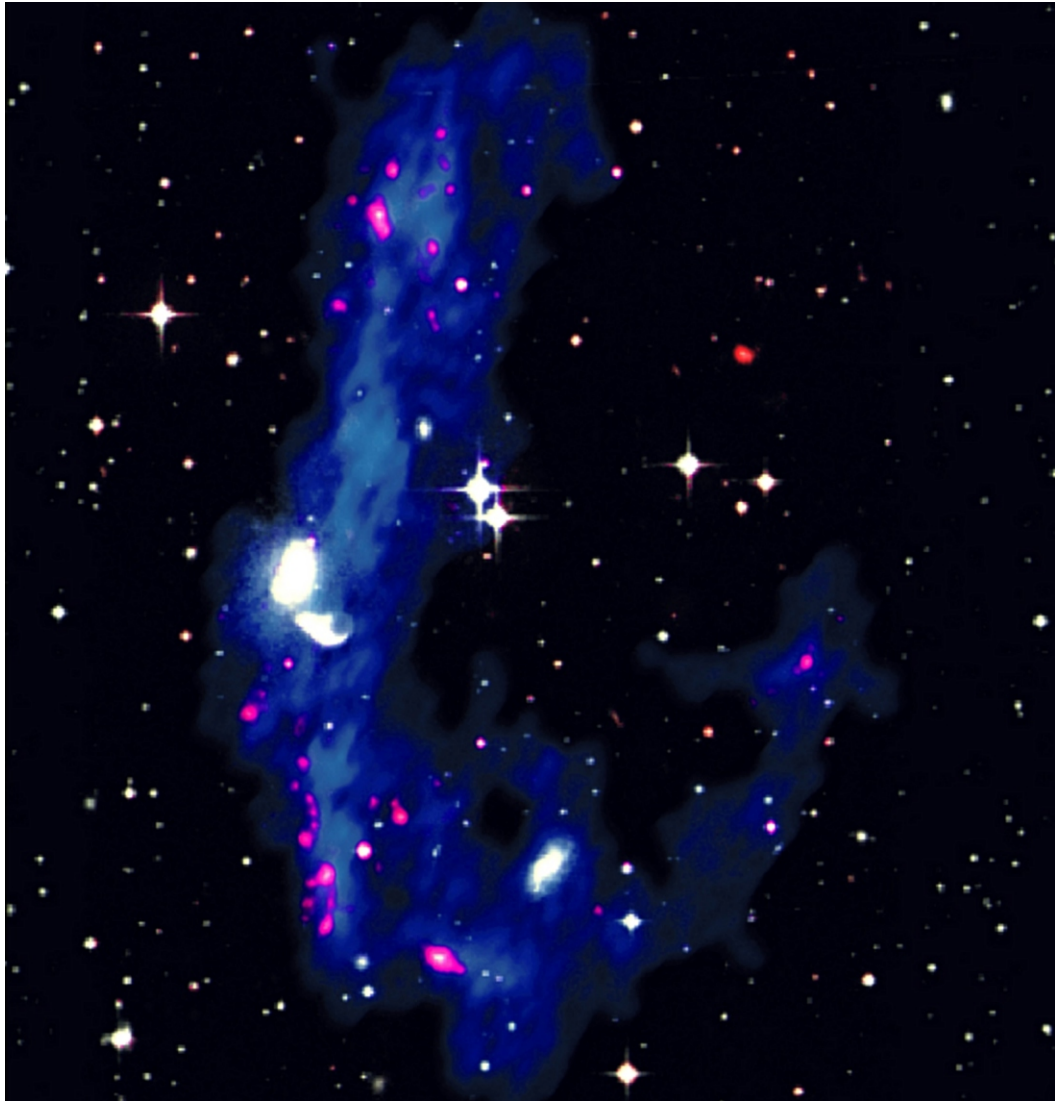


# NATIONAL RADIO ASTRONOMY OBSERVATORY



## Quarterly Report



April – June 2007



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*Cover Image: Composite radio/optical/ultraviolet image showing NGC 5291 and its surroundings, including the debris propelled outward by collision with another galaxy. Blue is atomic hydrogen observed with the VLA, white is optical, and red is ultraviolet observed with the GALEX satellite. Dwarf galaxies (red) formed by the collision contain more dark matter than expected, probably in the form of molecular hydrogen. For more information, see <http://www.nrao.edu/pr/2007/darkdwarfs/>.*

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### EXECUTIVE SUMMARY

#### NRAO 50<sup>th</sup> Anniversary

The NRAO celebrated the 50th anniversary of its founding by AUI and the NSF with an Observatory-wide all-staff meeting on June 14, which also honored the completion of the ALMA Array Operations Site Technical Building. The symposium “Frontiers of Astrophysics” held in Charlottesville from June 18–21 brought together nearly 200 scientists to review recent discoveries, provide guidance for future radio facilities and observations, and commemorate major achievements enabled by the NRAO instruments. Participants also attended a reception, an in-depth tour of the NRAO Technology Center, and an optional tour of the GBT. Two Town Hall meetings were held to obtain community input to the Committee on the Future of U.S. Radio Astronomy sponsored by AUI.

#### Science and Academic Affairs

During the second quarter the SAA was involved in several searches for staff positions, including the New Mexico operations Assistant Director, a scientific staff position for Socorro, a tenure-track scientist search and search for a new administrative head for SAA.

The SAA, through the Observatory Science Council (OSC), ran the evaluation process to decide on the scientific priorities for instrumentation developments on NRAO telescopes. The funds (\$4.5M) were made available as a result of the AUI settlement with Lockheed Martin. Approximately \$3M was set aside for scientific initiatives. A total of 15 proposals were received, requesting \$9M in total. The OSC produced a rank-ordered list and sent it to the Director’s Office for final approval.

The predoctoral, co-op, visiting scientist, and summer-student programs remain healthy. Twenty-two summer students have begun their terms at the NRAO sites, and there is an influx of visiting scientists.

#### Expanded Very Large Array (EVLA)

Since June 30 a total of ten EVLA antennas have been used routinely for astronomical observations, and they account for approximately 30% of VLA antenna hours. The mechanical overhaul of an eleventh EVLA antenna is nearly complete. Three EVLA program-plan goals were achieved during the quarter: the inaugural meeting of the Science Advisory Group for the EVLA in Socorro on May 22–23, the lamination of 20 L-band (1–2 GHz) feed horns, and the installation of all 72 fiber-junction boxes on the array. The installation of the correlator power plant and an uninterruptible power supply marked the completion of the civil-construction WBS element. The wideband (2 GHz) signal path, including the gain-slope equalizer, was tested and shown to meet project specifications. Problems with the 4P IF converter and the C-band (4–8 GHz) and Q-band (40–50 GHz) receivers were resolved so that the production backlog of these system components could be reduced. A critical design review affirmed the production readiness of the EVLA correlator chip, and the production order for the chips was placed. A new connectivity scheme for the correlator will be formally reviewed on July 31. The old Modcomp control computers were shut down and replaced with the new EVLA monitor and control system on June 27. EVLA participated in writing a document that describes the joint development of software tools for proposal submission, observation preparation, scheduling, data archive, and data processing by EVLA, ALMA, and the E2E Operations Division. The EVLA and ALMA projects are making good progress towards joint definitions of binary data formats and science data models.

### New Initiatives

The third in a series of planning meetings was held on the tracking-station design for VSOP-2, scheduled for launch in 2012. The NRAO and the Gamma-ray Large Area Space Telescope (GLAST) project signed a Memorandum of Understanding for collaborative observing by NRAO telescopes in conjunction with GLAST. The NSF notified Cornell University of funding for the Square Kilometer Array Technology Development Program, and the NRAO carried out discussions with Cornell that resulted in an agreement about NRAO participation in that program. The Frequency Agile Solar Radiotelescope (FASR) project is continuing to make progress on project organization and instrument development, activity that is being funded through the FASR Design and Development Plan by NSF. It is expected that the proposal for construction will go in to the NSF in 2008.

### Green Bank Operations

The azimuth-track replacement is in full swing this summer. The first half of the replacement was completed June 29, and the telescope was rotated onto the new sections. Demolition of the remaining components began immediately. We expect to finish during the second or third week in August. This project has encountered obstacles, but a high level of teamwork by NRAO's project team, contractors, and suppliers overcame them quickly. While most of the direct work is performed by contractors, a large number of NRAO Green Bank employees provided support by refurbishing splice plates, setting up services for contractors, assisting with movement of materials, and modifying the telescope structure itself to fit the new track. Earlier fears that the foundation may have suffered damage proved to be unfounded. The foundation, with the exception of a couple of isolated areas, was revealed to be in very good shape when the base plates were removed. Weather has caused a number of delays, with snow, sleet, and cold temperatures on May 18th forcing a complete shutdown for the day. The month of June also had twice the average number of thunderstorms. Weather improved again in late June and July, and we are eagerly pressing on to the finish.

The bulk of the effort on improving the high-frequency performance of the GBT (the PTCS project) this quarter went to creating a new pointing model that will more accurately compensate for alidade tilts caused by local irregularities in the azimuth track. Work continues on implementing the model in the antenna manager and evaluating the results. Measurement of the new track via inclinometers will commence after the construction work is completed. Work on servo upgrades awaits software effort, and work on the new laser rangefinder awaits engineering effort. Mathematical simulations of traditional holography are nearing completion. The results demonstrate both the utility and limitations of the technique, and they will provide a useful guide for reducing the small-scale surface errors of the GBT.

The Advanced Digital Backend program (CICADA—Configurable Instrument Collaboration for Agile Data Acquisition) is an umbrella program to coordinate the efforts of several projects building DSP-based telescope backends for spectroscopy, pulsars, and transient studies. Work ramped up this quarter with development hardware being received, software development tools in place, and project work underway by students from a number of different institutions working under the guidance of NRAO senior staff. Several NRAO staff attended the Center for Astronomy Signal Processing and Electronics Research (CASPER) workshop at the University of California at Berkeley, and they came away with a better understanding of the tools available and future directions of the CASPER program. We are setting up a lab to build configurable instruments, focusing on building simple effective instruments and deploying them to scientists quickly, rather than trying to build complex instruments that require many years to deploy, debug, and integrate. Our initial instrument, a transient-event detector, has been simulated



## EXECUTIVE SUMMARY

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successfully. Our next instrument, the NRAO Next Generation Common User Pulsar Processor, is currently being developed.

The new dynamic-scheduling system for the GBT underwent a number of reviews over the quarter, including a two-day review from a critical external review committee. Overall the reviews were quite favorable, although a number of modifications to the plans are being implemented as a result of feedback received from the reviews.

### **Very Large Array (VLA)**

Ten EVLA antennas have now rejoined the operational VLA. The transition to an operational EVLA continued with the first scientific observations using the wider-band tuning capability of the EVLA receivers at 4–8 GHz and 18–26.5 GHz. A special call for exploratory proposals resulted in 20 proposal submissions for the wider-band 4–8 GHz tuning, with 8 proposals accepted. The first observations, most of which used the new tuning capabilities to observe either excited OH near 6 GHz or methanol at 6.7 GHz, took place in May 2007. Finally, the old VLA control computers were decommissioned on June 27; both the VLA and EVLA now are controlled by the far more modern EVLA monitor and control system. The VLA had relied on similar Modcomp control computers, with several generations of hardware upgrades, for approximately 1/3 of a century, from 1974 to 2007.

### **Very Long Baseline Array (VLBA)**

The program to increase the VLBA sensitivity at 22 GHz, done in collaboration with the Max-Planck-Institut für Radioastronomie, continued throughout the quarter. By the end of the quarter, four of the ten VLBA antennas had upgraded receivers with system temperatures cut by as much as 50%. At the completion of this program in late CY 2007 or early 2008, the entire VLBA will have its sensitivity improved by nearly a factor of two for all observations in the 22 GHz band. A standard VLBA “tiger team” maintenance visit to Fort Davis also took place during the quarter.

### **North American ALMA Science Center (NAASC)**

The NAASC received the final written report from the NSF review committee on the NAASC plan, and a written response was submitted by the NRAO/AUI to the NSF. The JAO response to the global ALMA operations review was also presented to the ALMA Board.

J. Hibbard and C. Carilli visited the Spitzer Science Center to discuss user support at major astronomical facilities with T. Soifer and L. Storrie-Lombardi. Carilli also visited the Chandra Science Center and spoke with R. Brissenden.

Two ANASAC telecons were held. Issues discussed included project news, an ASAC update and the ASAC charges, an update on the NAASC/AOP proposal reviews, and future workshops. NAASC monthly organizational meetings continued, with Canadian participation.

The NAASC workshop “Transformational Science with ALMA: Through Disks to Stars and Planets” (see <http://www.cv.nrao.edu/naasc/disks07/>) was held June 2007. There were about 80 participants. The meeting continued the successful series of scientific workshops begun in 2006 to promote and refine the scientific use of ALMA. C. Brogan organized this interesting meeting.

## EXECUTIVE SUMMARY

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NAASC members participated in the bi-weekly E2E working-group meetings to consider progress on user-support issues and user software. The NAASC is updating ALMA operations-related web pages at the NRAO, including an integrated ALMA-NA calendar. NAASC members participated in a June meeting in Charlottesville to discuss ALMA Commissioning and Science Verification (CSV) with the newly hired Operations Project Scientist (R. Hills) and deputy (A. Peck), along with members from the JAO (A. Beasley) and the EU project (L. Testi, R. Laing).

NAASC staff participated in software testing, preparing for the Beta release of the CASA software as well as testing the Pipeline, Obstool, CASAPY user interface, and the simulator. Members of the CASA team visited Charlottesville to participate in intensive software testing.

NAASC reports were made to the Users committee, the Visiting committee, and the AUI Board. Talks on ALMA science were given in Italy and at the Carnegie Institute in Pasadena, Center for Astrophysics in Cambridge, MA, Johns Hopkins University, and the Department of Terrestrial Magnetism.

In the coming quarter, NAASC members will train for operations by taking part in PSI activities at the ATF. Software testing by NAASC staff will continue, including further testing of the offline software prior to the beta release scheduled for September 2007. Talks on ALMA will be given at U.S. and Foreign institutions. Members of the Herschel Science center will visit the NAASC to discuss science-center issues and coordination for optimal scientific return. Advertisements for new science staff will be placed in the fall for the NAASC commissioning liaisons. These liaisons will serve as the main contact points between the construction CSV team and the NA ARC, and they will train all NAASC staff for work in Chile. F. Lovas will visit the NAASC to work on the Spectral Line Catalog with A. Remijan.

Note: ALMA-related EPO activities are discussed in the NRAO EPO report. An ALMA EPO officer will be hired in the coming 6 months.

The ARC manager will attend a Science Operations face-to-face meeting at ESO in September and participate in the “ALMA day” at ESO. NAASC staff will also participate in the Directors program review in September in Santiago.

A new memorandum of understanding with Canada for ALMA operations is being drafted at the Herzberg Institute of Astrophysics. This will be discussed and completed in the coming quarter.

The ANASAC will hold its face-to-face meeting August 17 in Charlottesville. Charges have been agreed to, with the main charge being the reconsideration of the user grants program. The ANASAC will also propose a third NAASC-sponsored science meeting for 2008.

### **Central Development Laboratory (CDL)**

Activities at the Central Development Laboratory this quarter included:

Device and Component Research, Development, and Production:

- A major milestone was reached on the way to advanced NbTiN/insulator/Nb tunnel junctions for frequencies above 700 GHz. The University of Virginia Microfabrication Laboratory has successfully fabricated SIS junctions with AlN tunnel barriers as required for NbTiN SIS junctions.

## EXECUTIVE SUMMARY

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- Design of the ALMA Band 2 (67–90 GHz) LNA MMIC using the NGST 35nm InP HEMT process has been completed. The predicted cryogenic noise temperature of a 67–95 GHz MMIC low-noise amplifier is about 20K.
- Design of the EVLA 12–18 GHz feed was completed. Analysis shows the feed has an average illumination taper of –12 dB at the edge of the subreflector and a return loss better than –25 dB in the 12–18 GHz band.

### Instrument Development:

- Work continues on the Precision Array to Probe the Epoch of Reionization (PAPER) to measure the predicted step in the cosmic background intensity from neutral hydrogen at the Epoch of Reionization. Deployment of a 32-element array in Western Australia will begin in July 2007.
- The proposal for a small K-band (18–26 GHz) focal-plane array (~7 pixels) receiver for the GBT was reviewed and funding tentatively was approved by the Director contingent on a more detailed implementation plan. This receiver is designed to be easily expandable to a larger array (about 50 elements maximum) and to serve as a template for focal-plane arrays for other bands (e.g.,  $\lambda = 3\text{mm}$ ). The project will be carried out jointly by engineers at the CDL and Green Bank.

## Chile

The first ALMA production antenna arrived in Chile, and the VERTEX Site Erection facility received its provisional acceptance. Chilean labor milestones passed in this quarter include the startup of supplemental medical benefits and signing the AUI/NRAO–NAOJ Agreement on Local Labor. Business/contracting milestones include provisional acceptance of the AOS Technical Building located at 5000m elevation and the start of the ALMA Camp enlargement to be completed next quarter. [For simplicity and completeness, this Quarterly Report includes some ALMA construction activities reported by the organizational units (e.g., Chile Operations, the Central Development Laboratory, and the NAASC) where they are carried out. However, the NRAO operations is reimbursed by ALMA construction via direct charges and via the Directly Associated Costs].

## End to End (E2E) Operations

In this quarter there were two major organizational advances. First, a cooperative software-development plan was established by EVLA and ALMA NA to focus and combine efforts. This involved agreeing to formally combine development teams for scheduling, combining the various groups working on pipeline heuristics to ensure that those methods are shared between telescopes, and working with ALMA EU to determine how all NRAO telescopes (including ALMA) can share a mechanism for submitting proposals and preparing observations. Although there are many details to be worked out, the principles of the agreement provide a refreshed framework for moving forward as One Observatory. Second, the question of how to revitalize algorithm development at the NRAO was examined in the context of how the needs presented by the EVLA and ALMA will be met. As a result, algorithm R&D workshops are being planned for the next three to five years, with the first to be held in November 2007.

Key technical accomplishments of End to End Operations were: a) the continued use and refinement of the VLA data-processing pipeline, yielding nearly 42,000 new VLA images at more than 8000 sky positions ready for publication to the NRAO archive and the Virtual Observatory (VO), b) completion of the first round of development for Common Astronomy Software Applications (CASA) on June 15<sup>th</sup> in preparation for a beta release in September, c) the first proposal deadline for which the Proposal

## EXECUTIVE SUMMARY

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Submission Tool (PST) was maintained by E2E (service provided by Open Sky Software of Austin, TX), d) substantial progress on the establishment of a single-dish archive for both spectral-line and continuum observations, which began in earnest for current GBT observations as well as for archival 12m and 140-ft data, e) soliciting new NRAO web designs, reviewing and vetting those as part of the NRAO Web Transformation Project, a joint effort of EPO and E2E, and f) establishing relationships with the Pittsburgh Supercomputer Center and NRAO representation at the Petascale Applications Symposium in June. No proposals for external funding were submitted this quarter.

### Computer and Information Services (CIS)

In response to some widely publicized national events where personal data were lost or stolen, a data-security policy was formally approved. There were no formal security incidents during this quarter. The Exchange server providing email services primarily to business staff and the administration was successfully upgraded. A new video hub was deployed and used to provide video for the 50<sup>th</sup> Anniversary celebrations, including live video of the ribbon cutting at Chajnantor.

### Education and Public Outreach (EPO)

Extensive high-definition video of the VertexRSI unit-1 production antenna documented the move of the first VertexRSI ALMA production antenna from the manufacturing facility in Kilgore, TX through the port of Houston to delivery to the OSF in Chile. A “teaser” video was produced by the NRAO and the Paladin Media Group and was incorporated into the ALMA exhibit at the summer AAS meeting in Hawaii. This video has been widely distributed, including upload to YouTube. Production planning began for a 15-minute ALMA film of broader scope for the general public and the media. The ALMA EPO Working Group completed the Policies & Guidelines document. The AUI-funded *Sister Cities* cultural and educational exchange visit from Magdalena, NM to San Pedro de Atacama, Chile began on June 30.

AUI joined the NRAO as an exhibitor at the summer AAS meeting. EPO staff talked with numerous scientists, students, and teachers and distributed updated ALMA and EVLA brochures, new GBT and VLBA updates, the full-color NRAO brochure, color posters, pins celebrating ALMA and the NRAO 50<sup>th</sup> anniversary, and memory sticks branded with the NRAO 50<sup>th</sup> anniversary logo.

Three web-design contractors submitted design options for the NRAO website that were reviewed and down-selected by EPO, E2E, and the Director’s Office. EPO and the E2E Division drafted a specification for an alpha demo site so that a contractor can further design, structure, and build a new NRAO web presence based on the selected designs. The science/observer and EPO web sites are the highest priorities.

EPO collaborated with Photoworks, Creative Design, and FourLeaf Public Relations to write a proposal for a Public Affairs campaign that should significantly increase the visibility of the NRAO mission, science, and technology to the scientific community, the media, and the general public.

Seven press releases were written and distributed. Four of these releases featured new science from NRAO telescopes (three VLA, one GBT), and the intermediate-mass black-hole research of Ulvestad (NRAO), Greene (Princeton), and Ho (Carnegie) was featured at the Hawaii AAS meeting. Non-science releases included the announcement of a major NRAO/GLAST agreement, the NRAO 50<sup>th</sup> anniversary symposium, and the 2007 Jansky Lectureship announcement.

## EXECUTIVE SUMMARY

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Working with West Virginia University faculty from several departments, EPO developed and submitted a proposal to the NSF-ITEST program for a *Pulsar Search Collaboratory* (PSC). If funded, teachers and students around West Virginia will assist a worldwide team of astronomers in discovering new pulsars. The project will introduce students to computational mathematics and distributed computing applications while engaging them in authentic scientific research. The long-term goal is to integrate PSC tools and data into the National Virtual Observatory, making it possible for a broad cross-section of students and teachers from across the nation, and especially under-represented groups, to learn about current astronomy practice, actively participate in scientific research, and work with established scientists.

## SCIENCE HIGHLIGHTS

## Very Large Array

***Brown Dwarfs Show Beamed, Coherent Radio Emission***—Using the VLA, researchers detected periodic bursts of extremely bright, 100% circularly polarized coherent radio emission from two brown-dwarf stars. These beams of emission sweep the Earth with the rotation of the dwarf to produce periodic pulsar-like bursts of radio emission. The researchers concluded that electron cyclotron maser emission may be generated over the poles of the objects' large-scale magnetic fields, producing the beams.

*Investigators:* G. Hallinan, A. Golden, S. Bourke, and C. Lane (National University of Ireland, Galway); T. Antonova and G. Doyle (Armagh Observatory); R. Zavala and F. Vrba (U.S. Naval Observatory); Walter Briskin (NRAO); and R. Boyle (Vatican Observatory).

## Very Long Baseline Array

***VLBA Teams With Optical Interferometer to Study Mira Variable***—Using both the VLBA and ESO's Very Large Telescope Interferometer (VLTI) at Paranal, researchers performed the first multi-epoch study using concurrent mid-infrared and radio interferometry of an oxygen-rich Mira star. The technique provided simultaneous information on three layers in the star's outer envelope—the molecular shell, the dust shell, and the maser shell. They found a strong connection between the star's pulsation and its dust production and expulsion.

*Investigators:* M. Wittkowski (ESO); D. Boboltz (USNO); K. Ohnaka and T. Driebe (MPIfR, Bonn); and M. Scholz (Heidelberg U. and U. of Sydney).

## Green Bank Telescope

***Mercury's Core Molten, Radar Study Shows***—Scientists using a high-precision planetary radar technique for the first time have discovered that the innermost planet Mercury probably has a molten core, resolving a mystery of more than three decades. The discovery, which used the NSF's Robert C. Byrd Green Bank Telescope in West Virginia and Arecibo Observatory in Puerto Rico, and NASA/Jet Propulsion Laboratory antennas in California, is an important step toward a better understanding of how planets form and evolve.

Whether the core is molten or solid today depends greatly on the chemical composition of the core. To answer the question, the scientists implemented an ingenious, high-precision technique in which they sent a powerful beam of radio waves to bounce off Mercury, then received and analyzed the reflected signal using pairs of ground-based radio telescopes. While similar radar systems have been used in the past to map planetary surfaces, this technique instead measured the rate at which Mercury spins on its axis, and did so with an unprecedented precision of one part in 100,000. By making 21 separate observations, the research team was able to measure minute variations in the planet's spin rate. This was the key to learning whether Mercury's core is solid or molten. Using an understanding of the Sun's gravitational effect on the planet, they realized that the tiny variations in its spin rate would be twice as large if the core is liquid than they would be if Mercury has a solid core. Their technique also made the best measurement ever of the alignment of the planet's axis of rotation. "We improved the accuracy of this measurement by 100

## SCIENCE

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### *1. Science Highlights*

times and showed that Mercury's spin axis is almost, but not exactly, perpendicular to the plane of its rotation around the Sun," Margot said.

Reference: J. L. Margot, S. J. Peale, R. F. Jurgens, M. A. Slade, I. V. Holin *Science* Vol 316, pp 710-714.

## SCIENCE

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

#### SCIENCE AND ACADEMIC AFFAIRS (SAA)

##### Meetings, Conferences and Workshops

Milestones	Original Date	Revised Date	Date Completed
1. Presented EVLA/ALMA science talk at UNLV			04/12/07
2. Attended 2007 NRAO Fellowship Meeting			04/25/07
3. Presented Staffing Plan at AUI Board Meeting			06/15/07
4. Attended Committee on Future of Radio Astronomy			06/16/07
5. Ran internal meeting on Integrated Science Centers			06/21/07

##### Promotion and Hiring of Outstanding Staff

Milestones	Original Date	Revised Date	Date Completed
1. EVLA Commissioning-Scientist Search Committee	01/22/07	07/15/07	
2. NM Assistant-Director Search Committee	02/06/07		06/22/07
3. SAA Administrative-Assistant Search			05/15/06

##### Other

Milestones	Original Date	Revised Date	Date Completed
1. OSC ranking of Scientific Initiatives Proposals			04/24/07
2. Update and re-format SAA Web pages			05/10/07
3. Submitted Long Term Research Staffing Plan to AUI			06/08/07

##### Library Program

The journal collections in Socorro and Charlottesville were rearranged from LC (Library of Congress) Call number to alphabetical order. The Library began a pilot project to collect telescope proposal codes from authors when they contact the NRAO for page-charge support. Over 200 papers have been coded with their proposal numbers, and the database now allows searching of papers by proposal codes.

##### Graduate Student, Co-op, and Visiting Scientist Programs

The following pre-doctoral students were supported by SAA during this quarter: Kathryn Devine (University of Wisconsin) worked on infrared dark clouds and high-mass star formation with Claire Chandler at the Array Operations Center. She was co-supervised by Prof. Ed Churchwell at the University of Wisconsin. Esteban Araya (New Mexico Tech) worked on formaldehyde maser emission in the Galaxy with Miller Goss at the Array Operations Center. She was co-supervised by Prof. Peter Hofner at New Mexico Tech. Chataili Parashare (University of Virginia) worked on instrumentation for low-frequency radio astronomy arrays with Richard Bradley at the NRAO Technology Center. Buckner



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

Creel (University of New Mexico) worked with Mark Claussen at the Array Operations Center on VLBA astrometry of protoplanetary nebulae. He was co-supervised by Prof. Ylva Pihlstrom at the University of New Mexico. Hirofumi Kawakubo (University of Michigan) worked with Tim Bastian and Richard Bradley in Charlottesville and Green Bank on the development of antenna stations for low-frequency interferometric arrays, specifically a prototype for FASR. He was co-supervised by Prof. Chris Ruf of the Department of Electrical Engineering and Computer Science at the University of Michigan.

Katharine Johnston (University of St. Andrews) worked as a graduate intern with Debra Shepherd in Socorro on disk-outflow interactions in massive protostars. Katie Chynoweth (Vanderbilt University) began work as a graduate intern with Glen Langston in Green Bank modeling interacting galaxies in the M81/M82 cluster using GBT and VLA data. Ryan Lynch (University of Virginia) began work as a graduate intern with Scott Ransom in Charlottesville on improving spectral resolution of the GBT pulsar spigot and on pulsar observations with the GBT. Paul Ries (University of Virginia) began work as a graduate intern with Richard Bradley in Charlottesville measuring power patterns of low-frequency antennas using satellite downlink signals.

Jesse Pomeroy, an electrical engineering major at South Dakota School of Mines and Technology, worked as a co-op student with Dan Merteley in Socorro investigating RFI at the VLA Site. Brandon Rumberg, a senior undergraduate majoring in computer and electrical engineering at West Virginia University, began a three-month engineering internship working with Randy McCullough in Green Bank on the Advanced Digital Backends project.

Drs. Duncan Lorimer and Maura McLaughlin (West Virginia University) began two-month visiting scientist appointments at Green Bank to work on a large-scale pulsar drift-scan survey made with the GBT and on a fast data-acquisition system for pulsar studies with the 140-ft telescope. Dr. Andrew Harris (University of Maryland) worked as a visiting scientist at Green Bank to collaborate with GBT engineering staff on improving the performance of the GBT Ka-band receiver with both the Zspectrometer and NRAO's own instruments for observations at high redshifts. Dr. Greg Taylor (University of New Mexico) began a one-month visit to Socorro to work on liaison for the LWA, on the VIPS survey and preparation for GLAST, and on tests of VLBI at the VLA with the EVLA on-line system.

Other visiting-scientist appointments were made to Dr. Patrick Palmer (University of Chicago) to work with Miller Goss in Socorro on parallaxes and proper motions of excited-state OH masers, and to Dr. Malcolm Gray (University of Manchester, U.K.) to spend a sabbatical year in Socorro starting in September 2007. Dr. Gray will work with NRAO staff on theory and computational models associated with astrophysical masers in various environments.

## TELESCOPE USAGE

The NRAO telescopes were scheduled for research and for maintenance during the second 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 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, since we do not always have programs of the right length in the right range of sidereal times to fill in the gaps in the schedule. This is particularly true during the 6–8 weeks each year when antennas are being moved, since the mixed VLA configurations are not useful for the majority of our astronomical observations. In addition, EVLA testing and commissioning now takes priority for virtually all dynamic time, even at short notice. The EVLA testing sometimes fills part of a dynamic scheduling slot in such a way that there is no corresponding astronomical observation available to fill the rest of the slot.

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

Telescope Usage (hours)			
Activity	VLA	VLBA	GBT
Scheduled Observing	1442.59	1093.0	1520.0
Scheduled Maintenance and Equipment Changes	206.50	205.6	611.0
Scheduled Tests and Calibrations	534.99	257.8	32.0
Downtime	165.37	36.8	93.0
Scheduling Voids	109.68	591.6	0
Actual Observing	1167.54	1056.2	1427.0

## PROJECTS

### *1. Expanded Very Large Array*

#### EXPANDED VERY LARGE ARRAY

##### EVLA Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Provide capability for moving-source observation	12/18/06	04/03/07	04/03/07
2. Periodic earned-value assessment updated	04/05/07		04/05/07
3. Correlator 48v DC plant installed	02/14/07	04/16/07	04/16/07
4. Hardware acceptance tests complete on antenna 21	04/10/07		04/18/07
5. Antenna 21 turnover to Operations	04/12/07		04/19/07
6. Assemble prototype S-band feed	03/16/07	04/23/07	04/23/07
7. Start EVLA conversion of antenna 11	04/24/07		04/24/07
8. M302/3 utility module evaluated on antenna	02/28/07	04/13/07	04/27/07
9. First meeting of the Science Advisory Group for the EVLA (SAGE)	05/22/07		05/22/07
10. New VLA Control Building UPS installed	05/23/07		05/23/07
11. EVLA review of Project Data Model from ALMA	02/16/07	05/07/07	05/30/07
12. Hardware acceptance tests complete on antenna 19	05/17/07		06/01/07
13. Assemble Ka-band RF tree	02/01/07	04/05/07	06/01/07
14. Antenna 19 turnover to Operations	05/21/07		06/04/07
15. Risk and contingency analysis documented	06/05/07		06/05/07
16. Correlator chip CDR	06/06/07		06/06/07
17. S-band feed-horn prototype ready for tests	06/06/07		06/06/07
18. Final report on investigation of phase instability	04/20/07		06/07/07
19. EVLA Science Data Model definition	06/11/07		06/11/07
20. Array fiber infrastructure completed	06/15/07		06/15/07
21. Decommission Modcomp computers	06/29/07		06/27/07
22. S-band feed-horn pattern measurements completed	06/28/07		06/28/07
23. Start EVLA conversion of antenna 25	06/20/07	07/05/07	
24. Begin production installation of M302/3 utility system	07/05/07		
25. Develop correlator installation plan	04/23/07	07/09/07	
26. Complete tests of 2–4 GHz signal path	06/25/07	07/09/07	
27. Assemble prototype Ka-band receiver	02/28/07	07/12/07	
28. Update project risk register	04/11/07	07/13/07	
29. WBS Updates	07/18/07		
30. C-band OMT—broadband test in receiver	08/31/06	07/19/07	
31. Hardware acceptance tests complete on antenna 11	07/24/07		

## PROJECTS

### *1. Expanded Very Large Array*

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
32. Antenna 11 Turnover to Operations	07/25/07		
33. Install wideband C-band receiver on antenna	11/02/06	07/27/07	
34. Complete production of design of C-band OMT	04/27/07	07/27/07	
35. Prototype Ka-band receiver ready for use	06/11/07	07/31/07	
36. WIDAR Connectivity review	07/31/07		
37. Updated High-Level Architecture	05/01/06	08/01/07	
38. EVLA Science Data Model (SDM) review to ALMA	08/10/07		
39. Science Support System software PDR	06/05/07	08/14/07	
40. Antenna reference transmitter and RTP racks completed	08/24/07		
41. 4/P-band receiver system restored	08/24/07		
42. Begin production of the C-band OMT	02/28/07	08/30/07	
43. Agreement on common ALMA+EVLA Science Data Model	09/04/07		
44. OPT outputs a VLA observe script	10/25/06	09/04/07	
45. Issue FY 2008 budget plan	09/05/07		
46. Project Advisory Committee Meeting	09/06/07		
47. Status of hardware solutions for phase instability	09/14/07		
48. Hardware acceptance tests complete on antenna 25	09/25/07		
49. Antenna 25 Turnover to Operations	09/26/07		
50. 12 antennas retrofitted to EVLA design	09/28/07		
51. Begin lockdown of new correlator room	05/14/07	10/01/07	

### **Project Management**

The EVLA project is on track to complete its primary goal of retrofitting a total of 12 antennas to the EVLA design by September 30, 2007. Ten antennas are now used in routine scientific observations and account for approximately 30% of VLA antenna hours, up from only 3% a year ago. The mechanical overhaul of an eleventh EVLA antenna is nearly complete.

The inaugural meeting of the Science Advisory Group for the EVLA (SAGE) was held in Socorro on May 22–23, 2007. The charges to SAGE include defining high-priority observing modes and first-science cases and advertising the scientific capabilities of the EVLA to the astronomical community. Although the committee has yet to submit its report, it did discuss how to involve members of the scientific community in EVLA commissioning and the need for advanced algorithm development for data post-processing. A plan has since been developed for the organization of algorithm development within the Observatory. The committee also suggested that it is too early to define initial observing modes and first science cases, and that these topics might be better addressed at the SAGE meeting next year.

## PROJECTS

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### *1. Expanded Very Large Array*

The meeting of the EVLA Advisory Committee is scheduled for September 6–7, 2007. An NSF review of the project will not occur at the same time, as had been planned at last year's Advisory Committee meeting, but will likely occur in a separate meeting to be held in Q2 2008.

The risk-management plan for the EVLA was completed, and the original assessment of project risk was documented in a risk register that will be updated in July along with the project's WBS cost data sheets and earned value. Project contingency will be reassessed at that time.

#### **Systems Integration**

Antennas 21 and 19 are now operational and included in scientific observations. The equipment racks and most electronic hardware were ready for installation on Antenna 11 in early July, when it will be moved from the Antenna Assembly Building (AAB) to the master pad. Antenna 25 will then be brought into the AAB for its mechanical overhaul.

Considerable systems-integration effort was devoted to reconfiguring the VLA into the A array during May and June. This was the first time that EVLA antennas were moved out to the ends of the array arms. The reconfiguration required the evaluation and testing of antenna operation over long fiber runs. The system seems to be performing well. The only unexpected outcome was the requirement for erbium-doped fiber amplifiers (EDFAs) on the IF fibers from antennas closer to the array center, which could have a minor cost impact for the purchase of a few more EDFAs than originally anticipated. Further testing of the reasons for this will occur while the array is in the A configuration.

Planning is well underway for the relocation of the deformatter racks and networking equipment from the old correlator room to the new correlator room.

#### **Antennas**

Mechanical outfitting of Antenna 19 was completed in April as planned, and mechanical outfitting of Antenna 11 will be complete in early July. Assembly of the feed-cone housing, platform extensions, and other structural modifications for the twelfth EVLA antenna was completed, and the assembly of the thirteenth feed-cone housing is underway.

The fiberglass lamination of L-band (1–2 GHz) feed horns 1 through 20 is complete, and the lamination of horn 21 is underway. The first S-band (2–4 GHz) feed horn was fabricated. A total of 26 sets of L-band rings and 3 sets of S-band rings have been cut in preparation for laminating the feed horns. Components are available to assemble a second S-band feed horn. The circular-to-rectangular transitions for the S-band feed horns are complete. The designs for the Ku-band (12–18 GHz) feed horn and its mounting tower were completed.

#### **Civil Construction**

The –48 VDC power plant for the correlator was delivered to the VLA site in early March, and site personnel completed its installation and startup in late April.

A 225 KVA uninterruptible power supply (UPS) for the EVLA operations area was installed in May and is now operational. The installation of the UPS and the correlator power plant effectively marks the completion of the civil construction element in the project's work breakdown structure (WBS).

## PROJECTS

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### *1. Expanded Very Large Array*

#### **Local Oscillator System**

Overall, the production of LO modules is keeping pace with the antenna retrofitting schedule.

Laboratory and on-antenna tests conducted over the past six months identified the source of the phase instabilities in some LO and IF modules. The problem is being addressed by adding thermal mass within the modules. The design of the round trip phase (RTP) module is being modified slightly to address some problems with module component noise.

#### **Fiber Optics**

Each EVLA 3-bit, 4Gsps sampler is a custom circuit board designed around a commercially available digitizer chip. Requests for quotation for the production order of the chip were received and evaluated. A recommendation of the successful vendor has been submitted to the NSF for approval.

Junction boxes for optical-fiber connections are needed at each antenna location so that EVLA antennas can be connected to the optical fiber data-transmission system. All 72 junction boxes on the array have been installed, allowing more flexibility in locating EVLA antennas in the array.

#### **Intermediate-Frequency System**

The first set of 4P IF converters that upconvert RF signals from the 327 MHz and 74 MHz receivers to a 1–8 GHz IF was completed and installed on EVLA antennas. The wideband (2 GHz) signal path was tested and shown to meet project specifications. The production of IF modules is keeping pace with the antenna retrofits.

#### **Front End**

Antenna 19 had its interim L-band (1–2 GHz), X-band (8–12 GHz), and K-band (18–26 GHz) front ends installed in May. Antenna 11 has been stripped of its old receiver systems and electronics, and new cable trays have been installed in it. The Utility Rack is ready to be mounted in antenna 11, and work is well along on providing interim L- and X-band receivers as well as an EVLA-compliant K-band system.

Upgraded Q-band (40–50 GHz) receivers were installed on antennas 26, 23, and 17. The receiver for antenna 21 is undergoing final laboratory tests. Once it is installed, 9 of the 10 EVLA antennas will be outfitted with Q-band receivers.

A new C-band receiver was installed on antenna 23 and the one for antenna 21 is forthcoming. We are thus nearly caught up at this band; only antenna 19 lacks a C-band receiver.

Most of the fabrication problems with the new EVLA card-cage system seem to be behind us. A large portion of the circuit boards (control/sensor, bias, motherboard, daughter card, etc.) for the mass production of the 240+ card cages have been ordered and are now in house.

Assembly of the prototype Ka-band (26–40 GHz) receiver is nearly complete. Cool-down tests and RF evaluation of the receiver will begin in July.

## PROJECTS

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### *1. Expanded Very Large Array*

The first two test articles of the production L-band (1–2 GHz) orthomode transducer (OMT) have been delivered. Tests to evaluate the production OMTs will start this summer.

The fin spacing and probe lengths for the C-band (4–8 GHz) OMT have been determined, and cryogenic testing of the first two prototype units has begun. The receiver temperature across the full bandwidth appears to be within specification, but there is a broad bump in the middle of the passband that has yet to be eliminated.

The new 2–4 GHz OMT for the EVLA S-band receiver is being developed in Green Bank. Following the completion of this work, Green Bank will investigate an 8–12 GHz planar OMT design for the planned EVLA X-band receiver.

### **Correlator**

Testing components in the EVLA correlator has been steady and largely successful. Final testing of the correlator chip was completed and reviewed in a production sign-off critical design review (CDR) in early June. More tests were run at the direction of the CDR committee, and the sign-off for chip production was given in late June.

Many complex functions and data paths on the baseline board are now tested and working, including input data synchronization and routing, phase generation, long-term accumulator functions, and transmission of data packet frames to the correlator backend computer.

The station board has also undergone considerable testing. All data paths on the station board have been tested. Modifications to the station board are underway for the next prototype build.

Software development and testing has kept pace with the hardware debugging and testing required for both boards. Real-time algorithms and code for delay tracking, phase model generation, and integration control signaling are under development. Considerable work is being done to determine an output data format that is suitable for the EVLA and compatible with ALMA.

A face-to-face meeting of NRAO and DRAO personnel was held in Penticton in April 2007 to discuss software-related issues and interim results from correlator chip testing.

A new connectivity scheme for the EVLA correlator was proposed in early April. It was informally reviewed in Socorro on April 24–25 and will be formally reviewed for final approval at a design review in Socorro on July 31. This new scheme aims to reduce risk for the Canadian partner, improve the correlator processing capability, and improve reliability by reducing the number of modules, the number of racks, and most importantly the number of high-speed interconnect cables by a factor of three. The changes to existing development are minimal, with the most extensive changes being to the baseline board, which are already complete.

A new schedule has been proposed to speed correlator delivery by combining some of the pre-production stages of the correlator project plan. This new schedule would likely negate the need for an independent “prototype correlator” and replace it with a more significant interim capability (12 antennas) that more seamlessly merges with the final software.

## PROJECTS

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### *1. Expanded Very Large Array*

#### **Monitor and Control**

The retirement of the Modcomp-based VLA control system with a rollover to the EVLA Monitor and Control (M&C) Transition System was the main focus of the M&C Group during the quarter. The EVLA M&C Transition System was used regularly for scientific observations in late June 2007, and the shutdown of the old control system occurred on June 27. The main sequence of control and data acquisition within the EVLA M&C system, from control script to VLA-format records in the archive, has been demonstrated to work in one subarray for virtually all of the standard observing modes. The tools and utilities needed to monitor the progress of an observation, ascertain the health of the array, and diagnose problems are mostly ready and are being deployed. Considerable effort has been invested to ensure that what is needed to make the shutdown of the old system possible and practical is in place.

Progress has been made in preparation for the prototype correlator. A binary data format for output of data from the correlator backend has been specified, and a prototype implementation of that specification is nearing completion. Substantial progress has also been made on the specification of a complete archive-record format called the Science Data Model (see below).

#### **Science Support Systems**

A document describing the joint development of software tools for proposal submission, observation preparation, scheduling, data archiving, and data processing by ALMA, EVLA, and the E2E Operations Division was written and presented to NRAO management. The primary objectives of the document are to provide common software tools for ALMA and EVLA users and to minimize long-term software development and maintenance costs. The document defines responsibilities for software development across the Observatory.

EVLA has made progress on coming to an agreement with ALMA on a common format for science archive data. The definition has two parts: the raw binary data itself (the “Binary Data Format”, or BDF), and the descriptive metadata (the “Science Data Model”, or SDM). A document was written describing how the ALMA and EVLA BDFs differ, and several meetings were held to discuss how they could be reconciled. Additionally, a meeting was held to discuss the ALMA SDM and how it might need to be modified to support the EVLA.

The Observation Scheduling Tool (OST) was demonstrated to the ALMA software group and was well received.

Work on the Observation Preparation Tool (OPT) continues. The tool to manage catalogs of sources, including calibrator catalogs, is now quite mature and has been tested outside the Array Operations Center by NRAO staff in Charlottesville. A catalog of GBT calibrators, in addition to the VLA and VLBA calibrator catalogs, is now available in this tool. A prototype of the graphical interface into the calibrator catalogs (the beginnings of a Calibrator Selection Tool) was developed. These calibrator catalogs are being developed for Observatory-wide benefits, and E2E Operations is monitoring the progress.



## **PROJECTS**

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### *2. New Initiatives*

#### **NEW INITIATIVES**

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

The U.S. work plan for the SKA Technology Development Program (TDP) was funded by the National Science Foundation for four years, at a level somewhat below that proposed. The NRAO is an unfunded collaborator in this work plan. An agreement was reached regarding the nature of NRAO work cooperating with the TDP team in areas such as improving the noise performance of wide-band receivers. A presentation of the status of the EVLA Construction Project, with emphasis on its demonstration of key SKA technology, was made to the U.S. SKA Consortium at their May meeting in Washington, DC. At that meeting, a second NRAO representative was elected to serve out the remainder of a term representing the U.S. on the International SKA Steering Committee until early 2008; that position had been vacated by a U.S. representative who moved to a new position outside the U.S.

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

The Frequency Agile Solar Radiotelescope (FASR) is a priority facility designed to address solar, heliospheric, and space-weather physics. The instrument is under development by a consortium involving the NRAO and a number of university partners including NJIT, Berkeley, the University of Michigan, the University of Maryland, and Caltech. The consortium is being organized under management by AUI. It is expected that a proposal for the construction and operation of FASR will be submitted to the NSF in early 2008. The NRAO will be the managing partner of the construction project. A standalone observatory under AUI will take responsibility for FASR operations. Recent developments include the definition of the FASR Reference Instrument and the development and submission to the NSF of the FASR Operations and Maintenance Plan.

Future development will focus on designing and prototyping key elements of the array, including ultra-wideband front ends and frequency-agile RF/IF conversion.

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

NRAO representatives attended the third in a series of VSOP-2 tracking-station planning meetings in Sagami-hara, Japan, in April 2007. A preliminary draft of a common VSOP-2 tracking-station design was produced as an output of that meeting.

##### **External Partnerships**

A partnership with the Max Planck Institut für Radioastronomie will increase the sensitivity of the 22 GHz receiving systems on the VLBA. By the end of the quarter, four VLA antennas had these new systems installed. A Memorandum of Understanding (MOU) regarding the 22 GHz implementation and operational cooperation is well advanced, with signing delayed slightly until the 3<sup>rd</sup> quarter.

The NRAO has negotiated a collaborative observing agreement with the Gamma-ray Large Area Space Telescope (GLAST) that enables a single proposal to the GLAST Guest Investigator Program to result in the U.S. individual investigators receiving both funding from GLAST and observing time from NRAO. The MOU covering this agreement was signed during the 2<sup>nd</sup> quarter. In addition, a procedure for evaluating these collaborative proposals was developed. Several NRAO representatives attended a two-

## PROJECTS

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### *2. New Initiatives*

day workshop at the Goddard Space Flight Center on “VLBI in the GLAST Era.” The scientific potential of GLAST is significantly enhanced by the collaborative observing agreement.

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

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
1. Attend VSOP-2 Tracking-Station Meeting	04/18/07		04/18/07
2. Final Signatures on GLAST Collaboration MOU	05/31/07		05/03/07
3. Attend U.S. SKA Consortium Meeting	05/11/07		05/11/07
4. Final Signatures on MPIfR Cooperation MOU	06/22/07	07/27/07	
5. Organize and attend U.S. SKA Implementation Meeting	09/15/07		
6. Attend International SKA Working & Steering Meetings	10/07/07		

## OPERATIONS

### *1. Green Bank Operations*

#### GREEN BANK OPERATIONS

Green Bank highlights include:

- (1) The first half of the GBT azimuth-track replacement was completed on June 29, and the track replacement should be finished during the second or third week of August.
- (2) A new pointing model was developed to exploit precise inclinometer measurements of the new track; it should significantly improve GBT pointing accuracy.
- (3) The NRAO Next Generation Common-User Pulsar Processor is being developed.
- (4) The GBT dynamic-scheduling system successfully passed a critical external review.

#### Green Bank Site Milestones

As FY 2007 began on October 1, 2006, we have modified the GBT's goals here to reflect the goals established in our 2007 Program Plan. Additionally, we have consolidated the goals to reflect the project, rather than the division in which work will be done. These goals will be tracked throughout FY 2007.

#### GBT Site Milestones for FY 2007

Milestones	Original Date	Revised Date	Date Completed
<b>Azimuth-Track Refurbishment</b>			
1. First 24 wear and base plates manufactured	01/31/07	03/01/07	03/13/07
2. Next 24 wear and base plates manufactured	03/30/07	04/02/07	04/02/07
3. All components on site	03/30/07	04/05/07	04/05/07
4. Refurbishment starts	04/30/07		04/30/07
5. Refurbishment complete	08/31/07		
6. Telescope performance restored	08/31/07	09/30/07	
<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	08/31/07	
3. Commissioning Complete	03/01/07	09/30/07	
<b>Dynamic Scheduling</b> <sup>Note 2</sup>			
1. Test Phase I Complete	04/31/07	03/01/08	
2. Proposal Review	06/01/07		06/06/07
3. Stage I tools complete, dynamic scheduling begins	02/01/08	10/01/08	
4. Stage II tools complete	02/01/09	10/01/09	
<b>FPGA development Project</b> <sup>Note 3</sup>			
1. First version of the iBob and ADC modules produced and documented	06/01/07		06/28/07
<b>Penn Array Receiver</b> <sup>Note 4</sup>			
1. Document commissioning results	12/31/06	03/31/07	03/31/07
2. Verify improved noise & cryogenic performance on the GBT	08/30/07		
3. Install on GBT for engineering & early science	12/15/07		
4. Document results from second engineering run	03/30/08		

## OPERATIONS

### 1. Green Bank Operations

Milestones	Original Date	Revised Date	Date Completed
<b>PTCS</b>			
1. Trajectory Generation and Servo Improvements complete	12/31/06	08/30/07 <sup>Note 5</sup>	
2. PLC interlock system main servo complete	08/31/07	08/31/07 <sup>Note 6</sup>	
3. PLC interlock system complete	08/31/07	08/31/08 <sup>Note 6</sup>	
4. Small-scale surface errors characterized	08/31/07		
5. Laser rangefinder V2 development complete	09/31/07	03/01/08	
6. Recommissioning of traditional holography receiver	04/01/08		
<b>Spectrometer LTA Upgrade</b> <sup>Note 7</sup>			
1. LTA upgrade complete	10/01/07	07/15/07	
<b>Zspectrometer</b> <sup>Note 8</sup>			
1. Science validation complete	06/01/08		

Notes:

1. The C-band completion date was moved to accommodate Penn Array work. The C-band work will be completed during the summer shutdown.
2. Dynamic scheduling was pushed back for work on the high-frequency receivers.
3. The FPGA Development Project (CICADA) is a University Collaboration with the University of Cincinnati and West Virginia University.
4. The Penn Array is a University Collaboration with the University of Pennsylvania. The Penn Array is now known as MUSTANG.
5. Only slow-speed tracking improvements have been done.
6. Because of 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.
7. The LTA card will be repaired, not upgraded. Completion time has been moved up accordingly.
8. Zspectrometer is a University Collaboration with Andy Harris at University of Maryland.

## OPERATIONS

### 2. NEW MEXICO OPERATIONS

#### NEW MEXICO OPERATIONS

New Mexico highlights include:

- (1) Ten EVLA antennas are now part of the operational VLA.
- (2) The first scientific observations were made using the wider tuning range of the EVLA 4–8 GHz and 18–26.5 GHz receivers.
- (3) The old VLA control computers were decommissioned; both the VLA and EVLA are now controlled by the modern EVLA monitor-and-control system.
- (4) Four of the ten VLBA antennas have new 22 GHz receivers that reduce system noise temperatures by up to 50%. The remaining receivers will be installed by early 2008.

#### VLA and VLBA Milestones

##### Management and Scientific Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Proposal Selection Committee with five outside members	04/04/07		04/04/07
2. Return EVLA antenna 21 to operational VLA	04/15/07	04/12/07	04/27/07
3. First shared-risk science with EVLA 5 GHz tuning	04/30/07		05/03/07
4. VLA-VLBA Proposal and Large Proposal Deadline	06/01/07		06/01/07
5. Return EVLA antenna 19 to operational VLA	06/15/07	05/21/07	06/08/07
6. First shared-risk science with EVLA 22 GHz tuning	04/30/07	09/10/07	06/24/07
7. Retire VLA Modcomp Computers	03/31/06	06/29/07	06/27/07
8. Return EVLA antenna 11 to operational EVLA	07/25/07		
9. Remove St. Croix from VLBA for rust repair	09/15/07	09/10/07	
10. Return EVLA antenna 25 to operational VLA	09/26/07		
11. New Assistant Director on board for VLA/VLBA	09/30/07		
12. VLA-VLBA Proposal Deadline	10/01/07		
13. Return St. Croix to VLBA after rust repair	12/15/07		
14. First shared-risk science with EVLA 1.2–2 GHz	12/31/07		
15. Complete 22 GHz low-noise retrofit of VLBA	02/28/08		

Notes:

6. First 22 GHz science with wider tuning capabilities was deferred because of a lack of proposals for this capability with the relatively small number of EVLA antennas available. The first scientific proposals for this capability were accepted for the second trimester of 2007.

7. Delayed into 2007 to enable personnel to work on EVLA Monitor and Control software development.

14. We anticipate the first science with wider-band tuning for 1.4 GHz will be proposed and accepted for the VLA B configuration in the last trimester of 2007.

##### Computer Infrastructure Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Bring up EVLA Antenna-11 Network	04/15/07		05/01/07

## OPERATIONS

### 2. NEW MEXICO OPERATIONS

2.	Demo platform-independent calendaring system	05/15/07		05/30/07
3.	Add 8TB to archive for NGAS migration			06/15/07
4.	Install new central Network Appliance file server	12/31/06	07/31/07	
5.	Bring up EVLA Antenna-25 Network	08/15/07		
6.	Establish network tunnel to DRAO	08/31/06	08/31/07	
7.	Establish network tunnel to ESO	09/30/06	08/31/07	
8.	Prepare for 64-bit Windows migration	12/31/07		
9.	Prepare for 64-bit Linux migration	12/31/07		

Notes:

4. Netapp shipped incorrect model, replacement model to arrive mid July.

6. Requires further cooperation from DRAO under way – Establish network tunnel to DRAO

7. Requires further cooperation from ESO

8 & 9. Required for eventual migration to 64-bit operating systems spring/summer of '08.

### Electronics Milestones

	Milestones	Original Date	Revised Date	Date Completed
1.	Install K-Band sensitivity upgrade at LA VLBA	04/03/07		03/16/07
2.	Scheduled Maintenance Visit at Ft. Davis VLBA	05/07/07		04/17/07
3.	Install repaired Q-Band at FD VLBA	04/18/07		04/18/07
4.	Install K-Band sensitivity upgrade at KP VLBA	08/03/07		04/20/07
5.	Install K-Band sensitivity upgrade at FD VLBA	06/03/07		05/18/07
6.	Scheduled Maintenance Visit at Brewster VLBA	07/31/07		
7.	Pick up refurbished Maser #13 from Symmetricom	09/20/07		
8.	Build a prototype software-correlator computer cluster	11/15/07		
9.	Complete K-Band sensitivity upgrade in the VLBA	12/14/07		
10.	Begin testing a Digital Back End for the VLBA	03/15/08		
11.	Scheduled Maintenance Visit at Owens Valley VLBA	05/15/08		
12.	Complete a VLA prototype ACU system	08/01/08		

### Engineering Services Milestones

	Milestones	Original Date	Revised Date	Date Completed
1.	Complete A array reconfiguration	06/12/07		05/24/07
2.	Hancock VLBA foundation and subreflector repair	07/30/07		
3.	Repair 3 intersections (AW6, AW5, BW9)	05/30/07	07/31/07	
4.	Complete BnA array reconfiguration	09/21/07		
5.	Complete B array reconfiguration	10/12/07		
6.	Replace 4,000 Ties	11/30/07		
7.	St. Croix Antenna Painting	12/15/07		

Notes:

3. Intersection repairs delayed two months by the array reconfiguration and crane equipment failure.

## OPERATIONS

### 3. NA ALMA Science Center

#### NA ALMA SCIENCE CENTER

NAASC highlights include:

- (1) The final report from the NSF review of the NAASC plan was received, and the NRAO/AUI written response was submitted to the NSF.
- (2) The NAASC held a workshop “Transformational Science with ALMA: Through Disks to Stars and Planets” in June.

#### NAASC Milestones March - June 2007

Milestones	Original Date	Revised Date	Date Completed
1. 2 <sup>nd</sup> NAASC workshop—Protoplanetary Disks	06/22/07		06/22/07
2. Science center visits—Herschel, SSC (Note: Herschel has been postponed until Fall 2007)	05/30/07		05/30/07
3. Transfer AOP document and budget to JAO/Smeback	04/02/07		04/02/07
4. Respond to NSF panel report	04/27/07		04/27/07

#### NAASC Milestones Beyond June 2007

Milestones	Original Date	Revised Date	Date Completed
1. ANASAC Face to Face meeting	08/17/07		
2. NAASC offline-software testing prior to beta release	08/27/07		
3. Science center visits—Herschel	Fall 07		
4. Two new hires for commissioning	12/30/07		
5. New MOU with Canada for ALMA operations	09/01/07		
6. New ALMA EPO hire	12/01/07		
7. New NAASC science workshop 2008—topic and SOC	09/01/07		
8. ARC manager meeting at ESO	09/02/07		
9. Director’s ALMA program review	09/12/07		
10. Software testing: CASA, Pipeline, Simulator, Obstool	Ongoing		
11. Talks on ALMA science and status at NA institutions	Ongoing		
12. Spectral-line catalogue—continue resolving species	Ongoing		

## OPERATIONS

### 4. Central Development Lab

#### CENTRAL DEVELOPMENT LAB

CDL highlights include:

- (1) SIS junctions critical for receivers operating above 700 GHz were successfully fabricated.
- (2) The ALMA Band 2 (67–90 GHz) low-noise amplifier was designed.
- (3) The EVLA 12–18 GHz feed was designed.

#### 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	ongoing	
2. Design/redesign of cryogenic amplifiers using Cryo-3 TRW devices for EVLA, VLBA, GBT, and ALMA in the frequency range from 1 to 120 GHz	04/01/04	ongoing	

Notes:

2. Demonstration amplifiers for ALMA band 1 (31.3–45 GHz) and band 2 (67–90 GHz) are being developed. Changes were made in the 2–4 GHz and 4–8 GHz amplifier-assembly and bonding schedules to lower noise. The 1–2 GHz amplifier body was redesigned, and a redesign of the 2–4 GHz amplifier body is in progress. Both were done to reduce some parasitic effects on the amplifier performance. Six Cosmic Background Imager Ka-band (26–40 GHz) amplifiers were repaired/rebuilt and retested.

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

#### Amplifier Production Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Build/upgrade/repair cryogenic amplifiers using Cryo-3 TRW devices for EVLA covering frequency range from 1 to 50 GHz	12/31/15		ongoing activity
2. Build/upgrade/repair cryogenic amplifiers using Cryo-3 TRW devices for VLBA, GBT covering frequency range from 1 to 95 GHz	ongoing		ongoing activity
3. New amplifier test system development	06/30/06	09/30/07	

Notes:

1 and 2. First-quarter production shipments totaled 36 new and upgraded amplifiers, including L (1–2 GHz), S (2–4 GHz), C (4–8 GHz), K (18–26 GHz), and Q (40–50 GHz) band units primarily for EVLA receivers. All requested EVLA production is either on or ahead of schedule.

3. The PC/LabView-based noise-measurement system is operational and making all routine LNA measurements and performance documentation. Further enhancements are awaiting software support.



## OPERATIONS

### 4. Central Development Lab

#### Electrochemistry Laboratory

The Chemistry Lab's gold-plating output was similar to first quarter's with an estimated commercial value of \$20,000. Development work is progressing on new electroforming techniques to be used for a over 250 EVLA waveguide components. Demonstration pieces have been completed which indicate that electroforming on aluminum mandrels with pressed-in copper structures will be possible. Production jobs have included electroforming of microwave components, internal waveguide plating, plating of amplifier and mixer bodies, and the usual assortment of mounting plates, brackets, and straps. Items have been supplied to all NRAO sites and projects, including ALMA.

#### 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	04/01/08	
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 MMIC VCO	07/31/07	09/31/07	
6. Design ALMA band 2 (67–90 GHz) LNA MMIC using NGST 35nm InP HEMT process	05/31/07		05/21/07
7. Test 67–95 GHz 35nm InP MMIC LNA	10/31/07		

#### Notes:

1. Extensive effort has been put into designing this MMIC. Some progress has been made, but the combination of specs on input impedance, noise temperature, and dynamic range are proving to be most challenging. A serious design will have to wait for the appropriate MMIC wafer run to come along.
2. New insights into the high-order behavior of ultra-wideband mixers have made this approach less desirable than originally thought for decade-bandwidth systems. We still intend to explore it for other applications, but its priority has been reduced.
3. Small-signal wafer probe test results with the revised MMPA75B are good. However, the saturated output power measured in package and later in chip form is low by at least 3dB. Similarly, low power is measured in a package for the Band 3 (92–108 GHz) amplifier from the same lot. We are currently investigating the possible causes. The 70 nm GaAs wafer run has been delayed due to unforeseen problems with the new process. The process has been revised, and a new discrete-transistor wafer started which has already been to shown to be free of the problem. A MMIC run is now scheduled to enter fabrication in October 2007.
4. We have received sample devices from Northrop Grumman Space Technology (NGST) and are preparing to take cold DC measurements.
6. Received model of 35nm InP HEMT for new NGST 35nm InP HEMT process. We were asked to contribute designs for the next run of this process. We looked at the model data and converted the s-parameters to a circuit model and converted the frequency-dependent noise parameters to a temperature-dependent (Pospieszalski) noise model. A 67–95 GHz MMIC LNA was designed in this process with

## OPERATIONS

### 4. Central Development Lab

predicted 150K room-temperature noise temperature and 20K cryogenic noise temperature. The fabrication run is beginning this quarter.

#### Electromagnetic Support Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Design EVLA 12–18 GHz feed	09/30/04	06/30/07	04/30/07
2. Develop dual-band 345/800 MHz feed for the GBT	09/30/05	09/30/07	
3. Measure EVLA 2–4 GHz feed	03/31/07	07/31/07	06/30/07
4. Prototype, fabricate, and measure a 75–110 GHz phase shifter at 17–25 GHz band	03/31/07	09/30/07	
5. Preliminary design of polarizers for EVLA X (8–12 GHz) and Ku (12–18 GHz) bands	12/31/07		

Notes:

1. The feed has an average illumination taper of –12 dB at the edge of the subreflector and return loss better than –25 dB in the 12–18 GHz band, which meets EVLA requirements.
2. The gain/system temperature of the dual band feed varied between 0.5 and 1 compared to the single band feed at 345 MHz and between 0.55 and 0.73 at 800 MHz. Further work is required to improve the performance of the dual band feed.
3. Measured patterns agree with theory and the illumination taper is –12.8 dB at the edge of the subreflector. Cross-polarized sidelobes are below –27 dB. The measured return loss is –19 dB at 2.0 GHz and better than –30 dB for frequencies above 2.2 GHz.

Other Projects:

Measured far-field patterns of two sets of the 79 GHz and 104 GHz ALMA holography feeds in the Green Bank indoor anechoic range. The feed illumination taper at the edge of the main reflector of the ALMA antenna varies between –7.5 dB and –8.0 dB. The maximum phase variation across the reflector is  $\pm 7.5^\circ$ .

S. Srikanth presented a paper titled “A New Broadband Short-Backfire Antenna as a Prime Focus Feed: Single and Dual Band” at the IEEE AP-S International Symposium 2007 at Honolulu, HI.

#### Superconducting Millimeter-Wave Receiver Development Milestones

Milestones	Original Date	Revised Date	Date Completed
<b>350-<math>\mu</math>m Receiver Technology Development</b>			
1. Demonstrate SIS junctions with AlN barrier	07/01/07		05/02/07
2. Demonstrate NbTiN/insulator/Nb tunnel junction	10/01/06	12/01/07	
<b>Balanced SIS Mixer Development</b>			
3. Complete first balanced SIS mixer with superconducting IF hybrid	01/01/07	09/01/07	
4. Complete first balanced sideband-separating mixer	10/01/07	03/01/08	
<b>Other Mixer Development</b>			
5. 385–500 GHz SIS mixer Development	09/30/05	12/31/07	

## OPERATIONS

### 4. Central Development Lab

Notes:

1. Junctions with AlN barriers were successfully made with high critical current densities desirable for high-frequency broadband use. The IV characteristic of a two-junction array is shown in Figure 1.
- 1, 2. These projects are being done in collaboration with the UVa Microfabrication Laboratory.
3. In conjunction with Arizona Radio Observatory.
5. This project is on hold awaiting funds and engineering resources.



Figure 1.  $I(V)$  characteristic of a Nb/Al-AlN/Nb SIS junction with  $J_C = 30,000 \text{ A/cm}^2$

### 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:

1. The low-frequency antenna work has been delayed until fall 2007.

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

Milestones	Original Date	Revised Date	Date Completed
1. Major upgrade to instrumentation subsystems	07/15/07		05/30/07
2. 16-element prototype array, operating in the 100–200 MHz band in Green Bank	12/31/06	10/30/07	
3. A 4-element pathfinder array in Western Australia	07/15/07		
4. 32-element array in Western Australia	12/15/06	12/31/07	

## OPERATIONS

---

### *4. Central Development Lab*

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

<b>Milestones</b>	<b>Original Date</b>	<b>Revised Date</b>	<b>Date Completed</b>
1. Reference Instrument including engineering design document	06/16/06	04/15/07	04/15/07

## OPERATIONS

### 5. Chile Operations

#### CHILE OPERATIONS

Chile Operations highlights include:

- First ALMA antenna arrived in Chile.
- VERTEX Site Erection Facility building provisional acceptance.
- AOS TB (Array Operations Site Technical Building) provisional acceptance.

#### Local Labor Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Supplementary medical benefits startup.			05/20/07
2. Selection of ALMA Facilities Manager <sup>1</sup>			06/29/07
3. Hiring of new NRAO Chile expatriates consultant <sup>2</sup>			06/01/07
4. AUI/NRAO–NAOJ Agreement on Local Labor signed.			06/01/07

Notes:

1. ALMA Facilities Manager: Max Dollman.
2. NRAO Chile Office ExPat assistant (consultant): Liliana Stefano.

#### Business/Contracting Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Provisional acceptance and internal dedication of AOS TB <sup>1</sup> .	03/27/07	05/24/07	06/14/07
2. AOS Transporter Hangar call for bids.	11/30/06	02/08/07	05/18/07
3. ALMA Camp Enlargement starts	03/13/07	06/01/07	Next quarter
4. Univ. of Chile (Cerro Calán) rental contract for AIV	04/30/07		06/01/07
5. VERTEX Site Erection Facility building provisional acceptance.	05/10/07		06/04/07

Notes:

1. In coordination with NRAO's 50<sup>th</sup> anniversary videoconference.

#### Chile Antenna Milestones

Milestones	Original Date	Revised Date	Date Completed
1. First ALMA production antenna arrives in Chile <sup>1</sup> .			04/19/07

Notes:

1. VERTEX antenna.

## OPERATIONS

### 5. Chile Operations

#### Chile EPO Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Hiring of NRAO Chile EPO officer <sup>1</sup>			05/01/07
2. Preparation of Public seminar “Astronomy in Chile” sponsored and hosted by Foreign Ministry <sup>2</sup>			05/29/07
3. Documenting ALMA starts <sup>3</sup>			04/17/07

Notes:

1. NRAO Chile Office EPO: Sergio Cabezón.
2. Together with AURA, Carnegie, ESO. Seminar to be held 19 and 20 November
3. Arrival of first antenna filmed.

#### Other Milestones (Site protection, coordination)

Milestones	Original Date	Revised Date	Date Completed
1. Environmental reporting to CONAMA <sup>1</sup>	Monthly		Monthly
2. Mining-rights renewal for ALMA road area.	06/28/07		06/28/07
3. Opposition against groundwater exploration on ALMA concession <sup>2</sup> .	03/15/07		06/25/07
4. Opposition against groundwater exploration on ALMA concession <sup>3</sup> .	10/20/06		05/03/07
5. Opposition to mobile radars submitted to SUBTEL <sup>4</sup>	06/26/07		06/26/07
6. Chajnantor Working Group Meeting at OSF <sup>5</sup>	04/26/07		04/26/07
7. Start coordination group with Foreign Ministry <sup>6</sup>			05/03/07

Notes:

1. Monthly and bi-yearly reports are sent to CONAMA.
2. Requirement submitted by mining company SQM Salar to DGA (national Water office) on 01/25/07 and solved in June favorably to ALMA.
3. Requirement submitted by an individual to DGA on 10/20/06 and solved in May favorably to ALMA.
4. Opposition to proposed commercial use of mobile radars (Jama Road) in 76-77 GHz band. SUBTEL is the Chilean telecommunications regulatory agency. Resolution pending.
5. Yearly meeting of coordination WG comprising ALMA, CONICYT, and projects co-existing on the Chajnantor plateau.
6. Coordination group will look into various issues including importations for ALMA.

## OPERATIONS

### 6. END TO END Operations

#### END TO END (E2E) OPERATIONS

E2E operations highlights include:

- (1) A cooperative software-development plan was established to combine EVLA and ALMA efforts.
- (2) The refined VLA data-processing pipeline produced nearly 42,000 new images for publication to the NRAO archive and to the Virtual Observatory.
- (3) The Proposal Submission Tool was used successfully during the first proposal deadline under E2E supervision.

#### Management & Administration Activities

Milestones	Original Date	Revised Date	Date Completed
1. <b>External funding:</b> Prepare proposal for computational-science REUs	04/30/07	07/30/07	
2. Begin regular biweekly E2E email communications	04/30/07		04/30/07
3. Begin regular biweekly E2E in-person meetings	04/02/07		04/02/07
4. Complete CASA beta plan	04/17/07		04/17/07
5. Preparation of demos for Users Committee	05/17/07		05/14/07
6. New front page for <a href="http://e2e.nrao.edu">http://e2e.nrao.edu</a> published	06/30/07		06/30/07
7. Participate in Green Bank Dynamic Scheduling System (DSS) conceptual review	06/07/07		06/07/07
8. Determine feasibility of partnership for NSF PAARE diversity program for research in computational physics/astronomy with minority-serving institutions	07/15/07		
9. Create NRAO alpha web-site specifications with EPO; hold kickoff meeting with NRAO webmasters and outside design contractors	08/03/07		
10. <b>External funding:</b> If feasible, work with NCAT/NCSSM to prepare computational-science diversity program proposal for NRAO	08/03/07		
11. <b>External funding:</b> Prepare proposal for Community-Based Data Interoperability Networks	08/23/07		
12. <b>External funding:</b> Prepare proposal for Cyber infrastructure Training	08/27/07		
13. Participate in EVLA Advisory Committee meeting	09/06/07		
14. Complete first E2E Strategic Planning session	09/15/07		
15. Release <a href="http://my.nrao.edu">http://my.nrao.edu</a> dashboard for astronomers; begin receiving NRAO proposals using new interface	09/15/07		
16. <b>External funding:</b> Prepare proposal for CreativeIT program to encourage channeled creativity in software development and design at NRAO	09/21/07		
17. Complete specifications for Strategic Decision Support System (a management dashboard to dynamically examine, for example, the details of NRAO's user community submitting proposals)	09/30/07		

## OPERATIONS

### 6. END TO END Operations

Milestones	Original Date	Revised Date	Date Completed
18. First draft of E2E Strategic Plan complete	09/30/07		

Notes:

1. NSF proposal deadline shifted from June 6 to September 13.
- 10, 12. Requires university partners and leadership.

### Algorithm Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Plan for a strategic organizational initiative to revitalize algorithm development at NRAO complete (with E. Fomalont, M. McKinnon/EVLA)	06/07/07		06/07/07
2. Relationship established with the Pittsburgh Supercomputer Center to help NRAO with its algorithm development efforts	06/30/07		06/30/07
3. <b>External funding:</b> Submit proposal to NSF OCI for petascale applications, in conjunction with the University of Virginia and supported by the Pittsburgh Supercomputing Center	07/23/07		
4. Create project charter for algorithm development; establish and promote core values to distinguish algorithm R&D from software implementation	09/30/07		
5. Hold first NRAO Algorithm R&D Symposium	11/30/07		

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

Milestones	Original Date	Revised Date	Date Completed
1. Draft chapters for NVO Book	12/01/06		04/04/07
2. Concept and scope for SIA (Simple Image Access) V2			05/18/07
3. IVOA interoperability meeting (China)	05/14/07		05/14/07
4. Promote Simple Spectral Access (SSA) to PR	12/15/06		06/04/07
5. Edited chapters for NVO Book			07/02/07
6. Summer 2007 NVO team meeting (Tody/Radziwill)	07/31/07		
7. Revised SIA specification for PR	08/15/07		
8. SSA V1.1 working draft including Grid functionality	09/15/07		
9. Initial working draft and prototyping for SIA V2	09/15/07		
10. Initial working draft table access protocol (TAP)	05/01/07	09/15/07	
11. Concept and data model for handling time-series data	05/01/07	09/25/07	
12. IVOA interoperability workshop (Cambridge UK)	09/27/07		
13. Concept for handling SEDs and spectral aggregates	05/01/07	deferred	



## OPERATIONS

### 6. END TO END Operations

Milestones	Original Date	Revised Date	Date Completed
14. High-level plan for NRAO data center in place	06/31/07	10/30/07	
15. Draft Applications Messaging specification	10/25/07		
16. Draft Parameter Mechanism specification	10/25/07		

Note:

- This milestone was not listed in the January – March 2007 Quarterly Report.

### NRAO Archive Infrastructure & Interfaces

Milestones	Original Date	Revised Date	Date Completed
1. Complete VO-Google Beta	04/15/07	05/15/07	05/31/07
2. Devise archive-index schema and replication scheme; resolve data integrity issues in current NRAO archive	04/30/07	02/15/08	
3. Determine release date for Archive v2.0	03/15/07	05/15/07	05/15/07
4. Complete transfer of historical VLBA tape archive	12/31/06	12/31/07	
5. Complete transfer of 3 TB historical GBT science data to production single dish archive node	12/31/06	12/31/07	
6. Complete transfer of Tucson 12m data to disk	12/31/07		
7. Complete transfer of GB 140ft data to disk	12/31/07		04/30/07
8. Set up rsync between GB and CV to archive GBT data to transfer data daily to archive disks.	03/31/07	07/31/07	07/06/07
9. Generate index files for current (07A) GBT data before summer shutdown.	08/31/07		06/31/07
10. Develop database schema for the archive index files	06/31/07	08/01/07	
11. Develop search parameters for advanced searches of single-dish spectral-line data.	06/31/07		06/08/07
12. Generate automated script to load the index-file data into the archive index database	06/31/07		06/01/07
13. Develop pipeline to generate calibrated SDFITS data.	12/31/07		
14. Develop pipeline to generate preliminary calibrated, averaged dataset	12/31/07		
15. Edit the Spectral Line Search Engine (SLiSE) to query the single-dish spectra database	12/31/07		
16. Include 12m and 140ft data in the production single-dish archive node (requires capability to reduce data)	12/31/08		

8. The original rsync pulled all new data written to tape in GB; completed by 01/31/07. The revised date was to synchronize the data in GB updated every 24 hours to CV. This was completed on 07/06/07.

9. As of 06/31/07, GBT data since March 2006 were converted to SDFITS with metadata extracted. This includes all data from trimesters 07A and 06C. Work is nearly complete on trimesters 06B and 06A.

16. As of 07/13/07, all data from the 140ft telescope have been stored on dedicated single-dish archive machines and ~50% of the data from the 12m telescope have been stored on single-dish archive machines. These data have not yet been indexed for searching.

## OPERATIONS

### 6. END TO END Operations

#### NRAO Proposal Infrastructure & Interfaces

Milestones	Original Date	Revised Date	Date Completed
1. Successful maintenance of PST in first E2E-managed proposal deadline period	06/01/07		06/01/07
2. Work with ALMA EU (ObsPrep subsystem) so NRAO PST development over next 12–18 months is scoped properly to ensure commonality with ALMA	06/08/07		06/08/07
3. Complete PST performance improvements; ready for internal integration testing	05/20/07	08/01/07	
4. Conduct user acceptance testing for upgraded PST	08/15/07		
5. Conduct user acceptance testing for new Proposal Handling System	09/15/07		
6. Release PST upgrade; begin receiving new proposals using upgraded interface	09/15/07		
7. Successful management of October 2007 NRAO proposal deadline with upgraded software	10/01/07		

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

Milestones	Original Date	Revised Date	Date Completed
1. CASA Beta Release Plan Completed	04/09/07		04/17/07
2. CASA Alpha Release Patch 1	06/15/07		07/05/07
3. CASA ALMA ARC Tutorials (ESO Garching)	07/09/07		
4. CASA Alpha Release Patch 2	08/15/07		
5. CASA Beta Release Scheduled	09/30/07		

#### NRAO Pipeline Infrastructure & Interfaces

Milestones	Original Date	Revised Date	Date Completed
1. First half of VLA archive processed via pipeline	06/30/07		06/30/07
2. Second half of VLA archive processed via pipeline	06/30/08	06/30/09	
3. Develop plan for common VLA/Chandra sources	12/31/06	08/15/07	
4. Explore possibility of common NRAO/HST sources	12/31/06	08/15/07	
5. Explore possibility of common NRAO/Spitzer sources	12/31/06	08/15/07	
6. Process in place to pipeline and archive simple VLA/VLBA data within two weeks	01/31/07		04/30/07
7. Bind AIPS pipeline to live VLA observations	05/31/07	deferred	
8. Feedback from researchers regarding utility of pipelined products available and disseminated	06/30/07		

## OPERATIONS

### 7. Computer and Information Services

#### COMPUTER AND INFORMATION SERVICES (CIS)

##### Observatory-wide Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Moratorium on deployment of Vista adopted (b)	04/10/07		04/10/07
2. Formal approval of data security policy (a)	02/28/07	04/30/07	04/27/07
3. Upgrade of networking in Green Bank Science Center (d)	04/30/07		04/30/07
4. New 16-port video hub operational (d)	06/14/07		06/12/07
5. Appointment of webmasters (c)	07/31/07		
6. Annual system administrator conference in Green Bank (b)	08/23/07		
7. Upgrade link between UVa and NRAO-CV to 1 Gbps (d)	01/31/07	09/30/07	
8. New VPN concentrator available (d)	09/30/07		

Notes:

7. This will be installed by the University of Virginia as soon as the requisite components are available.

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

##### Charlottesville Computing Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Upgrade Exchange Server	03/31/07	04/15/07	04/22/07
2. Most IT staff relocated back into their offices	05/31/07		05/31/07
3. Order for new computer-room power conditioning	09/30/07		

## OPERATIONS

### 8. Education and Public Outreach

#### EDUCATION AND PUBLIC OUTREACH

EPO highlights include:

- Completion of the high-definition video teaser documenting the VertexRSI unit-1 antenna delivery from Kilgore, Texas to the ALMA OSF in Chile.
- Completion and review of NRAO web-design options.
- Completion of a Public Affairs Campaign proposal.
- Submission of the *Pulsar Search Collaboratory* proposal to the NSF ITEST program.

#### Publications / Documentation Milestones

Milestones	Original Date	Revised Date	Date Completed
1. Submit EPO Guidelines & Policies to ALMA Board	03/15/07	06/15/07	06/15/07
2. Two new posters complete	04/13/07	12/22/07	
3. Select contractor for ALMA unit-1 video in Chile	04/20/07		04/20/07
4. Complete post-production on ALMA unit-1 video teaser	05/23/07		05/23/07
5. Publish July 2007 NRAO Newsletter	07/11/07		
6. 3 <sup>rd</sup> annual AUI/NRAO Image Contest deadline	09/07/07		

Notes:

1. The first draft prepared by the ESO Public Affairs Dept. was not available to the ALMA EPO Working Group until March 8, so the submission to the ALMA Board was delayed until June 2007.
2. Owing to budget and higher priorities, new posters will not be printed until the completion of the 2007 AUI/NRAO Image Contest.
3. FilmoSonido (Santiago, Chile) was selected for this work.
4. Post-production by EPO and the Paladin Media Group (Charlottesville, VA).
5. The July 2007 Newsletter was published 10 days later than normal so that it could include some coverage of the mid-June NRAO 50<sup>th</sup> anniversary science symposium.

#### Online Outreach Milestones

Milestones	Original Date	Revised Date	Date Completed
1. WWW design RFQ / SoW distributed	04/03/07		04/03/07
2. WWW Project Plan complete	05/09/07		05/09/07
3. Initial design options due from 3 contractors	05/14/07	06/11/07	06/11/07
4. Review & down-select to best design options	05/25/07	06/12/07	06/12/07
5. Define alpha demo site characteristics for contractor(s)	07/20/07		
6. Contractors complete alpha demo site	09/21/07		

Notes:

2. This WWW Project Plan is a collaboration of the EPO and E2E Divisions.
3. Two contractors met the planned 14 May delivery date; one contractor did not deliver until 11 June.
5. The alpha demo site will include site structure and content for a new science/observer site, a new EPO site, and a new internal/Intranet site.

## OPERATIONS

### 8. Education and Public Outreach

#### Scientific-Community Outreach Milestones

Milestones	Original Date	Revised Date	Date Completed
1. NRAO Town Hall at winter AAS meeting	01/08/07		01/08/07
2. Complete brochure revisions for summer AAS meeting	04/27/07		04/25/07
3. ASAC reviews ALMA EPO Development Plan	05/09/07		05/09/07
4. Submit NRAO Town Hall proposal for Jan 08 AAS	05/15/07		05/14/07
5. AAS meeting / exhibition	05/27–31/07		05/27–31/07
6. NRAO 50 <sup>th</sup> Anniversary Science Symposium (CV)	06/17–21/07		06/17–21/07
7. 2 <sup>nd</sup> NAASC Workshop (CV)	06/22–24/07		06/22–24/07
8. NRAO-NAIC Single Dish Summer School (GB)	07/08–15/07		

Notes:

- ALMA and EVLA brochures, GBT and VLBA updates.
- As part of the May 2007 meeting in Tokyo, Japan, the ALMA Science Advisory Committee (ASAC) was charged by the ALMA Board to review the ALMA EPO Development Plan.
- The AAS has approved the proposed NRAO Town Hall for the January 2008 meeting in Austin.
- A well-attended press conference was organized on Monday, 18 June 2007, in conjunction with the NRAO 50<sup>th</sup> anniversary science symposium.
- EPO provided an NRAO exhibit and materials for distribution to meeting attendees, including copies of the ALMA video teaser and the ALMA brochure.

#### Education Programs

Milestones	Event Date
1. Chautauqua 2007 (GB)	06/03–08/07
2. Educational Research in Radio Astronomy (GB)	06/10–16/07
3. National Youth Science Camp staff training (GB)	06/17–21/07
4. Sister Cities program: San Pedro de Atacama (Chile)	06/30–07/14/07
5. Society of Amateur Radio Astronomers (GB)	07/01–03/07
6. Green Bank StarQuest IV (GB)	07/04–07/07
7. Chautauqua 2007 (SOC)	07/11–13/07
8. NASA/NRAO Joint Institute (GB)	07/15–20/07
9. Globe Workshop (GB)	07/22–27/07
10. 3 <sup>rd</sup> Annual Governor's School for Math & Science (GB)	07/29–08/11/07
11. Catch the Wave Camp: GEAR UP (GB)	08/12–14/07

Notes:

- A Sister Cities blog can be viewed on-line at <http://sanpedromagdalena.blogspot.com/>.
- More than 160 participants enjoyed excellent weather at this year's StarQuest.

## OPERATIONS

### 8. Education and Public Outreach

#### EPO Community & Development Milestones

Milestones	Original Date	Revised Date	Date Completed
1. EPO WWW Content Specialist selection complete	12/15/06	09/15/07	
2. ALMA EPO Working Group meeting (Tokyo, Japan)	05/06/07		05/06/07
3. Submit Pulsar Search Collaboratory proposal to NSF	05/10/07		05/10/07
4. NRAO Users Committee (CV)	05/17–18/07		05/17–18/07
5. NSF EPO Inventory visit (SOC)	07/26–27/07		
6. NM Education Officer selection complete	07/27/07		
7. Submit Annual Progress Report, Program Plan, Long Range Plan	08/01/07		
8. NSF EPO Inventory visit (GB)	08/07		
9. ASP EPO meeting (Chicago)	09/05–07/07		
10. ALMA EPO Program Officer selection complete	09/28/07		
11. Communicating Astronomy with the Public (Athens)	10/07–11/07		
12. Community Open House (GB)	10/21–22/07		
13. ALMA EPO WG face-to-face meeting (Chile)	11/07		

Notes:

1. A disappointing candidate pool required a revised advertising campaign and delayed this hire. This is a new position (CV2348).
2. This face-to-face meeting was held immediately prior to the ASAC meeting in Tokyo.
6. This position is a re-hire (SO3228).
8. An exact date has not yet been determined for the NSF EPO Inventory visit to GB.
10. This is a new position (CV3172).
11. Sponsored by IAU Commission 55, this CAP 2007 meeting will define the International Year of Astronomy–2009 program. The NRAO is also participating in an outdoor image exhibition in Athens that is being organized in conjunction with this international conference.
12. The Open House on 21 October is for the public; the Open House on 22 October is for schools.
13. An exact date has not yet been set for the next ALMA EPO WG face-to-face meeting.

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

Milestones	Event Date
1. Easton Area High School (GB Sci Ctr)	03/31–04/01/07
2. Beaver County Christian School (GB Sci Ctr)	04/04/07
3. Guided Public Tours (VLA Vis Ctr)	04/07/07
4. Bosque School (VLA Vis Ctr)	04/09/07
5. Grosse Point North High School (GB Sci Ctr)	04/10–12/07
6. Bosque School (VLA Vis Ctr)	04/11/07
7. Bosque School (VLA Vis Ctr)	04/12/07
8. Glenville State College (GB Sci Ctr)	04/12–14/07
9. Truth or Consequences Middle School (VLA Vis Ctr)	04/13/07

## OPERATIONS

### *8. Education and Public Outreach*

<b>Milestones</b>	<b>Event Date</b>
10. Truth or Consequences & Sierra Elementary schools (VLA Vis Ctr)	04/14/07
11. Rio Rancho High School Astronomy Club (VLA Vis Ctr)	04/14/07
12. Texas Tech University (VLA Vis Ctr)	04/14/07
13. Zuni High School (VLA Vis Ctr)	04/19/07
14. Trinity Christian School (GB Sci Ctr)	04/19/07
15. James Madison University (GB Sci Ctr)	04/20–22/07
16. Santa Fe Elderhostel (VLA Vis Ctr)	04/20/07
17. El Paso Service Club (VLA Vis Ctr)	04/21/07
18. Weirton St Paul (5 <sup>th</sup> grade) (GB Sci Ctr)	04/22/07
19. Newburgh Free Academy (GB Sci Ctr)	04/25–27/07
20. Cub Scout Pack 440 (GB Sci Ctr)	04/28/07
21. American Astronomical Society (GB Sci Ctr)	04/28/07
22. Fox Chapel (GB Sci Ctr)	04/29/07
23. Bosque School (VLA Vis Ctr)	05/01/07
24. Bosque School (VLA Vis Ctr)	05/03/07
25. Rio Rancho Middle School Gifted Program (VLA Vis Ctr)	05/03/07
26. Madison Middle School (GB Sci Ctr)	05/04–05/07
27. Cross Lanes Christian School (GB Sci Ctr)	05/10/07
28. Cottonwood School (VLA Vis Ctr)	05/11/07
29. Black Diamond Girl Scout Troop 2262 & 2032 (GB Sci Ctr)	05/12/07
30. Boy Scout Troop 14 (GB Sci Ctr)	05/18/07
31. Reinhardt College (GB Sci Ctr)	05/13–19/07
32. Fort Gay Middle School (GB Sci Ctr)	05/23–24/07
33. Tygart Valley High School (GB Sci Ctr)	05/24/07
34. Boy Scout Troop 78 (GB Sci Ctr)	05/25–27/07
35. AUI Board (GB Sci Ctr)	06/16/07
36. NRAO 50 <sup>th</sup> Anniversary Conference Site Tour (GB Sci Ctr)	06/22/07
37. NM Girl Scouts (VLA Vis Ctr)	06/24/07
38. Earthwatch (VLA Vis Ctr)	06/26/07
39. Summer science students (VLA Vis Ctr)	06/27/07
40. National Science Camp (GB Sci Ctr)	06/29/07
41. Isleta Public Library (VLA Vis Ctr)	07/19/07
42. VA Governor's School for Math, Sci, & Technology (GB Sci Ctr)	07/21/07
43. Mountain Vista Governor's School (GB Sci Ctr)	08/16/07
44. Madison Middle School (GB Sci Ctr)	09/25/07
45. Villanova Astronomical Society (GB Sci Ctr)	09/28–29/07

## **MANAGEMENT**

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### *1. Administration*

## **ADMINISTRATION**

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

On the ALMA Project, ES&S participated in the first acceptance process for Back End racks shipped to Chile. In New Mexico, ES&S completed the field work for the site-wide asbestos survey. In Green Bank, ES&S efforts are increasing as the GBT track-replacement project is developing. In Charlottesville, the card access system was brought online, with the fire-suppression system anticipated next quarter.

### **ALMA**

ES&S participated in design reviews including the AEM Consortium antenna design review, the transporter design review, the nutator systems readiness review, and the Band 9 Safety Documentation review. ES&S visited the VERTEX facility in Kilgore, Texas to review and resolve antenna safety discrepancies identified in the previous quarter. In March, ES&S participated in the face-to-face meetings for the ALMA Integrated Project Teams. During this meeting, the first coordinated efforts for the acceptance process were implemented for Back End items shipped to Chile.

### **NRAO-New Mexico**

ES&S completed the field work for the site-wide asbestos survey for the VLA. The sampling results report is anticipated next quarter. The U.S. Department of Transportation drug and alcohol testing program manual was completely implemented for Commercial Drivers. At the AOC the floor striping is still pending and under discussion with local management. At the VLA, the new waste-oil storage tank arrived and installation awaits completion of concrete foundation work. ES&S provided training services and support on preparation of a front-end safe-handling presentation at the Antenna Test Facility. ES&S completed the 2008 renewal application paperwork for the Emergency Medical Services (EMS) first responders as well as the EMS fund act paperwork for state funding. ES&S participated in the inspection for EVLA antenna No. 21 after a major overhaul and this quarter completed the VLA site Emergency Lighting, Emergency Shower, Eye Wash, and the Emergency Exit Sign inspection for the VLA site.

### **NRAO-Green Bank**

The Science Center fire-alarm system is now functioning correctly. The new 300 gallon double-walled steel waste-oil tank arrived; installation awaits a new concrete pad. The semi-annual cafeteria inspection was completed with no significant violations documented. ES&S is actively involved in the GBT track-replacement program by participating in the scheduling meetings, reviewing contractor safety plans, and developing safety guidelines for GB personnel and visitors during the track project. ES&S has been involved with oversight of the site wastewater treatment plant. First-quarter sampling results were within accepted guidelines for the NRAO permit to operate and discharge through the state of WV. Development of the GBT fire-suppression system project was deferred until the track project was underway.

### **NRAO-Charlottesville**

The NTC fire-detection and alarm systems and the card-access system were installed. Access cards were distributed and the system is working. The NTC system is identical to the Edgemont Road access control system and allows staff to access both buildings with a single card. The fire-detection and alarm system



## MANAGEMENT

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### *1. Administration*

has a few minor punchlist items remaining including employee training. Final testing and acceptance of is anticipated next quarter. An OSHA-type inspection was performed by ES&S at the NTC facility.

### **Future Efforts**

In the next quarter, the site safety representatives will further develop the GBT fire-suppression system with Green Bank staff, will complete the OSHA inspection at Charlottesville, and will begin development of the arc flash electrical safety program.

## MANAGEMENT

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### 2. Personnel

#### PERSONNEL

##### NEW HIRES

Saiprasad, Vidhya	Mechanical Engineer II	04/02/07
Wandji, Ketchiozo	Software Engineer III	04/16/07
Aafloy, Stian	Electronics Engineer III	05/01/07
Lopez, Phillip	Electronics Engineer III	05/14/07
Rumberg, Brandon	Undergraduate Intern	05/14/07
Demorest, Paul	Jansky Fellow	05/16/07
Lynch, Ryan	Intern, Graduate Level	05/16/07
Masui, Yoshihiro	Electronics Engineer III	06/01/07
Crabtree, Jason	Software Engineer III	06/04/07
Clevenson, Hannah	Intern	06/11/07

##### REHIRE

Peck, Alison	JAO Deputy Project Scientist/Associate Scientist	04/02/07
Brandt, Patrick	Research Assistant	05/29/07

##### TERMINATIONS

Wandji, Ketchiozo	Software Engineer III	04/30/07
Velasquez, Phil	Electrical Engineer III	05/31/07
Kornjut, Philip	Intern	06/30/07
Janes, Clinton	Division Head, ALMA (Retired)	04/02/07

##### TRANSFERS

Pursley, Michael	Electronics Engineer III	05/14/07
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##### PROMOTIONS

Hale, Andrew	Software Engineer II	04/01/07
Harland, David	Software Engineer I (Group Leader)	04/01/07
Ford, John	Electronics Division Head	05/01/07
White, Steve	Microwave Group Leader	05/01/07

## MANAGEMENT

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### *3. Budget*

#### **BUDGET**

The NRAO Operations is forecast to receive \$50,740k (including \$6,010k for EVLA) in new funding this fiscal year. When combined with prior-year commitments and prior-year carryover, the NRAO Operations total, less EVLA, is \$51,486k. As of June 30, \$38,005k has been received. Overall the NRAO Operations budget is approximately 15.1% (annualized) under-spent through the third quarter of the fiscal year. The following is a brief explanation of the WBS level 1 elements that are under- or over-spent in excess of 10%.

**ALMA Operations:** Significant underspending is occurring in the materials & services expense category because of the advance funding for Chile Operations. It is expected that up to \$3.2M will be available to carry forward into FY 2008.

**Central Development Lab:** Underspending is occurring in several expense elements. Hiring of a new Amplifier group technician was delayed, and more labor has been attributed to the ALMA construction project than was originally planned. Spending is expected to be more closely aligned with the linear spend rate when some facilities upgrades are undertaken late in the fiscal year and equipment in support of the 350-micron SIS mixer project is purchased.

**Green Bank Operations:** Expenditures continue to lag the linear spend rate in the materials and services expense category because of funds that have not yet been expended for the Green Bank Telescope track repair project.

**Observatory Management:** Expenditures during the third quarter trailed the linear projection with a majority of the dollar-based variance being in materials & services and planned carryover for FY 2008. Travel has also been less than expected; however, late summer travel is expected to lower the present variance.

## MANAGEMENT

### 3. Budget

NRAO Operations Expenses and Commitments FY 2007 Year to Date (October 1, 2006 to June 30, 2007) in \$000										Percent of fiscal year	75.0%
WBS Level I	Salaries & Benefits	Materials & Services	Travel	Revenue or Cost Recovery	Total	Linear Spending	Actual Exp + Comm	Actual Percent Expended & Committed	Annualized Variance		
Observatory Management	4,778.1	3,501.1	592.0	-150.0	8,721.2	6,540.9	5,219.7	59.9%	20.2%		
Education and Public Outreach	520.4	248.3	20.6	-125.0	664.3	498.2	530.0	79.8%	-6.4%		
Central Development Lab	1,501.6	256.7	30.0		1,788.3	1,341.2	1,147.1	64.1%	14.5%		
Green Bank Operations	8,637.9	2,997.9	143.2	-455.6	11,323.4	8,492.6	7,585.0	67.0%	10.7%		
New Mexico Operations	13,234.0	4,508.9	210.2	-80.0	17,873.1	13,404.8	13,173.9	73.7%	1.7%		
ALMA Operations	892.3	4,776.0	74.6		5,742.9	4,307.2	1,214.9	21.2%	71.8%		
Computer and Information Services	867.4	635.2	25.0		1,527.6	1,145.7	1,224.4	80.2%	-6.9%		
Science and Academic Affairs	2,197.1	1,323.3	324.8		3,845.2	2,883.9	2,707.9	70.4%	6.1%		
NRAO Operations totals	32,628.8	18,247.4	1,420.4	-810.6	51,486.0	38,614.5	32,802.9	63.7%	15.1%		

## APPENDIX

### *Acronyms and Abbreviations*

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Acronym	Definition
AAB	Antenna Assembly Building (EVLA)
AAS	American Astronomical Society
ACU	Antenna Control Unit
ADC	Analog to Digital Converter
AEM	consortium manufacturing the European ALMA antennas
AIPS	Astronomical Image Processing System
AIV	Assembly, Integration, and Verification
ALMA	Atacama Large Millimeter Array
AlN	Aluminum Nitride
ANASAC	ALMA North American Scientific Advisory Committee
AOC	Array Operations Center (Socorro, NM)
AOP	Array Operations Plan
AOS	Array Operations Site (ALMA)
ARC	ALMA Regional Center
ASAC	ALMA Scientific Advisory Committee
ASP	Astronomical Society of the Pacific
ATF	ALMA Test Facility
AUI	Associated Universities, Incorporated
AURA	Association of Universities for Research in Astronomy
BDF	Binary Data Format
C-band	4–8 GHz
CAP	Communicating Astronomy with the Public (IAU)
CASA	Common Astronomy Software Applications
CASAPY	CASA with Python interface
CASPER	Center for Astronomy Signal Processing and Electronics Research (Berkeley)
CCB	Caltech Continuum Backend (GBT)
CDL	Central Development Laboratory (Charlottesville, VA)
CDR	Conceptual Design Review
CICADA	Configurable Instrument Collaboration for Agile Data Acquisition
CIS	Computer and Information Services
CONAMA	Chilean National Environmental Commission
CONICYT	Comisión Nacional de Investigación Científica y Tecnológica de Chile
CSV	Commissioning and Science Verification (ALMA)
CV	Charlottesville
CY	Calendar Year
DAL	Data Access Language
DRAO	Dominion Radio Astrophysical Observatory
DSP	Digital Signal Processor
DTS	Digital Transmission System
E2E	End-to-End
EDFA	Erbium-Doped Fiber Amplifier
EMS	Emergency Medical Services
EPO	Education and Public Outreach
ES&S	Environment, Safety, and Security (NRAO)
ESO	European Southern Observatory

## APPENDIX

### *Acronyms and Abbreviations*

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Acronym	Definition
EU	Europe
EVLA	Expanded Very Large Array
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
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
HBT	Heterostructure Bipolar Transistor
HEMT	High-Electron-Mobility Transistor
HR	Human Resources
HST	Hubble Space Telescope
IAU	International Astronomical Union
iBob	internet Breakout board
IDL	Interactive Data Language
IF	Intermediate Frequency
InP	Indium Phosphide
IPT	Integrated Product Team
IT	Information Technology
ITEST	Information Technology Experiences for Students and Teachers (NSF)
IVOA	International Virtual Observatory Alliance
JAO	Joint ALMA Office
K	Kelvins (temperature)
K-band	18–26.5 GHz
Ka-band	26.5–40 GHz
KP	Kitt Peak (VLBA station)
Ku-band	12–18 GHz
KVA	KiloVolt Ampere
L-band	1–2 GHz
LA	Los Alamos (VLBA station)
LNA	Low-Noise Amplifier
LO	Local Oscillator
LTA	Long-Term Accumulator (GBT spectrometer)
LWA	Long-Wavelength Array
M&C	Monitor and Control
MHz	Megahertz
mm	millimeter
MMIC	Monolithic Microwave Integrated Circuit

## APPENDIX

### *Acronyms and Abbreviations*

Acronym	Definition
MOU	Memorandum of Understanding
MPIfR	Max Planck Institut für Radioastronomie
μm	micrometer
NA	North American / Not Applicable / Not Available
NAASC	North American ALMA Science Center
NAOJ	National Astronomical Observatory of Japan
NASA	National Aeronautics and Space Administration
Nb	Niobium
NbTiN	Niobium Titanium Nitride
NGAS	Next-Generation Archive System
NGST	Northrop Grumman Space Technology
NJIT	New Jersey Institute of Technology
nm	nanometer
NRAO	National Radio Astronomy Observatory
NSF	National Science Foundation
NTC	NRAO Technology Center (Charlottesville)
NVO	National Virtual Observatory
OCI	Office of Cyber Infrastructure (NSF)
OMT	Orthomode Transducer
OSC	Observatory Science Council
OPT	Observation Preparation Tool
OSHA	Occupational Safety and Health Administration
OSF	Operations Support Facility (ALMA)
OST	Observation Scheduling Tool
P-band	327 MHz
PAARE	Partnerships in Astronomy & Astrophysics Research and Education (NSF)
PAPER	Precision Array to Probe the Epoch of Reionization
PC	Personal Computer
PDR	Preliminary Design Review
PLC	Programmable Logic Controller
PR	Proposed Recommendation
PSC	Pulsar Search Collaboratory
PSI	Prototype System Integration
PST	Proposal Submission Tool
PT	Pie Town (VLBA station)
PTCS	Precision Telescope Control System (GBT)
Q	Quarter
Q-band	40–50 GHz
R&D	Research and Development
REU	Research Experiences for Undergraduates (NSF program)
RF	Radio Frequency
RFI	Radio-Frequency Interference
RFQ	Request For Quotation
rsync	program that synchronizes remote data sets
RTP	Round-Trip Phase

## APPENDIX

### *Acronyms and Abbreviations*

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Acronym	Definition
S-band	2–4 GHz
SAA	Science and Academic Affairs (NRAO division)
SDM	Science Data Model
SAGE	Science Advisory Group for the EVLA
SDFITS	Single-Dish Flexible Image Transport System
SED	Spectral Energy Distribution
SIA	Simple Image Access
SIS	Superconductor–Insulator–Superconductor
SKA	Square Kilometre Array
SLiSE	Spectral-Line Search Engine
SoW	Statement of Work
SRBS	Solar Radio-Burst Spectrometer (Green Bank)
SSA	Simple Spectral Access
SSC	Spitzer Science Center
STScI	Space Telescope Science Institute
TAP	Table Access Protocol
TB	Technical Building (ALMA)
TDP	Technology Development Program
TRW	TRW Corporation
U-band	12–18 GHz
UNLV	University of Nevada, Las Vegas
UPS	Uninterruptable Power Supply
UVa	University of Virginia
VCO	Voltage-Controlled Oscillator
VDC	Volts, Direct Current
VERTEX	VertexRSI (antenna supplier)
VIPS	VLBA Imaging and Polarization Survey
VLA	Very Large Array
VLBA	Very Long Baseline Array
VLBI	Very Long Baseline Interferometry
VLTA	Very Large Telescope Interferometer
VO	Virtual Observatory
VPN	Virtual Private Network
VSOP	VLBI Space Observatory Program
VSOP-2	VSOP 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