









The format followed on this agenda provides orientation to the structure of this briefing, gives some high level science results and metrics, and then spends some time discussing performance at each of the telescope locations. Also presented are activities is the areas of new initiatives and observatory-wide operations that occurred in the January - March timeframe. Finally, an overview of the remaining 2009 schedule for publications is provided.





This Quarterly Status Update (QSU) provides an executive summary of NRAO science, progress, and accomplishments for the period January 1 - March 31, 2009, the second quarter of Fiscal Year (FY) 2009. The QSU replaces the NRAO Quarterly Report deliverable and employs a new and more readable format, as agreed by NSF/AUI/NRAO in April 2009. The QSU will be delivered to the NSF as a briefing with back-up documentation in the form of attached notes.





**Black Holes Grow Before Galaxy Bulges:** Observations of high-redshift galaxies acquired with the VLA and the Plateau de Bure Interferometer have provided new insights as to whether galaxies or the black holes at their cores formed first. Analysis of the gas dynamics for a sample of distant galaxies indicates that the mass ratio of their central black holes to their host galaxy bulges differed in the early Universe compared to later times, where this ratio is essentially constant across a wide range of galaxy sizes and ages. The black hole to bulge ratio for these young galaxies is significantly larger because the black holes are more massive than expected. This result implies that the supermassive black holes in the cores of galaxies apparently formed first and started growing before their host galaxy bulges.

**Probing a New Domain in AGN Jet Physics:** A long-standing problem in AGN physics is that the radiative lifetimes of the synchrotron-emitting electrons are significantly shorter than the time required for these electrons to travel down the jets, where they are observed. The presumption is that some mechanism re-accelerates the particles far from the galactic nucleus. This mechanism might be observable as a variation in spectral index along the jet emission, but this requires measuring the jet at widely spaced frequencies with good angular resolution and high sensitivity, an observational feat that was difficult to accomplish in the past. With the availability of the MUSTANG bolometer array on the GBT, however, it is now possible to acquire sensitive images at 90 GHz with 8.5 arcsec angular resolution. MUSTANG has recently been used to observe two AGN, M87 and Hydra A, and make a comparison with archival VLA data acquired at lower frequencies. The results suggest that the M87 jet shows only small spectral changes along its length providing little evidence of electron aging. The spectrum is curved everywhere, however, indicating a complex history of electron energetics. The Hydra A spectrum, however, shows dramatic changes with position suggesting that particle acceleration slows or stops fairly early in the jet. Hydra A also has a curved spectrum, however, suggesting a similarly complex history of particle loss and resupply.

A Survey of  $C_6H$  and  $C_6H$  in Carbon Chain Sources in the Galaxy: Negative molecular ions (anions) had long been predicted to be constituents of interstellar gas but have only been recently discovered. To date  $C_6H^-$  is the most readily detected molecular anion possibly because the neutral species  $C_6H$  is produced at fairly high abundances in molecular clouds. To determine the distribution and abundance of anions in the ISM, a survey of 24 molecular clouds was conducted in the  $C_6H^-$  line with the Robert C. Byrd Green Bank Telescope. The observations also covered the  $C_4H$  and  $C_6H$  lines. The anion  $C_6H^-$  was detected in two new sources,  $C_6H$  was detected in six sources, and  $C_4H$  was detected in 11 sources, being seen in nearly every dark cloud in the sample. The anion/neutral ratios suggest that  $C_6H^$ may be just below the detection threshold in many clouds. The anion observations yield a fairly direct measure of the electron density in dark clouds: for the two detections, the fractional ionization is  $10^{-8}$  to  $10^{-7}$ , comparable to the values derived from measurement of positive molecular ions.

Shedding New Light on the Structure and Kinematics of the Taurus Star-forming Region: The trigonometric parallax of the weak-line T Tauri star HP Tau/G2 in the Taurus star-forming region has been measured using multi-epoch VLBA observations. The best-fit distance of 161.2 pc $\pm$ 0.9 pc suggests that the eastern portion of Taurus, where the star is located, is the far side of the molecular cloud complex. Previous VLBA observations have shown that T Tau, located south of the complex, is at an intermediate distance of ~ 147 pc, whereas the region around L1495 corresponds to the near side at ~ 130 pc. While the observations to date are insufficient to reliably determine the 3D structure of the entire Taurus complex, they demonstrate the power of the VLBA to very accurately measure distances to multiple sources in a star-forming region and provide the structure of these stellar nurseries.

Proper motion measurements were obtained simultaneously with the parallax data. When combined with earlier VLBA measurements of the kinematics of young stars in Taurus, these data indicate that the peculiar velocity of the Taurus molecular cloud is  $\sim 10.6$  km/s and almost entirely parallel to the Galactic plane.

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Telescope Usage (hours)							
retivity	VLA	VLBA	GBT				
cheduled Observing	1333.51	897.25	1809.00				
cheduled Maintenance and Equipment Changes	195.50	219.00	174.00				
cheduled Tests and Calibrations	432.89	285.85	177.00				
Sime Lost	136.42	38.58	166.00				
Inscheduled	182.00	735.40	0.00				
Actual Observing	1197.08	858.66	1643.00				
ual Observing	182.00	735.40 858.66	0.0 1643				

The NRAO telescopes were scheduled for research and for maintenance during the second quarter of 2009 as described in the table above. Time lost and actual observing times for the arrays are computed as fractions of the total antenna arrays. For example, losing 27 VLA antennas for one hour counts as 1.0 hours of array time lost, while losing one out of ten VLBA antennas for one hour counts as 0.1 hours of array time lost. Antennas being modified for the EVLA, and therefore not available for astronomical observations, are counted as lost for observing.

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

There are three primary factors that create unscheduled periods for the VLBA. (1) Both dynamically scheduled and fixed-schedule VLBA projects are typically 10–16 hours in length; with only 10 antennas, the VLBA cannot effectively take snapshots. The lack of scientifically compelling proposals that last for only 2–4 hours means that gaps of this length usually cannot be filled by dynamically scheduled programs, and 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 pace, only if gaps are left 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.





This provides a sense of the scientific results that were being realized from the telescopes. Non-refereed papers are generally quite a bit slower than refereed papers to be published as they are almost always conference proceedings papers that take from 18 months to 5 years to be published. Survey papers cover all the surveys identified to date; they are: a). COSMOS b). FIRST c). LITTLETHINGS.

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The graph illustrates the full lifecycle. The vertical line represents where we are today. The CP represents the critical path.

This briefing provided this visualization to represent the project evolution from construction to operations. Operations typically is not shown and this was done for illustrative purposes only. Future versions will not show this view.



The graph illustrates this fiscal year view. The vertical line represents where we are today. The CP represents the critical path.

The first phase of the conditional acceptance review of Vertex Antenna #1 was held in **mid-January** [shown as a milestone]. On February 6 at  $\sim$  9:30 am, the ALMA Director and the North America (NA) Project Manager signed the conditional acceptance agreement for the first Vertex antenna. Antenna #1 has now been lifted and **relocated to the OSF** and the **AIV team** has already integrated the Front End and Back End electronics.

Work continued towards the conditional acceptance of the second Vertex antenna, though the intention is that the all-sky pointing will be fully accepted. Work by Vertex to improve the settling time of the metrology system has been successful. Acceptance data taken on DV02 show that the all-sky pointing performance can be achieved within the specified 2 second settling time, as opposed to DV01, which needed 5 seconds to settle. Discussions continue within the project and with Vertex over the next steps towards final verification of the low temperature performance of the surface.

Following the successful resolution of the metrology problems in late November, Vertex successfully changed out the main drive motors in December (replacing them with units with considerably lower "cogging") and completed servo tuning in mid-January. Offset pointing and fast switching data were taken and reports were issued for the delta review.

Vertex has now installed a new version of the tilt meters into antenna #2. The new tilt meter includes two level sensors that are mounted vertically atop each other and share a common vertical axis. This new tilt meter has been installed on Vertex #2 and aligned to the antenna's azimuth axis with a theolodite. Settling time performance after a large slew is substantially improved.



The **Band 3 Manufacturing Readiness Review (MRR)** *[shown as a milestone]* was held in Victoria February 12. All CDR action items were closed, and beginning of production was approved. is being prepared. SN16 is under test. The cryostat temperature automation software for the mixer test system is complete; this wCartridge SN13 testing was completed and Cartridge SN14 is ready for test.

The Preliminary Acceptance In-house (PAI) review meeting for cartridges Band 3 SN09, 10, 11, and 12 is scheduled for April 8. The acceptance test for cartridge SN15 is complete and acceptance report will improve testing efficiency.

The successful recovery of the Band 3 schedule will now mean that Band 6 will become a critical item for the delivery of completed Front Ends (FEs). As a result, a plan is being developed to double the throughput of the mixer-preamp test set to both compress the schedule and add some margin.

Preliminary Acceptance In-house (PAI) for the eighth Band 6 cartridge delivery (SN10) was held. Cartridges 16-18 are under construction.

Costing for a second Band 6 cartridge test system is complete and a change request is in preparation. This will allow the Band 6 production rate to be improved considerably. The first phase of the automated Warm Cartridge Assembly noise test software was completed. This reduces the test time for one key test from four hours to forty minutes and will relieve a great deal of pressure on the test facilities.

Local Oscillator Photonic Receiver (LPR) remains a critical path item in the short term for getting front ends to Chile. In December unit **#104** was completed and shipped to RAL for integration into EU FE#1 in early January. Sufficient components are in-house to support a total NA FE#2 and one more FE. S/N 104 passed PAS tests and was installed in EU FE#1 at RAL. PAI testing on **Back End Antenna Article # 5** was completed in Socorro the week of February 9 (shown as a milestone). S/N 105 is nearing completion in Charlottesville; this will be the last of the pre-production series. Meanwhile, the production contract for LPRs has been placed with Lightwave 20/20.



The major software testing activities included (1) a CASA tutorial for about 25 Chile-based ALMA scientific staff in Santiago on January 27-28; (2) release of the CASA beta version 2.3.1 in preparation for the Santiago tutorial (1/22/09); (3) testing and prioritization of development targets for the next CASA release (version 2.4); (4) collaboration with University of Maryland staff to more easily import CARMA telescope data into CASA with later scope for SMA, WSRT, ATCA and perhaps other interferometers; (5) user support through the CASA helpdesk (26 new queries received; 14 tickets closed).

NAASC has selected the Kayako product for baseline testing as its helpdesk system. **Kayako** is in use by both the NASA Herschel Science Center and the Spitzer Science Center. Agreement was reached across NRAO to test this system for the NRAO-wide science user **helpdesk**. The ALMA Helpdesk Requirements are under review by the ARCs and JAO. Testing will begin by the NRAO E2E division with an installation hosted at the Kayako site, while investigations into local security issues are being undertaken by the NRAO IT division, in preparation for a local installation.



Visits were made to the **National Herschel Science Center** at Caltech in Pasadena (Jan 9-13) and **Space Telescope Science Institute** (Jan 28), to strengthen collaborative connections with NAASC. Detailed planning was initiated with AOC & GBT staff for collaboration with EVLA, VLBA and GBT in the development and support of various observatory user systems, ranging from web documentation, the user portal, the new helpdesk system incorporating a knowledgebase, archiving, VO, and data access rates.

The NRAO booth at the **AAS conference** (Long Beach, California, 4-8 January) was the backdrop for two new demonstrations of NAASC tools: the spectral line database *Splatalogue*, and the ALMA simulator. A re-designed NRAO booth was supported at the AAS conference (Long Beach, California, 4-8 January). The booth featured a new, interactive large-screen graphics display. NAASC staff helped to promote and execute NRAO's successful Town Hall meeting at that conference. NAASC staff also gave science talks, including discussion of the potential for ALMA.

The NAASC supported both the NRAO booth at the AAAS conference (Chicago, 12-16 February, and NRAO's Science Symposium entitled "Cosmic Cradle of Life", which included a well-received press conference. Presentations by NAASC staff were made.

The production of a 44-page ALMA Media Prospectus booklet designed to elevate awareness of ALMA among science writers, documentary producers, and other science communicators and popularizers was completed. Hundreds of copies were distributed to television documentary producers and network executives at the RealScreen Summit Conference, 1-4 February in Washington, and via mail.





This was a first attempt to represent the financial trends for the program; both the construction (SPO 2) and Operations (SPO 8) budget versus cost lines. There are a few things you need to know right up front. The budget line is a straight line representation as if you took funding for the year and strictly divided it by 12, then made it additive across all months. The cumulative cost line has a significant caveat in that it represents booked costs for month and does not reflect committed costs. Most earned value and budgeting tools do not provide tracking of committed costs against the budget and this would require significant tracking by hand. It is not clear that it is worthwhile to do so at this point. Further analysis is required. Investigating if a process change with the calculation would be value added.

So these charts do not reflect the actual distribution of funds from NSF, nor do they reflect the internal spending plan. That severely affects their usefulness, except as a high level visualization.







Overall, the EVLA project remains on schedule. The conversion of antennas to the EVLA design is scheduled to be complete in Q3 2010. The installation of the WIDAR correlator is scheduled for completion in Q1 2010. The last EVLA receiver will be installed in late 2012.



Systems Integration: The installation of new electronics in the 19<sup>th</sup> and 20<sup>th</sup> antennas was completed this quarter. These antennas were returned to the array for science observations. The electronics outfitting of the 21<sup>st</sup> antenna is nearly complete. It will be returned to the array next quarter.

The mechanical overhauls of the 20<sup>th</sup> and 21<sup>st</sup> EVLA antennas were completed [shown as a milestone]. The mechanical overhaul of the 22<sup>th</sup> antenna is under way and will be completed on schedule next quarter. The critical path to project completion runs through the conversion of the antennas to the EVLA design and will segue to receiver production at the start of FY2011.

During the past quarter for Front End, the **20<sup>th</sup> EVLA antenna was outfitted** [shown as a milestone] with interim L and X-band receivers as well as fully EVLA-compliant C, K, and Q-band systems.



Modules for the LO and IF systems are being built on a slightly accelerated schedule to meet the goal of having all modules finished by the end of FY 2009. Modules completed to date include the L301 frequency synthesizer, the L353 LO reference transmitter, the L304 LO reference receiver, and the T305 baseband controller [shown as a milestone].

A plan for the transition from the VLA correlator to the WIDAR correlator has been developed to support EVLA early science opportunities. The transition will occur in Q1 2010. The first subset of the final WIDAR correlator, known as **WIDAR-0**, **was installed at the VLA site** [shown as a milestone] this quarter. **First fringes were recorded with WIDAR-0** [shown as a milestone] using five antennas and 512 MHz bandwidth on March 6. Fringes from eight antennas were recorded a week later. WIDAR-0 can accept inputs from up to 10 antennas. It will be used to test, verify, and integrate the two WIDAR configurations used in early science observations in Q1 2010.

Although it will not officially reach version 1.0 until the WIDAR correlator becomes available, the new web-based **Observation Preparation Tool (OPT)** *[shown as a milestone]* is available to observers now and has already been used for science observations. The new OPT is the only supported way to access the extended tuning ranges of the EVLA, such as those provided by the new Ka-band and C-band receivers. This tool is in its infancy but has the capability needed to prepare observations. OPT work in the next quarter will focus on the usability of the tool. The OPT is available via the NRAO User Portal (https://my.nrao.edu/).



A meeting of the **EVLA Advisory Committee** was held March 19-20, 2009. The Committee was very impressed with the overall progress on the project. The preliminary findings and recommendations of the Committee include: (a) develop science-driven plans for archiving EVLA data and getting the data to users; (b) take more action to ensure user acceptance of CASA; (c) further integrate "project external" developments (e.g. CASA and Observatory Science Operations) in the project plan; (d) maintain and grow a vibrant science community at Socorro for the EVLA; and (e) quickly develop a vision for high-impact science. The Committee's final report is expected in Q2 2009.

The committee report was received from the meeting of the Science Advisory Group for the EVLA (SAGE) that was held December 2008. The most important part of the report was the SAGE recommendation for the prioritized growth path of EVLA science capabilities, primarily with the WIDAR correlator. The priorities are to implement wide bandwidth capability, improve spectral resolution by implementing WIDAR recirculation, and enable the high-frequency operation of the array. Other WIDAR configurations, such as phased array operation for VLBI and pulsar capability, were deemed to be lower priority. The SAGE endorsed the NRAO shared-risk observing program and recommended methods for advertising the EVLA. The SAGE also recommended that a second EVLA science workshop, on stars, be held in Socorro on May 26-28.



The VLA completed moves from **A to BnA** configuration, and from **BnA to B** configurations, in January and February, as scheduled. Site staff completed a fuel tank upgrade to comply with NMED requirements.

The migration to a new **40TB archive disk** storage was completed in March. Worked continued on the upgrade of the Science Operations Center Internet connection to 1Gbit; this upgrade will be complete in June if Western New Mexico Telephone remains on schedule.

The **FRM brake power supply** and new interface board was installed for testing in a single VLA antenna in March.



The same caveats with ALMA financials hold true here. An additional chart has been inserted here on the overall EVLA budget to show a more comprehensive view of the budget situation. You also have the committed versus booked costs showing.

For FY 2009 expenditures currently lag the allocated funds, primarily due to delayed purchases for components for receivers and modules in the data transmission system. Where possible, they are expediting the purchase of those items.

The WBS cost data sheets for the EVLA project were updated during the quarter. Project contingency is \$2.86M, or about 21.4% of the estimated cost to completion. The percentage contingency remains at historically high levels. However, the contingency is needed to address the risks that face the project.

The EVLA risk register was also updated during the past quarter. When compared to the first risk assessment made in December 2006, the number of risks has been reduced from 79 to 46, the financial impact of the risks has been reduced from \$11.2M to \$7.1M, and their weighted impact has been reduced from \$3.3M to \$2.4M. Current project contingency is adequate to cover the weighted financial impact of the risks. The risk register comparison shows that project risks are actively managed and that progress is being made towards their elimination.

Comparisons of the cumulative NSF funding for the EVLA construction project with the cumulative expenditure of those funds for FY2009 and for the entire project through FY2008 are shown in the attached EVLA financial status figures. Total expenditures for the entire project through FY2008 are comparable with the total funds received. For FY2009, expenditures currently lag the allocated funds, primarily due to delayed purchases for components for receivers and modules in the data transmission system. We are expediting the purchase of these items where possible.





The GBT **Dynamic Scheduling Systems (DSS)** team began work on the final version of this system. During this quarter, the DSS team rewrote the underlying algorithm which scores the **individual scheduling sessions**, adding significant code efficiency and allowing for rapid system testing. DSS is scheduled for a Q4 final release of the complete suite of telescope scheduler tools after an initial delay necessitated by work on the high-frequency receivers.

The **Precision Telescope Control System (PTCS)** is an infrastructure project designed to increase the GBT efficiency and gain. The PTCS project made significant progress in the area of traditional and out-of-focus (OOF) holography this quarter. **The first large (2 degree, 200 column) 11.7 GHz holography maps** of a geostationary satellite were obtained in January and February, leading to the first improvement in the small-scale surface error since 2001 when the photogrammetry offsets were applied. After the first round of corrections to the actuator home positions, the total surface error was reduced from 390 to 340 microns rms. The improvement has been confirmed by the 50% increase in signal seen by the MUSTANG bolometer array. In March, the data model was improved to include panel corner offsets, leading to an additional 10% increase in signal.

In Q2 FY2009, the **K-Band Focal Plane Array (KFPA)**, a 7-pixel 18-26 GHz traditional feed horn focal plane array, underwent laboratory testing of system temperature, baseline stability, integrated total power stability, gain versus frequency response, and spectral purity. The measurements verified the instruments system specifications for system temperature, baseline stability and integrated power stability. The gain versus frequency specification was not met and a design modification is being implemented. The type II downconverter was tested and met all specifications. The LO doubler system was also tested during this period and revealed the requirement for a design change to extend the doubler range beyond the original specification. The engineering M&C system was tested and performed well with only minor changes required. Software development resources have been secured for full M&C development to begin in April. The KFPA was **installed on the GBT** for more comparison tests with the current K-band receiver, specifically to resolve a discrepancy with earlier system temperature measurements. An **external review** of the receiver capabilities was then conducted with scientists and engineers from the Five College Radio Observatory, NASA Goddard, University of Pennsylvania, and the NRAO. The reviewers reported that the receiver design was robust and recommended completing construction of the receiver.

![](_page_27_Figure_1.jpeg)

![](_page_28_Figure_1.jpeg)

The 10GbE daughter cards for the Mark5C recorders were delivered in February; the software package will be delivered April. Delivery of the Mark5C recorders (units 1-3) will be complete next quarter. Work continues on the Servo Board upgrade that will be completed in August.

Mexico's CONACyT funded a Universidad Nacional Autonoma de Mexico (UNAM) proposal to upgrade eight VLBA recording systems from **Mark 5A to Mark 5C**, which will increase the maximum data recording rate from 1 to 4 Gbit/s. A **purchase order** for these eight units (\$90K) was issued during the quarter. Full implementation of a 4 Gbit/s capability will require the digital backends and software correlator that should be implemented by the end of 2009, as well as additional recording hardware and media.

A meeting that included the Program Manager for the Deep Space Network and the Deputy Associate Administrator in charge of Space Communications and Navigation was held at NASA Headquarters in January. A conceptual agreement was made to provide significant VLBA operations funding, if NSF would equip the VLBA with **33 GHz receiver systems**. NRAO submitted a white paper to NSF outlining the additional benefits to the NSF community from this receiver implementation and received a favorable response. A draft MOU between NASA and NSF was prepared and submitted to NASA counsel. At quarter's end, further discussions between NASA and NSF were on hold, pending internal budget negotiations within NASA. Formal NASA/NSF discussion of the **draft MOU** is expected to resume during Q3 2009.

Further VLBA partnership discussions were held with the **Max Planck Institut für Radioastronomie (MPIfR)** and the **US Naval Observatory**. MPIfR partnered with NRAO on a Major Research Instrumentation proposal to NSF to equip the VLBA with wideband 4-8 GHz receivers that cover the methanol line at 6.7 GHz; this strongly masing line can be used for highly accurate astrometric measurements of the Milky Way's structure.

![](_page_29_Figure_1.jpeg)

![](_page_30_Figure_1.jpeg)

The second meeting of the SKA Science and Engineering Committee was held in Cape Town, and was attended by two NRAO staff. The AUI President also attended several of the associated SKA meetings in Cape Town. Significant discussion was held regarding the medium- and long-term SKA schedule. Because of the late beginning for the PrepSKA program funded by the European Commission, and the need for a two-year period to prepare for SKA-mid construction, the earliest starting date for SKA-mid was revised from 2012-2013 to 2015-2016. SKA site selection requirements were discussed, and it was agreed that infrastructure requirements for Phase 3 (SKA-high) would not be considered in the final site recommendation. Based on this understanding, the possible site for SKA-high now is almost completely decoupled from the site for SKA-mid and SKA-low.

Several NRAO engineers and scientists visited South Africa for 1-2 week periods in February and March; these visits **assessed the possibilities for increased cooperation between NRAO and the South Africa SKA Project Office (SASPO).** They follow a collaboration agreement between NRAO and SASPO that was signed in August 2008. Areas of common interest that were identified included the overall MeerKAT system design, and algorithm development for EVLA and SKA. Longer-term visits later in 2009 are under discussion.

An **NRAO Senior Management Retreat** in March confirmed the decision that a focus on the **SKA** should be **one of NRAO's five main strategic priorities**. As a follow-up to this decision, formation of an NRAO SKA Program Office is under discussion and is expected by the end of summer.

![](_page_31_Figure_1.jpeg)

![](_page_32_Figure_0.jpeg)

![](_page_32_Figure_1.jpeg)

Work continued on the research on noise properties of heterostructure bipolar transistors (HBTs) and CMOS MOSFETs. The designs of **demonstration amplifiers for ALMA band 1** (31-45 GHz) and **band 2** (67-90 GHz) receivers have been completed. Experimental evaluation awaits the availability of technician time.

During this quarter, 28 amplifiers were shipped. New production included three 1-2 GHz low noise, three 1-2 GHz high dynamic range, four 4-8 GHz, two 4-12 GHz, two 18-26 GHz, two 26-40 GHz, and one 38-50 GHz amplifier. Repair, upgrade, and retesting of amplifiers included one 1-2 GHz (low noise), two 4-8 GHz, two 8-18 GHz, one 18-26 GHz, and five 38-50 GHz amplifiers. The **delivery of amplifiers for the GBT K-band focal plane array** project has been completed and the deliveries of 38-50 GHz amplifiers in support of Korean VLBI network are on schedule. Due to the training of a new assembler, the EVLA amplifier production is slightly behind on the S-band and Ka-band schedule but ahead on other bands. The training is now completed and we should be able to catch up with the schedule before the end of August 2009. No impact on the EVLA receiver production is expected.

The revised L-band Digital Sideband Separating Mixer (DSSM) shows greatly improved stability and smooth calibration coefficients. Sideband separation is at least 60 dB over the entire 500 MHz band and this degrades to no worse than 50 dB when the temperature of the box is raised 12°C above the calibration temperature. It was also tested on the GBT, capturing the entire L-band spectrum in one 130 msec snapshot.

The 8-12 GHz (X-band) Digital Ortho-Mode Transducer (DOMT) modules have been completed and await testing. The downconverter module needed for testing them is being designed based on the lessons learned from the improved L-band DSSM tests. The development of a **new X-band (8-12 GHz) OMT** was completed. The main body of the OMT has three major pieces and the Y-junctions have two pieces each. All the pieces were machined out of aluminum. The weight of the assembled OMT is about 4 lbs. It fits within a circle of radius of 5" and measures 2.7" from the flange of the square port to the flange of the rectangular port. The OMT should be small enough for the EVLA X-band Dewar.

The development of the **Precision Array to Probe the Epoch of Reionization (PAPER)** continues in collaboration with U.C.-Berkeley and other groups. **Single polarization data** using the Green Bank 16-element engineering array were taken in January and February 2009 followed by **dual-polarization data in March**. These data are currently being calibrated and reduced.

**Prototyping began in January 2009** with the design of the **Frequency Agile Solar Radiotelescope Design and Development Plan (FASR)** band B system consisting of the log-periodic feed, low noise MMIC amplifiers, and front-end receiver board. The components have been fabricated and are ready for assembly and evaluation beginning in April 2009.

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Exhibitions were organized and staffed at the January American Astronomical Society (AAS) meeting in Long Beach, CA. The NRAO Town Hall and reception at this AAS meeting were very successful, attracting a record 240+ attendees, including many young scientists and new faces. The NRAO exhibits were re-designed for the Long Beach meeting to be more open and welcoming, and to support multimedia content.

An NRAO "one Observatory" exhibit and a science symposium titled **"The Cradle of Life"** were organized for the 2009 AAAS Annual Meeting. The science symposium featured half-hour talks by Crystal Brogan (NRAO, massive star formation), Anthony Remijan (NRAO, molecules), and David Wilner (CfA, protoplanetary disks); 140+ scientists and press with little or no previous NRAO exposure attended.

**Four news releases** were produced and distributed, one each from ALMA, GBT, VLA, VLBA. The January 5 release that described the M. Reid (CfA) et al research on the structure and rotation rate of the Milky Way attracted the most media attention, including the Comedy Channel's *Colbert Report*.

A **Discovery Channel film crew** visited the VLA and the Pete V. Domenici Science Operations Center for a feature on "Cosmic Collisions" that aired in January.

EPO marketed NRAO science and facilities to **major documentary producers** at the *RealScreen Summit* in February, an annual non-fiction film and television industry event. A media prospectus was created to help market radio astronomy and ALMA to the major media at the *RealScreen Summit* and at the American Association for the Advancement of Science (AAAS) Annual Meeting.

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A patch release to version 2.3 (2.3.1) was made to Common Astronomy Software Applications (CASA) this quarter with a number of bug fixes and modest improvements (e.g., improved UV continuum subtraction with many spectral windows, MacOS distribution of SDM filler). Development was initiated for version 2.4 which is scheduled for release in June 2009.

The **algorithm R&D** working group **charter** was written this quarter and is now posted on the NRAO Software wiki. International discussions will resume at the February 2009 science conference in Cape Town, and continue through the April 2009 SKA algorithms meeting in Socorro.

The NRAO also hosted the 4th meeting in the series of SKA Calibration and Imaging Workshops (**CalIm09**) in Socorro, organized by S. Bhatnagar. This workshop focused on progress in algorithms, software, and computing aimed at solving the challenges in calibration and imaging requirements of the SKA, its pathfinders, and other major new radio telescopes such as EVLA, ALMA, LOFAR, ASKAP, MeerKAT, MWA, LWA, and eMERLIN.

The development of a **high-level archive infrastructure** that addresses the operations needs for all NRAO telescopes has converged. An executive summary for NRAO Archive and High-Performance Computing Strategy, which is also being presented to the 2009 Users Committee, spans the services provided by NRAO as well as the services provided by facilities such as the National Center for Supercomputer Applications (NCSA). This executive summary also details the increase in data volume over time for all NRAO instruments, and presents a strategy for shifting data from NRAO to the national facilities for long-term data curation.

Extensive work has been done to expand the archive infrastructure to support the EVLA, both from the telescope site to the Science Operations Center and within the Socorro Data Center. The initial set of archival NGAS host machines that collect EVLA data in real-time are now installed and are in a testing phase.

The NRAO proposal submission tool (PST) successfully handled 169 proposals (91 VLA, 50 GBT, and 28 VLBA/HSA) proposals for the February 2, 2009 deadline. Nine large proposals were submitted. Minor changes were made to improve the user interface for proposal submission, such as adding the capability to copy data from previous proposals.

![](_page_36_Figure_1.jpeg)

The **National Radio Quiet Zone (NRQZ)** administrator is processing nearly 300 applications for satellite terminals from the West Virginia State Lottery. During January - March 2009, 159 transmitter requests at 268 sites were reviewed and 42 restrictions were issued.

The **Radio Frequency Interference (RFI)** Group continues to compute coverage maps at several frequencies to facilitate coordination with transmitters covered by geographic area licensing, such as home satellite broadband internet connections used in areas lacking DSL and TV cable connections. The hope is that installations in large portions of the NRQZ can be approved on a pro forma basis once suitable areas have been identified, in cases where large numbers of individual installations are possible. The Group also continues to collaborate with the Navy and Virginia Tech in propagation calculations covering the Quiet Zone.

VLA management is continuing to work with the **New Mexico State Land Office (SLO)** to protect the EVLA site from detrimental RFI produced by new high-voltage power transmission lines that would cross the Plains of San Augustin to distribute power generated by new wind farms. A mechanism to establish a buffer zone around the array was identified in a February meeting with the SLO and is now being pursued.

Technical analysis and discussions are underway with AirCell to reduce the **VLBA**-Pie Town impact of a proposed 11 GHz cellular base station-fiber optic portal link. AirCell is one of several companies that provide broadband internet connectivity to commercial airlines using a narrow slice of the 900 MHz cell phone spectrum. Communications between airlines and cell phone towers require Internet gateway links to cell towers, and where fiber is unavailable the links must be completed using microwave transmission.

Interference monitoring and coordination continued, e.g., between **VLBA** stations near the Canadian border and temporary Canadian military use of frequencies near the Ku band (14.5 and 15.3 GHz) allocations to radio astronomy. NRAO continues to be the point-of-contact for periodic testing of military GPS frequencies.

There was a (Working Party) WP7D meeting in Geneva in mid-February at which the usual housekeeping chores were addressed in preparation for the World Radio Conference (WRC) in 2011. Work continues on several items related to protection of radio astronomy receivers from high-powered earth-sensing radars in low earth orbit that are proliferating at many frequencies (most recently: 6, 9.6, and 94.1 GHz). Operators of these radars will be requested to inform radio astronomy operators when such radars are planned or launched so that radio astronomy can take appropriate protective measures.

![](_page_38_Figure_1.jpeg)

The Office of Science and Academic Affairs (OSAA) participated in and helped coordinate submissions to the on-going **Astro2010 Astronomy & Astrophysics Decadal Survey**. This included Science White Papers, State of the Profession Position Papers, and Project White papers. In addition, a response was submitted to a January deadline for **Notices of Intent for proposals** to the NSF Major Research Equipment Program (MRI).

![](_page_39_Figure_1.jpeg)

The **Jansky Fellow** Selection Committee met on **January 9**. The committee consists of six members, two from within NRAO and four drawn from the broader astronomical community. **Seventy-five** applications were received for the 2009 Jansky Fellowship Program.

**Three new Jansky Fellows** will join NRAO in fall 2009 and spring 2010. Their names and current affiliations are provided below. Two of the new Fellows will be at NRAO sites, Charlottesville and Socorro, and the third will be hosted at the University of Arizona in Tucson. In addition, Adam Leroy, MPIfA, will be joining the NRAO in Charlottesville as a **Hubble Fellow**.

Arrivals: Manuel Aravena, Charlottesville Research Associate working with Chris Carilli under Carilli's Max Planck grant beginning in March . Denis Barkats began his appointment in Chile in January, working as an ALMA Commissioning Scientist. Juan Cortez Lopez began his appointment this January working in Chile as an ALMA Science Operations Astronomer. Juergen Ott was promoted in January from Jansky Fellow to Assistant Scientist/A working for the Socorro Scientific Services division.

Departures: Wei-Hao Wang left his Jansky Fellowship at the end of February to accept a position in Taiwan.

NRAO Scientific Staff are at:

http://www.nrao.edu/administration/directors office/currentscistaff.shtml.

Current and past postdocs are at

http://www.nrao.edu/administration/directors\_office/pastpostdocs.shtml.

![](_page_40_Figure_1.jpeg)

2009 NRAO Summer Student Program, **20 undergraduate and graduate students** will pursue a variety of research projects in collaboration with scientists in Green Bank, Socorro, and Charlottesville. A full list is available upon request.

Predocs: Katie Mae Chynoweth (Vanderbilt University) continues to be supported through a predoctoral position working with Glen Langston in Green Bank on HI observations of interacting galaxies with the GBT and VLA. Rohit Gawande (University of Virginia) continues to work with Richard Bradley at the NTC developing and fabricating ultra-wide-band feeds for a variety of radio astronomy applications. Cheng-Yu Kuo (University of Virginia) continues to be supported through a pre-doctoral position working with Jim Braatz in Charlottesville on reducing and analyzing VLBI observations of water-maser emission from galactic nuclei as part of the Megamaser Cosmology Project. Urvashi Rao-Venkata (New Mexico Tech) continues working with Fraser Owen in Socorro.

![](_page_41_Figure_1.jpeg)

Graduate Interns: Nimish Sane (University of Maryland) continued a graduate internship working with John Ford in Green Bank on digital processing for radio spectroscopy. Abhirup Datta (New Mexico Tech) began a 9 month graduate internship in February working with Chris Carilli and Sanjay Bhatnagar in Socorro on simulations of reionization and low frequency data processing, as well as performing a search for the most distant HI 21 cm absorption toward z > 5 QSOs. Dongliang Liu (NAOC) continued a graduate internship working with Scott Ransom in Charlottesville, learning about new instrumentation for astronomical observation of radio pulsars. Megan Decesar (University of Maryland) visited the NRAO in Charlottesville to work with Scott Ransom on the interface between radio millisecond pulsars (MSPs) and Low Mass X-ray Binaries (LMXBs) Alyson Ford (Swinburne University) visited the NRAO in Green Bank beginning in March to work with Jay Lockman on HI halo cloud research. Rosy Torres (UNAM) visited the NRAO in Socorro beginning in March to work with Amy Mioduszewski on research toward her Ph.D. thesis.

Undergraduate Interns: Colton Dunlop, Fred Davis, and Kate Theisen (all New Mexico Tech) are undergraduate interns working with Steve Durand on EVLA electronics.

Visiting Scientists: Stacey Palen completed up her six-month Visiting Astronomer appointment in Socorro. Dave Roberts (Brandeis University) enjoyed a three-week visit to the NRAO in Socorro to work with George Moellenbrock from mid-February to early March. Robert Sault (University of Melbourne) began a four-month visit to the NRAO in Socorro in March to work with Bryan Butler on EVLA computing. Ingyin Zaw (NY University) visited the NRAO in Charlottesville for a few weeks during February and March to work with Jim Braatz.

![](_page_42_Figure_1.jpeg)

The NRAO Student Observing Support (SOS) Committee met in January to discuss proposals submitted during the previous trimester. The SOS committee, composed of five faculty members from U.S. universities, reviewed the science case and student-support application for each proposal, and selected those listed below for funding.

• Miranda Nordhaus (U. Texas - Austin, Supervisor: N. Evans) will receive \$35,000 for work related to the GBT proposal 09A-080 " $NH_3$  in Dense Cloud Cores Selected from the 1.1 mm Continuum BGPS."

• Ben Zeiger (U. Colorado, Supervisor: J. Darling) will receive \$20,500 for work related to the GBT proposal 09A-064 "A Spectral Survey of an Opaque Atmospheric Window."

• Shea Brown/Damon Farnsworth (U. Minnesota, Supervisor: L. Rudnick) will receive \$17,400 for work related to the GBT proposal 09A-008 "Relativistic Probes of the WHIM."

• Katie Chynoweth (Vanderbilt U., Supervisor: K. Holley-Bockelmann) will receive \$19,000 for work related to the GBT proposal 09A-046 "A Search for Faint Extended HI in Nearby Galaxy Groups."

The OSAA was able to locate funds from another program to assist this PI/student:

Michael Alexander (U. Wyoming, Supervisor: C. Kobulnicky) received \$1,500 in travel support related to the GBT proposal 09A-060 "Characterizing a Massive Star Cluster of Red Supergiants using SiO Masers."

Complete SOS info is at:

http://wiki.gb.nrao.edu/bin/view/Observing/NRAOStudentSupportProgram.

![](_page_43_Picture_1.jpeg)

As part of the process of optimizing operations, the Library staff began integrating the unique items of this world-class radio observatory collection. This integration assures the maintenance and availability of the collection for future generations.

NRAOPapers (the NRAO bibliographic database) Astrophysics Data System (ADS) Linking Project is now 86% complete with 12,900 records updated and linked to ADS.

The number of **outside reference requests** (non-NRAO) increased by 63% from Q1 to Q2 FY2009 for a total of 752 requests for this quarter.

Support of NRAO staff this quarter included requests for digitized copies of selected correspondence, copies of newspaper clipping, and historical photos. Because of the Archives web presence, use of our resources by people outside NRAO continues to increase. Visitors to the Archives included the **National Air and Space Museum** senior curator for the history of astronomy and space sciences.

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CIS completed requirements gathering for an external facing Helpdesk and confirmed that the current internal helpdesk solutions are unsuitable. A review of the ALMA-proposed **Kayako's SupportSuite** for the NRAO-wide observer support helpdesk solution successfully verified authentication compatibility with existing systems.

The upgrade of the Green Bank-Charlottesville **WAN link to DS3 speeds** began this quarter. This is needed to better support transfer of data from the GBT to the archive in Charlottesville as well as the JDEdwards business applications. In response to the call for proposals on federally-sponsored broadband initiatives, a proposal was generated for a high-speed link to Green Bank via WVU to service both scientific and community needs. This high-speed line with allow for the archival of GUPPI data from the GBT at a NSF sponsored SuperComputer center as well as enhanced support for remote observations.

By moving to a vendor of qualified, reconditioned Network Appliance storage systems, a substantial savings was achieved on the purchase of **8 TeraBytes of storage** for Green Bank. This will be installed in the next quarter once downtime can be negotiated. The installation and cutover will require coordination with the observation schedule due to the critical nature of this service.

The development of a new risk management framework is nearing completion and has already identified social engineering (e.g. phishing) as a major vector for security compromises. In response, CIS completely **revised the NRAO Computing Security Policy** and implemented an all-employee education program. Users were regularly updated regarding topical issues of concern, such as increasingly sophisticated and customized phishing E-mails and the Conficker virus. The major emphasis has shifted from system level security to user education as socially engineered attacks continue to be a growing risk.

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Completed the **New Mexico Tech re-piping project** oversight at Science Operations Center, and the NMED response assistance. We continued the weekly "tailgate" safety meeting topic. A users' survey was distributed; we are awaiting responses. Twelve tailgate topics have been distributed thus far in 2009.

**Inspection of the VLA site Maintenance Building** was completed January 15. The Spill Prevention Control and Countermeasure (SPCC) plan was submitted for review, and the new Correlator FM-200 Fire suppression system was tested in February. Both **VLA Firefighter training** and **prototyping of the Sband feed** cone flange to protect employees from contact injury, were completed in March.

A Hearing Protection refresher course was held in January. **Two inspections were conducted**: the semi-annual cafeteria inspection in January, and the annual fire extinguisher inspection in February. The **annual chemical** inventory update concluded in March.

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HR completed implementation of its new recruitment system on **March 31**. Manager training will be conducted in April. The web-based system supports the job requisition, posting, position description, application tracking, and candidate evaluation and selection processes. The system will also offer supervisor self-service in the recruitment and selection processes. It will also play an important role in supporting NRAO recruitment and employment of females and minorities.

HR initiated the **annual performance evaluation** process in March. In support of the NRAO Diversity Plan and AUI Broadening the Base Plan, employee training sessions were organized in April and May to assist employees in preparing a more effective self evaluation. On-site training will be provided at the Charlottesville, Green Bank, Socorro and VLA locations. A live video link will provide training to NRAO staff in Chile.

**KPMG concluded its study** of NRAO's Cost of Living coverage for its U.S. expatriates working for ALMA in Chile. KPMG concluded that the compensation package NRAO provides its expatriates provides them with the most net income after expenses. The study also resulted in two coverage improvements. The first is the use of the observed dollar rate from the Bank de Chile that better reflects the USD to CPL exchange rate. The second provides expatriates with currency conversion fee reimbursement coverage of two conversions per month not to exceed a combined total of \$50 per month.

Hispanic Electronics Engineer Juanita Banda, NA ALMA Photonics Group, Charlottesville, VA was interviewed for the February/March edition of **Diversity Careers in Engineering & Information Technology magazine**. The article highlights Juanita as one of several Hispanic engineers working in the government and science sector.

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The following Affirmative Action information reflects the continued minority and women diversification efforts of the Observatory in the science and professional/technical workforce.

The Observatory continues to sustain its progress in hiring and retaining minorities in two key groups: Sr. Managers & Division Heads; and Scientific, Engineers and Computer Professionals. NRAO hired three minorities to the scientific staff during this quarter, increasing minority representation by 1% among our Scientific, Engineer and Computer Professional staff.

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![](_page_48_Figure_1.jpeg)

The Observatory continues to sustain its progress in hiring and retaining females in two key groups: Sr. Managers & Division Heads; and Scientific, Engineers and Computer Professionals. NRAO filled its second key management position this fiscal year within with another female, increasing female representation by 1% among our Sr. Manager & Division Heads staff.

![](_page_49_Figure_0.jpeg)

![](_page_49_Figure_1.jpeg)

The NRAO turnover increased by 0.5% in Q2 FY 2009. The loss of 3 employees in Charlottesville increased attrition at this site by 2.4%. The impact of the NRAO Early Retirement program that was implemented in Q1 FY2009 is seen most dramatically at the site level: Green Bank incurred a 4% increase (10% to 14%) and Socorro incurred a 2% increase (7% to 9%).

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During Q2 FY 2009, the NRAO Operations budget operated under continuing resolution funding. At this level, the FY 2009 new funding is \$45,096K including \$39,086K for NRAO Operations and \$6,010K for EVLA. To relieve a projected Q3 FY 2009 cash flow shortfall, the NRAO requested and received a 75% advance funding totaling \$33,822K of the authorized continuing resolution funding level.

Once the continuing resolution is lifted, it is anticipated that the FY 2009 funding will be \$49,790K including \$43,600K for NRAO Operations and \$6,190K for EVLA. When combined with prior year commitments and prior year carryover, the NRAO Operations total budget, less EVLA, is \$47,684K.

Overall, the NRAO Operations budget is  $\sim 8.3\%$  below a linear spending rate of 50% through the second quarter. The following is a brief explanation of the WBS level 1 elements that are under/over spent in excess of 10% based on a linear projection rate.

Observatory Management. The overall Materials and Services expense is lagging a linear spend rate. This is due to collection in advance of 75% of the annual Directly Associated Costs (DAC) from ALMA Construction and ALMA Operations. Additionally, the leave pool is running a positive variance. Although the leave pool variance data is reported within the Observatory Management cost group at the end of the fiscal year the actual variance will be distributed (or collected in the case of under recovery) to the business units generating the variance.

WBS Level 1	Salaries & Benefits	Materials & Services	Travel	Revenue or Cost Recovery	Total	Linear Spending	Actual Exp + Comm	Actual Perce Expended & Committee
bservatory Management	6,029	2,913	333	-175	9,099	4,550	1,197	13.2%
ducation and Public Outreach	625	145	37	-125	683	341	402	58.9%
entral Development Lab	1,530	240	23		1,793	897	821	45.8%
ireen Bank Operations	8,624	2,823	177	-463	11,161	5,581	5,316	47.6%
lew Mexico Operations	14,955	3,965	191	-73	19,038	9,519	9,475	49.8%
Computer and Information Services	1,045	784	25		1,854	927	978	52.8%
cience and Academic Affairs	1,777	1,875	403		4,055	2,028	1,674	41.3%
NRAO Operations total	34,585	12,745	1,190	-836	47,683	23,842	19,863	41.7%
cience and Academic Affairs NRAO Operations total	1,045 1,777 34,585	1,875 12,745	403	-836	4,055	2,028	1,674 19,863	41

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