they are identified.

### **Fiber Optic System**

Modules for the digital transmission system (DTS), formatter, and deformatter continue to be built to meet the antenna retrofitting schedule.

Tests of the engineering samples of the 3 bit, 4Gsp/s digitizer show they perform as expected. Production quantities of the digitizer chips were delivered to the NRAO in September. The digitizers will be installed in a sampler module. Unfortunately, the production of the sampler modules has been delayed by a clocking problem in a serial-to-parallel converter on the sampler board. We expect production of the sampler modules to resume in January 2009 at the rate of slightly more than one antenna per month.

The fiber-optics group led the installation of equipment racks for the final correlator. The racks are now ready for the installation of the production correlator boards. Access, cleanliness, and electrostatic discharge (ESD) procedures were implemented in the correlator shielded room in October.

### **Correlator**

In early July two station boards (SBs) and one baseline board (BB) were installed in the rack for the prototype correlator (PTC). The SBs were connected to two EVLA antennas on a short baseline. Dynamic fringes were recorded on August 7, although there were some anomalies in the data. By the end of August these anomalies were resolved, and full dynamic fringes were found with all of the signal processing required for delay and phase tracking. On September 16 the short baseline was extended to an A-configuration baseline, and fringes were detected on the first try. On September 18 data from the correlator were passed all the way through to AIPS, where more detailed and critical data analysis can and will be performed. By the end of September, the PTC rack was upgraded to four SBs to receive signals from four different antennas in the A configuration. Again, fringes were found on the first try.

Six more SBs are being tested in Penticton in preparation for their deployment to the VLA site in November. These boards, along with the four in the PTC, will be used to assemble a 10-station correlator in the racks for the final correlator.

Industry-standard quality control tests of the correlator chips were successfully completed. They indicate that the chip is very reliable. All of the production correlator chips have now undergone a burn-in screen test at full speed. The failure rate of the chips was 0.7%, due largely to incomplete scan test coverage and partially due to infant mortality induced by the burn-in screen. This low failure rate means that the spare chips on hand will be more than sufficient for the lifetime of the correlator. The chips have been delivered to the correlator PCB manufacturer (BreconRidge).

The first “stage 3” BB has been built. The BB successfully completed its boundary scan test. Functional tests of the BB are underway in Penticton. Five more boards are to be delivered from BreconRidge to Penticton in October. If the tests of these latter boards are successful, eight more boards will be built.

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### *1. Expanded Very Large Array*

The critical design review (CDR) for the correlator is now set for December 2–3 in Socorro. Expert panel members have been selected for the review. The success of the CDR depends on the successful completion of critical on-the-sky (OTS) tests and tests of the stage 3 BB. A successful CDR will trigger the full production of the correlator PCBs in early 2009.

Dave Fort, the designer of FPGAs on the correlator SBs, suffered a heart attack in July and was on sick leave for six weeks. Nevertheless, steady and significant progress was made.

### **Monitor and Control (M&C)**

The major M&C activities were related to successfully testing the prototype correlator (PTC), obtaining its “first fringes”, and developing capabilities for on-the-sky (OTS) tests with the PTC.

Modifications to the Executor M&C module allowed OTS tests to be carried out using EVLA antennas simultaneously with ongoing VLA observations. The tests included the preparation of scripts that were executed using a test executor. Graphical user interfaces (GUIs) were developed and used to configure and monitor low-level-board components. The actual tests required painstakingly debugging a series of low-level problems in both hardware and software. First fringes were recorded once these problems were resolved. OTS tests are now carried out almost routinely.

Most tests of the PTC have focused on monitoring and displaying board-level details. However, they also included producing metadata that conform to the Science Data Model (SDM) and binary data that conform to the binary data format (BDF) specified in the SDM. These data from the OTS tests have been loaded into CASA and AIPS for analysis. An ongoing effort to improve this process is underway. Changes to the Executor, correlator backend (CBE), and metadata and capture (MCAF) modules now allow SDMs to be produced without hand editing, a big step toward the goal of automating the process of merging SDMs and BDFs. The generation of the SDM/BDF combination enables one to load the data into CASA and AIPS on a routine basis.

In an agreement with ALMA, the EVLA has taken on the primary responsibility for documenting the SDM. A new version of the SDM document will be completed in the next quarter.

In addition to the PTC software, the following EVLA modules were updated over the past quarter: alerts loader, alert server, executor, operator’s software, front-end controller module (F317), DTS module (D30x, added support for the 3 bit digitizer), and the round-trip-phase module (L352).

### **Science Support Systems**

Several features were added to the Observation Preparation Tool (OPT) to aid Ka-band observations scheduled for the coming months. Among these are the ability to specify scheduling constraints, such as wind velocity and atmospheric phase, the ability to perform Doppler tracking, a richer calibrator search mechanism, and summary listings of the scans that comprise a scheduling block. Support for tipping scans and fixed-date specification of scheduling blocks was also added. The OPT is now ready for the next phase of testing, which will expose the tool to a wider audience and will involve running execution scripts produced from the information collected in the observation configuration process.

## PROJECTS

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### *1. Expanded Very Large Array*

A review of the Virtual Correlator Interface (VCI) was held in July 2008. The VCI is the protocol through which tools such as the OPT will communicate configuration requests to the WIDAR correlator. The document describing the VCI lists the details of all correlator configurations and operations in all observing modes. Software is being written to implement the VCI. Work began on a user interface for configuring WIDAR. The interface will be the first phase of WIDAR support within the OPT. It will be used in testing the 10 station prototype correlator in early 2009. Subsequent phases will seek to simplify the configuration of all EVLA hardware, including WIDAR.

## PROJECTS

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### *2. New Initiatives*

## **2. NEW INITIATIVES**

### **Square Kilometer Array (SKA)**

The U.S. SKA Consortium subcommittee that is planning for the decadal review met several times by teleconference and exchanged draft plans and sets of priorities. It became clear that convergence on a final strategy required a better understanding of the ground rules for the decadal survey and the required state of readiness for any program to be presented. The fog lifted slightly near the end of the quarter as the decadal committee chair was named and the committee charge was made public. The U.S. Consortium will discuss strategy in detail at its next face-to-face meeting in November.

The NRAO has initiated a “Lab Notebook” column in its monthly electronic newsletter that will highlight technological and scientific developments at the NRAO that are applicable to the SKA. The first introductory column was produced in the third quarter, and the first technical article is scheduled to appear in October 2008. We plan to collect these contributions and document them on the NRAO SKA website, thereby providing a more coherent picture of NRAO contributions to future meter/centimeter-wavelength radio telescopes that may comprise the SKA Program.

Direct discussions have been initiated with the International SKA Program Development Office regarding NRAO participation in the global PrepSKA program for developing the overall SKA system. One option under discussion is the possibility of testing candidate SKA antenna systems at an NRAO site, probably the VLA, in 2011 or later. These discussions will continue during the fourth quarter.

### **VLBA Partnerships**

Following the decision not to fund the U.S. Mission of Opportunity proposal for participation in the VSOP-2 Space VLBI mission, further discussions have been carried out with our colleagues in Japan’s Institute of Space and Astronautical Science (ISAS) and the National Observatory of Japan (NAOJ) regarding the options for supporting VLBA operations together with the VSOP-2 spacecraft. Face-to-face discussions now are scheduled in Japan for December 2008, in conjunction with the meeting of the VSOP-2 International Science Council. A future meeting about collaborative opportunities between the VLBA and the Japanese VERA telescope is anticipated for 2009.

The NRAO has completed the documentation required for participation in the European Community funding of the “Trans National Access” portion of the Radionet proposal to the Framework Programme-7 opportunity in Europe. It is expected that the funding of this proposal will yield some funding for VLBA participation in Global VLBI observing sessions two or three times per year.

Meetings were held with management of the NASA Deep Space Network and navigation personnel associated with the NASA Mars programs to discuss the results from VLBA tracking of the Phoenix spacecraft and a possible long-term collaborative effort on spacecraft tracking. A draft summary of the NASA “Return on Investment” (ROI) for use of the VLBA was prepared; this ROI was discussed with the relevant NASA Deputy Associate Administrator late in the quarter. In view of the Continuing Resolution for the U.S. federal budget and the consequent lack of funding for new efforts, further serious discussions will be deferred until the second quarter of CY 2009.

## PROJECTS

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### *2. New Initiatives*

#### **Frequency Agile Solar Radiotelescope (FASR)**

A FASR proposal was submitted to NSF's Division of Atmospheric Sciences (ATM) in June 2008. We expect the results of the proposal evaluation to be returned in the fourth quarter of CY 2008.

#### **Other Activities**

The NRAO participated in a proposal for an "Astrophysics Node", which was submitted to the NASA Lunar Science Institute in August. The NRAO also hosted visits of management and technical teams from the Chinese Academy of Sciences and the South Africa SKA Project Office to discuss opportunities for long-term collaborations. Specific issues of mutual interest are being pursued in ongoing discussions. These discussions focus on large telescope construction and VLBI with the Chinese and on algorithm development with the South Africans.

#### **New Initiatives Office Milestones**

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
1. Draft "Return on Investment" for NASA use of the VLBA	08/31/08		07/10/08
2. First NRAO observing in NRAO/GLAST program	08/15/08		07/16/08
3. EVN Directors meeting	11/04/08		
4. U.S. SKA Consortium meeting	11/30/08	11/17/08	
5. VISC-2 meeting	12/05/08		
6. Submit final report on VLBA Phoenix results	10/15/08	01/31/09	
7. VSOP-2/VERA collaboration meeting	04/30/09		



## OPERATIONS

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### *1. Green Bank Operations*

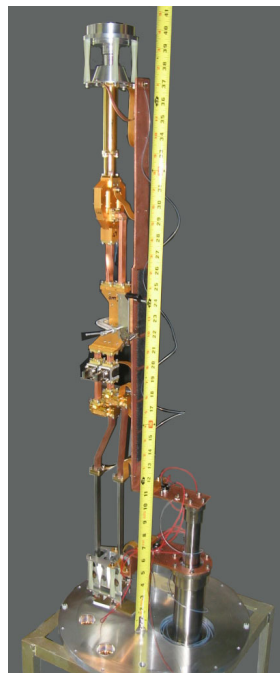
## OPERATIONS

### ***1. GREEN BANK OPERATIONS***

Green Bank highlights for the quarter include:

- First light and initial commissioning observations using the first pixel of the K-Band Focal Plane Array (KFPA).
- Successful completion of the GBT Dynamic Scheduling beta tests.
- MUSTANG preparations for the winter observing season.
- A new Out-of-Focus (OOF) holography application provided the first observer access to beam maps and active-surface corrections.
- Excellent GBT azimuth-track performance revalidation in tests spanning one year.
- GBT PLC antenna controllers were deployed and are in regular operation.
- Breakthrough on implementation challenges for CICADA resulting in an alpha release for tests.
- GBT EPO hosted the West Virginia Governor's school and launched the Pulsar Search Collaboratory in cooperation with West Virginia University.

The K-band Focal Plane Array prototype single-pixel receiver was completed, cooled, and tested in the lab. In early September the prototype was installed on the GBT and passed first-light and initial commissioning tests with a minimum of issues. The receiver was removed, and adjustments and corrections were made in advance of an October reinstallation and continued commissioning activities.



*Figure 1. The K-band Focal-Plane Array (KFPA) prototype single-pixel receiver.*

## OPERATIONS

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### *1. Green Bank Operations*

The NRAO software team working on the data pipeline software for the KFPA met throughout the quarter and defined the basic observing modes for the instrument. The team is now refining the pipeline architecture and evaluating the data requirements for pipeline development and tests. The 08B trimester beta test period for the GBT's prototype Dynamic Scheduling System (DSS) ended on September 30, 2008. Overall the beta test operations went extremely smoothly. GBT telescope schedules were created daily for the upcoming 24–28 hour period. The DSS was then monitored during the day to determine if weather conditions changed after the schedule was complete. After the beta operations period ended, GBT scheduling reverted to the old scheduling system pending the full release of the DSS (currently planned for 2009). The DSS team accumulated a great deal of user feedback on the system algorithms, policies, and user interface. This information will inform their work on the system in preparation for full deployment next summer. Details of the DSS and access to the system are available on-line at <http://www.gb.nrao.edu/dss>

A new bolometer array was received from Goddard for the MUSTANG project and cooled for initial characterization. We hoped this detector array would have lower intrinsic noise and a lower (though still adequate) saturation power, with improved sensitivity. Unfortunately the array did not survive the second cool-down cycle and had to be rejected. The original array was reinstalled and will be used for the shared-risk observing this winter. While loss of the new array was a disappointment to the project team, attention has returned to a new mechanical architecture that should improve the robustness and performance of future arrays. In preparation for the upcoming high-frequency observing season, a number of modifications are being made to the MUSTANG hardware. These changes will improve instrument electronics stability, simplify long-term operation of the receiver, and increase the instrumental sensitivity by as much as a factor of two. Complete MUSTANG M&C functions are being integrated into the graphical user interface to the Green Bank M&C system.

The MUSTANG science team significantly improved the data-analysis pipeline during the third quarter. The main advances were made in the IDL pipeline initially written for quick-look and commissioning analysis; this pipeline now produces astronomically correct images in FITS format as well as publication-quality postscript. A comprehensive least-squares map-making algorithm was also added that makes images comparable in quality to those produced by Bill Cotton's single-dish CLEAN in Obit. The independent pipeline allowed several minor bugs to be identified and fixed, and the consistency of the least-squares and Obit images, produced by completely different techniques, is excellent.

The Precision Telescope Control System (PTCS) project team worked on two main areas of the GBT: the antenna surface and the servo control system. New observations made during the third quarter, combined with processing of archived data, show great promise in the combination of Out of Focus (OOF) and traditional holography to provide accurate, repeatable characterization of the antenna surface and correction data for adjusting the active surface. The acquisition and analysis of OOF holography data has been streamlined into a new Astrid procedure called AutoOOF that is intended to improve the daytime high-frequency efficiency of the GBT surface. The traditional-holography team upgraded the holography correlator manager, and subsequent lab tests of the full system revealed phase instabilities arising from the DRO (Dielectric Resonance Oscillator) local oscillators driving the room temperature LNBs (Low Noise Block converters). New units were ordered, and integration of the new units and subsequent lab tests have begun. Six geostationary satellites with strong continuous beacon tones near 11.70 GHz have been identified and should make good signal sources for holography beam maps.

## OPERATIONS

### 1. Green Bank Operations

The final piece of documentation for the current pointing and focus model is being written. It will be a project note that describes the parameter estimation in the Matlab fitting scripts. Pointing research has now shifted to empirical calibration of the quadrant detector aimed at providing offline corrections to astronomical data, including MUSTANG images. An inclinometry run in early September shows that the features in the new azimuth track have been stable throughout the first year of operation, a good sign. Below is an overlay of five measurements taken during the past year.

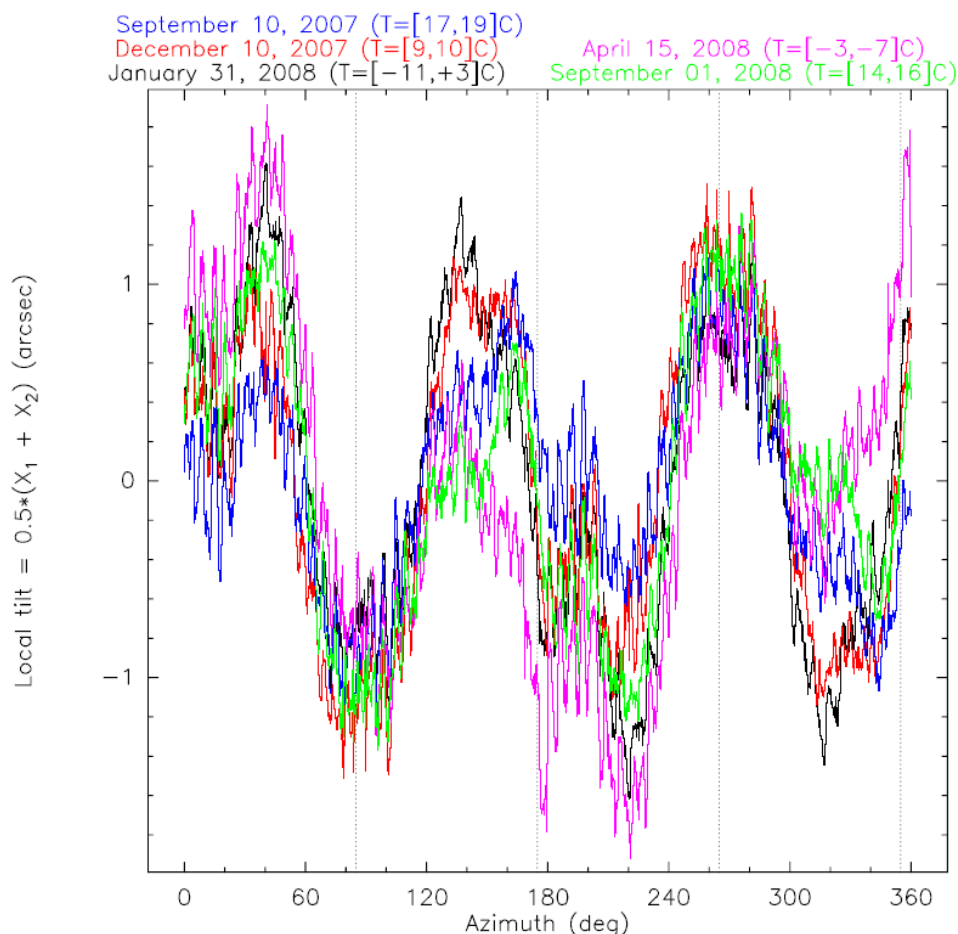


Figure 2. GBT track measurements, September 2007–September 2008.

The PTCS servo team turned over the PLC (Programmable Logic Controller) Interlock system to operations. This system has operated the telescope without failure, a tribute to careful planning and testing. Servo-system design teams continue to develop hardware and software architectures with a constant eye towards the complex issues of deploying and testing on an operating GBT. Modeling the existing controller nears completion, representing the first step in modeling the digital servo system. This work will result in detailed specifications for various system rates, measurement/monitoring resolutions, and system latencies. In a parallel effort, work continues on the high-level design of the control software. Over the summer the servo team conducted technical discussions with visiting experts from the GMRT

## OPERATIONS

### *1. Green Bank Operations*

and the LMT. In addition to receiving useful suggestions and experiences from these experts, the team was able to validate many of the concepts and techniques at the core of the new servo system.

The Configurable Instrument Collection for Agile Data Acquisition (CICADA) team successfully overcame a series of difficult timing and synchronization problems and announced an alpha release of the GUPPI pulsar backend for early (shared risk) science use and testing. A poster on this work was presented at the URSI conference held in late August.

Members of the Zpectrometer design and support teams met in Green Bank to prepare this wideband spectrometer for shared-risk observing this winter. There are over 200 hours of accepted proposal time to be scheduled with the Zpectrometer over the course of the high-frequency observing season.

With a grant from the NSF's education division, the GBT's EPO team and West Virginia University created the Pulsar Search Collaboratory (PSC) to combine the capabilities of the NRAO and WVU to provide a unique opportunity for teachers and students to join in cutting-edge scientific research. The PSC program includes training for teachers and student leaders at Green Bank, with an annual scientific seminar at WVU where all participants can present the results of their research. During the year, participants will share information through an online collaboration site called the "collaboratory" operated by Northwestern University. Student teams will receive parcels of data from the GBT and analyze the data to discover pulsars. Of the 1500 hours of GBT observing data taken during the summer of 2007, some 300 hours are reserved for analysis by the student teams. This reserved data set is expected to include tens of new pulsars and about 100 known pulsars.

The GBT summer maintenance season concluded on August 31. In addition to the routine structural maintenance and painting that occurs over this period, a comprehensive analysis of active-surface actuator status, informed by the early traditional holography analysis and combined with visual inspection, allowed engineers to fix nearly all of the broken actuators. At the completion of the summer season, observers were afforded the best active-surface conditions since the initial commissioning and acceptance of the GBT. A new state-of-the-art fire suppression system was installed on the GBT, offering improved protection to the telescope and to the personnel who work on it.

In an effort to reconcile all the project milestone reporting obligations of the GBT, all projects conformed their milestones to those in the NRAO Program Plan. Milestones shared by the Program Plan and this report now have the same names and descriptions to eliminate ambiguity. The milestones below reflect those changes, and future Quarterly Reports will be consistent with these new milestones.

**GBT Site Milestones for FY 2008**

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
<b>Dynamic Scheduling<sup>1</sup></b>			
1. Stage II tests complete	09/30/07	09/30/08	09/30/08
2. Complete trial run of new scheduling algorithms	06/30/08	09/30/08	09/30/08
3. Complete Stage II	10/01/07	10/01/08	09/30/08
4. Incorporate feedback from trial run into system design	08/30/08	12/01/08	

## OPERATIONS

### 1. Green Bank Operations

Milestones	Original Date	Revised Date	Date Completed
5. External review	12/01/07	12/10/08	
6. Release barebones DSS system for general use	06/01/08	09/30/09	
7. Release enhanced DSS system for general use	10/01/09	09/30/10	
<b>CICADA<sup>2</sup></b>			
1. Next Generation Pulsar Machine Phase 1 (Spigot replacement)	01/01/08	08/30/08	08/30/08
2. Incoherent pulsar backend deployed (initial modes)	09/30/08		09/30/08
3. Incoherent pulsar backend complete	09/30/08	12/31/08	
4. Coherent de-dispersion modes added; testing begins	06/30/08	03/30/09	
5. Release as common user instruments; project complete	06/30/08	08/30/09	
<b>K-Band Focal-Plane Array</b>			
1. M&C hardware module with support software complete	05/13/08	08/01/08	08/01/08
2. Single-pixel construction complete	05/08/08	08/01/08	08/01/08
3. Single-pixel testing complete with CDR acceptance	08/08/08	11/01/08	
4. KFPA prototype pixel accepted	11/31/08		
5. Monitor and control software complete	02/13/09		
6. Multi-pixel construction complete	06/09/09		
7. System integration and fully laboratory tested	11/03/09		
8. Data pipeline complete	02/18/10		
9. K-band focal-plane array commissioned	11/08/10		
10. K-band focal-plane array released for use	11/30/10		
<b>MUSTANG<sup>3</sup></b>			
1. MUSTANG open for shared-risk proposals	10/01/08		
2. Offline data-reduction pipeline complete	07/30/09		
3. Available as a facility instrument	10/01/08		
4. Online data-reduction pipeline complete	12/30/09		
<b>PTCS<sup>4</sup></b>			
1. PLC interlock system complete	08/31/07	08/31/08	08/31/08
2. Laser rangefinder V2 development complete	09/31/07	09/30/08	09/30/08
3. Recommissioning of traditional holography receiver	04/01/08	11/01/08	
4. Small-scale surface errors characterized with traditional holography	08/31/08	12/31/08	
5. Small-scale surface error initial corrections applied	04/30/09		
6. PTCS servo Critical Design Review	01/30/09		
7. Implement and test new digital servos	09/30/09		
8. Servo performance improvements complete	09/30/10		

## OPERATIONS

### *1. Green Bank Operations*

Milestones	Original Date	Revised Date	Date Completed
9. Initial deployment of AutoOOF (Out-of-focus holography) for observations	11/01/08		
10. Optimization of AutoOOF procedure complete	07/01/09		
<b>Zspectrometer<sup>5</sup></b>			
1. Instrument open for shared-risk proposals	10/01/08		10/01/08
2. Switchover to use as a facility instrument	10/01/09		

Notes:

1. Dynamic scheduling work was delayed by work on the high-frequency receivers.
2. CICADA (FPGA Development Project) is a University Collaboration with the University of Cincinnati and West Virginia University.
3. MUSTANG (Penn Array Receiver) is a University Collaboration with the University of Pennsylvania.
4. Deployment of the traditional-holography receiver has been delayed by the discovery of thermal instability of the first LO that requires device replacement and retesting. The recommissioning date is set by the Oct/Nov GBT observing schedule.
5. The Zspectrometer is a University Collaboration with Andy Harris at the University of Maryland.

## OPERATIONS

### 2. NEW MEXICO OPERATIONS

#### 2. NEW MEXICO OPERATIONS

New Mexico Operations Management highlights for this quarter include:

- In August, concerns were raised by managers of the Long Wavelength Array (LWA) project at the University of New Mexico that the State Land Office (SLO) might be close to approving the power-line route proposed by UPC. In addition to severely compromising the VLA's scientific capabilities, the proposed route would also produce unacceptably high interference levels for the LWA. New Mexico Operations management is currently seeking additional meetings with the New Mexico State Land Office Commissioner to clarify the status of the power-line route proposal and to reemphasize the critical interests of the Observatory in this matter. Management asked NSF's Division of Astronomical Sciences and Office of General Counsel to determine whether there are Federal legal actions that could be taken forestall the requested routing of the UPC power line close to the VLA site.
- The VLA/VLBA Proposal Scheduling Committee met in Socorro August 11–13.
- The NSF continued its panel review of AUI's proposal for NRAO Operations funding FY 2010–FY 2015 with a site visit on September 10–12.
- The NSF carried out a review of progress on the EVLA project during the NRAO/AUI Proposal review on September 10.
- A major cooling-system failure at the Domenici Science Operations Center (DSOC) led New Mexico Tech Facilities Management to install a temporary external chiller that remained in place for approximately six weeks while the failed unit was repaired. New Mexico Tech has begun linking the DSOC to the campus cooling system. Once that task is complete, the DSOC building's internal cooling system will be used only as an emergency backup.

VLA highlights for this quarter include:

- Seventeen EVLA antennas have now been retrofitted and restored to routine service with the VLA. The array reconfiguration from D to A began as scheduled on September 15 and was completed ahead of schedule 10 days later.
- Tests of the prototype WIDAR correlator installed at the VLA site last quarter continued, with first fringes obtained in August.

VLBA highlights for this quarter include:

- The tiger-team maintenance visit to the Owens Valley site was carried out as planned.
- The management structure of the VLBA wideband upgrade project was refined to improve its efficiency.

#### New Mexico Operations Management and Scientific Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Proposal Scheduling Committee meeting	08/11/08		08/11/08
2. Antenna 3 turnover to operations	08/08/08		08/25/08
3. Proposal deadline	10/01/08		

## OPERATIONS

### 2. NEW MEXICO OPERATIONS

Milestones	Original Date	Revised Date	Date Completed
4. Complete reconfiguration move from D to A	10/03/08		09/25/08
5. Antenna 28 turnover to operations (18 <sup>th</sup> EVLA antenna)	10/08/08		
6. Replace two azimuth wheel assemblies and an elevation bearing on the SC VLBA antenna	10/27/08		
7. Install refurbished subreflector on the SC antenna	10/27/08		
8. Complete WIDAR station-board production review	12/02/08		
9. Proposal Scheduling Committee meeting	12/12/08		
10. SAGE Science Workshop and meeting ends	12/20/08		
11. Freeze AIPS version 31DEC08, begin 31DEC09	12/31/08		

### Computer Infrastructure Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Bring up EVLA antenna-3 network	07/15/08		07/17/08
2. Assist with Data Security Plan rollout	07/30/08		08/10/08
3. Install EVLA correlator network	10/30/08	08/31/08	08/21/08
4. Bring up EVLA antenna-28 network	10/15/08		09/16/08
5. Install CASA 16 node development cluster			09/19/08
6. Assist with ETK rollout	07/20/08	10/20/08	
7. Bring up EVLA antenna-9 network	11/15/08		
8. Support 10 station board correlator installation	11/15/08		
9. Establish EVLA/AOC fiber plan	11/30/07	12/31/08	
10. Migrate to new 40TB archive disk storage	12/15/08		
11. Redhat EL5 upgrade	10/30/08	12/31/08	

Notes:

- 5. Project created after previous quarterly report
- 6. In progress, completion date is driven by rollout date
- 9. Delayed by available time, not yet time critical
- 11. In progress, start delayed till 09/15/08 by Redhat release delays

### Electronics Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Design an EVLA-compatible API	07/30/08		07/30/08
2. Complete a VLA prototype ACU system design	08/01/08		08/01/08
3. Scheduled maintenance visit at OV-VLBA	05/15/08	08/25/08	08/25/08
4. Complete VLA P-Band receiver upgrade white paper	10/24/08		
5. Install FRM brake power supply and new interface board for testing in a single VLA antenna.	09/19/08	11/15/08	
6. Install an EVLA-compatible API at the VLA	08/27/08	11/21/08	



## OPERATIONS

### 2. NEW MEXICO OPERATIONS

Milestones	Original Date	Revised Date	Date Completed
7. Scheduled maintenance visit at SC-VLBA	11/20/08		
8. Install the Mark5 pressure enclosure at MK-VLBA	05/09/08	12/05/08	
9. Delivery of the Mark5C recorders (units 1–3)	06/25/08	01/15/09	
10. Lab prototype DBE with samplers, attenuators, and anti-aliasing filters in a proper enclosure	03/15/08	01/15/09	
11. Order Mark5A to Mark5C upgrade kits	03/07/09		
12. Initial DBE/M5C installation at one VLBA site	04/01/09		
13. Complete DBE installation at 10 VLBA sites	08/15/09		

Notes:

- The EVLA project has priority over this task.
- This is a low priority task and will be completed as time permits.
- Conduant Inc. delivered the three Mark5C chassis in June 2008. The 10GE daughter cards will be delivered in December 2008.
- Revisions to the Berkeley ROACH computer card delayed the board manufacturing. Version 1 hardware was tested in June. Version 2 hardware will be delivered in September for testing. Complete DBE testing will start in December when the Mark5C recorders are 100% functional.

#### Engineering Services Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Antenna 28 azimuth bearing replacement	08/12/08		08/01/08
2. Complete A array reconfiguration	10/03/08		09/25/08
3. St. Croix visit: subreflector, paint, EL bearing, AZ wheel assembly replacement, general mechanical maintenance	10/30/08	11/14/08	
4. St. Croix antenna painting	12/15/07	11/14/08	
5. Replace 4,000 ties	11/30/08		
6. Complete BnA array reconfiguration	01/23/09		
7. Complete B array reconfiguration	02/13/09		

Notes:

- Antenna painting is 99% complete; the area inside the truss structure just below the dish needs its final topcoat. Painting will be completed during the Major Mechanical Maintenance Visit in the fall.

## OPERATIONS

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### 3. North American ALMA Science Center (NAASC)

#### 3. NORTH AMERICAN ALMA SCIENCE CENTER (NAASC)

NAASC highlights for the quarter include:

- John Stoke, formerly of STScI, began work as the North American ALMA EPO Program Officer.
- Advertisements were posted for the second NAASC Commissioning Liaison, a CASA developer, and the first two NAASC postdocs.
- The third NAASC Science Workshop “Transformational Science with ALMA: The Birth and Feedback of Massive Stars, within and Beyond the Galaxy” was held on September 25–27, 2008 in Charlottesville.
- The NAASC hosted face-to-face meetings of the ALMA EPO Working Group, the ANASAC, and the ASAC.
- A Memorandum of Understanding with our Canadian partners was completed and signed, and the first face-to-face meeting was held to discuss the Canadian contribution to ALMA core support.
- The first fully public version of the CASA offline software system was released, with user support provided by the NAASC.
- A Memorandum of Understanding was signed with the University of Virginia Microfabrication Laboratory to manufacture and supply replacement SIS mixer chips for ALMA.
- A 500 GHz SIS mixer using an AlN junction was designed.

#### NAASC Personnel

Staffing remains a high priority for North American (NA) ALMA operations. John Stoke, formerly of STScI, started in his post as the NA ALMA EPO Program Officer (more below), and advertisements were posted for a second NAASC Commissioning Liaison, a CASA developer, and the first two NAASC postdocs. The two postdoc positions are for young submillimeter-wavelength experts to (1) exercise the scientific capabilities of the CASA offline software package, and (2) contribute to the content and evaluation of the molecular spectral-line database *Splatalogue*.

#### Community Support

The 3rd NAASC Science Workshop, “*Transformational Science with ALMA: The Birth and Feedback of Massive Stars Within and Beyond the Galaxy*”, was held in Charlottesville on September 25–27, 2008 with over 140 scientific participants, including members from the ANASAC and ASAC. The SOC, led by A. Baker from Rutgers and R. Indebetouw from the NAASC/UVA, developed a broad and compelling scientific program exploring massive-star formation from high-resolution views of individual cores in our Galaxy to galaxy-wide scaling laws in the local universe. The program also included the feedback effects of massive stars on their natal cores, clouds, and entire host galaxies plus relevant aspects of astrochemistry, including line identification, modeling, and analysis of the many molecular tracers accessible to ALMA. In addition to the rich scientific program, the meeting included a half-day breakout session for the participants to discuss future science drivers for ALMA development. This provided broad NA input to the ASAC meeting that occurred in the days immediately following the workshop. Future NAASC workshops will follow this very successful format.

## OPERATIONS

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### 3. North American ALMA Science Center (NAASC)

Both the ANASAC and the ASAC held their face-to-face meeting in September at the NAASC, the former shortly before the NAASC workshop and the latter immediately following. The ANASAC discussed a number of important issues including pre-ALMA science program support and the fate of the NA prototype antenna, and it provided input to the ASAC charges, such as the scientific priorities for the ALMA development program. Alicia Weinberger (OCIW) was elected as the new ANASAC Chair, while the former Chair (Andrew Baker, Rutgers) joined the ASAC.

NAASC support and testing of ALMA offline software continued, coordinated by ALMA CASA Subsystem Scientist Crystal Brogan. The major activities during this quarter were (1) the Beta Patch 2 release in July, which is the first fully open release of the CASA software, and (2) testing in preparation of Beta Patch 3 (scheduled for 2008Q4). The NAASC provides the bulk of the user support for CASA via the CASA helpdesk. Patch 2 saw significant improvements to the CASA ALMA Simulator *almasimmos* (work overseen by Remy Indebetouw), and several NAASC staff traveled to the “Workshop on Simulations for ALMA” held in Grenoble to give a demonstration of *almasimmos* and to learn of similar efforts worldwide. Beta Patch 3 testing focused on new capabilities for heterogeneous-array imaging (required for CARMA and future ALMA 12m + ACA imaging) and independent antenna- and baseline-based bandpass solutions for each spectral window (needed for SMA and future ALMA data reduction). Status reports on CASA were given at the ANASAC and ASAC face-to-face meetings.

### Education and Public Outreach (EPO)

The NRAO and the NAASC hosted the face-to-face meeting of the international ALMA EPO Working Group in August. This included planning for the worldwide coordination of ALMA EPO efforts and joint activities related to the International Year of Astronomy 2009 (IYA). The new NA ALMA EPO Program Officer (Stoke) hit the ground running, providing support for and input to ALMA articles for an upcoming issue of Readers Digest magazine and the Popular Mechanics website. The latter resulted in a very positive online article about ALMA construction and future science that was picked up by the Yahoo News portal and resulted in over a million visits. He also contributed articles to the NRAO eNews and recorded presentations and interviews at the September ALMA Workshop on massive-star formation. He provided extensive editorial consultation and rewriting on the English translation of ESO's ALMA planetarium program being produced with ESO funding by the Association of French-Speaking Planetariums.

NAASC staff attended a number of meetings and gave science talks that featured discussions of ALMA's potential. These meetings included the Kavli Institute in Peking meeting “Reionization and First Light” (Carilli), the LANL Cosmology summer school (Carilli), the Green Bank “Pulsar Search Collaboratory Teacher Workshop” (Brogan), the Grenoble “Workshop on Simulations for ALMA” (Indebetouw, Wootten, Reid), the “Polarization 2008” meeting (Wootten), and the 3<sup>rd</sup> NAASC Science Workshop (Brogan).

### International Partnership

The “Memorandum of Understanding” for Canadian participation in ALMA Operations was completed and signed, and a face-to-face meeting of Gerald Schieven and James di Francesco from the Millimeter Astronomy Group (MAG) from HIA with incoming NAASC head Carol Lonsdale and other NAASC staff was held to discuss the Canadian contribution to ALMA core support in 2009. The skill sets of the

## OPERATIONS

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### 3. North American ALMA Science Center (NAASC)

two groups are very complimentary, and the MAG will contribute in-house expertise for CSV support, testing single-dish plus interferometer algorithms, and possibly end-user documentation.

NAASC staff discontinued support of the ALMA Test Facility (ATF) in Socorro this quarter, as it is now being used as a software test bed. Discussions on the possible fate of the NA prototype were held at the ALMA Simulator workshop and the NAASC Workshop, with input provided to the ANASAC and ASAC at their face-to-face meetings.

The NA ARC Manager traveled to Mitaka, Japan in September for a meeting of the Science Operations Working Group, where progress was made on the ALMA Helpdesk requirements document, ARC Mirror Archive plan, and participation in user software tests. The Joint ALMA Observatory (JAO) Head of Administration traveled to Charlottesville in August to discuss the CY 2007–2008 JAO budgets and reconciliation and the preliminary CY 2009 budget. These budgets were used to complete the NAASC FY 2009 Program Plan.

### Special Projects

The NAASC-developed spectral-line database *Splatalogue* ([www.splatalogue.net](http://www.splatalogue.net)) continues to be updated under the guidance of Anthony Remijan. By the end of the quarter, ~40% of all data in *Splatalogue* have been rigorously tested for completeness and reliability. Testing and additions continue with a goal of reaching 100% reliability by the end of the calendar year. Also, the requisite software is being used and tested to import the metadata from each molecular species into *Splatalogue*, and a new software developer was contracted to work on the software used to display the predictions of line strengths of transitions in the LTE (local thermodynamic equilibrium) low-opacity case. A user “focus group” was held in September to set priorities for the desired content and look-and-feel to be developed before the January 2009 AAS meeting, where hands-on tutorials of *Splatalogue* are planned.

An MOU was signed between the NRAO and UVa following NSF approval last quarter of a subaward to the UVa Microfabrication Laboratory (UVML) for development of high-frequency SIS mixers. The competing of this contract and pending completion of the accompanying contractual agreement, which should occur in the coming quarter, has delayed Band 10 mixer development.

A 500 GHz SIS mixer using an AlN junction was designed. This is an essential step on the way to a 900 GHz SIS mixer because they share the same basic design and much of the new fabrication technology. Staff at the NRAO Technology Center (NTC) investigated a new, simply fabricated, split-block orthomode transducer (OMT) that appears suitable for scaling to ~ 1 THz. A 100 GHz version of the OMT was tested and performed as expected from simulations. However, the sensitivity of the polarization isolation to misalignment between the two halves was greater than expected. The NTC will work with the designer at CSIRO to reduce this sensitivity in a version for operation in ALMA Band 10.

## OPERATIONS

### 3. North American ALMA Science Center (NAASC)

#### NAASC Milestones July to September 2008<sup>1</sup>

Milestones	Original Date	Revised Date	Date Completed
1. Complete Canadian MOU	09/01/07	08/08	08/08
2. Write the FY 2008 Project Summary	07/28/08		07/28/08
3. Budget face-to-face planning with JAO in Charlottesville	08/06–08/08		08/06–08/08
4. Revise NAASC FY 2009 budget using revised JAO CY 2009 budget	08/10/08		08/10/08
5. ALMA EPO Working Group face-to-face meeting in Charlottesville	08/11–12/08		08/11–12/08
6. Write the FY 2009 Program Plan	08/20/08		08/20/08
7. Participate in the ALMA Simulator Meeting in Grenoble	09/08/08		09/08/08
8. ANASAC face-to-face meeting in Charlottesville	09/12/08		09/12/08
9. SciOps IPT face-to-face meeting in Mitaka	09/18–20/08		09/18–20/08
10. NAASC Science Workshop III	09/25–27/08		09/25–27/08
11. ASAC face-to-face meeting in Charlottesville	09/27–29/08		09/27–29/08
12. CASA testing for Beta Patch 3 Release	09/30/08		09/30/08
13. Talks on ALMA science and status at NA institutions	Ongoing		
14. Software testing: CASA, Pipeline, Simulator, and Obstool	Ongoing		
15. Testing at the ATF	Completed		07/08
16. Spectral line catalogue—resolve species	Ongoing		
17. Participation in SciOps IPT, ARC managers meetings	Ongoing		
18. Resolve CASA helpdesk tickets	Ongoing		

<sup>1</sup> Milestones for SIS Mixer development are listed in the CDL section of this report.

## OPERATIONS

### 4. Central Development Lab

#### 4. CENTRAL DEVELOPMENT LAB (CDL)

CDL highlights for the quarter include:

- Additional tests on new high-frequency MMIC power amplifiers using a short gate length (70 nm) GaAs MMIC process have been conducted and show first-pass success on a larger number of designs than originally indicated.
- The 16-element PAPER prototype array has been successfully deployed in Green Bank.
- A compact turnstile junction OMT has been designed for the EVLA X-band receiver.

#### Amplifier Design and Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Develop prototype ALMA Band 1 and Band 2 amplifiers		12/30/08	

Note:

1. Demonstration amplifiers for ALMA Band 1 (31–45 GHz) and Band 2 (67–90 GHz) receivers have been designed. Experimental evaluation awaits the availability of technician time.

Other Projects: Research continues on the noise properties of heterostructure bipolar transistors (HBTs) and CMOS MOSFETs.

#### Amplifier Production Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Build/upgrade/repair cryogenic amplifiers using Cryo-3 TRW devices for the EVLA covering the frequency range from 1 to 50 GHz	12/31/15		ongoing
2. Build/upgrade/repair cryogenic amplifiers using Cryo-3 TRW devices for the VLBA and the GBT covering the frequency range from 1 to 95 GHz	ongoing		ongoing
3. Improve existing noise-measurement systems	ongoing		ongoing

Notes:

1. and 2. New amplifier production included two 1–2 GHz low-noise, four 1–2 GHz high-dynamic-range, four 4–8 GHz, two 12–18 GHz, six 18–26 GHz and two 38–50 GHz amplifiers. Repair, upgrade, and retesting of amplifiers included one 1–2 GHz low-noise, two 12–18 GHz, five 18–26 GHz and eight 38–50 GHz amplifiers. In total, 36 amplifiers were shipped. EVLA and GBT amplifier production is on the average approximately on schedule. We are behind in shipment of four 2–4 GHz amplifiers and four 26–40 GHz amplifiers but ahead in shipment of four 18–26 GHz and four 38–50 GHz amplifiers.

## OPERATIONS

### 4. Central Development Lab

#### MMIC Design and Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Develop differential LNA for balanced feeds	12/01/06	12/01/08	
2. Develop integrated wideband LNA+feed package	12/01/06	12/01/08	
3. Design and test GaAs W-band (75–110 GHz) power amplifiers to improve the reliability of millimeter-wave local oscillators	03/01/07	12/01/08	
4. Demonstrate a wideband, digitally enhanced sideband-separation receiver at L band in an integrated package	12/01/08		
5. Demonstrate a digitally enhanced polarization-isolation receiver at X band in an integrated package	12/01/08		
6. Integrate analog and digital components for digitally enhanced receivers in a single compact housing	6/01/09		
7. Test 67–95 GHz 35 nm InP MMIC LNA	10/31/07	08/15/08	08/15/08
8. Develop cryogenic noise-calibration modules	03/31/08	09/30/08	09/30/08

#### Notes:

1. Further progress on this task awaits an appropriate MMIC wafer run.
2. Optimization studies have been performed on the high-impedance transition between log-periodic feed antennas above a ground plane and the microstrip circuitry of the active balun. Simulations show that a decade-bandwidth transition can be made with minimal electrical path length and >30 dB return loss by appropriately shaping the ground-plane aperture.
3. Fabrication was completed in June 2008, and on-wafer small-signal tests showed that almost all of the new 70 nm MMIC designs were successful, including at least one first-pass success from each targeted band. Chips have been diced and are currently being characterized in ALMA modules.
4. The integrated L-band converter was completed and is being tested. A suitable high-speed digitizer and data acquisition system has also been procured, and test scripts are being written in preparation for measurements with the analog module.
5. The front-end digitally enhanced OMT package design is complete, and parts are being procured.
6. Preliminary studies lead us to believe that it is possible to integrate analog and digital components in a common housing with sufficient isolation for radio astronomy work.
7. The 67–95 GHz MMIC LNA using the new NGST 35nm InP HEMT process was packaged and tested at the CDL. The measured noise temperature at cryogenic temperatures was less than 30 K from 78 to 95 GHz with a minimum of 22 K from 83 to 87 GHz. The measured gain cold is 27–31 dB for the designed band. This is the lowest noise temperature ever reported for an amplifier at these frequencies. Analysis is ongoing to tune the lowest-noise band to cover ALMA Band 2 (67–90 GHz) as well as to design a new amplifier to cover 84–116 GHz. Two more packaged amplifiers have been assembled using the current MMIC design, and they also show <25 K noise temperature. Funding for future wafer runs in this process may also become available through the Keck Institute for Space Studies (also see note #1).
8. An integrated calibration source and coupler for the single-pixel KFPA prototype was designed and fabricated based on the approved design using a commercial MMIC LNA as the noise source. Tests were

## OPERATIONS

### 4. Central Development Lab

successful, and it is currently integrated with the single-pixel prototype KFPA receiver that is undergoing astronomical testing on the GBT.

Other:

First-pixel tests on the prototype K-Band Focal Plane Array receiver have been completed in Green Bank. The warm analog electronics were integrated in a compact MMIC-based module developed at the CDL, which led to a marked improvement in baseline stability compared to conventional GBT receivers.

#### Electromagnetic Support Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Develop a dual-band 345/800 MHz feed for the GBT	09/30/05	12/31/08	
2. Design and prototype an EVLA X-band (8–12 GHz) OMT	09/30/08	01/31/09	
3. Design and prototype an EVLA X-band phase shifter	09/30/08	03/31/09	
4. Measure and complete the design of the Ku-band (12–18 GHz) phase shifter	09/30/08	12/30/08	
5. ALMA Band 8 optics design	12/31/08		

Notes:

2. The turnstile junction, stepped transformer, and OMT Y junction (combiner) have been designed.
4. Postponed owing to the fabrication delay at the outside machine shop.

Other Projects:

Measurements on 16 production Ka-band phase shifters for the EVLA were completed.

Scaled prototypes of the W-band phase shifter with different lengths were measured. The measured axial ratio is  $< \pm 0.5$  dB in the 17–24 GHz range, corresponding to 76–107.6 GHz at W band.

#### Superconducting Millimeter-Wave Receiver Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Complete 500 GHz mixer test set	12/31/08	03/31/09	
2. Measure new orthomode transducer	10/31/08		09/31/08
3. Measure drop-in hybrid at 500 GHz	01/31/09		
4. First measurements of the 500 GHz SIS mixer	01/31/07	03/31/09	
5. Design $\lambda = 350$ $\mu$ m optics	04/30/09	06/31/09	
6. Complete initial mixer design for a 900 GHz mixer	04/30/09	06/31/09	
7. Complete a 900 GHz mixer test set	06/30/09	12/31/09	
8. Measure the first 900 GHz receiver	09/30/09	03/31/10	



## OPERATIONS

### 4. Central Development Lab

#### Notes:

- 1, 4, 5, 6, 7, and 8. The schedule was revised owing to the loss of a key collaborator at the Arizona Radio Observatory and the delay in establishing a contract between the NRAO and the UVA.
2. A WR-10 (75–110 GHz) version of the new OMT was tested, and it performed as expected. The sensitivity of the polarization isolation to misalignment between the two halves was much greater than expected. We will work with the CSIRO designer to reduce this sensitivity in a 900 GHz version.
3. RF hybrids are crucial parts of the 500 GHz and 900 GHz balanced and sideband-separating SIS mixers.
4. Developing the 500 GHz SIS mixer is an essential step on the way to the 900 GHz SIS mixer. They share the same new basic design and much of the new fabrication technology. This and item 3 are being supported in part by the Arizona Radio Observatory.
6. The 900 GHz SIS mixer will be based on the 500 GHz design.
7. This is an extension of milestone 1, with different optics and LO and signal sources.

#### Other:

The work on microwave loss reduction in cryogenically cooled conductors by copper or gold plating has been published—R. Finger & A. R. Kerr, “Microwave Loss Reduction in Cryogenically Cooled Conductors,” *Int J Infrared Millimeter Waves*, vol. 29, no. 10, pp. 924–932, Oct. 2008. <http://springerlink.com/content/k0j72513131h1q11/fulltext.pdf>

### Green Bank Solar Radio Burst Spectrometer (GB/SRBS) Milestones

Milestones	Original Date	Revised Date	Date Completed
<b>GB/SRBS Phase III:</b>			
1. 10–80 MHz, dual polarization, four crossed dipoles, new digital spectrometer	09/30/05	TBD	

#### Note:

1. The spectrometer is back in regular operation following a system upgrade. The low-frequency antenna work has been delayed, pending funding.

### The Precision Array to Probe the Epoch of Reionization (PAPER) Milestones

Milestones	Original Date	Revised Date	Date Completed
1. 16-element prototype array operating in the 100–200 MHz band in Green Bank	12/31/06	07/15/08	09/30/08
2. 32-element array in Western Australia	12/15/06	04/30/09	

#### Note:

1. Delayed by the extended period required to explore outsourcing options.

## OPERATIONS

### 4. Central Development Lab

#### Frequency Agile Solar Radiotelescope (FASR) Milestones

Milestones	Original Date	Revised Date	Date Completed
1. FASR design team formed	08/15/08		09/09/08
2. Prototype FASR B Subsystem	03/15/09		

Note:

1. Construction funding is indefinitely delayed, but some development and “pathfinder” R&D may continue.

#### Electrochemistry Laboratory Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Provide electroplating services for amplifier and SIS mixer bodies, and for passive electromagnetic devices			Ongoing activity
2. Qualify new electroforming process for production of electromagnetic structures	12/15/08		08/01/08
3. Provide electroforming services for EVLA, GBT, and other telescope receiver systems			Ongoing activity
4. Add additional electroforming tank for increased production capacity	05/01/09		

Notes:

1. The Chemistry Lab’s gold plating output for the quarter (bondable and “hard” gold) was 217 grams. This represents a gold cost to the CDL of approximately \$6,200 and a commercial plating value of \$90,000. Primary consumers continue to be ALMA and the EVLA.

2. The new copper-electroforming system and process performed reliably during the quarter, with production from this single 10-gallon tank far exceeding that of the previous 50-gallon tank. Several demanding components (complex structures, difficult to electroform) have been completed and tested with excellent results. The tank has been upgraded to three plating “stations” and, by assembling small mandrels in a series arrangement, we have reliably plated up to nine component mandrels per tank load, typically requiring 10–12 days per load.

3. Completed components have included complex phase-shifter prototypes, simpler waveguide twists and circular-to-square adapters, and various prototype transformer sections. All electroforming production to date has been dedicated to EVLA requirements. A typical tank “load” represents \$1,500–\$2,500 at commercial prices, and our product quality consistently meets or exceeds commercial standards.

4. The Electrochemistry Lab is still hoping to implement a second electroforming tank before year end, but doing so will require shutting down the existing tank for two to three weeks. We will complete critical component prototyping work before attempting to add capacity.

## OPERATIONS

### 5. Chile Operations

#### 5. CHILE OPERATIONS

Chile operations highlights for the quarter include:

- Reaching the 120 mark in the number of local labor contracts signed by NRAO/AUI.
- Completing business reconciliation for CY 2007, in addition to site-related security actions
- Implementing EPO activities with the Local community.

##### Local Labor Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Local labor contract No. 120 signed			09/01/08

##### Business/Contracting/Safety & Security Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Reconciliation of ALMA Operations CY 2007 costs with all Executives completed			09/01/08
2. Risk analysis and Security Plan, Phase 2 (risk mitigation system) completed			07/10/08
3. 24/7 patrols initiated at the AOS			08/01/08

##### Education and Public Outreach Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Media coverage (TV, newspapers) of transport of first ALMA antenna (NA)			07/08/08
2. Begin student (as opposed to teachers) exchange between Magdalena and San Pedro de Atacama (Sister Cities Program)			08/19/08
3. Logistics support for Popular Mechanics-USA magazine media tour of ALMA			09/07/08
4. Sponsorship, logistics, and media coverage of "Meteorology and Radio Astronomy" at Universidad de Valparaíso			09/25/08
5. Logistics and participation in ALMA filming by Filmosonido			09/26/08

## OPERATIONS

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### *6. END TO END Operations*

#### **6. END TO END (E2E) OPERATIONS**

End-to-End Operations highlights for this quarter include:

- Substantial development of CASA data-processing software for v2.3 release in October.
- NGAS archive infrastructure is now collecting EVLA data at the telescope site.
- Proposal software supported 186 new proposals at the end of September 2008.
- A Memorandum of Understanding (MOU) between the NRAO and MeerKAT (South Africa) was signed; information sharing in M&C systems and algorithm development is to start in Q4.
- Software for semantic searching of the NRAO Data Vault and infrastructure to support searching 140 Foot and 12 Meter data were developed in preparation for a Q4 rollout.

#### **Management & Administration**

Q3 2008 was a strong quarter for establishing collaborations and promoting strategic alliances. The most significant accomplishment was a proposal submitted by Penn State, as the lead institution, and NRAO as a co-investigator, to fund a three-year Focused Research Group to study statistical pattern detection in the enormous data sets that will be produced by the EVLA and ALMA. If funded, a team of eight researchers and students from the university community will work to solve this very challenging problem, which has the potential to revolutionize the way sources are located in giant data sets. The NRAO was also involved in a successful Radionet (EU) proposal and will receive a small amount of funding to work on mosaicing in the data-processing software. Finally, the NRAO Director's Office signed an MOU with MeerKat (South Africa) to collaborate on monitor and control (M&C) systems and algorithm research. Weekly meetings were initiated at the end of September to schedule collaborative tasks through summer 2009.

Another important milestone in Q3 2008 was the first public release of CASA in early July. As a result, at the end of Q3 CASA management was shifted back into the domain of the ALMA and EVLA projects, with an observatory and ALMA project steering group. This step will increase ALMA and EVLA control of day-to-day decision-making so that CASA development can most effectively respond to changes demanded by development and commissioning of both projects.

#### **Data Processing/Common Astronomy Software Applications (CASA)**

Under the interim leadership of B. Glendenning, CASA focused on preparing the new version of the software, v2.3, to be released in Q4. The key functionality being developed for the new release is:

- Heterogeneous imaging (especially important for ALMA).
- Widefield imaging (especially important for the EVLA).
- Calibration improvements, particularly in interpolation and applying the calibrations.
- Improvements to the viewer, including printing enhancements, improved annotation capabilities, and DS9 file format overlay (which will broaden access to EVLA and ALMA data processing to established users of the DS9 package).

A high-performance computing cluster, with 16 nodes and 8 cores per node, was purchased by ALMA and EVLA jointly and installed in Socorro. This cluster will be used to enhance CASA performance by parallelizing critical portions of the code, and it will also be used for exploratory algorithm research. It is

## **OPERATIONS**

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### *6. END TO END Operations*

important to note that CASA is now relied upon for certain aspects of commissioning for both the EVLA and ALMA. It is being used every day at the ALMA Test Facility at the VLA site in both interferometric and single dish modes, and it is also being used to fill data from the EVLA WIDAR prototype correlator for further data processing in CASA or any other package.

### **Algorithm Research & Development (R&D)**

Preparations to formalize an algorithm R&D working group were made in Q3, with the intention of activating it fully in Q4 with a group charter. Participants included scientific staff members from all NRAO telescopes. The group will work to bring together the algorithm-development community in radio astronomy so that research efforts of individuals and small teams are supported more strongly and opportunities for knowledge sharing are more easily identified. Events currently being planned include:

- November 2008 – Team of software engineers from MeerKAT visits two NRAO sites.
- December 2008 – Oxford UK meeting, led by eMerlin.
- February 2009 – Cape Town meeting, led by MeerKAT.
- April 2009 – SKA algorithm development meeting, led by the NRAO.

### **Archive and Pipeline Operations**

The Next Generation Archive System (NGAS) developed by ALMA is now being battle tested on the EVLA. Archive infrastructure work focused on data management for the EVLA, especially ingesting the data stream from the EVLA into NGAS at the site. A new standalone NGAS archive host was installed there, and it is currently operational and undergoing extensive tests. J. Benson is developing automated processes to acquire and stage the raw data files produced by the WIDAR Prototype Correlator (using SDM/BDF formats). These processes will be used to archive data from the operational EVLA WIDAR.

Data have actively been transferred from the older systems to the new NGAS system in operations. Seven terabytes of archive data have been transferred from the disk array to an NGAS server, and all new VLBA correlator data files are being funneled into this NGAS server. Daily VLA data files are being ingested into the NGAS host in Socorro, replacing old disk array systems. The EVLA NGAS host now supports subscription requests from the main archive NGAS host in the AOC. In this way EVLA data will be automatically delivered to the main archive in the AOC.

Two archive-related summer student projects were completed during Q3: a prototype service to access historical VLA cover sheets back to 1982 was developed, and a prototype semantic search service to tag NRAO archive data based on the taxonomy used for SIMBAD/VO. Both services will undergo development and rigorous testing for release in Q4. Substantial progress was also made on investigating data from the 140 Foot and 12 Meter telescopes for ingesting into the archive and accessing from the archive interfaces. Data available early in this process will be released to users by the end of the calendar year.

Progress in VLA pipeline imaging picked up in Q3, and 76,524 images (with calibrated data files) of 16,658 unique sky positions are now available.

## OPERATIONS

### 6. END TO END Operations

#### Proposal Operations

The proposal submission tool (PST) successfully handled 186 VLA, VLBA/HSA, and GBT proposals in September 2008 for the October 1, 2008 deadline. There was no additional development on the tool in Q3 owing to budget constraints.

#### Virtual Astronomical Observatory (VAO) Operations

The applications framework project of the Virtual Observatory (VO) is an attempt to provide a common desktop and server framework to observatories. This will bring data processing from multiple observatories into a common environment to improve functionality and interoperability, reduce costs, and help integrate observatory data processing with VO and distributed multiwavelength data analysis. Progress on this project over the past quarter has been encouraging. A joint workshop with AURA, AUI, and NVO representatives was held in Hilo in late June. A first draft (D. Tody, ed.) of a document detailing the architecture and conceptual design of the common framework was distributed in mid-July. A coordinating meeting and a BOF (Birds of a Feather) session are planned for the ADASS conference in early November, with implementation planned to begin in early 2009.

The DALServer framework, used to provide a reference implementation for implementing VO data services, was enhanced during the summer to add support for the legacy cone-search service for access to catalogs and images via the Simple Image Access Protocol (SIAP). The support for access to 1-D spectra was also updated to the latest IVOA standards. A first draft of a document outlining the architecture and standard service profile for the second-generation IVOA data-access layer (DAL) interfaces was distributed (D. Tody [NRAO], F. Bonnarel [CDS], M. Dolensky [ESO]). A first working draft of the new IVOA Table Access Protocol (TAP) was produced late in the quarter (D. Tody, G. Rixon [UK-AstroGrid]), P. Dowler [CADC]).

J. Crossley and R. DuPlain attended the NVO Summer School in Santa Fe in September. D. Tody also attended as a member of the faculty. Crossley and DuPlain won the first prize in the technology area for their summer-student project integrating Google Sky with the VO image-access interfaces to produce the “KML Now!” prototype. Using this prototype, a user can execute a VO search and have the results displayed in the Google Sky application.

#### Management & Administration Activities

Milestones	Original Date	Revised Date	Date Completed
1. Complete E2E strategic planning exercise	09/15/07	04/30/08	07/31/08
2. Complete specifications for the Strategic Decision Support System (a management dashboard)	09/30/07	09/30/08	09/30/08
3. Prepare Partnership in Astronomy & Astrophysics Research and Education (PAARE) diversity proposal with NC A&T University	08/01/08		Canceled

## OPERATIONS

### 6. END TO END Operations

Milestones	Original Date	Revised Date	Date Completed
4. Prepare Education & Information Services proposal with the NRAO library for scanning equipment to link older proposals, memos, and publications	09/26/08		Canceled
5. Launch Management Dashboard v1.0	12/31/08		
6. Launch Management Dashboard v2.0	09/30/09		

Notes:

3. NC A&T proposal was cancelled because their administration was not enthusiastic about participating, which is the reason our last proposal was rejected. The PI at A&T has been working on generating support - we're not giving up on this, it will just be tried again next August.

4. The writing of this proposal was canceled because we discovered by emailing the representative from the program that our idea was not aligned with what they would fund.

### Algorithm Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Procure and install computing cluster	09/30/08		
2. Develop test scenarios for computing cluster (CASA/Algorithm R&D)	11/30/08		
3. Identify emerging trends at Supercomputing 08	11/30/08		
4. Host MeerKAT visit at Charlottesville & Socorro	11/30/08		
5. Represent NRAO at Oxford algorithms meeting	12/21/08		
6. Complete group operations charter	12/31/08		
7. Conduct joint NRAO/MeerKAT meeting in South Africa to advance partnership	02/28/09		
8. Complete at least one prototype from R&D work	06/30/09		
9. Complete two outreach efforts, including April 2009 SKA algorithms meeting in Socorro	06/30/09		

### NRAO Participation in the National Virtual Observatory (NVO) Project

Milestones	Original Date	Revised Date	Date Completed
1. First draft applications framework interfaces document	03/01/08	08/01/08	08/01/08
2. Initial release of service load-testing framework	07/15/08	08/15/08	08/15/08
3. DALServer updated for SSA standard (V1.02)	11/05/07	08/15/08	08/15/08
4. VOClient with CLI, registry, and SSA support	02/15/08	08/15/08	08/15/08
5. Conduct sessions at the 2008 NVO summer school	09/15/08		
6. Initial working draft and prototyping for SIA V2	09/15/07	10/01/08	

## OPERATIONS

### 6. END TO END Operations

Milestones	Original Date	Revised Date	Date Completed
7. TAP prototype with SimpleQuery functionality	11/05/07	10/15/08	
8. Revised SIA V1.0 specification for PR	08/15/07	10/15/08	
9. IVOA interoperability workshop (Baltimore)	10/27/08		
10. Planning for NRAO VAO operations (Tody/Radziwill)	12/15/08		

### NRAO Archive Infrastructure & Interfaces

Milestones	Original Date	Revised Date	Date Completed
1. Invite scientists to contribute material for the NRAO Showcase on Google Sky	05/19/08	08/15/08	Deferred (Staff Change at Google)
2. Document description and diagram of existing archive infrastructure	03/31/08	03/31/09	
3. Document database schema and diagrams (ERD) for the archive metadata/registry	06/31/07	03/31/09	
4. Install the Spectral Line Search Engine (SLiSE) to query the single-dish spectral database	12/31/07	03/31/09	
5. Include 12 m and 140 ft data in the production single-dish archive node (requires the ability to reduce data)	12/31/08		
6. Integrate semantic search capability into Data Vault	11/30/08		
7. Develop interface from CASA to Archive	12/31/08		
8. Install prototype GBT data service to Archive	03/31/09		
9. Produce images for common VLA/Chandra/Spitzer & HST searches	06/30/09		
10. Complete specifications for initial pulsar archiving	06/30/09		
11. Make progress on radio background in Google Sky with new team at Google	09/30/09		

### NRAO Proposal Infrastructure & Interfaces

Milestones	Original Date	Revised Date	Date Completed
1. 08C revisions available for user acceptance testing	08/08/08		08/08/08
2. 08C PST release	08/16/08		08/16/08
3. Enable export of GBT source catalogs	06/01/08	01/31/09	
4. Resolve author/institution duplicates	09/16/08		09/16/08
5. Install prototype for online helpdesk	09/16/08		09/16/08
6. 09A revisions available for user acceptance testing	12/20/08		



## OPERATIONS

### 6. END TO END Operations

Milestones	Original Date	Revised Date	Date Completed
7. Release data transfer mechanism to support the EVLA observing tool	12/31/08		
8. 09A PST release	01/14/09		
9. Move online helpdesk into production environment	01/14/09		
10. Release proposals.nrao.edu	01/31/09		
11. Complete standalone authentication (CAS) service	01/31/09		
12. Create modules to export proposal objects to sites	01/31/09		
13. 09B revisions available for user acceptance testing	04/30/09		
14. 09B PST release	05/14/09		
15. Add referee user type and refereeing capabilities	05/14/09		
16. 09C revisions available for user acceptance testing	08/31/09		
17. 09C PST release	09/14/09		

### Data Processing (CASA) Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Transition to new management structure for CASA	10/01/08		
2. CASA Release 2.3.0 (Beta Update 3.0)	10/15/08		
3. Identify parallelization benchmarking cases and datasets	12/31/08		
4. Complete ALMA Director's Review of CASA	12/31/08		
5. CASA Release 2.4.0	06/30/09		

### Other/Virtual Astronomical Observatory (VAO)

Milestones	Original Date	Revised Date	Date Completed
1. Complete Operations Plan for VAO at the NRAO	Pending funding		
2. Implement live chat for proposal and archive system	02/28/09		
3. Deploy code.nrao.edu to serve as repository for sharing	06/30/09		
4. Complete one prototype to make the VO "real" to the NRAO user community	08/31/09		
5. Support HPC development for GBT CICADA	09/30/09		

## OPERATIONS

### 7. Computer and Information Services

#### 7. COMPUTER AND INFORMATION SERVICES (CIS)

CIS highlights for this quarter include:

- Presented supporting material to the AUI Cooperative Agreement review panel with a focus on high-performance computing and cyber security.
- Defined the long-term strategic plan for computing, including the FY 2009 milestones.
- FY 2008 year-end budget cycle completed successfully.
- Released NRAO Papers web application to support the library's reporting and bibliography-management responsibilities.
- Supported the NAASC "Massive Star Formation Within and Beyond the Galaxy" workshop held in Charlottesville, September 25–27, 2008.
- Implemented bastion-host authentication on network perimeter to mitigate the risk from passwordless SSH-key compromise on non-NRAO systems used by external observers.
- Successfully completed data security training for all users who handle sensitive data.
- Initiated a policy requiring encryption and managerial approval before storing sensitive data on mobile devices owing to risk of loss.

#### Observatory-wide Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Upgrade link between UVa and NRAO-CV to 1 Gbps (d)	01/01/07	On Hold <sup>1</sup>	
2. Data security plan rollout to Tier 2 users (a,b)	05/31/08	07/22/08	07/22/08
3. Develop and deploy NRAO Paper bibliography service (c)	07/18/08		07/18/08
4. Rebid Wide Area Network contract (d) <sup>2</sup>	04/30/08	08/28/08	08/28/08
5. Definition of Standard Computer Hardware specification (b)	10/31/08		
6. Voicemail upgrade for GB site (d)	11/30/08		
7. Migrate Outlook users to Exchange 2007 server (b)	12/31/08		
8. Consolidation of directory service for phonebook / email (b)	12/31/08		
9. Fair Opportunity for GSA Networx contract (d)	01/31/09		
10. Coordinate scalable-computing workshop	01/31/09		
11. Service management review for operational support	01/31/09		
12. Evaluate calendar and room reservation systems (b,c)	02/28/09		
13. Upgrade the central disk filer in Green Bank (d)	03/31/09		
14. Train users and deploy Microsoft Office 2007	03/31/09		
15. Complete deployment of new Linux RHEL5 (b)	03/31/09		
16. Pilot release, Web Content Management Testbed System (c)	03/31/09		
17. Design new risk-management framework (a)	03/31/09		
18. System administrators meeting in Socorro (b)	04/30/09		

## OPERATIONS

### 7. Computer and Information Services

Milestones	Original Date	Revised Date	Date Completed
19. Evaluate migration of mbox to maildir (b)	04/30/09		
20. Network architecture and perimeter defenses review (a,d)	05/31/09		
21. First annual employee security training presentation (a)	06/30/09		
22. Coherent and consistent NRAO-wide system monitoring (b)	07/31/09		

Notes:

1. The contract was formalized but installation has been postponed owing to budget concerns.
2. Transition Manager has been established with GSA for Networx contract (track to milestone 9).

- (a) Security
- (b) Common computing environments
- (c) World-wide-web infrastructure
- (d) Telecommunications

#### Charlottesville Computing Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Upgrade Exchange Server	03/31/08	07/31/08	07/31/08
2. Initial implementation plan for North American ARC	10/31/08		
3. Limit internal network access for untrusted machines	11/30/08		
4. Support expansion of E2E archive infrastructure	12/31/08		

## OPERATIONS

### 8. Education and Public Outreach

#### 8. EDUCATION AND PUBLIC OUTREACH (EPO)

Education and Public Outreach highlights for this quarter include:

- A new, modernized NRAO logo was created.
- ALMA EPO Program Officer John Stoke arrived.
- Four teachers participated in the 2008 NRAO Research Experiences for Teachers (RET) program.
- A two day high-definition video and high-resolution stills shoot took place at the VLA.
- Eleven scientists submitted 20 images to the 2008 AUI/NRAO Image Contest.
- Pulsar Search Collaboratory workshops for teachers and students were held in Green Bank.
- The West Virginia Governor's School for Math & Science was held in Green Bank for the fourth consecutive summer.
- The Sister Cities student exchange for the August–December 2008 semester began.

#### Education and Public Outreach Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Design experts database for News Center	06/27/08	12/19/08	
2. Chautauqua Short Course (SOC)	07/09–11/08		07/09–11/08
3. StarQuest V (GB)	07/02–05/08		07/02–05/08
4. Pulsar Search Collaboratory Teacher Workshop (GB)	07/06–17/08		07/06–17/08
5. Pulsar Search Collaboratory Student Workshop (GB)	07/21–25/08		07/21–25/08
6. Revise Feb 2009 AAAS science symposium proposal	08/15/08		08/15/08
7. WV Governor's School for Math & Science, Teacher/Mentor Training (GB)	08/01–02/08		08/01–02/08
8. WV Governor's School for Math & Science (GB)	08/03–15/08		08/03–15/08
9. NRAO Town Hall planning for AAS meeting begins	10/01/08		
10. Install ViewSpace at the GB Science Center and the VLA Visitor Center	11/28/08		
11. Complete science conference exhibit-booth redesign	11/28/08		
12. Complete multimedia presentation for new exhibit booth	12/19/08		

Notes:

1. Delayed by higher-priority work on the NRAO website.
2. The "Cradle of Life" science symposium proposed for the February 2009 AAAS Annual Meeting was peer reviewed and accepted.
9. The NRAO Town Hall will take place January 7, 5:30–7:00 p.m. at the Long Beach (CA) AAS meeting.

## MANAGEMENT

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### *1. Observatory Management*

## MANAGEMENT

### ***1. OBSERVATORY MANAGEMENT***

NRAO prepared presentations and hosted the AUI Cooperative Agreement Proposal review panel in Charlottesville on 25-27 August 2008. A planned site visit to Green Bank following the Charlottesville review was cancelled. NRAO senior management responded to advance follow-up questions, prepared presentations, and hosted a site visit at the VLA site and at the Dominici Science Operations Center in Socorro on 10-12 September 2008. The site visit included an EVLA project mini-review.

The Annual Progress Report detailing accomplishments for FY 2008 was prepared and submitted to NSF. NRAO senior management attended the AUI Executive Committee meeting on 3 September 2008 by videoconference.

Searches were completed and appointments were made for two new Assistant Directors: Carol Lonsdale for the ALMA North American Science Center and Karen O'Neil for Green Bank Operations. Both appointments took effect on 1 October 2008.

## MANAGEMENT

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### *2. Administration*

## **2. ADMINISTRATION**

### **Environment, Safety, and Security (ES&S)**

ES&S focused on completing the security evaluations at Edgemont Road and the NTC. The University of Virginia Police Department evaluated our Edgemont Road facility as “better” than the norm for security on the UVa campus. Some improvements to cameras and physical security remain to be made, and they will be as needs require and budgets permit.

OSHA Training on respirator use (refresher) was completed in the third quarter. Sewer treatment plant DMR (Discharge Monitoring Report) results all met permit requirements.

Socorro DSOC (AOC) mechanical-room refurbishment awaits final repairs by the New Mexico Tech Maintenance Department. All remaining NRAO materials will be out of that space as soon as the ALMA Storage building is complete. That space is currently kept locked and is in service as a “Mechanical” room once again.

We continue to integrate our new ES&S Manager, Bob Daniels. Bob has visited Green Bank and the GBT, Socorro, and the VLA, and he is scheduling a visit to the ALMA facilities for Q4 2008.

### **Environment, Safety, and Security Milestones**

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
1. Green Bank water-tower tank inspection	05/01/08		07/22/08
2. ES&S manager replacement	06/13/08		07/18/08
3. Socorro DSOC (formerly AOC) mechanical room refurbishing oversight (nearly complete)	06/23/08	Pending completion of ALMA Storage Bldg	
4. NRAO New Mexico safety-manual review & revision	06/16/08	02/02/09	
5. Edgemont Road security evaluation	09/15/08		09/15/08
6. NTC security evaluation (survey complete—awaiting Albemarle County Police Department report)	11/17/08		

## MANAGEMENT

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### 3. *Human Resources*

### 3. *HUMAN RESOURCES (HR)*

Human Resources highlights for this quarter include:

- Assistant Director for the NAASC selected to begin October 2008 (Female).
- Assistant Director of Green Bank Operations selected to begin October 2008 (Female).
- High School summer intern from local public-school science program selected from Charlottesville, Virginia area (Female).
- M.I.T. undergraduate Engineering Intern selected (Female).
- University of Cincinnati engineering co-op student completes NRAO practical experience prior to graduation (Female/Minority).
- NRAO Sister City Exchange Program initiated by AUI/NRAO EPO between sister cities in the U.S. and Chile continued.
- HR acquires and begins implementation of a paperless self-service recruitment and position management web-based service for supervisors.
- Observatory receives 2008 Reader's Choice Award for Best Diversity Company in Government Sector by its readers.

### **Diversity**

The Sister Cities exchange program sponsored by AUI/NRAO and managed by the NRAO EPO program formally began in the fall 2006 when Magdalena, NM proclaimed San Pedro de Atacama, Chile its Sister City, and San Pedro proclaimed the same of Magdalena. Principal Myriam Rivera, teacher Gabriela Rodriguez, and Alcaldesa Sandra Berna visited Magdalena in February 2007 and participated in numerous school and community events. Magdalena School teachers Jim Sauer and Sandra Montoya then traveled to San Pedro in July 2007 to contribute to a wide range of Chilean school and community programs. In the August/December 2008 semester, AUI/NRAO and the NRAO EPO program continued their sponsorship of these Sister Cities by creating a student exchange, enabling two young persons from each community to spend a semester experiencing and learning the culture of another hemisphere. Additional information regarding the Sister Cities student exchange program appeared in the August 2008 NRAO eNews.

## MANAGEMENT

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### 3. Human Resources



*Figure 3.1. The Chilean and U.S. students participating in the 2008 Sister Cities student exchange program between Magdalena, NM and San Pedro de Atacama (left to right): Aracelli Ramirez, Lenaya Montoya, Soiky Casanga, and Charles Chavez.*

The Observatory was notified in June that it had again been recognized by the readers of Diversity/Careers in Engineering and Information Technology Journal as a Reader's Choice Government Sector Employer and contributor to diversity in the workplace. This honor is being received for the second year in a row. The Diversity/Careers journal is read by over 190,000 professional and student readers and distributed at major diversity conferences throughout the year.

The Human Resources department initiated contact with Heritage University in Washington State. Heritage has a diverse undergraduate population that is 53% Hispanic and 11% Native American. It is a small school with a total student population of 1,300 in 2006. Materials were sent to the Dean of the Computer Science program to promote awareness of the Observatory's interest in CS students.

The Observatory hosted the Howard University chairs of the physics, engineering, and computer science departments for an onsite visit of the NRAO headquarters and a tour of the NRAO Technology Center. A follow-up conference between both institutions is scheduled in the first quarter of FY 2009 to develop short- and long-term collaborative efforts including science talks, senior research projects, and student participation in student-experience programs in astronomy, engineering and computer science.



## MANAGEMENT

### 3. Human Resources



Figure 3.2. Members of the Howard University faculty and students spent the day at the Observatory and toured the CDL. Included in the picture are left to right Roy Norville, Dr. John Webber, Rykiel Robinson, Dr. Legand Burge, Dr. Mohamed Chouikha and Dr. James Lindesay.

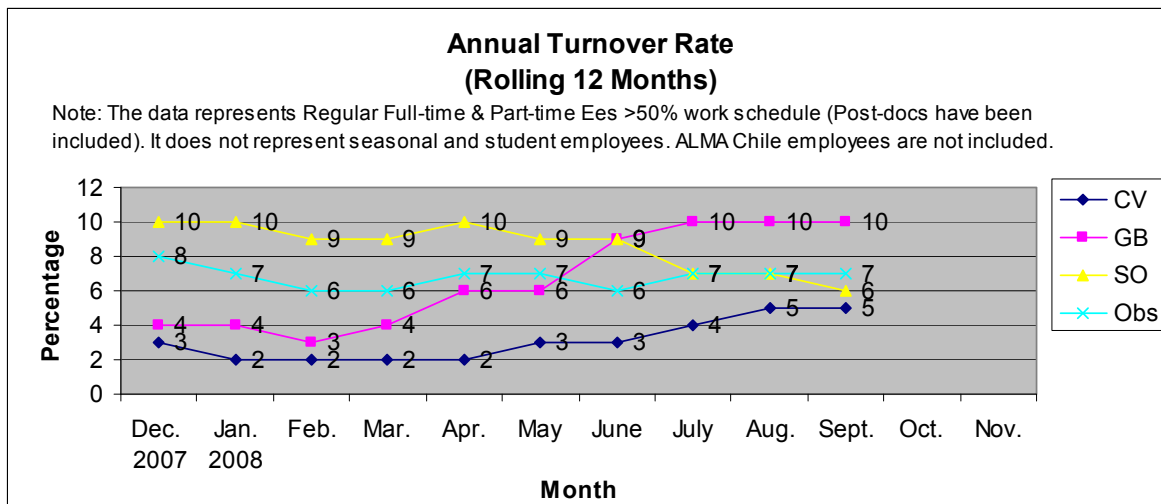
## Employment

**Recruitment/Application Tracking**—The HR Division acquired and implemented a web-based job requisition, posting, position-description, application-tracking, and selection-process system that will allow for supervisor self-service in the recruitment and selection processes in a paperless environment. The system is expected to “go live” in the first quarter of FY 2009 (December). The system is known as PeopleAdmin, and it is recognized as Best of Class for over 400 U.S.-based universities, research institutes and government agencies. Special emphasis has been placed on the program to address deficiencies identified by the Observatory’s AAP/Diversity consultant.

**Turnover**—The Observatory-wide turnover rate held steady at 7% for the fourth quarter because there were no terminations other than anticipated seasonal workers.

## MANAGEMENT

### 3. Human Resources

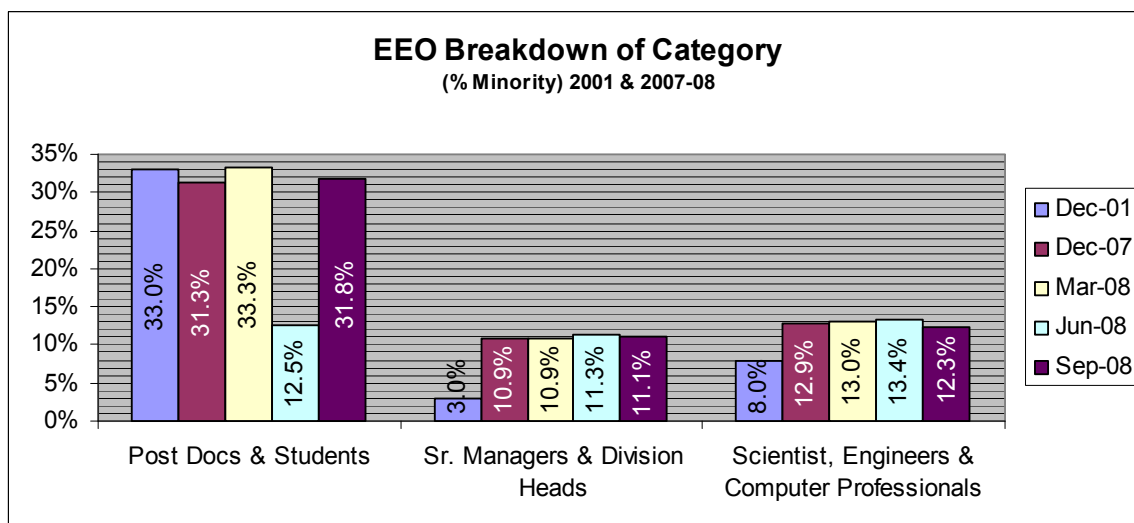


### Recruitment

The following Affirmative Action charts reflect the continued minority and women diversification efforts of the Observatory in the science and professional/technical workforce. Two trends are readily apparent.

**Minority Recruitment**—In the area of minority recruitment within Senior Management and within Scientist, Engineers, and Computing professionals (S, E & CP), the staffing level has increased or is holding steady since the first quarter of FY 2008.

Most significantly at FY 2008 year end, the Observatory recruitment-effort comparison from the benchmark year of FY 2001 to present is a clear positive increase of representation—8 percent in Senior Management and greater than 4 percent increase in S, E & CP.

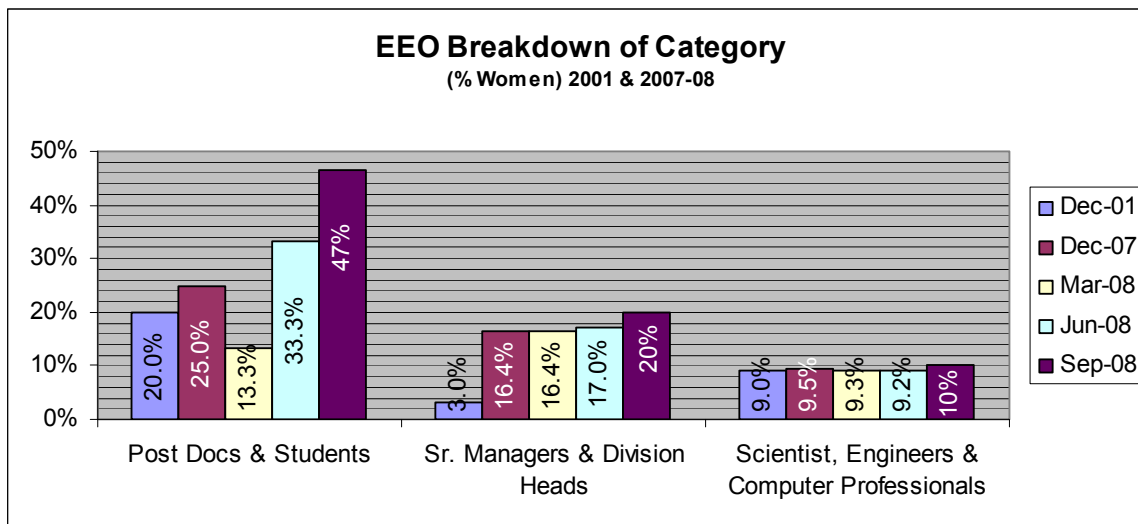


## MANAGEMENT

### 3. Human Resources

**Women Recruitment**—In the area of female recruitment within Sr. Management and within S, E & CP, the Observatory has had outstanding success at recruiting senior women managers as reflected by the 4 percent increase in FY 2008. More significant is the 17 percent increase over the FY 2001 benchmark. Only slight gains can be seen in S, E & CP recruitment results in the FY 2008 quarter-over-quarter results, and they reflect little change over the FY 2001 benchmark; however, it needs to be pointed out that many Scientists that were counted in these ranks have been promoted to the Senior Management level in FY 2008, thus producing a false negative in the report.

The results of postdocs and students placement demonstrates a 5% increase in women entering radio-astronomy-related experiences from FY 2001 to FY 2007, but more impressive is the fourth quarter number of 47% female participation in predominantly summer research and co-op experiences.



## MANAGEMENT

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### 3. Human Resources

#### Personnel

##### New Hires

Araya, Esteban	Jansky Fellow	09/01/08
Berger, Luana	Senior Electronics Technician	07/21/08
Dalal, Nagini	Electronics Engineer II	09/08/08
Daniels, Robert	Safety and Environmental Protection Manager	08/18/08
Duthie, Ruth	Systems Administrator I	07/14/08
Kent, Brian	Jansky Fellow	09/01/08
Stoke, John	EPO Program Officer	08/04/08

##### Terminations

Allen, Robin	Executive Assistant	07/22/08
Chandra, Poonam	Jansky Fellow	08/31/08
Dorpinghaus, Buffy	Systems Administrator I	07/18/08
Haverkorn, Marijke	Jansky Fellow	08/29/08
Indebetouw, Remy	Research Associate	08/21/08
Meier, David	Jansky Fellow	08/19/08

##### Rehire

Chynoweth, Katie	Junior Fellow	09/01/08
Nguyen, Ngoc	Co-op Student	08/07/08

##### Promotions

McCarty, Michael	Software Engineer II	08/01/08
Malone, Joshua	Systems Administrator I	08/01/08
Michalski, Stefan	Project Manager III	09/01/08
Witz, Stephan	Software Engineer I	08/01/08

##### Appointments

Indebetouw, Remy	Assistant Scientist/A –Joint Appointment (UVa)	08/22/08
Meier, David	Assistant Astronomer, Adjunct	09/01/08

## MANAGEMENT

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### *4. Budget*

#### **4. BUDGET**

The NRAO Operations new funding for FY 2008 is \$45,070k including \$6,010k for EVLA. Excluding EVLA, the net NRAO Operations budget new funding is \$39,060k. When combined with prior year commitments and prior year carryover, the NRAO Operations total budget, less EVLA, is \$47,046k. Overall, the NRAO Operations budget is approximately 5.9% below a linear spending rate through the fourth quarter. This under-run was the result of an intentional directive by management to generate carry-over funds to compensate for an anticipated Continuing Resolution in FY 2009. The following is a brief explanation of the WBS level 1 element that is under/over-spent in excess of 10% based on a linear projection rate.

- Observatory Management. Materials and Services expense continues to lag a linear spend rate owing to the need to retain reserve as an offset to the expected FY 2009 funding shortfall and Continuing Resolution.

# MANAGEMENT

## 4. Budget

NRAO Operations Expenses and Commitments FY 2008 Year to Date (October 1, 2007 to September 30, 2008) in \$000							Percent of fiscal year elapsed:	
WBS Level 1	Salaries & Benefits	Materials & Services	Travel	Revenue or Cost Recovery	Total	Linear Spending	Actual Exp + Comm	Actual Percent Expended & Committed
Observatory Management	6,059	2,386	374	-200	8,619	8,619	7,058	81.9%
Education and Public Outreach	679	209	37	-125	800	800	778	97.3%
Central Development Lab	1,491	216	23		1,730	1,730	1,641	94.8%
Green Bank Operations	8,901	2,766	145	-463	11,349	11,349	10,410	91.7%
New Mexico Operations	14,369	4,509	194	-80	18,992	18,992	19,014	100.1%
Computer and Information Services	1,066	737	25		1,829	1,829	1,719	94.0%
Science and Academic Affairs	1,795	1,548	385		3,728	3,728	3,651	97.9%
NRAO Operations total	34,360	12,370	1,183	-868	47,046	47,046	44,271	94.1%

## APPENDIX

### *Acronyms and Abbreviations*

Acronym	Definition
AAAS	American Association for the Advancement of Science
AAP	Affirmative Action Plan
AAS	American Astronomical Society
ACA	Atacama Compact Array
ACU	Antenna Control Unit
AGN	Active Galactic Nucleus
AIPS	Astronomical Image Processing System
ALMA	Atacama Large Millimeter Array
AlN	Aluminum Nitride
ANASAC	ALMA North American Scientific Advisory Committee
AOC	Array Operations Center (now DSOC)
API	Atmospheric Phase Interferometer
ARC	ALMA Regional Center
ASAC	ALMA Scientific Advisory Committee
ATF	ALMA Test Facility
AUI	Associated Universities, Incorporated
AURA	Associated Universities for Research in Astronomy
Band 1	31–45 GHz ALMA band
Band 2	67–90 GHz ALMA band
Band 10	780–950 GHz ALMA band
BB	Baseline Board (EVLA correlator)
BDF	Binary Data Format
C band	4–8 GHz
CASA	Common Astronomy Software Applications
CDL	Central Development Laboratory (Charlottesville, VA)
CDR	Critical Design Review
CICADA	Configurable Instrument Collaboration for Agile Data Acquisition
CIS	Computer and Information Services
CLI	Command-Line Interface
CMOS	Complementary Metal-Oxide Semiconductor
CO	Carbon Monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
CSV	Commissioning and Science Verification
CV	Charlottesville
DAL	Data Access Layer
DBE	Digital Back End
DDS	Direct Digital Synthesizer
DSOC	Domenici Science Operations Center (formerly AOC)
DSS	Dynamic Scheduling System (GBT)
DTS	Digital Transmission System
E2E	End-to-End
EPO	Education and Public Outreach
ERD	Entity Relationship Diagram
ES&S	Environment, Safety, and Security (NRAO)

## APPENDIX

### *Acronyms and Abbreviations*

Acronym	Definition
ESO	European Southern Observatory
ETK	Electronic Time Keeping
EU	European
EVLA	Expanded Very Large Array
EVN	European VLBI Network
FASR	Frequency-Agile Solar Radiotelescope
FITS	Flexible Image Transport System
FPGA	Field-Programmable Gate Array
FRM	Focus/Rotation Mount
FY	Fiscal Year
GaAs	Gallium Arsenide
GB	Green Bank
GB/SRBS	Green Bank Solar Radio Burst Spectrometer
Gbps	Giga bits per second
GBT	Green Bank Telescope
GHz	Gigahertz
GLAST	Gamma-ray Large-Area Space Telescope
GMRT	Giant Metrewave Radio Telescope
GSA	General Services Administration
Gsps	Giga samples per second
GUPPI	Green Bank Ultimate Pulsar-Processing Instrument
H <sub>2</sub> O	Water
HBT	Heterostructure Bipolar Transistor
HEMT	High-Electron-Mobility Transistor
HI	Neutral Hydrogen
HIA	Herzberg Institute of Astrophysics
III	Ionized Hydrogen
HPC	High-Performance Computing
HR	Human Resources
HSA	High-Sensitivity Array
HST	Hubble Space Telescope
IF	Intermediate Frequency
InP	Indium Phosphide
ISAS	Institute of Space and Astronautical Science (Japan)
IPT	Integrated Product Team
IVOA	International Virtual Observatory Alliance
JAO	Joint ALMA Observatory
k	thousand
K	Kelvins (temperature)
K band	18–26.5 GHz
Ka band	26.5–40 GHz
KFPA	K-band Focal-Plane Array receiver (GBT)
Ku band	12–18 GHz
L band	1–2 GHz



## APPENDIX

### *Acronyms and Abbreviations*

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Acronym	Definition
LANL	Los Alamos National Laboratory
LMT	Large Millimeter (wave) Telescope
LNA	Low-Noise Amplifier
LO	Local Oscillator
M	Million
M&C	Monitor and Control
MAG	Millimeter (wavelength) Astronomy Group
MHz	Megahertz
MK	Mauna Kea (VLBA station)
mm	millimeter
MMIC	Monolithic Microwave Integrated Circuit
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
MOU	Memorandum of Understanding
MPIfR	Max Planck Institut für Radioastronomie
μm	micrometer
MUSTANG	Multiplexed Squid TES Array at Ninety GHz (GBT “Penn Array” receiver)
NA	North American
NAASC	North American ALMA Science Center
NAOJ	NAtional Observatory of Japan
NASA	National Aeronautics and Space Administration
NGAS	Next Generation Archive System
NGST	Northrop Grumman Space Technology
NIO	New Initiatives Office
Nm	Nanometer
NRAO	National Radio Astronomy Observatory
NSF	National Science Foundation
NTC	NRAO Technology Center (Charlottesville)
NVO	National Virtual Observatory (now VAO)
OH	Hydroxyl radical
OMT	Orthomode Transducer
OOF	Out Of Focus (holography)
OPT	Observation Preparation Tool
OSAA	Office of Science and Academic Affairs (NRAO)
OSHA	Occupational Safety and Health Administration
OTS	On The Sky
OV	Owens Valley (VLBA station)
P band	310–344 MHz
PAPER	Precision Array to Probe the Epoch of Reionization
PCB	Printed Circuit Board
PDR	Preliminary Design Review
PLC	Programmable Logic Controller
PR	Proposed Recommendation
PSC	Pulsar Search Collaboratory
PST	Proposal Submission Tool, Pacific Standard Time

## APPENDIX

### *Acronyms and Abbreviations*

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Acronym	Definition
PTC	ProtoType Correlator (EVLA)
PTCS	Precision Telescope Control System (GBT)
Q	Quarter
Q band	40–50 GHz
R&D	Research and Development
RET	Research Experiences for Teaches (NSF program)
RF	Radio Frequency
RFI	Radio Frequency Interference
ROACH	Reconfigurable Open Architecture Computing Hardware
S band	2–4 GHz
SAGE	Science Advisory Group for the EVLA
SB	Station Board (EVLA correlator)
SC	Saint Croix (VLBA station)
SDM	Science Data Model
SIA	Simple Image Access
SIAP	Simple Image Access Protocol
SIMBAD	SIMBAD astronomical database
SIS	Superconductor–Insulator–Superconductor
SKA	Square Kilometer Array
SMA	Sub-Millimeter Array
SOC	Socorro or Scientific Organizing Committee
SOS	Student Observing Support (NRAO program)
SRBS	Solar Radio-Burst Spectrometer (Green Bank)
SSA	Simple Spectral Access
SSH	Secure SHell
STScI	Space Telescope Science Institute
TAP	Table Access Protocol
TBD	To Be Determined
TRW	TRW Corporation
U band	12–18 GHz
URSI	International Radio Science Union
USIP	Undergraduate Student Internship Program (NRAO)
UVa	University of Virginia
VAO	Virtual Astronomical Observatory
VCI	Virtual Correlator Interface (EVLA)
VERA	VLBI Exploration of Radio Astronomy (Japanese VLBI array)
VISC-2	VSOP-2 International Science Council
VLA	Very Large Array
VLBA	Very Long Baseline Array
VLBI	Very Long Baseline Interferometry
VO	Virtual Observatory
VSOP-2	VLBI Space Observatory Program successor
W band	68–117 GHz
WBS	Work Breakdown Structure

## APPENDIX

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### *Acronyms and Abbreviations*

Acronym	Definition
WIDAR	Wideband Digital Interferometric Architecture (EVLA correlator)
WV	West Virginia
WVU	West Virginia University
X band	8–12 GHz