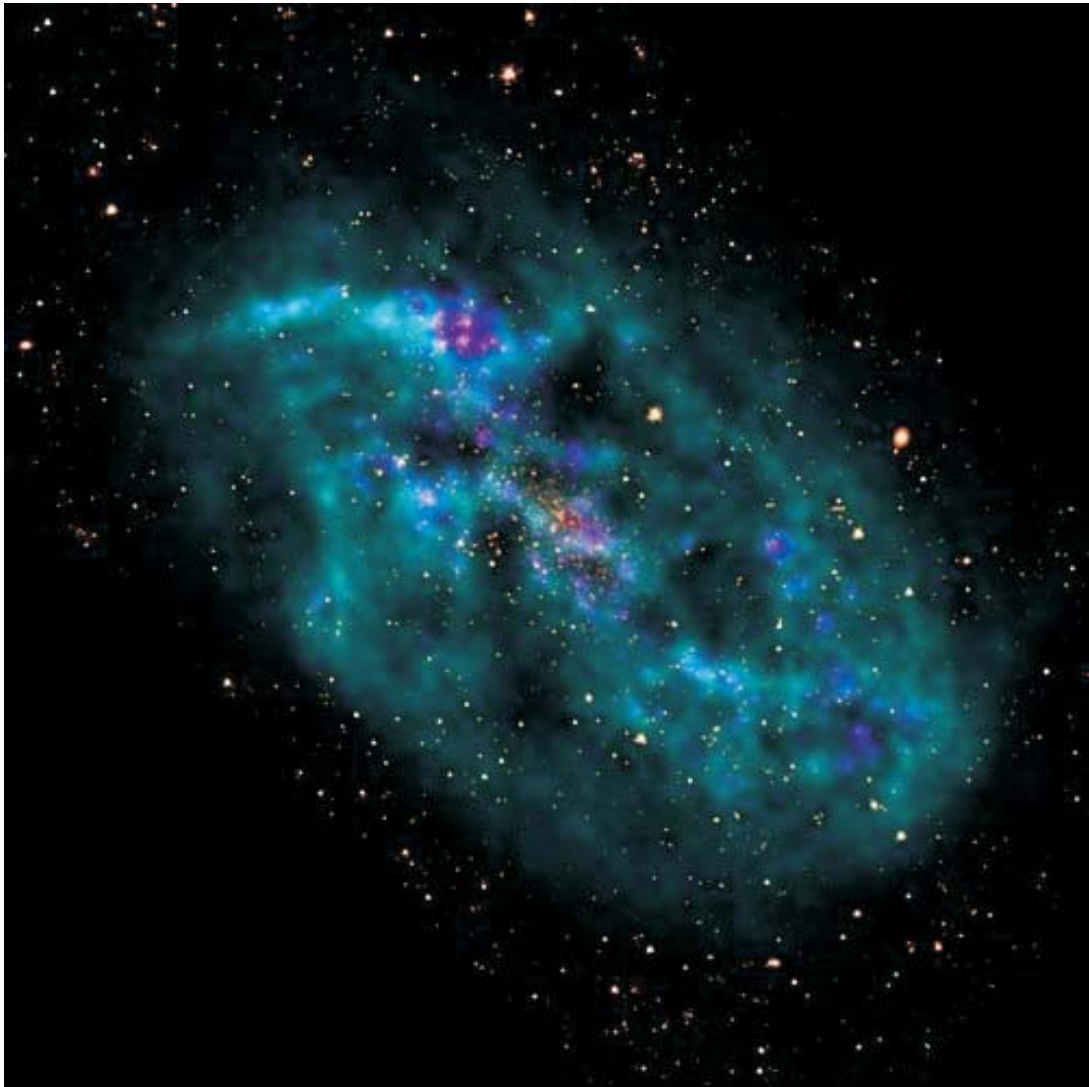


# NATIONAL RADIO ASTRONOMY OBSERVATORY



Quarterly Report



October – December 2007



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*Cover Image: Neutral hydrogen (blue) in the dwarf galaxy IC 2574 was imaged by the VLA as part of THINGS (The HI Nearby Galaxy Survey), led by Fabian Walter of the Max Planck Institute for Astronomy in Heidelberg, Germany. The large holes or “bubbles” are probably caused by multiple supernova explosions of massive stars.*

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### EXECUTIVE SUMMARY

Observers have used the VLBA's astrometric capabilities to revise the distance to Orion Nebula Cluster to 389 (+24 -21) parsecs, considerably smaller than the canonical distance. Using the Green Bank Telescope, observers have measured 21 cm HI absorption from a damped Lyman-alpha system at  $z = 2.347$  toward which there were optical measurements of Zn and Fe. The measurement allows the abundance of these elements to be estimated as well as the spin temperature of the neutral hydrogen. Archival data from the VLA, together with data from MERLIN, Spitzer, Chandra, and HST, indicate that the jet from the radio galaxy 3C 321 is colliding with a neighboring galaxy.

Thirteen EVLA antennas have been retrofitted and restored to routine service; a fourteenth is now being retrofitted. October's scheduled reconfiguration to the B array was completed as planned and slightly ahead of schedule. A daylong workshop to familiarize New Mexico scientific staff with the CASA astronomical software package was held in early December. A major overhaul of both VLA site backup generators was completed this quarter. Dr. Emmanuel Momjian joined the New Mexico operations staff as an EVLA Commissioning Scientist.

The GBT began its 2007/2008 high-frequency observing season with greatly improved C-band and Ka-band receivers. The early-science run for the MUSTANG  $\lambda = 3$  mm bolometer-array receiver began on December 15, and the first scientific observing with the wideband Zpectrometer took place during this quarter. The Precision Telescope Control System (PTCS) team made considerable progress over the quarter. Improvements to the GBT servo system are moving along at a rapid pace. The new GBT Dynamic Scheduling System (GBT DSS) team completed their study of using weather predictions to schedule the telescope 24 and even 48 hours in advance. The results indicate that advance notification of observers will be quite feasible within the DSS. The CICADA (Configurable Instrument Collaboration for Agile Data Acquisition) project continued work on the next-generation pulsar processor GUPPI (Green Bank Ultimate Pulsar-Processing Instrument).

The program to increase the VLBA's sensitivity at 22 GHz, done in collaboration with the Max Planck Institut für Radioastronomie, was completed ahead of schedule in mid-December 2007. All ten VLBA stations have now had their sensitivity in the scientifically important K band increased by as much as 50%. The St. Croix antenna returned to service as scheduled on September 10, 2007 after undergoing extensive structural maintenance and repainting. A new hydrogen maser was ordered as a backup spare for the VLBA and is scheduled for delivery in the first quarter of 2008.

The third North American ALMA antenna arrived at the Operations Support Facility in Chile. Various site-related contracts and calls for bids were initiated or completed, including the antenna vendors' camp-extension contract and the security-services contract for ALMA Facilities. Risk-assessment methodology and procedures for the establishment of health and safety committees were communicated to ALMA management.

The NAASC continues an active search for staff in the ramp-up to early ALMA operations. NAASC staff helped complete the ALMA Operations Plan (version D), which was accepted by the ALMA Board, and updated the NAASC plan accordingly. We participated in a face-to-face meeting of the Science Operations Working Group working to implement the array operations plan. The NAASC staff supported a beta release of the CASA offline software, organized beta testers from scientific advisory committees, and implemented a helpdesk system. The ANASAC is considering interim charges on ALMA development and has defined next year's science workshop on massive-star formation.

## EXECUTIVE SUMMARY

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The Central Development Lab (CDL) continued device and component research, development, and production. The cryogenic evaluation of TRW Cryo-3 devices was completed. The design/redesign of cryogenic amplifiers using Cryo-3 TRW devices for the EVLA, VLBA, and GBT was also finished. An 18–26.5 GHz feed for the GBT K-band focal-plane-array receiver was designed. The preliminary design of the EVLA X-band (8–12 GHz) and Ku-band (12–18 GHz) polarizers was achieved. The new PC/LabView-based amplifier test system was deployed.

End-to-End Operations released the beta version of the Common Astronomy Software Applications (CASA) package and held training sessions for U.S. and European constituents. A Google Sky prototype, integrating images from the NRAO image gallery, was created. The Data Vault beta was released at <http://archive.cv.nrao.edu> for community comment; this site is intended to provide a portal to new content and interfaces for the NRAO data repositories.

The primary efforts of the New Initiatives Office were forming a US key science team and preparing a proposal to NASA for support of VSOP-2, including operational support of the VLBA for the key science. That proposal will be submitted in early 2008. The US SKA Consortium met, and the NRAO is developing concepts for mid- and high-frequency SKA options for consideration by the next US decadal survey committee. A formal agreement for long-term cooperation in radio astronomy was signed between the NRAO and Germany's Max Planck Institut für Radioastronomie.

The EPO strategic plan was drafted and reviewed by the EPO team. The *Cosmic Radio* program series was completed. Additional high-definition video documentation of ALMA was acquired at the OSF and AOS in Chile. Taylor Johnson joined the EPO team as Senior Web Designer. The Alpha2 demo web site was delivered. A community open house was held in Green Bank.

Computer and Information Services (CIS) hired a new CIO (Chief Information Officer) for the NRAO (David Halstead). Next-generation VPN (Virtual Private Network) concentrator and central power-conditioning solutions were evaluated and purchased. CIS stabilized the NRAO web portal with upgrades to the disk controller and optimized web-crawler indexing. CIS also completed evaluation of Joomla, an open-source web-content management system. There were no security incidents this quarter.

The Office of Science and Academic Affairs (OSAA) conducted several searches for staff positions, the Jansky Fellowship program, and a tenure-track scientific position. OSAA received approval for continued funding of the NSF Research Experience for Undergraduates/Teachers programs for the period 2009–2013. The historical Archives project received outside funding during the quarter and is processing a large number of NRAO documents. The library staff implemented ways to provide electronic resources and also save money. The annual NRAO Postdoctoral Symposium and the NRAO Scientific Staff Retreat were scheduled for the spring of 2008.



### SCIENCE

#### SCIENCE HIGHLIGHTS

##### Very Large Array

***Radio Galaxy's Jet Impacting Neighbor Galaxy***—Archival data from the VLA, along with MERLIN, Spitzer, Chandra, and HST observations, indicate that the jet from the radio galaxy 3C 321 is impacting its neighbor galaxy. A bright spot in the radio images marks the point of impact, at which point the jet is deflected. Features in the images indicate that this event is relatively short-lived, with the impact starting only about one million years ago.

*Investigators:* D. Evans (CfA) et al.

##### Very Long Baseline Array

***VLBA Revises Distance to Orion Nebula***—The parallax and proper motion of the flaring non-thermal radio star GMR A, a member of the Orion Nebula Cluster, were determined using the VLBA. The new distance, 389 (+24 –21) parsecs, is considerably smaller than the previous canonical distance. This change lowers the luminosities of the stars in the cluster by a factor of about 1.5 and has major implications for the age spread of the pre-main-sequence stars.

*Investigators:* G. Bower, K. Sandstrom, J.E.G. Peek, A. Bolatto, and R. Plambeck (Berkeley).

##### Green Bank Telescope (GBT)

Kanekar and collaborators measured the 21 cm HI absorption spectrum from a damped-Ly $\alpha$  system at  $z = 2.347$  toward which there were optical measurements of Zn and Fe lines. The radio detection of HI was at 424 MHz in absorption against radio continuum from a background QSO. The HI spectrum contains several velocity components that match those in Fe and Zn and allow the abundances of these elements to be estimated, as well as the spin temperature of the HI. This damped-Ly $\alpha$  absorber appears to contain some gas that is rich in dust and metals and has a relatively large 21 cm optical depth, plus a component poorer in heavier elements and having weaker 21 cm absorption. The absorbing object must have a rather non-uniform interstellar medium. (Kanekar et al 2006, MNRAS, 370, L46)

Another system at  $z = 0.67$  is of interest because it is a rare case of a radio-loud active galactic nucleus (AGN) in a disk galaxy. GBT observations of HI and OH toward the AGN in this system (redshifted to 805 and 997 MHz, respectively) show a broad HI line with continuous absorption out to a blueshift some 600 km/s from the QSO velocity. Observations at two epochs show variation in the HI optical depth of several percent. These data are interpreted as evidence of gas outflowing from the AGN and cooling rapidly after an interaction with the radio jet. The implied flow rate is 12 solar masses per year, and the detection of OH implies that the flow may be 20% molecular. This is the highest redshift at which such a high-velocity outflow has been observed and the only case where molecular gas has been detected. (Kanekar & Chengalur 2007, astro-ph: 0710.3224.

## SCIENCE AND ACADEMIC AFFAIRS

### Office of Science and Academic Affairs

One of the major responsibilities of the Office of Science and Academic Affairs (OSAA) is to oversee and support the diverse activities by and for the research staff across all of NRAO. This oversight includes the co-op, undergraduate and graduate student, and the postdoctoral and outside visitor programs, as well as the Library and Observatory Archives, and the NRAO colloquium series. The OSAA also provides some funds and support for scientific travel so that NRAO staff can attend scientific meetings, participate in observing runs, etc.

The OSAA has been busy this fall with routine tasks in support of the NRAO scientific staff with such things as issuing travel budgets, processing travel requests to various scientific meetings and observing opportunities, and meeting and event planning for the 2008 Scientific Staff Retreat: “Future Prospects and Developments at the NRAO and in the US Radio Community” and the 2008 NRAO Postdoctoral Fellows Symposium. Both of these events have been scheduled for April 2008. The OSAA received 65 applications for the Jansky Fellowship program and 20 applications for a tenure-track position.

### Archives

A one-year grant from the American Institute of Physics, Center for the History of Physics, supported work in 2007 to organize, process, and index Director’s Office files of the Observatory’s first two directors, Otto Struve and David Heeschen, covering the years from NRAO’s founding through 1978. The 85 linear feet of processed materials cover all aspects of the NRAO in this exciting period, from the vision of its founders through its establishment as a world-class observatory operating four sites (Green Bank, Charlottesville, Tucson, and Socorro) and multiple state-of-the art instruments.

Processing work continues on the papers of John D. Kraus and the personal papers of David Heeschen, and we continue to digitize photographs for public access via the online catalog. A student has begun working part-time to digitize Grote Reber materials. All family correspondence, general correspondence, and correspondence with the Research Corporation have now been digitized, and the pdf documents have been linked from the Archives online catalog.

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

### Library Program

The NRAO Library revamped journals subscriptions for 2008 to reduce costs. All print subscriptions to Elsevier and Springer journals have been canceled, while online access has been extended. This allows greater electronic access to articles and saves money formerly spent processing and binding paper copies. In addition, all paper subscriptions to IEEE and IEE journals have been canceled. Electronic copies of IEEE and IEE journals and conference proceedings can now be accessed through IEEEXplore at <http://ieeexplore.ieee.org/Xplore/dynhome.jsp>.

The NRAO Library scanned all “International Symposium on Space Terahertz Technology” papers from 1990 through 1996. Dr. Jack East has made them available via <http://www.eecs.umich.edu/~jeast/>.

### *2. Science and Academic Affairs (SAA)*

Jeff Mangum was appointed Head of the NRAO Library Advisory Committee this quarter, replacing Tim Bastian.

### **Scientific Appointments**

#### ***Arrivals/Promotions***

Aaron Evans, formerly of Stony Brook University, joined the NRAO Scientific Staff as an Associate Astronomer with tenure. Dr. Evans has been working on an on-call basis since October 1, 2007 while on sabbatical from Stony Brook, and he will become a regular part-time employee effective January 1, 2008. Evans will convert to full-time employment with the NRAO this summer in Charlottesville, and he will assume a joint NRAO/UVa appointment in August.

Dr. Evans' primary functional responsibilities at the Observatory will be to assist with the establishment and operation of the NAASC and commissioning ALMA into an operational facility.

In November 2007, Remy Indebetouw joined the scientific staff in Charlottesville as a part-time Senior Research Associate for a fixed term that will end in August 2008, concurrent with his transfer to a Joint Faculty position as an NRAO Assistant Scientist and University of Virginia Assistant Professor. His NAASC responsibilities include assisting with CASA testing and user support, commissioning activities, and developing the ALMA CASA simulator.

Six adjunct appointments were renewed this fall, and two members of the New Mexico Tech scientific staff (Ylva Pihlstrom and Lisa Young) received new appointments as Adjunct Assistant Scientists. Adjuncts have provided advice and guidance to the Observatory for many years. Adjunct appointments are also intended to facilitate cooperative programs with the NRAO and collaborations with members of the NRAO scientific staff.

#### ***Departures/Extensions***

Jansky Fellow Kristine Spekkens completed six months of her third year at the NRAO on December 31 and left to take a position as Assistant Professor at the Royal Military College of Canada in Ontario, Canada. Juergen Ott, a Jansky Fellow stationed in Charlottesville, relocated to California and will complete the third year of his fellowship at Caltech.

### **REU/Summer-Student Program**

The 2007 summer-student session ended in August 2007 with 22 students completing their appointments—five at Green Bank, seven at Charlottesville, and ten at Socorro. Students submitted their final project summaries, which can be viewed in the 2007 REU Program Report. A total of 11 summer students plan to present results from their 2007 projects at the January 2008 AAS Meeting in Austin, Texas. All of the presentations are of high quality and are expected to receive positive feedback from meeting attendees.

Associate Scientist Toney Minter replaced Jeff Mangum as Summer Student Coordinator this quarter. Toney began the recruitment process for the 2008 program shortly after assuming this role. He updated the application system and the REU-specific web and wiki sites. REU/RET program posters were distributed nationwide via hard copy and also via email to our list of colleges and institutions.

**Student (Graduate and Co-op) and Visiting-Scientist Programs**

Four pre-doctoral students were supported by the OSAA during this quarter. Esteban Araya (New Mexico Tech) is studying formaldehyde maser emission in the Galaxy with Miller Goss at the AOC and is co-supervised by Prof. Peter Hofner at New Mexico Tech. Chataili Parashare (University of Virginia) is working on instrumentation for low-frequency radio-astronomy arrays with Richard Bradley at the CDL. Buckner Creel (University of New Mexico) is working with Mark Claussen at the AOC on VLBA astrometry of protoplanetary nebulae, co-supervised by Prof. Ylva Pihlstrom at the University of New Mexico. Alok Singhal (University of Virginia) is working with Rick Fisher in Charlottesville and Karen O'Neil in Green Bank on parametric comparison of a kinematic model for HI in galaxies having rotation curves and HI distributions based on aperture-synthesis and single-dish data. He is co-supervised by Prof. Ed Murphy at the University of Virginia.

Urvashi Rao-Venkata (New Mexico Tech) is a graduate intern with Dale Frail and Frazer Owen in Socorro 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. Alyson Ford (Swinburne University) is a graduate intern with Jay Lockman in Green Bank analyzing the distribution, structures, and properties of HI clouds above the galactic plane.

Kendra Krueger, who is pursuing a dual major in electrical engineering and physics at Rensselaer Polytechnic Institute, worked as a co-op student in Socorro with Dan Merteley and the Interference Protection Group at the VLA Site.

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

**Support Programs*****Student Observing Support (SOS)***

This support program is intended to strengthen the proactive role of the Observatory in training new generations of telescope users. At this time, regular proposals submitted for the GBT, VLBA, and High Sensitivity Array (HSA) are eligible for funding, but regular VLA proposals are not. Large proposals for the VLBA, GBT, HSA, VLA, and any combination of these telescopes are also eligible. General information on the structure and background of this student-support program is available online at <http://wiki.gb.nrao.edu/bin/view/Observing/NRAOStudentSupportIntro>.

In FY 2008 we have \$330k for student observing support. Approximately one quarter of these funds are available for allocation to qualifying 08A proposals requesting Student Observing Support. We have 12 such approved 08A proposals. The Student Support Committee plans to meet in January 2008 to discuss the proposals and allocate the funds.

## TELESCOPE USAGE

The NRAO telescopes were scheduled for research and for maintenance during the fourth quarter of 2007 as described in the table below. Time lost and actual observing for the arrays are computed as fractions of the total antenna arrays. For example, losing all 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 are counted as lost for observing.

We now schedule approximately 15% of the VLA time dynamically, prototyping our dynamic-scheduling process for the EVLA. There are voids in this process because we do not always have programs of the right length in the right range of sidereal times to fill 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 take priority for virtually all dynamic time, even at short notice. 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 scheduling voids for astronomical programs with the VLBA, which we fill with tests, calibration, and maintenance:

- (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 short gaps 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 needed to visit multiple antennas during the same week.

<b>Telescope Usage (hours)</b>			
<b>Activity</b>	<b>VLA</b>	<b>VLBA</b>	<b>GBT</b>
Scheduled Observing	1527.10	868.75	1781.00
Scheduled Maintenance and Equipment Changes	195.50	404.00	187.00
Scheduled Tests and Calibrations	424.38	277.95	168.00
Time Lost	244.40	45.10	121.00
Unscheduled	126.94	585.30	72.00
Actual Observing	1282.71	823.65	1660.00

## PROJECTS

### 1. Expanded Very Large Array

## PROJECTS

### EXPANDED VERY LARGE ARRAY (EVLA)

EVLA highlights include:

- Thirteen antennas have been retrofitted to the EVLA design and now account for 44.8% of all antenna hours in scientific observations
- The prototype orthomode transducer for the S-band receiver was fabricated
- Production of the M302/M303 utility modules began
- Production of the gain-slope equalizers began
- The first fully EVLA-compliant Q-band receivers were installed on antennas 11 and 25

#### EVLA Milestones

Milestones	Original Date	Revised Date	Date Completed
1. L-band receiver dewar design completed	10/04/07		10/04/07
2. Round-trip-phase (RTP) test series started	10/08/07		10/08/07
3. Status of hardware solutions for phase instability	09/14/07	10/08/07	10/09/07
4. CASA Beta release	09/30/07	10/15/07	10/15/07
5. Complete antenna reference transmitter and RTP racks	08/24/07	10/19/07	10/19/07
6. Agree on common ALMA+EVLA Science Data Model	09/04/07		10/22/07
7. Decide on new DDS design for L302	11/15/07		10/29/07
8. Develop production schedule for Ka-band receiver	11/01/07		11/01/07
9. Develop production schedule for Q-band receiver	10/26/07		11/13/07
10. Start EVLA conversion of antenna 4	10/30/07		11/14/07
11. Prototype antenna paging system installed	12/06/07		12/06/07
12. S-band receiver OMT fabrication completed	12/19/07		12/19/07
13. Hardware acceptance tests complete on antenna 1	11/27/07		12/19/07
14. Antenna 1 Turnover to Operations	11/28/07		12/20/07
15. Start installation of RTP modules	12/27/07		12/27/07
16. EVLA Science Data Model (SDM) review to ALMA	08/10/07	01/03/08	
17. Complete lab tests of prototype Ka-band receiver	01/10/08		
18. WBS, earned value, and risk register updated	01/14/08		
19. Complete waveguide-style design of X-band receiver	01/15/08		
20. Develop requirements for EVLA-designed weather station	11/01/07	01/15/08	
21. Start EVLA conversion of antenna 5	01/17/08		
22. Correlator-room access control implemented	12/05/07	01/18/08	

## PROJECTS

### 1. Expanded Very Large Array

Milestones	Original Date	Revised Date	Date Completed
23. Start L-band receiver OMT testing	11/15/07	01/22/08	
24. Prototype Ka-band receiver ready for use	06/11/07	01/25/08	
25. Status report on RTP measurement resolution limits	01/25/08		
26. Common ALMA+EVLA SDM (v. 3.0) accepted	12/31/07	01/31/08	
27. Common ALMA+EVLA CalDM accepted	12/31/07	01/31/08	
28. RF design of S-band receiver completed	01/31/08		
29. Hardware acceptance tests complete on antenna 1	02/04/08		
30. Antenna 1 turnover to Operations	02/05/08		
31. L-band dewar drawings ready for fabrication	11/08/07	02/11/08	
32. RF design of Ku-band receiver completed	02/14/08		
33. C-band OMT—broadband test in receiver	08/31/06	02/15/08	
34. Install wideband C-band receiver on antenna	11/02/06	02/28/08	
35. T301 solar attenuators tested on one antenna	02/29/08		
36. 1 <sup>st</sup> production Ka-band receiver installed	03/03/08		
37. Delivery of high-speed cables from Penticton	12/18/07	03/03/08	
38. Begin T304 total-power detector installation	03/07/08		
39. The OPT outputs an EVLA observe script	10/25/06	03/13/08	
40. Complete production design of the C-band OMT	03/14/08		
41. Delivery of correlator racks from Penticton	03/18/08		
42. Start EVLA conversion of antenna 2	03/18/08		
43. Science Support System software PDR	06/05/07	03/26/08	
44. Complete production design of the C-band OMT	04/27/07	04/04/08	
45. Begin production of the C-band OMT	02/28/07	05/01/08	

### Management

Current financial records indicate that EVLA project contingency is \$3.49M, or about 16.7% of the estimated cost to complete the project. This percentage contingency is the highest in project history. However, contingency will decrease in the next few months because additional resources are needed in the front-end group to address its protracted schedule. Contingency status will be reviewed in February 2008 after the project's WBS cost data sheets and risk register are updated.

Antenna retrofitting is generally proceeding at the desired rate of about six antennas per year. The recent retrofit of antenna one was hampered by staffing shortages caused by the holidays and the assignment of two antenna mechanics to the rust-proofing of the VLBA antenna in St. Croix. Non-EVLA-related problems with antenna one's servo system, including a failed elevation encoder, also contributed to the delay. Although antenna one was about a month late in returning to the array, the overall retrofitting schedule was delayed by only one week.

## PROJECTS

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### *1. Expanded Very Large Array*

The November schedule for the WIDAR correlator showed a three-month delay in the delivery of the prototype correlator. After a great deal of discussion between the DRAO and the NRAO, we recovered this delay by adjusting priorities and reassessing assumptions in the schedule. The delay underscored the need for better management communication between the NRAO and the DRAO. As a result, a face-to-face meeting will be held at Penticton in February 2008 to review management processes.

The major procurements that occurred during the quarter include the centrifugal castings and lamination contract for the S-band feed horn, gain-slope equalizers, RF components for the Ka-band receivers, and production components for local LO, IF, and DTS (data transmission system) modules.

To help address schedule delays in the front-end group, the technical and managerial responsibilities were split between two people.

The response to the report of the 2007 EVLA Advisory Committee was written and submitted to the Committee.

The EVLA change control board approved requests to outsource the production of the junction boxes for the M302/303 utility modules and to provide additional funding for the fabrication of the S-band feed horns.

### **Systems Integration**

Electronics outfitting of the 13<sup>th</sup> EVLA antenna was completed. All 13 antennas are used in routine observations, and they now account for 44.8% of all antenna hours in scientific observations.

The communication problems that occurred between the M301 converter interface module and the T301 and T302 downconverters have been analyzed and identified. Signals passing through the RFI filters on the modules were being corrupted by crosstalk and reflections in the filter. We solved the problems by installing low-cost toroids as common-mode filters on the signal cables in the T301/302 modules.

The final versions of the P301/302 power supplies are now being refitted into the antennas. They include full monitor, control, and safety features, as well as additional temperature sensors for the racks and vertex rooms. These sensors have already enabled us to identify stability issues in the HVAC (heating, ventilation, and air conditioning) system and to correlate LO stability issues with temperature changes. The remaining modules should be upgraded by midyear.

Production of the M302 and M303 utility modules was started in December 2007. The modules provide a number of functions, including temperature sensors and emergency-shutdown capabilities, to the vertex and pedestals rooms of the antennas. Production of the utility modules represents the completion of a program-plan goal for the EVLA.

### **Civil Construction**

The civil-construction WBS element of the EVLA project is nearly complete. The only remaining work is to assist the Electronics Division with the installation of the WIDAR correlator in the new shielded room, install control and alarm wiring for the air conditioning equipment in the shielded room, implement the humidity-control features of the air conditioning units in the shielded room, and activate the FM200 gas cylinders in the fire-suppression system of the shielded room once the correlator is installed.



## PROJECTS

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### *1. Expanded Very Large Array*

#### **Antennas**

The mechanical overhaul of the 13<sup>th</sup> EVLA antenna was completed, and the mechanical overhaul of 14<sup>th</sup> EVLA antenna was started. The feed cones for three EVLA antennas were assembled.

The fiberglass lamination of 25 L-band feed horns is complete. All of the aluminum rings for the L-band horns have been fabricated, and fabrication of the rings for the S-band horns continues. The purchase order for the centrifugal castings for the S-band feed horn was placed, and the contract to laminate the horn is out for bid. The prototype S-band feed horn was installed in antenna 1.

Ten mounting towers for the Ku-band feed horns have been completed. The machine shop in Green Bank is building two prototypes of the Ku-band horn.

#### **Front End**

During the past quarter, the 13<sup>th</sup> EVLA antenna was outfitted with interim L- and X-band receivers as well as fully EVLA-compliant K-band systems. The first fully EVLA-compliant Q-band receivers were installed on antennas 11 and 25. The current status of each receiver band is summarized below.

**L-band:** The new design for the L-band dewar is complete, and the dewar mechanical drawings are scheduled to be complete in mid-February 2008. The initial machined parts for the dewar are scheduled to be complete by the end of February.

The fin-and-clamshell profile for the L-band quad-ridge orthomode transducer (OMT) was revised. In numerical simulations, the revised profile gives an impressive return loss that is 5 dB better than specification and improved broadband performance overall. Also, a shorting block is being investigated for the throat section of the OMT. Initial simulations of the block's performance gave promising results. The block is easier and cheaper to manufacture than the shorting pins that are currently used. These refinements to the OMT will be tested soon.

**S-band:** The two prototype quad-ridge sections of the S-band OMT were delivered late in the quarter. OMT testing will commence in early January 2008. The old VLA L-band dewar will be reused for the new S-band receiver, and drawings are being made to document the required dewar modifications. Two L-band dewars have been identified for the prototype testing scenarios.

**C-band:** Construction of interim C-band receivers has caught up with the antenna-outfitting schedule. The interim C-band receiver for antenna 4 is scheduled to be installed in late January.

The quad-ridge sections of the prototype C-band OMT are meeting specifications. The refinements made to the L-band quad-ridge OMT are probably scaleable to the C-band unit. Similar refinements to the C-band unit are currently under investigation.

There are two pending issues to be resolved with the EVLA prototype C-band receiver: (1) selecting hybrids that function reliably at cryogenic temperatures and (2) phase matching the two polarizations. These issues are not major, but they are not trivial either.

**X-band:** The X-band receiver is still in the design stage.

## PROJECTS

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### *1. Expanded Very Large Array*

**Ka-band:** The prototype Ka-band receiver meets specifications and is currently undergoing tests of its LO drive level. The receiver is scheduled to be installed in the array by the end of January 2008. The second Ka-band receiver is under construction and should be completed in April 2008. Preparations are being made for mass production of the Ka-band receivers this year.

**K-band:** The installation of EVLA-compliant K-band receivers is keeping pace with the antenna-outfitting schedule.

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

Modules for the LO and IF systems of the EVLA continue to be built to meet the antenna retrofitting schedule. They may still need some retrofitting, mostly to meet upgraded hardware and RFI requirements.

Phase stability is still under investigation in some of the LO and IF modules. Most modules have been tested and meet the phase-stability requirements. Those that do not are being retrofitted with better cables and better thermal design.

The redesigned L352 round-trip-phase (RTP) module has been assembled and tested. It now meets or exceeds all performance specifications. After some minor modifications to the L352 printed-circuit board and a final test in the array in early 2008, the project quantity of these modules will go into production in the second quarter of FY 2008.

A production order for the gain-slope equalizers was placed. The equalizers will be delivered in January 2008. The placement of this order represents the completion of an EVLA program goal to start the production of the equalizers.

The final procurement of parts for all LO/IF modules has begun and will be completed by the end of the calendar year. All LO/IF modules are scheduled to be complete by the fourth quarter of FY 2009.

### **Fiber-Optic System**

Modules for the digital transmission system (DTS), formatter, and deformatter continue to be built to meet the antenna retrofitting schedule. The components needed to build the remaining deformatters were purchased in December 2007. The deformatter build should be complete by the end of CY 2008.

The installation schedule for the 3-bit, 4Gbps digitizers was revised to accommodate the delivery schedule of the digitizers, which were ordered last quarter. Engineering samples of the digitizers will arrive in Socorro in June 2008, and performance testing of the digitizer in its sampler module will begin the following month. Two digitizer chips are installed in a sampler module, which in turn is housed in a DTS module. Three DTS modules, complete with sampler modules made from the digitizer engineering samples, will be installed in the array in July 2008 to prepare for the arrival of the prototype correlator. The antennas receiving these DTS modules will also need to have the new gain-slope equalizers installed in their T304 downconverters. The production order of digitizers is scheduled to arrive in October 2008, and the full production of the sampler modules will commence immediately thereafter. At that time, we expect to install fully functional DTS modules at the rate of eight (two antennas' worth) per month through the normal antenna outfitting process and by retrofitting existing DTS modules.

The optimum deployment of deformatters was discussed in the context of supporting test observations with the prototype correlator in the summer of 2008. The deformatters can be deployed to send baseband

## PROJECTS

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### *1. Expanded Very Large Array*

signals to the VLA correlator or to the prototype correlator. Each antenna requires four deformatters, and a total of 120 deformatters will be built. (The total number of deformatters is insufficient to provide 27 baseband inputs to both the VLA and WIDAR correlators). Ten deformatters are needed to support the ten baseband inputs of the prototype correlator. The inputs can come from a single baseband from each of ten antennas or two basebands from five antennas. Existing hardware racks will allow the installation of deformatters for up to 22 antennas that provide baseband inputs to the VLA correlator. Prior to the completion of the retrofit of the 22<sup>nd</sup> EVLA antenna in June 2009, we will need to decide if the WIDAR correlator will be used for future observations or if additional hardware should be purchased to allow the VLA correlator to be used with more than 22 antennas.

### **Correlator**

This quarter has seen a flurry of activity in acquiring all of the hardware elements needed for the delivery of the prototype correlator in mid-2008. Most components for correlator-rack assembly are in place, although some have been delayed by component shortages. However, it appears that at least eight racks, and possibly all 16, will be ready for delivery in May 2008, provided no unforeseen supplier delays are encountered. All of the high-speed Meritec cables, which are used for interconnecting the correlator racks, have now arrived; and the assembly, labeling, and testing of these cables has begun. Based on the rate of assembly, we estimate that the 128 rack-to-rack cable bundles will be delivered to the VLA site by the end of February 2008.

The correlator chip manufacturer, iSine, has indicated it is on schedule for delivering the first 1,200 chips in early February 2008 and the remaining 11,000 chips by the end of March 2008. The first set of chips will be used for qualification testing and for the prototype correlator boards. The remaining chips should be available in the summer, well in advance of final production. A company that specializes in industry-standard integrated-circuit qualification, failure analysis, and screen testing was selected to test the chips and evaluate production reliability.

The beta prototypes of the correlator baseline board and station board are now being fabricated, and their delivery is expected in January 2008. There have been some fabrication problems with the baseline board. For example, one connection out of tens of thousands on the first board was an open circuit. Fortunately, there is a work-around and, as of this writing, the board is undergoing boundary scan tests. The second board had four open circuits. It may not be useable, and it may have to be re-fabricated. To reduce risk in the fabrication of baseline boards for the prototype correlator, quotations have been requested from two other suppliers, and more than one printed-circuit board fabricator will build the boards. The station board does not have these fabrication problems. It appears that everything is on track for the delivery of the prototype correlator in mid-2008, but actual delivery will depend upon the outcome of the tests of the prototype boards in January and February 2008.

A number of other boards have been designed or have had their designs finalized. These boards are also being fabricated, including the RTP module interface board, the PC/104 monitor-and-control mezzanine card (in quantities for the prototype correlator), and the patch board. Testing of the delay module was recently completed, and the quantities needed for the prototype correlator will be ordered shortly. The design of the crossbar board, the only board yet to be designed, has begun.

A face-to-face meeting was held in Socorro in December 2007 to discuss all software elements required for the prototype correlator and on-the-sky tests. After the meeting, a number of focused discussions were held on the resource and interconnection capability of the correlator, with the goal of incorporating the correlator's capabilities into the EVLA observation preparation tool (OPT). This work will continue

## PROJECTS

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### *1. Expanded Very Large Array*

through a series of regular teleconferences until the correlator interface and OPT functionality are finalized.

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

The work of the M&C group was divided among three major areas: (1) maintaining the transition observing system, (2) working on the EVLA antenna M&C system, and (3) working on the EVLA correlator M&C system.

Transition observing continued relatively smoothly during the quarter. For example, the M&C processor has now been up and running for 100 days without a crash, a significant improvement over the past. There were various bug fixes and low-level maintenance items, and some more substantive ones, including the support of VLBA/VLBI observing, solution of cross-hand delays, cleaning up of many timing and data-labeling issues, and an improved document-tracking system. In addition, two new versions of the EVLA Operators Software were released, with improvements to the Fringe and Alert screens, and a new screen for feed heater status.

The EVLA antenna M&C system work revolved around new software for the module-interface boards for the L352 round-trip-phase module, the antenna control unit (ACU), the M301 downconverter interface module, and the L350 central reference-generator module. In addition, an application was created to load a module's image or configuration file on all the antennas with one click of a mouse.

There was a considerable amount of work on the WIDAR M&C system, culminating in a face-to-face meeting in Socorro in December. DumpTrig and delay and phase models have now been implemented for the station boards and tested satisfactorily. Support for the correlator module interface board has been added for the new baseline board phased-array design. The graphical user interface for the correlator's retiming, crossbar, and phasing boards was completed; it is now ready for testing and debugging. The core engine for Intelligent Diff was completed, which will eventually be integrated into the Test Executor suite. The framework for correlator backend software was enhanced, including the incorporation of a head node for the compute node processes. A draft of a joint ALMA/EVLA correlator output Binary Data Format (BDF) specification document was completed and sent to ALMA for comment. This will allow the two interferometers to have a common data format, saving much effort on archive read/write software. A preliminary design was made for the Metadata Capture and Format subsystem. It has been prototyped, with focus on data collection, Science Data Model (SDM) handling, and communications.

Work in the next quarter will be focused on getting ready for the prototype correlator, to arrive in the summer of 2008.

#### **Science Support Systems**

Work is being completed on the "parminator," a web-based interface that operators will use to maintain many of the parameters essential to the operation of the EVLA. A document that gives a detailed description of the values in this database was written. This document was used to implement a system for rigorous error checking. Also, the user interface was rewritten using the standards of the other new web tools. Formal testing of the parminator will begin in January 2008, and it will be deployed a month later.

Instrument configuration capabilities were added to the Observation Preparation Tool (OPT). The OPT now has a model of the EVLA antenna electronics that can be used for baseband tuning. New ideas were developed for how the configuration of the WIDAR correlator will be presented to users of the OPT. The

## PROJECTS

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### *1. Expanded Very Large Array*

programming staff found third-party tools that could be used to implement these ideas. The look and feel of the OPT was changed to be more like that of the Proposal Submission Tool (PST). The new version of the OPT will be submitted to scientists for review in January 2008.

A plan was formulated to allow astronomers to set up observations with Ka-band receivers in 2008. The plan calls for an early release of the new web-based OPT in time for the first call for Ka-band proposals. The plan also allows for backup approaches, should an early release of the OPT be deemed unwise. We will assess the OPT in April to decide on which approach to use.

Discussions regarding the configuration of the new WIDAR correlator were held with DRAO personnel immediately after the correlator face-to-face meeting in December. Designing and writing the software for configuring the correlator will be a major activity for the group in the upcoming quarter.

An initial design for archiving the visibility data from WIDAR (using a BDF and SDM consistent with ALMA's) has been developed. The design will easily support the data rates from the prototype correlator. Implementation of this design will proceed over the next six months.

## PROJECTS

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### *2. New Initiatives*

#### **NEW INITIATIVES**

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

NRAO representatives attended the last meeting of the International SKA Steering Committee (to be replaced by the SKA Science and Engineering Committee in 2008) as well as the SKA-related Jodrell Bank science symposium. A draft SKA specifications document was completed and released, with key NRAO participation on the tiger team drafting the document. The international consortium has deferred the high-frequency component of the SKA indefinitely and not included it within a nominal budget of 2 billion Euros for the SKA Program. The US SKA Consortium also met during the quarter, with emphasis placed on planning for the upcoming US decadal committee study. Following an NRAO presentation on options for high-frequency (10–50 GHz) science and technology in the next decade, a high-frequency subgroup led by the NRAO was formed to develop these options further. The NRAO already is playing a key role in developing a proposal for the mid-frequency SKA in the context of a possible Radio Synoptic Survey Telescope (RSST).

##### **VLBI Space Observatory Programme-2 (VSOP-2)**

The NRAO played a leading role, working with the Jet Propulsion Laboratory (JPL), in organizing the US science team for a VSOP-2 proposal to NASA that would utilize the VLBA and other NRAO telescopes. We co-organized and attended a US–Japan key-science meeting in October as well as the VSOP-2 Symposium in December. The NRAO developed a plan and budget for NRAO participation in the program to be proposed to NASA and incorporated into the draft NASA Mission of Opportunity proposal. By the end of the quarter, the proposal was at a very advanced draft stage, in anticipation of submission to NASA at the January 15, 2008 deadline.

##### **External Partnerships**

A Memorandum of Understanding (MOU) was signed with the Max Planck Institut für Radioastronomie covering future cooperation in several areas of radio astronomy. The first area, improving the 22 GHz systems on the VLBA, is now well along, with most of the VLBA systems upgraded by the end of the quarter and completion expected early in 2008.

The peer review was held for Cycle 1 of the GLAST (Gamma-ray Large Area Space Telescope) Guest Investigator program. Preliminary proposal ranking was done, with final NASA decisions and allocation of NRAO observing time to take place during the first quarter of 2008.

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

FASR is a priority facility designed to address solar, heliospheric, and space-weather physics. The project is being developed by a consortium under AUI management that includes the NRAO and a number of university partners: NJIT, UC Berkeley, the University of Michigan, the University of Maryland, and Caltech. A letter of intent was signed by the partners at a team meeting in August 2007. FASR design and development activities have been centered at the University of Michigan AOSS (Atmospheric, Oceanic, and Space Science) Department (digital systems) and at the NRAO CDL (analog systems), with Tim Bastian serving as PI of the development effort. The NRAO CDL has supported front-end design work (feeds, receivers) and work on optical data transmission. These activities included the efforts of Gawande (grad student), Morgan, Saini, Breyerton, and Richard Bradley, with Richard Bradley

## PROJECTS

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### *2. New Initiatives*

providing overall supervision and coordination as interim project engineer. Dick Thompson made contributions as a consultant to issues of delay corrections, fringe rotation, and phase switching. Other members of the FASR team have focused on software and data-management planning (UCB, UMd) and operations and science planning (NJIT).

The team prepared and submitted a preliminary proposal for facility construction in January 2008. The proposal was submitted to the NSF Midsized Infrastructure (MSI) Opportunity program. It is anticipated that the FASR team will be invited to submit a full proposal in June. If successful, the project could achieve a funding start by the end of FY 2008.

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

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
1. Attend International SKA Steering Committee	10/07/07		10/07/07
2. Attend VSOP-2 key science meeting in Japan	10/23/07		10/23/07
3. Final signatures on MPIfR Cooperation MOU	06/22/07	11/15/07	11/15/07
4. Attend VSOP-2 tracking-station meeting in Japan	12/08/07		12/08/07
5. Submit NASA MoO proposal for VSOP-2 support	01/15/08		
6. Attend NASA Navigation Workshop	01/24/08		
7. NRAO-NM planning meeting for decadal survey	02/07/08		
8. Support first meeting of AUI Operations review	03/01/08		
9. SKA Science and Engineering Committee meeting	04/08/08		
10. FASR Team Meeting	03/08		
11. NSF/MSI Proposal	06/08		

## OPERATIONS

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### *1. Green Bank Operations*

## OPERATIONS

### GREEN BANK OPERATIONS

Green Bank highlights include:

- Completion of the C-band receiver upgrade
- Early science run for MUSTANG began December 15, 2007.
- The first scientific observing with the Zpectrometer occurred during this quarter.

The GBT began its 2007/2008 high-frequency observing season with the considerably improved Ka receiver, a much-modified MUSTANG array receiver, and the UMd Zpectrometer. As noted in the previous quarterly report, the Ka-band receiver was modified to increase the symmetry in its circuitry and thereby improve its correlation capability. This improvement was done at the loss of a channel, but the improved system temperature and baselines are compensating for the loss. The MUSTANG 90 GHz array receiver had further work done to reduce the level of  $1/f$  noise caused by the pulse-tube cooler. Also a wider (20 GHz) bandpass filter was received from Cardiff, installed, and tested; it is expected to increase sensitivity by a factor of two or more. The receiver was installed on the telescope during the week of 15 December, and astronomical commissioning of the instrument has begun. Finally, the UMd wide-bandwidth Zpectrometer was installed on the GBT for its first astronomical run. The data from that run are still being analyzed, and the instrument will be placed back on the telescope during the first quarter of 2008.

The GBT Precision Telescope and Control Systems (PTCS) team made considerable progress over the quarter. Improvements to the GBT servo system are moving along at a rapid pace. The first version of the friction compensator was released, and significant progress toward the PLC upgrade and the trajectory preprocessor was made. By the end of the quarter there was still a small but persistent oscillation seen in tracking data in both azimuth and elevation for the servo response subproject, but the problem is being investigated. The MUSTANG receiver is being used for OOF (Out Of Focus) holography experiments, and the traditional holography receiver is being upgraded.

The K-band Focal-Plane Array (KFPA) project team held a workshop to discuss the scientific plans for the KFPA and its data pipeline. The workshop was fairly successful, and a number of collaborations have come from it. The team also completed the feed-horn design and submitted drawings to the machine shop for fabrication. The phase shifters (45 degree twist mandrels) were completed and bids collected for electroforming. The thermal analysis of the FPA was completed and the thermal gap was selected, with drawings again sent to the machine shop. Work was begun on the mechanical design, the LO distribution design, and the down-converter module design.

The GBT Dynamic Scheduling System (GBT DSS) team completed their study of using weather predictions to schedule the telescope 24 and even 48 hours in advance. The results are very encouraging and show that advance notification of observers will be quite feasible within the DSS. The team also began work on the actual DSS software interface. A prototype scheduling tool was developed and tested during the quarter. This iterative process of rapid development and testing of the tool will continue through the next quarter as additional functionality is added. Near the end of the quarter the team had another discussion of the DSS plans with the Green Bank staff and also gave an overview of the project in Charlottesville. The team prepared the documentation needed for the DSS tests to be run during the summer 2008 trimester on the GBT. Further information on the GBT DSS can be found online at <http://www.gb.nrao.edu/DSS>.



## OPERATIONS

### 1. Green Bank Operations

The CICADA (Configurable Instrument Collaboration for Agile Data Acquisition) project worked on the next-generation pulsar processor (GUPPI—Green Bank Ultimate Pulsar-Processing Instrument). In late October the team held a workshop (including students and scientists from West Virginia University, the University of California at Berkeley, and Caltech) to form the design team. Work is now underway in Green Bank, Charlottesville, and West Virginia University on the hardware, software, and gateway. Over the course of the quarter the iBOB/iADC/Bee2 was put into service, a 10 GbE interface was installed, configured and tested, FPGA programming was begun, and software development began with help from the E2E division.

#### GBT Site Milestones for FY 2008

Milestones	Original Date	Revised Date	Date Completed
<b>C-band Receiver Upgrade</b> <sup>Note 1</sup>			
1. Design Review	04/24/07		04/24/07
2. Upgrade complete	02/15/07	09/30/07	09/30/07
3. Commissioning complete	03/01/07	11/15/07	11/07/07
<b>Dynamic Scheduling</b> <sup>2</sup>			
1. Stage II tests begin	08/15/07	06/01/08	
2. Stage II tests complete	09/30/07	09/30/08	
3. Design Review	12/01/07	12/01/08	
4. Release Stage III software for general use	06/01/08	10/01/09	
<b>CICADA</b> <sup>3</sup>			
1. Next Generation Pulsar Machine Phase 1 (Spigot Replacement)	01/01/08	03/01/08	
2. Next Generation Pulsar Machine Phase 2 (Coherent Machine)	06/30/08	08/30/08	
3. Next Generation Pulsar Machine Phase 3 (Common User Machine)	06/30/08	08/30/09	
4. Design study for array spectrometer	09/30/08		
<b>K-Band Focal Plane Array</b>			
1. System design complete with Conceptual Design Review acceptance	01/15/08	02/15/08	
2. M&C Hardware Module with support software complete	05/13/08		
3. Single pixel construction complete	05/08/08		
4. Single pixel testing complete with Critical Design Review acceptance	08/08/08		
<b>MUSTANG</b> <sup>4</sup>			
1. Install on GBT for engineering & early-science run	12/15/07		12/15/07
2. Document results from second engineering run	03/30/08		
<b>PTCS</b> <sup>5</sup>			
1. Trajectory generation and servo improvements complete	12/31/06	03/30/08	
2. PLC interlock system main servo complete	08/31/07	02/28/08	
3. Interlock system complete	08/31/07	08/31/08	
4. Laser rangefinder V2 development complete	09/31/07	03/01/08	
5. Recommissioning of traditional holography receiver	04/01/08		

## OPERATIONS

### *1. Green Bank Operations*

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
<b>Zpectrometer<sup>6</sup></b>			
1. Commissioning tests complete	10/13/06	10/15/07	10/15/07
2. Science validation complete	06/01/08		

Notes:

1. The C-band completion date was moved to accommodate MUSTANG work. Commissioning was moved to accommodate high-frequency commissioning activities.
2. Dynamic-scheduling work was delayed by work on the high-frequency receivers.
3. CICADA (FPGA Development Project) is a University Collaboration with the University of Cincinnati and West Virginia University.
4. MUSTANG (Penn Array Receiver) is a University Collaboration with the University of Pennsylvania. MUSTANG progress has been slowed by difficulties in fabricating the detector array.
5. The trajectory generation and servo improvements are delayed because the development of the new track model took longer than was anticipated. Owing to necessary engineering work on other antennas, it was not possible to complete design work on the secondary-optics part of the PLC upgrade. That work has been deferred until next summer's painting and inspection period.
6. The Zpectrometer is a University Collaboration with Andy Harris at the University of Maryland.

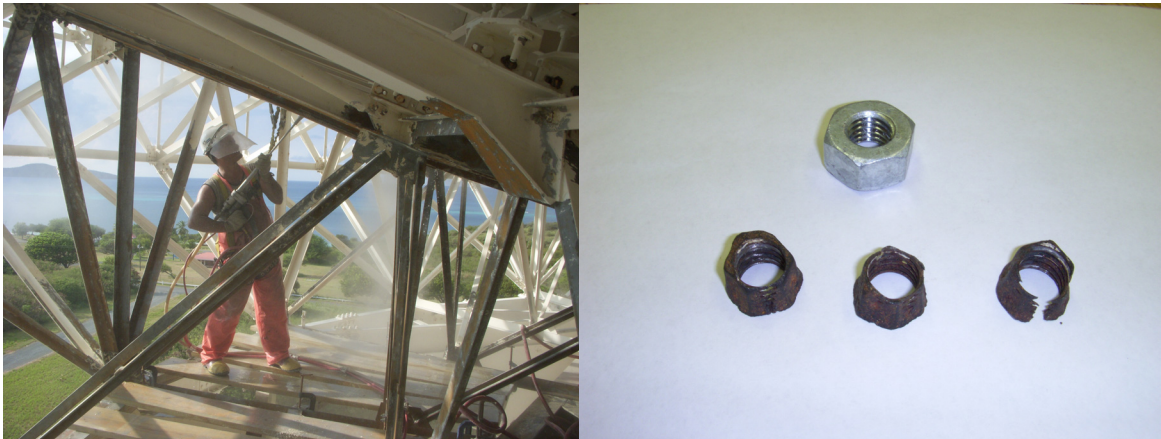
## OPERATIONS

### 2. NEW MEXICO OPERATIONS

#### NEW MEXICO OPERATIONS

New Mexico highlights include:

- October's scheduled reconfiguration to B array was completed slightly ahead of schedule.
- The thirteenth EVLA antenna retrofit was completed and the antenna restored to service with the VLA. The fourteenth antenna began its EVLA retrofit process.
- A daylong workshop for NM Operations staff was held in early December in order to familiarize staff with the feature set and general status of the CASA data-analysis package.
- The St. Croix VLBA antenna was returned to service after an extensive 3-month structural overhaul. Corroded parts were replaced, the elevation bearing was replaced, and the antenna was sandblasted and repainted (Figures 1a, 1b).



*Figures 1a, 1b: Sandblast preparation of the St. Croix VLBA antenna (L). Corroded backup-structure nuts, replaced as part of the 2007 overhaul.*

- A new hydrogen maser was ordered as a spare for the VLBA. It is scheduled for delivery midway through Q1 of 2008.
- A major overhaul of both VLA site generators was completed.
- The program to increase the VLBA sensitivity at 22 GHz, done in collaboration with the Max-Planck-Institut für Radioastronomie, was completed ahead of schedule in mid-December 2007. At this point, all ten VLBA stations have had their sensitivity in the scientifically important K band increased by as much as 50%.
- Dr. Emmanuel Momjian joined the NRAO New Mexico Operations staff as an EVLA Commissioning Scientist.

#### VLA and VLBA Management and Scientific Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Complete reconfiguration to B array	10/19/07		10/17/07
2. Start EVLA conversion of Antenna 4	10/30/07		11/14/07
3. Return EVLA Antenna 1 to operational array	11/17/07		
4. CASA workshop for scientific staff	12/04/07		12/04/07
5. Return St. Croix to VLBA after rust repair	12/15/07		12/20/07

## OPERATIONS

### 2. NEW MEXICO OPERATIONS

Milestones	Original Date	Revised Date	Date Completed
6. First shared-risk science with EVLA 1.2–2 GHz	12/31/07	12/31/08	
7. Start EVLA conversion of Antenna 5	01/17/08		
8. VLA/VLBA proposal deadline	02/01/08		
9. Local scientific-staff retreat	02/07/08		
10. Return EVLA Antenna 4 to operational array	02/13/08		
11. Complete reconfiguration to CnB array	02/15/08		
12. Complete 22 GHz low-noise retrofit of VLBA	02/28/08	12/31/07	12/17/07
13. Complete reconfiguration to C array	03/07/08		

Notes:

6. As of 12/31/07 there were no proposals to make use of the new tuning range available at the high-frequency end of L band.

### Computer Infrastructure Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Install new Network Appliance file server	12/31/06	10/06/07	10/04/07
2. Bring up EVLA Antenna-1 Network	11/15/07		11/08/07
3. Install prototype paging system in Antenna 1	11/15/07		11/20/07
4. Prepare for 64-bit Windows migration	12/31/07		12/31/07
5. Prepare for 64-bit Linux migration	12/31/07		12/31/07
6. Complete EVLA correlator network design	01/31/08		
7. Bring up EVLA Antenna-4 Network	01/24/08		
8. Establish network tunnel to DRAO	08/31/06	01/31/08	
9. Establish network tunnel to ESO	09/30/06	01/31/08	
10. Establish EVLA/AOC fiber plan	11/30/07	02/28/08	
11. Retrofit antennas with new paging system	03/31/08		

Notes:

- 4., 5. Essentially complete, new targets will be created for actual migration.  
 8., 9. Requires further cooperation from CV, DRAO, and ESO.  
 10. In progress, working with MRO (Magdalena Ridge Observatory) on letter of intent.

### Electronics Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Build a prototype VLBA software-correlator computer cluster using the MARK5 playback units.	11/15/07		11/15/07
2. Complete VLBA K-Band sensitivity upgrade	12/14/07		12/14/07
3. Develop a plan to address the VBLA maser issues	01/18/08		12/05/07
4. Upgrade 12 P-Band receivers with COTS Amps	01/18/08		12/14/07
5. Place into operation 12 more Mark5 disk packs	02/15/08		
6. Begin testing a VLBA Digital Back End (DBE)	03/15/08		
7. Repair the elevation bearing at FD-VLBA	04/04/08		

## OPERATIONS

### 2. NEW MEXICO OPERATIONS

Milestones	Original Date	Revised Date	Date Completed
8. Build a VLBA software-correlator computer cluster using dual-quad processors installed in commercial stand-alone computers.	04/21/08		
9. Install the MARK5 pressure enclosure at MK-VLBA	05/09/08		
10. Scheduled maintenance visit at NL-VLBA	05/30/08		
11. Scheduled maintenance visit at OV-VLBA	05/15/08	09/19/08	
12. Pick up new maser #14 from Symmetricom, Inc.	06/05/08		
13. Install the WIDAR correlator BGA rework machine	06/27/08		12/11/07
14. Design and install an EVLA-compatible API	07/30/08		
15. Complete a VLA prototype ACU system	08/01/08		
16. Scheduled maintenance visit at SC-VLBA	11/20/08		
17. Perform development testing of the DBE1 and the MARK VB+ at six VLBA sites	11/21/08		

### Engineering Services Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Complete B-array reconfiguration	10/12/07	10/19/07	10/17/07
2. Replace 4,000 ties	11/30/07		11/23/07
3. Complete CnB-array reconfiguration	02/15/08		
4. Complete C-array reconfiguration	03/07/08		
5. Complete VLA Visitor Center theater remodel	03/15/08		
6. Ft. Davis elevation bearing replacement	03/21/08		
7. St. Croix antenna painting	12/15/07	04/16/08	
8. Complete DnC-array reconfiguration	06/06/08		
9. Complete D-array reconfiguration	06/27/08		
10. Antenna 28 azimuth bearing replacement	08/12/08		
11. Complete A-array reconfiguration	10/03/08		
12. Replace 4,000 ties	11/30/08		

Notes:

7. St. Croix painting 99% complete; inside truss structure just below the dish needs the final topcoat.

## OPERATIONS

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### 3. NA ALMA Science Center

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

NAASC highlights for the quarter include:

- ALMA Operations Plan version D (AOPvD) accepted by the ALMA Board
- NAASC plan updated to AOPvD
- A. Evans & R. Indebetouw joined the NAASC
- Job searches initiated for CSV liaison and CASA developer
- CASA beta-release tutorial held in Socorro
- Provided user support for CASA beta release

Staffing remains a high priority for North American ALMA operations. An active search is underway to fill a number of new positions at the NAASC, including two Commissioning and Science Verification (CSV) positions, an ALMA EPO officer, and a CASA developer. These positions will be filled over the coming few months, and the NAASC is coordinating with the OSAA and ALMA construction in this effort. Aaron Evans and Remy Indebetouw have also accepted joint positions with the University of Virginia and the NAASC. This is in addition to the numerous positions being filled in ALMA operations in Chile.

Version D of the ALMA Operations Plan (AOPvD) was accepted by the ALMA Board, and NAASC personnel propagated these changes into the NAASC long-range budget. A memo documenting these changes is being prepared to send to the NSF in the coming quarter. The ARC Manager went to Santiago to participate in the quarterly Science Operations IPT face-to-face meeting to implement the AOP.

NAASC support and testing of ALMA software continued. Crystal Brogan is coordinating NAASC support of CASA testing as the ALMA CASA Subsystem Scientist. Testing and preparation for the CASA beta release was a major activity during this quarter. A two-day CASA tutorial was held in mid-October in Socorro for representatives from the NA, EU, and EA ARCs, ALMA commissioning personnel, and EVLA scientific staff to train user-support specialists for CASA. In mid-November the beta release was opened to volunteers from the regional ALMA scientific advisory committees, NRAO users committee, and EVLA science advisory committees. During the holidays feedback was limited, but we anticipate more participation in the next quarter. A helpdesk and triage system has been established. Remy Indebetouw began developing a comprehensive plan to create a flexible ALMA simulation tool within CASA. Tony Remijan continued his work on the Splatalogue spectral-line database, which will have a beta release in 2008.

Chris Carilli participated in a number of “Futures of Radio Astronomy” committee meetings and contributed sections to their report. NAASC members also participated in the NRAO strategic planning retreat in December.

NAASC staff participates in the turno staffing at the ALMA Test Facility in Socorro. This activity involves prototype antenna and software testing, to gain familiarity with the system and train for eventual work in Chile and at the NAASC.

The ANASAC held its bi-monthly teleconference and discussed interim charges. The main charge will concern scientific input into the long-range development plan for ALMA, coordinated through the ASAC and the JAO project scientist. Official charges will be submitted to the ANASAC in January. The ANASAC has also approved the topic for the next NAASC workshop: “*Transformational Science with ALMA: The Birth and Feedback of Massive Stars Within and Beyond the Galaxy*” to be held in

## OPERATIONS

### 3. NA ALMA Science Center

Charlottesville in October 2008. The SOC has also been formed with Remy Indebetouw (NAASC/UVa) and ANASAC chair Andrew Baker (Rutgers) as SOC Co-chairs; Crystal Brogan is also on the SOC.

The Canadian MOU was updated to reflect changes in the AOPvD. Comments have been received from AUI, and Chris Carilli is revising it. The MOU will be sent to the HIA for final comment in February. Lewis Knee left his position as Canadian ALMA operations representative and moved to Chile as a member of the Assembly, Integration & Verification team. James di Francesco will be assuming the operations duties in October.

The FY 2013 Long Range Plan was generated this quarter. NAASC staff worked with the NSF on the NAASC near-term budget projections. The NAASC is also preparing for a major AUI review of NRAO operations in Q1 2008.

#### NAASC Milestones October to December 2007

Milestones	Original Date	Revised Date	Date Completed
1. MOU for UVa joint positions, and first 2 hires	10/15/07		10/15/07
2. CASA user-support boot camp	10/16/07		10/16/07
3. New NAASC science workshop 2008—topic and SOC	09/07	11/07	11/07
4. Version D of ops plan—effect on NAASC plan/budget	12/07	01/08	
5. NAASC long-range plan	12/07		12/07

#### NAASC Milestones beyond January 2008

Milestones	Original Date	Revised Date	Date Completed
1. Science center visits—Herschel	Fall 07	03/08	
2. Presentations at AAS: Invited review (Brogan); NRAO Town Hall (Carilli)	01/10/08		
3. AUI NRAO ops review	03/08		
4. New MOU with Canada for ALMA operations	9/1/07	02/08	
5. New ALMA EPO hire	12/01/07	02/08	
6. Two new hires for commissioning	12/30/07	02/08	
7. ANASAC interim charges—sci input to development plan	01/15/08		
8. Talks on ALMA science and status at NA institutions	On-going		
9. Software testing: CASA, Pipeline, Simulator, Obstool	On-going		
10. Offline-software cookbook	On-going		
11. Spectral-line catalogue—continue resolving species	Ongoing		
12. Participation in SciOps IPT, ARC managers meeting	Ongoing		
13. CASA tutorials	Ongoing		

## OPERATIONS

### 4. Central Development Lab

#### CENTRAL DEVELOPMENT LAB (CDL)

CDL highlights include:

- Completed the cryogenic evaluation of TRW Cryo-3 devices.
- Completed the design/redesign of cryogenic amplifiers using Cryo-3 TRW devices for the EVLA, the VLBA, and the GBT.
- Finished the design of an 18–26.5 GHz feed for the GBT K-band focal-plane-array receiver.
- Completed the preliminary design of polarizers for the EVLA X (8–12 GHz) and Ku (12–18 GHz) bands.

#### Amplifier Design and Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Evaluation of TRW Cryo-3 devices to determine noise, signal, and DC properties at cryogenic temperatures	04/01/04	12/31/07	12/31/07
2. Design/redesign of cryogenic amplifiers using Cryo-3 TRW devices for the EVLA, VLBA, and GBT	04/01/04	12/31/07	12/31/07
3. Development of prototype ALMA band 1 and band 2 amplifiers		06/30/07	

Notes:

3. The design of demonstration amplifiers for ALMA band 1 (31.3–45 GHz) and band 2 (67–90 GHz) has been completed. Experimental evaluation awaits the availability of technician time.

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

#### 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 activity
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 activity
3. Develop new amplifier-test-system	06/30/06	09/30/07	12/31/07

Notes:

1 and 2. New amplifier production included four 1–2 GHz low-noise, four 1–2 GHz high-dynamic-range, four 2–4 GHz, four 4–8 GHz, one 8–18 GHz, and two 18–26 GHz amplifiers. Repair, upgrade, and retesting of amplifiers included one 2–4 GHz, two 4–8 GHz, two 18–26 GHz, and ten 40–50 GHz amplifiers. Four CBI (Cosmic Background Imager) Ka-band amplifiers were repaired/rebuilt and retested. In total, 38 amplifiers were shipped. All EVLA production is on or ahead of schedule.

3. The PC/LabView-based noise-measurement system is operational and making all routine LNA measurements and performance documentation. Software enhancements will be added when needed.



## 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	04/01/08	
2. Develop integrated wideband LNA-feed package	12/01/06	04/01/08	
3. Design and test GaAs W-band (75–110 GHz) power amplifiers to improve reliability of millimeter-wave local oscillators	03/01/07	07/01/08	
4. Evaluate InP HBTs for use in cryogenic amplifiers.	06/01/08		
5. Package and test ALMA band 10 (787–959 GHz) driver module using a MMIC VCO	07/31/07	05/31/08	
6. Test 67–95 GHz 35nm InP MMIC LNA	10/31/07	04/01/08	
7. Develop cryogenic noise-calibration modules.	03/31/08		

#### Notes:

1. Extensive effort has been put into designing this MMIC. Some progress has been made, but the combination of specifications on input impedance, noise temperature, and dynamic range are proving to be the most challenging. A serious design will have to wait for the appropriate MMIC wafer run.
2. See #1 above
3. Revised amplifier designs for bands 3, 4, 7, 8, and 9, and new designs for band 10 have been completed based on the latest non-linear 70nm process models available from BAE Systems. Design-rule verification is underway, and fabrication is expected to begin early 2008.
4. Several different sizes of InP HBTs from NGST (Northrop Grumman Space Technology) have been measured at temperatures down to 12 K. We see a marginal (20%) increase in current gain ( $\beta$ ) when they are cooled, accompanied by a small decrease in transconductance ( $g_m$ ). These devices will work in cryogenic amplifiers; however, they will not give the large drop in noise temperature that HEMTs give when cooled. They may still prove useful in later stages of cryogenic amplifiers, where they can lower  $1/f$  noise compared with all-HEMT amplifiers. The next step is obtaining a small-signal model of the device to integrate with a temperature-dependent noise model.
6. The design of the 67–95 GHz MMIC LNA, based on the new NGST 35nm InP HEMT process, was completed in the second quarter of 2007. The predicted amplifier noise temperature is about 150K at room temperature and around 20K at cryogenic temperature. The chips are currently being fabricated at NGST.
7. Two commercial K-band (18–26 GHz) MMIC LNAs and one Schottky-detector MMIC have been packaged and are currently under test as candidates for a stable cryogenic noise calibration source for the GBT K-band Focal Plane Array (KFPA).

#### Electromagnetic Support Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Design 18–26.5 GHz feed for the KFPA	11/15/2007		11/30/2007
2. Develop dual-band 345/800 MHz feed for the GBT	09/30/2005	06/30/2008	
3. Measure EVLA 12–18 GHz feed	12/31/2007	06/30/2008	
4. Prototype, fabricate, and measure a 75–110 GHz phase shifter at the 17–25 GHz band	03/31/2007	03/31/2008	

## OPERATIONS

### 4. Central Development Lab

5. Preliminary design of polarizers for the EVLA X (8–12 GHz) and Ku (12–18GHz) bands	12/31/2007		12/31/2007
6. Measure K-band (18–26.5 GHz) KFPA feed	03/31/2008		
7. Design transitions for EVLA Ku band	03/31/2008		

Notes:

- Design effort on hold because of higher priorities of other projects.
- Delayed by shop fabrication schedule.
- Measured two 75–110 GHz phase shifters. Insertion loss of Serial #03 is about 0.4 dB. Measured phase difference is shown in the following figure. Serial #02 did not meet the design specification. Measuring the scaled version at 17–25 GHz will confirm the design.

Other Projects:

Analyzed the beam properties of the various elements in the GBT K-band array receiver.

#### Superconducting Millimeter-Wave Receiver Development Milestones

Milestones	Original Date	Revised Date	Date Completed
<b>Balanced SIS Mixer Development</b>			
1. Complete first balanced SIS mixer with superconducting IF hybrid	01/01/07	delayed	
2. Complete first balanced sideband-separating mixer	10/01/07	delayed	
<b>Other Mixer Development</b>			
3. 385–500 GHz SIS mixer Development	09/30/05	10/30/08	

Notes:

- 1 and 2. Delayed until the Arizona Radio Observatory (ARO) constructs a mixer test system. Balanced-mixer development is now continuing in the 385–500 GHz band—see 3.
- 1, 2, and 3. These projects are being done in conjunction with the ARO.
3. This project was on hold awaiting funds and engineering resources. It has now been restarted with support from the ARO. Balanced SIS mixers are being designed at the CDL. The University of Virginia Microfabrication Laboratory (UVML) succeeded in treating the back side of Si membranes to minimize their curvature—an important step towards making these very small circuits useable in multi-chip circuits (e.g., balanced or sideband-separating mixers).

#### 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	

Notes:

- The low-frequency antenna work has been delayed until summer 2008, pending funding.

## OPERATIONS

### 4. Central Development Lab

#### 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	03/31/08	
2. 32-element array in Western Australia	12/15/06	09/15/08	

Notes:

1. Delayed by shop fabrication schedule and correlator delivery.

#### Electrochemistry Laboratory

The Chemistry Lab's gold-plating output (counting only large jobs) was approximately \$25,000. Small-scale jobs related to various development efforts are not estimated on a commercial basis, but they represent an ongoing savings in terms of materials, purchasing, shipping and receiving, and other transactional costs. Development work is progressing on electroforming techniques to be used for a large number (over 250) of waveguide components for the EVLA. We have also prepared a detailed Statement of Work and have issued an RFQ for consulting services in establishing a new electroforming system, including the possibility of purchasing such a system in "turnkey" form. Bids are due by January 18, 2008. We hope to be able to resume copper electroforming with current-generation processes by the second quarter of 2008.

## OPERATIONS

### 5. Chile Operations

#### CHILE OPERATIONS

Chile Operations highlights include:

- Arrival of the third Vertex antenna
- Labor-related procedures for health and safety communicated and explained to ALMA management prior to actual implementation
- Various site-related contracts and calls for bid initiated or completed
- Documenting NA ALMA construction continues

#### Local Labor Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Workplace risk-assessment methodology explained to ALMA management	Q42007		12/05/07
2. Procedures for setting up Health and Safety committee communicated to ALMA management <sup>1</sup>	Q42007		12/05/07

Notes:

1. Known as “Comité Paritario de Higiene y Seguridad”, it includes the Santiago offices at El Golf, Alsacia, and Cerro Calán.

#### Business/Contracting Milestones

Milestones	Original Date	Revised Date	Date Completed
1. AOS transporter hangar construction: 70% complete	05/02/07	09/20/07	
2. ALMA camp enlargement stages 3 and 4 contract (68 new rooms): 40% complete	09/21/07	Q1 2008	
3. Antenna vendors’ camp extension contract (24 new rooms) completed	10/08/07		11/11/07
4. Security Services contract for ALMA Facilities signed	12/03/07		12/03/07
5. Additional foundation (#6) construction at the site erection facility: 90% completion	09/28/07		
6. Annual external fiscal audit of the Chile Office by KPMG Company completed			12/07
7. Invitation for bid for grading of the central antenna cluster	11/20/07		
8. Invitation for bid for OSF catering, cleaning and maintenance	12/13/07		

Notes:

4. Long-term contract (three years).
5. Antenna attachment inserts to be installed Q1 2008.
7. Bids due Q1 2008
8. Bids due Q1 2008

## OPERATIONS

### 5. Chile Operations

#### Chile Antenna Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Third Vertex antenna arrived	12/17/07		12/14/07

#### Chile EPO Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Coordination and supervision of filming of second Vertex antenna arrival and antennas progress	09/2007		10/20/07
2. NRAO EPO Chile Officer led the coordination of 18 institutions participating in Ministry of Foreign Affairs International Seminar of Astronomy in Chile	06/2007		12/06/07
3. Joining Chilean team for IYA '09 in the area of education	October 2007		

#### Other Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Environmental reporting to CONAMA	Monthly		Monthly
2. Environmental reporting to CONAMA	Biyearly		Biyearly

Notes:

1. Monthly reports are sent to CONAMA;
2. Biyearly reports are sent to CONAMA.

#### END TO END (E2E) OPERATIONS

In Q4 2007 the key accomplishments of End-to-End Operations were:

- The Common Astronomy Software Applications (CASA) beta version was released in October
- CASA training sessions, for U.S. and European constituents, were held in October and December
- A Google Sky prototype, integrating images from the NRAO image gallery, was created
- The Data Vault beta was released at <http://archive.cv.nrao.edu> for community comment; this site is intended to provide a portal to new content and interfaces for the NRAO data repositories
- Staff participated in the Green Bank GUPPI workshop in October and the Focal Plane Array workshop in November to discuss pipelining needs

The technical accomplishments of the archive development team include: a) various bug fixes in the query tool, b) support for image queries to over 125,000 images drawn entirely from VLA and VLBA survey projects, c) easy web access to GBT data taken through 2006, d) integration of free-text search queries for VLA and VLBA data, e) a query-caching prototype that minimizes execution time for GBT queries, f) improvements to GBT metadata integrity, g) an updated search-tool web template, h) support for user authentication with NRAO Interactive Services, i) a prototype design for the interface between the EVLA correlator and the NRAO Archive, and j) a Google Sky prototype for NRAO radio images, which involved creating “skymarks” in the Keyhole Markup Language (KML) understood by the Google application.

NRAO participation in the NVO technical effort in Q4, led by D. Tody, has emphasized participation in ongoing IVOA standards development and related implementations, preparing for operation of the NVO Facility, and producing and publishing VO-ready data from NRAO instruments. In standards development, the spectral-access protocol and spectrum data model now have multiple implementations. Good progress has been made on specifying the new Table Access Protocol (TAP) and on the Simple Image Access (SIA) V2 design, both of which will be major topics of development next year. For Data Access Layer (DAL)-related implementations, the main focus was the scalable applications framework, with work in late December and January to plan a joint US–EU (OPTICON) implementation effort. As part of NVO Facility planning, both D. Tody and N. Radziwill have produced more formal processes for NVO software development and testing, and they helped to test new development tools for code and project management. L. Sjouwerman, J. Benson, J. Crossley, and E. Fomalont continue to process legacy VLA data and have produced over 75,000 images from pointed VLA continuum observations, which are available through the Data Vault and VO searches. J. Crossley also officially started contributing to the NRAO NVO effort this quarter.

End-to-End Operations supported software activities in Green Bank, focusing on technical mechanisms for communicating with users of the Dynamic Scheduling System (DSS) and integrating high-performance FPGA computing into operations as part of the Green Bank Ultimate Pulsar-Processing Instrument (GUPPI) project, which is a component of the CICADA FPGA development program. For DSS the simplest end-to-end working system possible for executing scheduling was completed on schedule. Also this quarter, the DSS project team presented the current DSS plans to Green Bank and Charlottesville staff and evolved the documentation required for upcoming DSS tests on the GBT during the 08B trimester. Software development for GUPPI is well underway, and we plan to deploy the first version in early 2008 as a Spigot replacement for the GBT, with coherent de-dispersion over 800 MHz of bandwidth available in a second version to be available in June. GUPPI will be an expert-user instrument until software-development resources become available to complete the full integration into the GBT system as a common-user backend (expected for FY 2009). Building on the momentum from a team

## OPERATIONS

### 6. END TO END Operations

workshop held in late October 2007, the software development team, which includes a member of the E2E group, has evolved the high-level design and is on schedule to support first-light commissioning.

#### Management & Administration Activities

Milestones	Original Date	Revised Date	Date Completed
1. First draft of E2E Strategic Plan complete	09/30/07	12/31/07	12/31/07
2. <b>External Funding:</b> Proposal for exploring prototypes for using multiple data-analysis packages from a common user interface	12/05/07		12/05/07
3. Prepare for EVLA Science Support Systems review	03/31/08		
4. Prepare for Visiting Committee review	03/31/08		
5. Complete E2E strategic-planning session	09/15/07	04/30/08	
6. Complete specifications for Strategic Decision Support System (a management dashboard)	09/30/07	07/15/08	

#### Algorithm Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Create project charter for algorithm development	09/30/07	03/31/08	
2. Hold first NRAO Algorithm R&D Symposium	11/30/07	11/30/08	

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

Milestones	Original Date	Revised Date	Date Completed
1. Metadata information schema proposal for the TAP	10/31/07		11/15/07
2. TAP high-level design (JHU meeting)	11/20/07		11/20/07
3. Updated data-processing framework architecture	01/31/08		
4. TAP prototype with SimpleQuery functionality	11/05/07	03/15/08	
5. DALServer updated for SSA standard (V1.02)	11/05/07	03/15/08	
6. SSA V1.1 working draft	09/15/07	03/31/08	
7. VOClient with CLI, registry, and SSA support	02/15/08	04/01/08	
8. Draft Applications Messaging specification	10/25/07	04/30/08	
9. Revised SIA V1.0 specification for PR	08/15/07	04/30/08	
10. Initial working draft and prototyping for SIA V2	09/15/07	05/01/08	
11. First draft of applications framework interfaces doc	03/01/08		
12. IVOA interoperability workshop (Trieste)	05/12/08		
13. 2008 NVO summer school	09/15/08		

## OPERATIONS

### 6. END TO END Operations

#### NRAO Archive Infrastructure & Interfaces

Milestones	Original Date	Revised Date	Date Completed
1. Release Data Vault (Archive v2.0) beta	10/26/07	12/10/07	12/10/07
2. Devise archive-index schema and replication scheme; resolve data-integrity issues in current NRAO archive	04/30/07	02/15/08	
3. Document database schema and diagrams (ERD) for the archive metadata/registry	06/31/07	03/31/08	
4. Complete Data Vault (Archive v2.0) beta, production release of Archive v2.0 (stable Google-like search query, results, and download of VLA, VLBA, and GBT data)	12/31/07	03/31/08	
5. Install the Spectral Line Search Engine (SLiSE) to query the single-dish spectra database	12/31/07	03/31/08	
6. Document description and diagram of existing archive infrastructure	03/31/08		
7. Receive cost estimates from the NCSA for long-term hosting and data curation	03/31/08		
8. Develop pipeline to generate calibrated SDFITS data.	12/31/07	06/30/08	
9. Develop pipeline to generate preliminary calibrated, averaged datasets	12/31/07	06/30/08	
10. Include 12 m and 140 ft data in the production single-dish archive node (requires capability to reduce data)	12/31/08		

#### NRAO Proposal Infrastructure & Interfaces

Milestones	Original Date	Revised Date	Date Completed
1. Complete PST performance improvements	05/20/07	08/01/07	08/21/07
2. Conduct user-acceptance test of the upgraded PST	08/15/07	08/31/07	08/31/07
3. Test user acceptance of Proposal Handling System	09/15/07		09/21/07
4. Release the PST upgrade; begin receiving new proposals	09/15/07		09/14/07
5. Successful management of the October 2007 NRAO proposal deadline with upgraded software	10/01/07		10/01/07
6. Prepare specifications for February 2008 additions	11/23/07		
7. 08B revisions available for user-acceptance testing	01/04/08		
8. 08B PST release	01/16/08		
9. Integrate the VLBA/HSA into the PST	06/01/08		
10. Enable export of GBT source catalogs	06/01/08		



## OPERATIONS

### 6. END TO END Operations

#### Data Processing (CASA/GBTIDL) Milestones

Milestones	Original Date	Revised Date	Date Completed
1. CASA beta release	09/30/07		10/15/07
2. Release CASA beta Helpdesk	11/01/07		11/08/07
3. Complete beta update 0.5 (bug fixes)	11/15/07		11/23/07
4. Complete beta update 1.0 (bug fixes)	12/31/07	02/15/08	
5. Evaluate effectiveness of the CASA beta Helpdesk and global issue-resolution process	12/31/07		12/31/07
6. Complete memo detailing CASA efficiency and throughput (“Terabyte Initiative”), and summarize resulting recommendations	04/30/08		
7. Complete gap analysis to determine when CASA will be “done”	04/30/08		
8. Plan for first public release, with dates, complete	05/15/08		
9. Complete beta update 2.0 (bug fixes + functionality)	05/15/08		

#### NRAO Pipeline Infrastructure & Interfaces

Milestones	Original Date	Revised Date	Date Completed
1. Develop plan for common VLA/Chandra sources	12/31/06	12/15/07	12/15/07
2. Explore the possibility of common NRAO/HST sources	12/31/06	12/15/07	12/15/07
3. Explore the possibility of common NRAO/Spitzer sources	12/31/06	12/15/07	12/15/07
4. Publish all 75,000 NVAS images to the VO	12/31/07		12/10/07
5. Bind the AIPS pipeline to live VLA observations	05/31/07	*	
6. Expand AIPS VLA pipeline to Level 2 processing	12/31/08		
7. Implement common search for VLA/Chandra	12/31/08		
8. Implement common search for NRAO/HST	12/31/08		
9. Implement common search for NRAO/Spitzer	12/31/08		
10. Second half of VLA archive processed via pipeline	06/30/08	06/30/09	

Notes: \* Deferred indefinitely until the impact of the EVLA on data quality is fully understood.

## OPERATIONS

### 7. Computer and Information Services

#### COMPUTER AND INFORMATION SERVICES (CIS)

CIS highlights include:

- New wide-bed printers are now generally available for use at all sites. This is of special value to EPO, drafting, and scientists making posters for meetings.
- A new version of the “Gold Book,” which contains IT information for all NRAO staff, has been created. It will be deployed early next year.

#### Observatory-wide Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Upgrade link between UVa and NRAO-CV to 1 Gbps (d)	01/31/07	06/30/08	
2. New VPN concentrator available (d)	09/30/07	02/29/08	
3. Web reliability initiative (c)	12/31/07		12/20/07
4. Replace wide-bed printers	12/31/07		12/14/07
5. “Gold Book” upgrade (c)	01/31/07		
6. Annual system administrator conference in CV (b)	04/30/08		
7. Re-bid Wide Area Network contract (d)	04/30/07		
8. Deploy Microsoft Office 2007 (b)	05/31/08		
9. Web content management overhaul (c)	05/31/08		
10. Begin deployment of new Linux (RHEL5) (b)	05/31/08		

Notes:

1. This will be installed by the University of Virginia as soon as the requisite components are available.
2. The equipment was ordered and delivered and has been deployed for test use. It has not been released for general use.

- (a) Security  
(b) Common Computing Environments  
(c) World-wide-web infrastructure  
(d) Telecommunications

#### Charlottesville Computing Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Order for new computer-room power conditioning	09/30/07	11/30/07	11/30/07
2. Install new computer-room power conditioning	02/29/08		
3. Increased storage on the disk filer	03/31/08		
4. Upgrade Exchange Server	03/31/08	05/31/08	

Notes:

4. We have determined that this will require replacement server hardware; it will consequently be delayed for two months from its originally planned date.

## OPERATIONS

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### 8. Education and Public Outreach

#### EDUCATION AND PUBLIC OUTREACH (EPO)

EPO highlights include:

- The EPO strategic plan was drafted and reviewed by the EPO team.
- The *Cosmic Radio* program series was completed.
- Additional ALMA high-definition video documentation was acquired at the OSF and AOS.
- Taylor Johnson joined the EPO team as Senior Web Designer.
- The Alpha2 demo web site was delivered.
- A community open house was held in Green Bank.

Santiago-based contractor FilmoSonido spent three days in October documenting the status of the ALMA project by acquiring high-definition video footage at the ALMA Operations Support Facility, at the Array Operations Site, and in and around San Pedro de Atacama. Interviews with eight ALMA scientists and engineers were recorded in Charlottesville to high-definition video for use in ALMA videos and multimedia features. A draft script and storyboards were written for a new ALMA video that broadly chronicles the project's compelling science, technology, and value.

The EPO team met in Green Bank for its annual planning meeting on December 3 and 4. The first day was devoted to a detailed review and discussion of the draft EPO strategic plan; the second day was devoted to completing the new EPO website structure and content. Website contractor Category 4 Design delivered their "alpha-2" demonstration site for the renovated NRAO website.

EPO and Allegheny Mountain Radio completed the 26 short programs that will launch as *Cosmic Radio* in early 2008. The individual programs cover a wide range of topics, including recent NRAO discoveries. The new *Cosmic Radio* series was distributed on CD to over 500 National Public Radio affiliated stations, and a website was created that will be updated weekly: <http://www.nrao.edu/cosmicradio/>. The Corporation for Public Broadcasting funded *Cosmic Radio* development. The concept is modeled after the McDonald Observatory *StarDate* program. Our goal is to increase public awareness of science, radio astronomy, and the NRAO.

The NRAO 2008 Calendar was produced and distributed. This calendar includes each of the prize-winning entries from the 3<sup>rd</sup> annual (2007) AUI/NRAO image contest.

More than 600 guests participated in a community open house held in Green Bank on October 21 and enjoyed a day of science demonstrations, lectures, activities, and behind-the-scenes tours of the GB electronics lab, machine shop, and the GBT.

Three press releases were written and distributed.

Taylor Johnson joined the NRAO EPO team on 1 October as our WWW content specialist and senior web designer. Taylor has more than a dozen years experience in web development and graphic design, including web content, tools, technologies, and standards.

## OPERATIONS

### 8. Education and Public Outreach

#### Publications / Documentation Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Publish October 2007 NRAO Newsletter	10/01/07		10/10/07
2. Call for January 2008 NRAO Newsletter submissions	12/01/07		12/01/07
3. Complete publications revisions for AAS meeting	12/15/07		12/18/07
4. Publish January 2008 NRAO Newsletter	01/02/08		
5. Call for April 2008 NRAO Newsletter submissions	03/01/08		

#### Online Outreach Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Contractor (Cat 4) completes the alpha-2 demo website	11/07	12/04/07	12/20/07
2. Complete design & structure review with contractor (Renegade)	01/15/08		
3. Beta website demo for Director's Office	01/25/08		
4. Beta website review and feedback complete	02/18/08		
5. New science & EPO web sites rollout	03/14/08		

#### Scientific Community Outreach Milestones

Milestones	Original Date	Revised Date	Date Completed
1. 23 <sup>rd</sup> Annual New Mexico Symposium (Socorro)	10/19/07		10/19/07
2. American Astronomical Society (Austin)	01/07–11/08		
3. American Association for the Advancement of Science (Boston)	02/14–18/08		

Notes:

2. NRAO Town Hall held 9 January 2008 during the AAS meeting; EPO conducted the Astro-Zone public outreach event.

#### Education Programs

Milestones	Event Date
1. Jansky Lectures (SOC, GB, CV)	10/19-24/07
2. 2007 Science Bowl (GB)	11/01/07

#### EPO Community & Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. ALMA EPO Program Officer selection complete	09/28/07	04/08	
2. Communicating Astronomy to the Public (Athens)	10/07–11/07		10/07–11/07

## OPERATIONS

### 8. Education and Public Outreach

Milestones	Original Date	Revised Date	Date Completed
3. Community Open House (GB)	10/21–22/07		12/21–22/07
4. Draft NRAO EPO Strategic Plan	11/07	12/07	12/4/07
5. ALMA EPO WG face-to-face meeting (Chile)	11/07	11/14–16/07	11/14–16/07
6. EPO Planning meeting (CV)	12/07		12/3–4/07

Notes:

1. This position was re-advertised in the January 2008 AAS Job Register.

#### Custom EPO Programs & Tours: GB Science Center & VLA Visitor Center

Milestones	Event Date
1. Renaissance School (GB Science Center)	10/02–03/07
2. Baptist Bible College (GB Sci Ctr)	10/05/07
3. Guided Tours, 11:30 am – 4:00 pm (VLA Visitor Center)	10/06/07
4. Santa Fe High School (VLA Vis Ctr)	10/08/07
5. Bernallio Village Academy Charter School (VLA Vis Ctr)	10/09/07
6. Enchanted Skies Star Party (VLA Vis Ctr)	10/11/07
7. Boy Scouts of American Troop 221 (GB Sci Ctr)	10/13/07
8. Madison Middle School (GB Sci Ctr)	10/15/07
9. New hires (VLA Vis Ctr)	10/16/07
10. Indiana University of Pennsylvania (GB Sci Ctr)	10/19/07
11. Marshall University (GB Sci Ctr)	10/21–22/07
12. Chaco Canyon Astronomy / NM Kids Magazine (VLA Vis Ctr)	10/24/07
13. HamFest (VLA Vis Ctr)	10/26/07
14. West Virginia University (GB Sci Ctr)	10/27/07
15. Lynchburg College (GB Sci Ctr)	11/01/07
16. University of Virginia (GB Sci Ctr)	11/03/07
17. University of Maryland (GB Sci Ctr)	11/03/07
18. Inez Elementary School (VLA Vis Ctr)	11/06/07
19. Village School (GB Sci Ctr)	11/08/07
20. Broadway High School (GB Sci Ctr)	11/09/07
21. NMSU Electronic majors (VLA Vis Ctr)	11/09/07
22. Inez (NM) Elementary School (VLA Vis Ctr)	11/09/07
23. Concho (AZ) Elementary School (VLA Vis Ctr)	11/15/07
24. Festival of the Cranes (VLA Vis Ctr)	11/15 & 16/07
25. Concho Elementary School (VLA Vis Ctr)	11/15/07
26. NMT Astronomy 511 (VLA Vis Ctr)	11/16/07
27. NMT educators (VLA Vis Ctr)	11/17/07
28. Tygart Valley High School (GB Sci Ctr)	11/27/07
29. Fairfield High School (GB Sci Ctr)	11/30–12/01/07

## OPERATIONS

### *8. Education and Public Outreach*

<b>Milestones</b>	<b>Event Date</b>
30. Albuquerque Astronomy Club (VLA Vis Ctr)	12/27/07
31. Sante Fe seniors (VLA Vis Ctr)	01/02/08
32. Fort Hill High School (GB Sci Ctr)	01/18-20/08
33. Virginia Department of Education (GB Sci Ctr)	01/22-24/08
34. Radford University (GB Sci Ctr)	01/25-26/08
35. UNM Astronomy (VLA Vis Ctr)	02/03/08
36. NM Seniors (VLA Vis Ctr)	02/08/08
37. Los Lunas Valencia High School (VLA Vis Ctr)	02/08/08
38. Western Albemarle High School (GB Sci Ctr)	02/08–09/08
39. NM Seniors (VLA Vis Ctr)	02/09/08
40. Boy Scout Troop 111 (GB Sci Ctr)	02/15–16/08
41. Boy Scout Troop 2215 (GB Sci Ctr)	02/15–16/08
42. Providence Day School (GB Sci Ctr)	02/21–23/08
43. West Stanly HS (GB Sci Ctr)	02/28–03/01/08
44. South Charleston High School (GB Sci Ctr)	03/05/08
45. Girl Scout Troop (GB Sci Ctr)	03/08/08
46. Georgia High School Academy (VLA Vis Ctr)	03/11/08
47. Linwood Holton Governor's School (GB Sci Ctr)	03/15/08
48. Lynchburg College (GB Sci Ctr)	03/20/08

## MANAGEMENT

### *I. Administration*

## MANAGEMENT

### ADMINISTRATION

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

ES&S work this quarter focused on the physical-security audit for the Observatory. The draft report of findings was reviewed and is planned for presentation at the January 2008 administration meeting. Additionally, significant resources were applied to the installation of the card-access system in Green Bank. The card-access system installation was delayed to allow for RFI shielding of the control units. The card system is identical to and will function seamlessly with the existing system in Charlottesville.

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
1. Establish Health and Safety training/ recordkeeping database	FY 2007		03/06/07
2. Provide annual calendar of OSHA or other regulatory-required training programs	FY 2007		03/06/07
3. Pre-program scheduling of essential ES&S training to ensure compliance-based training needs are met	FY 2007		03/06/07
4. Identify compliance-required training programs	FY 2007		03/06/07
5. Avian-flu planning	FY 2007		04/04/07
6. Develop and implement an environmental control process to address NEPA issues and Environmental Categorical Exclusion issues	FY 2007		06/26/07
7. Coordinate installation of card access to the secure servers in Green Bank	12/01/07		11/01/07
8. Complete update of the NRAO safety manual. DRAFT complete and posted on ES&S web page.	FY 2007		11/09/07
9. Conduct physical security audit NRAO-wide	12/01/07		12/16/07
10. Implement card access controls for Green Bank	12/01/07	03/01/08	
11. Plans for NRAO emergency-preparedness efforts	12/01/07	01/31/08	
12. Supplement ES&S staff in Socorro	01/01/08	01/07/08	
13. Business-continuity planning, pending Peoplesoft completion	FY 2007	Pending	

Notes:

1-6. Milestones not reported previously.

## HUMAN RESOURCES

### Diversity Program

- Quarterly changes in female and minority hiring and promotions:
  - Deputy Assistant Director for Science in Socorro (Female)
  - Deputy Assistant Director for Operations in Socorro (Female)
  - Site Human Resources Manager in Socorro (Minority/Male)
  - Sr. Benefits Administrator in Charlottesville (Female)
  - Engineering Co-Op student in Green Bank (Female/Minority)
  - Accountant in Green Bank (Female)
  - Accountant in Green Bank (Female)
  - Research Associate in Socorro (Female)
  - Sr. Human Resources Assistant/HRIS Coordinator (Female/Minority)
- Initiated contact with the Head of the Electrical Engineering Dept., Tuskegee University, Tuskegee, Alabama to determine if mutual interest in Electrical and Computer Engineering can be established.
- Awarded 2007 Best Diversity Company by the Readers of Diversity/Careers in Engineering & Information Technology. Added the award certificate to the Diversity web site.
- Committed the Observatory to participate in three minority- and female-recruiting conferences specifically focused on software and electrical engineers. Fully utilized the female and minority NRAO staff members as recruiters in the booth. The following are in the upcoming quarter:
  - BEYA – Black Engineer of the Year. Most HBCU Engineering School Deans attend. Professionals and students Feb. 14–16, 2008
  - NSBE – National Society of Black Engineers, professionals and students Mar. 19–23, 2008
  - SWE – Society of Women Engineers - this conference was planned but is not scheduled until Nov. 2008
- Made additions and revisions to the Diversity web pages and links to the Co-Op and Internship pages that highlight special diversity funding and other informative links.
- Requested funding for an Observatory applicant-tracking system that will allow for real-time EEO statistical data analysis and enhanced reporting to supervisors and hiring authorities.
- Complete NRAO's 2007 Affirmative Action Plan. Will brief NRAO management on NRAO AAP progress and goals for 2008.



## MANAGEMENT

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### 2. Human Resources

#### Personnel

##### NEW HIRES

Bloss, Martin	Project Manager II	12/03/2007
Indebetouw, Remy	Sr. Research Associate	11/15/2007
Johnson, Taylor	Web Designer, Sr.	10/01/2007
Knee, Lewis	Test Scientist	11/01/2007
Momijian, Emmanuel	Assistant Scientist	10/26/2007
Peters, Walter	Sr. Systems Administrator	10/15/2007
Yao, Lihong	Scientific Associate	10/08/2007

##### TERMINATIONS

Chambers, Kennon	Facilities Engineer II	10/05/2007
Creel, Buckner	Junior Fellow	12/31/2007
Spekkens, Kristine	Jansky Fellow	12/31/2007

##### REHIRES

Crossley, Jared	Scientific Associate II	10/01/2007
Nguyen, Ngoc	Coop Student	12/12/2007

##### PROMOTIONS

Chandler, Claire	Scientist A-Deputy Asst Dir for Sci	10/09/2007
Jacques, Christophe	Electronics Engineer I	10/01/2007
Lewis, Allen	Site Human Resources Manager	10/01/2007
Perley, Margaret	Deputy Asst Dir for Ops	10/09/2007
Stogoski, Michael	Quality Assurance Engineer II	10/01/2007

##### TRANSFERS

Kanekar, Nissim	NRAO Post Doc	10/01/2007
McMullin, Joseph	System Integration Leader/Sci CS	11/01/2007
Ulvestad, James	Assistant Director, New Initiatives Office	10/01/2007

#### BUDGET

The NRAO is operating under a continuing resolution as of the end of Q1, FY 2008. The pre-continuing-resolution President's Request Level budget was expected to be \$52,740k. With the continuing resolution in place, the NRAO is funded to its FY 2007 level of \$50,740k, or \$2,000k less than the President's Request Level budget. At the beginning of the fiscal year, the NRAO Operations budget included \$7,644k for ALMA Operations and \$6,010k for EVLA. Early in the first quarter, ALMA Operations was established as a separate Scientific Program Order under the AUI Cooperative Agreement. The resultant non-ALMA NRAO Operations budget was reduced by \$7,644k from \$50,740k to \$43,096k, including EVLA. With EVLA removed, the NRAO Operations budget is \$39,086k.

When combined with prior-year commitments and prior-year carryover, the NRAO Operations total budget, less EVLA, is \$47,071k. As of December 31, new funding in the amount of \$10,774k was received for NRAO Operations and \$1,911k was received for ALMA Operations. Overall, the NRAO Operations budget is approximately 7% (annualized) below a linear spending rate through the first quarter. The following is a brief explanation of the WBS level 1 elements that are under/over spent in excess of 10% based on a linear rate.

- **Observatory Management.** Materials and Services is significantly lagging a linear spend rate, retaining reserves to offset the expected FY 2009 and FY 2010 funding shortfalls.
- **Education and Public Outreach.** Travel and materials costs are tracking behind a linear spending plan. However, recent expenses in both cost elements will bring the overall spending back into alignment with expectations.
- **Central Development Lab.** The Observatory received KFPA project funding earlier this fiscal year that moved the incurred costs from CDL to the project and created an underspending situation in CDL.
- **Computer and Information Services.** Prepaid expenses associated with software licensing have resulted in services spending exceeding a linear rate. This situation is not unexpected and will resolve as the year progresses.
- **Science and Academic Affairs.** Materials and services expenses are exceeding a linear rate in several business units within the OSAA but were not unexpected. Commitments for traineeships and advance payments for library subscriptions are the two primary cost drivers.
- **ALMA Operations.** The overall spending in ALMA Operations is well below a linear spending rate. Expenses will pick up later in the fiscal year and approach the linear spending plan as operations accelerate in Chile.

MANAGEMENT

3. Budget

NRAO Operations Expenses and Commitments FY 2008 Year to Date (October 1, 2007 to December 31, 2007) in \$000							Percent of fiscal year	25.0%	
WBS Level 1	Salaries & Benefits	Materials & Services	Travel	Revenue or Cost Recovery	Total	Linear Spending	Actual Exp + Comm	Actual Percent Expended & Committed	Annualized Variance
Observatory Management	6,214	2,690	344	-150	9,098	2,274	1,355	14.9%	40.4%
Education and Public Outreach	582	244	21	-125	722	180	161	22.3%	10.7%
Central Development Lab	1,491	209	23		1,723	431	313	18.2%	27.2%
Green Bank Operations	8,901	2,761	145	-463	11,344	2,836	2,804	24.7%	1.1%
New Mexico Operations	14,489	4,230	157	-80	18,796	4,699	4,643	24.7%	1.2%
Computer and Information Services	999	678	25		1,703	426	471	27.6%	-10.6%
Science and Academic Affairs	1,831	1,470	383		3,685	921	1,195	32.4%	-29.7%
NRAO Operations total	34,508	12,284	1,098	-818	47,071	11,768	10,944	23.2%	7.0%

## APPENDIX

### *Acronyms and Abbreviations*

<b>Acronym</b>	<b>Definition</b>
AAP	Affirmative Action Plan
AAS	American Astronomical Society
ACU	Antenna Control Unit
AIPS	Astronomical Image Processing System
ALMA	Atacama Large Millimeter Array
ANASAC	ALMA North American Scientific Advisory Committee
AOC	Array Operations Center (Socorro, NM)
AOPvD	ALMA Operations Plan version D
AOS	Array Operations Site (ALMA)
API	Atmospheric Phase Interferometer
ARC	ALMA Regional Center
ARO	Arizona Radio Observatory
ASAC	ALMA Scientific Advisory Committee
AUI	Associated Universities, Incorporated
BDF	Binary Data Format
BAE	British Aerospace Engineering
BGA	Ball-Grid Array
C band	4–8 GHz
CalDM	Calibration Data Model
CASA	Common Astronomy Software Applications
CDL	Central Development Laboratory (Charlottesville, VA)
CfA	Center for Astrophysics
CICADA	Configurable Instrument Collaboration for Agile Data Acquisition
CIO	Chief Information Officer
CIS	Computer and Information Services
CLI	Command-Line Interface
CMOS	Complementary Metal-Oxide Semiconductor
CONAMA	Chilean National Environmental Commission
COTS	Common Off-The-Shelf
CSV	Commissioning and Science Verification (ALMA)
CV	Charlottesville
CY	Calendar Year
DC	Direct Current
DAL	Data Access Layer
DBE	Digital Back End
DDS	Direct Digital Synthesizer
DRAO	Dominion Radio Astrophysical Observatory
DSS	Dynamic Scheduling System (GBT)
E2E	End-to-End
EA	East Asian
EEO	Equal Employment Opportunity
EPO	Education and Public Outreach
ES&S	Environment, Safety, and Security (NRAO)
ESO	European Southern Observatory
EU	European
EVLA	Expanded Very Large Array

## APPENDIX

### *Acronyms and Abbreviations*

<b>Acronym</b>	<b>Definition</b>
FASR	Frequency-Agile Solar Radiotelescope
FD	Fort Davis VLBA station
FPGA	Field-Programmable Gate Array
FY	Fiscal Year
GaAs	Gallium Arsenide
GB	Green Bank
GB/SRBS	Green Bank Solar Radio Burst Spectrometer
GbE	Gigabit Ethernet
Gbps	Giga bits per second
GBT	Green Bank Telescope
GBTIDL	GBT Interactive Data Language
GHz	Gigahertz
GLAST	Gamma-ray Large-Area Space Telescope
Gsps	Giga samples per second
GUPPI	Green Bank Ultimate Pulsar-Processing Instrument
HBCU	Historically Black Colleges and Universities
HBT	Heterostructure Bipolar Transistor
HEMT	High-Electron-Mobility Transistor
HAS	High-Sensitivity Array
HIA	Herzberg Institute of Astrophysics
HRIS	Human Resources Information System
HST	Hubble Space Telescope
IDL	Interactive Data Language
IF	Intermediate Frequency
InP	Indium Phosphide
IPT	Integrated Product Team
IT	Information Technology
IYA	International Year of Astronomy (2009)
IVOA	International Virtual Observatory Alliance
JAO	Joint ALMA Observatory
JHU	Johns Hopkins University
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
LNA	Low-Noise Amplifier
LO	Local Oscillator
M&C	Monitor and Control
MHz	Megahertz
MK	Mauna Kea (VLBA station)
mm	millimeter
MMIC	Monolithic Microwave Integrated Circuit
MoO	Mission of Opportunity (NASA)

## APPENDIX

### *Acronyms and Abbreviations*

<b>Acronym</b>	<b>Definition</b>
MOSFET	Metal-Oxide Semiconductor Field-Effect Transistor
MOU	Memorandum of Understanding
MPIfR	Max Planck Institut für Radioastronomie
MSI	MidSized Infrastructure (NSF program)
µm	micrometer
MUSTANG	Multiplexed Squid TES Array at Ninety GHz (GBT “Penn Array” receiver)
NA	North American
NAASC	North American ALMA Science Center
NASA	National Aeronautics and Space Administration
Nb	Niobium
NbTiN	Niobium Titanium Nitride
NCSA	National Center for Supercomputing Applications
NEPA	National Environmental Policy Act
NGST	Northrop Grumman Space Technology
NJIT	New Jersey Institute of Technology
NL	North Liberty (VLBA station)
nm	nanometer
NMSU	New Mexico State University
NMT	New Mexico Tech
NRAO	National Radio Astronomy Observatory
NSF	National Science Foundation
NTC	NRAO Technology Center (Charlottesville)
NVAS	NRAO VLA Archive Survey
NVO	National Virtual Observatory
OMT	Orthomode Transducer
OPT	Observation Preparation Tool
OPTICON	Optical–Infrared Coordination Network for Astronomy
OSAA	Office of Science and Academic Affairs (NRAO)
OSHA	Occupational Safety and Health Administration
OSF	Operations Support Facility (ALMA)
OV	Owens Valley (VLBA station)
P band	327 MHz
PAPER	Precision Array to Probe the Epoch of Reionization
PC	Personal Computer
PDR	Preliminary Design Review
PI	Principal Investigator
PLC	Programmable Logic Controller
PR	Proposed Recommendation
PST	Proposal Submission Tool
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)
REU	Research Experiences for Undergraduates (NSF program)
RF	Radio Frequency

## APPENDIX

### *Acronyms and Abbreviations*

<b>Acronym</b>	<b>Definition</b>
RFI	Radio-Frequency Interference
RFQ	Request For Quotation
RTP	Round-Trip Phase
S band	2–4 GHz
SAA	Science and Academic Affairs
SC	Saint Croix (VLBA station)
Sci Ctr	Science Center (Green Bank)
SDFITS	Single-Dish Flexible Image-Transport System
SDM	Science Data Model
SIA	Simple Image Access
SIS	Superconductor–Insulator–Superconductor
SKA	Square Kilometre Array
SOC	Socorro, NM or Scientific Organizing Committee
SRBS	Solar Radio-Burst Spectrometer (Green Bank)
SSA	Simple Spectral Access
TAP	Table Access Protocol
TBD	To Be Determined
TRW	TRW Corporation
U band	12–18 GHz
UCB	University of California at Berkeley
UMd	University of Maryland
UVa	University of Virginia
VCO	Voltage-Controlled Oscillator
Vis Ctr	Visitor Center (VLA)
VLA	Very Large Array
VLBA	Very Long Baseline Array
VLBI	Very Long Baseline Interferometry
VO	Virtual Observatory
VPN	Virtual Private Network
VSOP-2	VLBI Space Observatory Program successor
W band	68–117 GHz
WBS	Work Breakdown Structure
WG	Working Group
WIDAR	Wideband Digital Interferometric Architecture (EVLA correlator)
WWW	World-Wide Web
X band	8–12 GHz