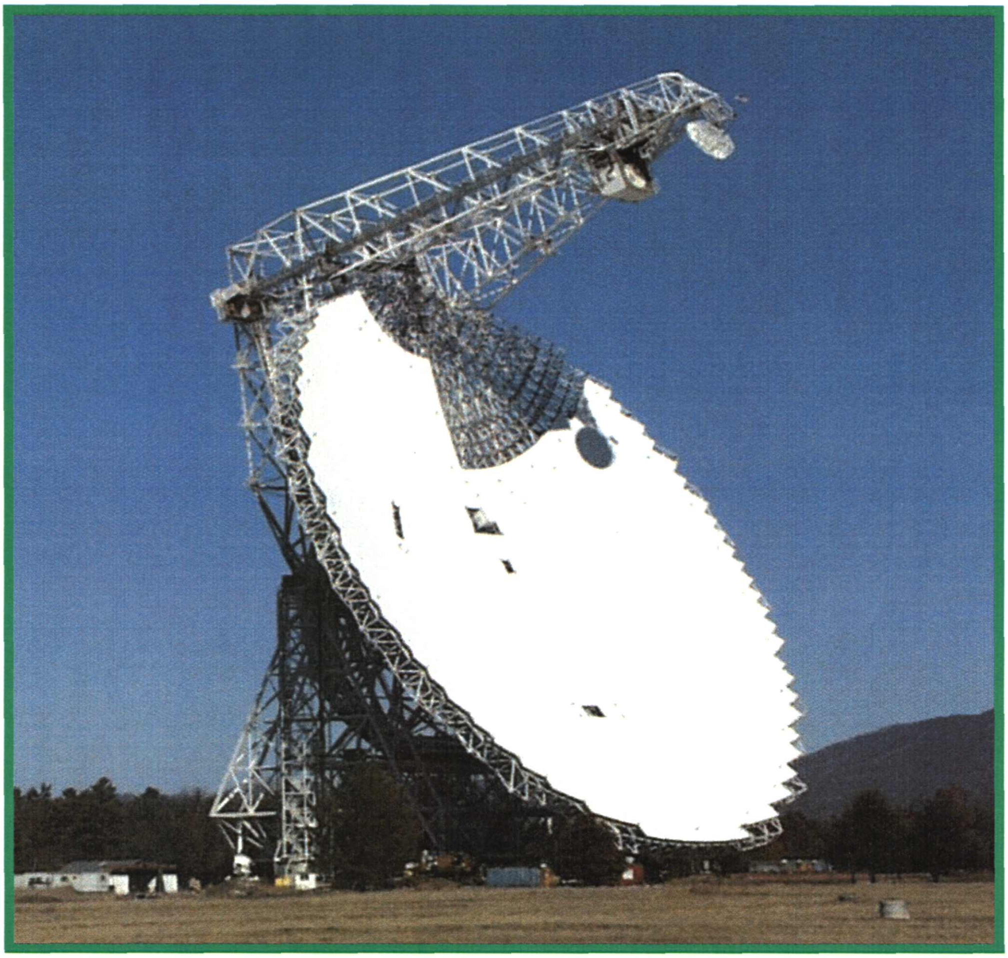

QUARTERLY REPORT

January 1 to March 31, 2000

NATIONAL RADIO ASTRONOMY OBSERVATORY

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A. SCIENCE HIGHLIGHTS

Introduction

In this section we review the highlights of science results derived from NRAO instruments over the last quarter. In a number of cases these projects generated press releases which were presented at the 196th American Astronomical Society meeting in Atlanta, Georgia, in January 2000.

Socorro

Rapidly responding to reports of an optical and X-ray outburst from the variable V4641 Sgr, VLA observations showed relativistic expansion of radio jets. A presumed black-hole binary system, V4641 Sgr showed the most dramatic X-ray intensity changes ever seen from such a system. The first VLA observations, made within 24 hours of the X-ray outburst, indicated that the jets had expanded sufficiently to show structure. This object's behavior makes it part of a new subclass of X-ray novae, and, at its distance of 1,600 light-years, the black hole in this system is the closest black hole to Earth yet discovered.

Investigators: R. Hjellming and M. Rupen

Water Molecules in Galaxy's Circumnuclear Disk "Reverberate" In Response to Central Engine - Maser emission from a circumnuclear disk of water molecules in the galaxy NGC 1068 varies in strength in response to changes in the energy output from the galaxy's central engine, VLA observations indicate. The water masers on both sides of the circumnuclear disk, some 5 light-years across, brightened within about two weeks of each other. Since dynamical processes within the disk itself would have taken much longer to affect both sides, the researchers presume the variations are due to changes in the energy output from the central engine's accretion disk. Such an effect promises to yield new information about both the maser disk and the central engine itself.

Investigators: J. Gallimore and M. Claussen; C. Henkel (MPIfR); I. Glass (SAAO); and A. Prieto (ESO).

Tucson

A Search for Azaheterocyclic Interstellar Molecules - Many large organic molecules are expected to be catalyzed on grains. Theoretical chemical models have demonstrated that many of the organic species observed are not the products of grain surface reactions but are synthesized in the warm gas from simpler species that are surface reaction products. Many observed organic molecules, however, have controversial or unknown formation routes in the gas phase. Recent theories suggest that grain-surface formation of some complex molecules can lead to cyclic isomers, such as ethylene oxide (c-C_2H_4O), ^{2}H-Azirine, and Aziridine. Several studies using the 12 Meter Telescope are currently underway with the goal to further delineate the chemical composition and evolution of hot molecular cores. 12 Meter Telescope measurements made during the first quarter of 2000 resulted in several new identifications of spectral lines from Aziridine. Firm identification awaits confirmation measurements using the 12 Meter Telescope during the spring 2000.

Investigators: Y.-J. Kuan (Nat'l Taiwan Normal U. & ASIAA); S. Charnley (NASA/Ames & UC, Berkeley);
S. Rodgers (NASA/NRC); H. Butner (SMTO); and L.Snyder (UIUC).

Calibration of the CO Tully-Fisher Relation - A homogenous and deep sample of equidistant galaxies has been observed in the CO 1-0 transition to study the effects of star formation on the Tully-Fisher relation. The primary goal of this project is to derive the z=0 calibration for the CO Tully-Fisher relation as a function of a galaxy's dust content and temperature, color, morphology, and surface brightness. A total sample of 20-25 galaxies are being used for this study.

Investigators: M. Verheijen and M. S. Yun; M-H. Rhee (Yonsei University); and A. Chung (Yonsei University).

Molecular D/H Ratios in Low Mass Cores - Observations of the deuteration properties of a number of low-mass protostellar cores indicate that molecular D/H ratios are enhanced over those observed in cold quiescent clouds by as much as 10 percent. Such high D/H ratios cannot be produced by simple cold, dense gas phase chemistry, thus requiring grain mantle chemistry to play a significant role in the chemistry of these regions. To further study the deuteration properties of low-mass cores, the DCN/HCN and HDCO/H_2CO ratios in a sample of approximately 10 low-mass cores are being studied. One main goal of this project is to determine if D/H ratios are universally high in low-mass cores.

Investigators: J. Hatchell, T. Millar, G. Fuller, H. Roberts, and J. Buckle (UMIST).

Sulfur Chemistry in Protostellar Outflows - The details of the process by which outflows clear the circumstellar material around protostellar sources are presently unclear. Recent data suggests that this may happen very early in protostellar evolution, with the outflow initially erupting in an energetic burst and impacting with the circumstellar material. This initial burst sweeps up a significant amount of material, but as the source evolves from Class 0 to Class I, the outflow close to the protostar becomes much more poorly coupled to the circumstellar material. By observing the evolution of sulfur chemistry in the central portions of young stellar objects, this evolutionary scenario can be tested. Chemical models predict differential abundances between sulphur-bearing species as the star formation process commences. By observing the relative abundances of hydrogen sulfide (H_2S), sulfur monoxide (SO), and sulfur dioxide (SO_2) toward Class 0 and Class I sources, the time since the onset of grain mantle evaporation can be derived. 12 Meter Telescope measurements of these molecules in their 2 and 3 mm transitions are currently being used to derive this timescale.

Investigators: J. Buckle, G. Fuller, J. Hatchell (UMIST).

B. MILLIMETER ARRAY PROJECT

In the past three months, the U.S. side of the ALMA Project continued to transition to a joint U.S.-European Project. During this period, we held a number of joint design reviews, reached consensus on significant technical approaches and completed a full cost analysis of the construction phase. This cost analysis has been submitted to the NSF for its review.

Principal progress made in several of the major task areas of the U.S. ALMA Project in the past quarter include the following:

Antenna

The contract with Vertex Antenna Systems (VAS, previously known as TIW) for the ALMA-U.S. prototype antenna was signed on February 22. A Kick-off Meeting was held at the VAS Offices in Santa Clara, CA, on March 16. Also present at the meeting were VAS's partners in the contract, Vertex Antennentechnik (VA, previously known as Krupp Antennentechnik) from Duisburg, Germany. Vertex's current plan is for VA to do most of the design of the antenna and the fabrication of the reflector, with VAS fabricating the pedestal and providing the field assembly at the VLA site. At the meeting, clarification of various specifications and Interface Control Documents (ICDs) were provided, and VA provided dates for all milestones specified in the contract.

On 20 March, a teleconference was held with the second place bidder, Antedo, for the purpose of debriefing them on the antenna procurement. This meeting was held at the request of Antedo and included representatives of their major subcontractors, Composite Optics, Inc., and Codem. The NRAO reviewed the chronology of the procurement and answered Antedo's questions concerning aspects of the Antedo proposal. The meeting was cordial and Antedo seemed to accept NRAO's responses.

Site Development

We are pleased to report that the Chilean Finance Minister has signed a decree listing explicitly the exemptions AUI shall enjoy in relation to the construction, installation, maintenance, and operation of the MMA in Chile. The list includes import duties, Value Added Tax, property taxes, Municipal taxes and fees, diesel oil taxes, and some other minor exemptions. We requested this decree because otherwise some of the exemptions, such as the 18 percent VAT, by virtue of being only implicit in the decree of 1998, could not have been claimed.

Interaction of the U.S. group with Daniel Hofstadt (ESO) began in earnest on issues related to the AUI-ESO mode of joint operation in Chile. An outline of an operations plan and a baseline list of personnel to staff the observatory operations was produced. This information will be input to the cost estimation process.

Receivers

The sideband-separating, balanced mixer design for the 211-275 GHz band was completed and it has been sent to the mask maker for fabrication. This design will be fabricated using the NRAO standard 211-275 GHz elemental mixers by the University of Virginia as soon as the masks are received. The design of the mounting block was continued, and it is anticipated that mounting blocks will be ready when the first wafer is received from UVA.

Two new SIS wafers were delivered by the University of Virginia: one with elemental mixers, and one with balanced mixers. The I-V (current-voltage) curves for the junctions on these new wafers look very good and are expected to yield good noise temperatures.

Work on the layout of the first 650 GHz SIS mixer wafer for fabrication at the State University of New York at Stony Brook was completed. The design is now at Stony Brook and they have begun the detailed layout. We hope to have mixers to test about the first of April 2000.

Investigations of the properties of various materials which may be suitable for the construction of low-loss, wide-band, zero leakage vacuum windows were carried out. Most of this work was done at Brookhaven National Laboratories using the National Synchrotron Light Source, which is the highest intensity source available at millimeter wavelengths. Investigations of various possible Fourier Transform Spectrometers which may be suitable for testing of materials were continued, but no definite conclusion was reached.

Local Oscillator System

The investigation of how to minimize local oscillator phase noise continued with detailed measurements on individual components in the LO chain: intrinsic YTO noise, amplifier noise, and multiplier noise. This noise is best characterized in the time domain, since in the case of ideal noiseless components it will be the same at all frequencies. The expected noise from the antennas and atmosphere at Chajnantor on a typical good day is about 100 femtoseconds RMS. The oscillator chain presently under test exhibits about 20 femtoseconds RMS, so that if the higher frequency components are close to ideal, the electronic contribution to phase noise will be satisfactorily small. We obtained the excellent result that the phase noise contribution of a 22 GHz power amplifier is the same whether it is operated in a saturated or non-saturated mode, which is an important factor in providing sufficient LO drive power. We received an 80 GHz MMIC power amplifier from JPL on loan for test and expect to measure its characteristics in February. Work is continuing on optimizing the performance of the phase-locked loop circuit which drives the fundamental oscillator.

IF System

The design of the micro controller portion of the second synthesizer/fringe generator was refined. The design will be reviewed at the ALMA System review in March. The laser controller was successfully instructed to communicate over the CAN bus and its functionality appears satisfactory. The next step involves writing routines to communicate with the DS1820 temperature monitor and serial number generator.

Fiber Optics System

Research was conducted on the availability of Optical Wavelength Lockers for maintaining laser operating wavelength over extended periods of time.

An analysis was completed on the options for locating the FIR filter and for alternative schemes of FO transmission. The current baseline scheme is found to adequately address the existing correlator chip and system design. An estimate for the cost of hardware for 10 Gbps Tx/Rx sets will be between $15k and $10k. Alternatives may require a significant redesign of the correlator to match a ~ 155 MHz clock speed.

We are also researching the cost and availability of 2.5 Gbps FO components as requested by the system integration group. We have determined that the cost of 2.5 Gb/s logic is comparable to the 10 Gbps hardware— mainly because of the added cost of DWDM Mux and Demux hardware. Added complexity and difficulty exist because of the problem of retiming data arriving on different fibers (3 fibers for 2.5 Gbps solution), and changing the correlator clock from 125 MHz to 155 MHz. Changing the clock to 155 MHz simplifies both 2.5 and 10 Gbps systems. The cost of three fibers versus one is part of the analysis.

Discussions were held with the ESO FO group (Marc Torres) on the performance of the Diamond E-2000 series optical connector. Torres uses this at the IRAM array and finds that this connector is far superior to other connectors for phase stability as a function of applied mechanical forces.

Correlator

Work continued on designing the signal interfaces for the digital FIR filter card. Laboratory tests of Xilinx Virtex series chips produced data on how to configure the chip-to-chip interfaces.

A kick-off meeting was held with selected custom correlator chip designer. Detailed exploration of the design alternatives was begun; this will lead to a decision on whether to select 0.25 or 0.18 micron technology, and whether to double the spectral resolution by designing a chip with 8 K instead of 4 K lags.

Design work continued on all parts of the ALMA correlator. Software work continued for the test correlator.

The correlator Preliminary Design Review was held in Charlottesville on January 20-21. There were 26 attendees for at least part of the proceedings. The committee reached the conclusion that the ALMA correlator design is excellent, providing the capabilities specified by the science goals at minimal cost. A draft report was written and will be distributed and posted on the ALMA web site after review and approval.

Computing

The standard interface daughtercard was laid out and bids were received for prototype manufacturing. An initial VxWorks M&C device binding was written. A Frequently Asked Questions document was written for the M&C interface to answer questions about why some design decisions were taken. Besides lab testing, the standard interface will be used for compressor monitoring at the 12 Meter telescope, a real world test. A discussion of time distribution and device synchronization was started with the system group. A test correlator software design document was released, and a panel for its CDR is being solicited. The ALMA Science Software Requirements committee met in Socorro to further their work on a first report for software requirements, to be issued as an ALMA memo in late February. The U.S. and European software groups held a first joint phone meeting, to be repeated at monthly intervals.

System Integration

A practical test of the viability of using optical offset pointing to refine and maintain the pointing of the ALMA antennas was conducted at the 12 Meter Telescope. The system integration group used the optical pointing camera on the telescope: it is normally used for optical pointing runs, recording the data for later processing in order to derive pointing model constants. The new experiment was designed to test the viability of using real-time feedback into the control system to guide the telescope. That is, true offset guiding, locking on to a star optically to control the radio telescope pointing.

In operation, data from the CCD were processed in real time by two orthogonal one-dimensional Gaussian fits (i.e., nominally in azimuth and elevation) to the star image, to derive offsets from the nominal CCD field center. These offsets were then fed continuously to the telescope real-time tracking system, as additional pointing corrections. The cycle time of the feedback was about 5 seconds. The 12 Meter tracking was held to significantly better than an arc second with this technique, over a period of several hours. Because the optical images (recorded at up to a 30 Hz rate) were averaged over a few seconds, it's possible to do much better than the normal optical seeing limit. This technique will be followed up on the ALMA prototype antennas.

Calibration and Imaging

The Calibration and Imaging Division concentrated on configuration issues, including continuing work on the problem of where to place the compact configuration at the site, given topographic and other constraints, and the creation of a mask for antenna placement. An e-mail reflector was arranged for the configuration working group. A work plan was created, identifying issues and designating individuals to lead the efforts. Planning continued for the CoDR in Tucson on March 20-21. A Site Monitoring Review was scheduled for 22 March in Tucson. Web sites with Interest Groups and email addresses were set up for configurations, water vapor radiometry, and site testing. Representatives attended the Science and Software Requirements meeting and the AIPS++ sponsored "Pipelines in Radio Astronomy" meeting in Socorro. Wootten attended the Correlator PDR; the proposed correlator design can fulfill nearly all the science requirements which now exist or can be reasonably foreseen, with good upgrade paths for future needs. The ASAC meeting was held on January 10, at which the ASAC charter was developed and plans for the March 10-11 meeting developed. Work began on Project Book updates and on the ALMA construction costing exercise.

The malfunctioning radiotheodolite was shipped from Chajnantor and tested in the lab prior to return to vendor. Subsequently, it was sent to the shop for mechanical repairs. A list of coordinates of landmarks, etc., on site was compiled and added to the web pages. The 350 μm tipper data was analyzed and the results were inserted in the compilation on the web. An upgrade to the seismometer firmware was received from the manufacturer Kinemetrics. An exchange of correspondence with Y. Robson (MRAO) about cross correlation of interferometer data was used to help define the WBS task for WVR radiometery.

C. GREEN BANK TELESCOPE

Project Summary

Of the 2,004 panels that make up the primary reflecting surface, 1,985 have been installed on the telescope. The panel manufacturer, Radiation Systems, Inc., has completed the fabrication, measurement, and painting of all GBT surface panels. All of the panels have been delivered to the GBT construction site, and all of the 2,209 surface actuators that support the panels have been aligned and welded in place. The setting of panel corners will resume in early April. Eight of the surface panels were slightly damaged during the installation process, and these were returned to the manufacturer for a re-measurement of their surface accuracy. The re-measured surface RMS of each panel was still within specification; therefore, none of the eight panels needed to be reconditioned.

The 30 gear segments that make up the elevation bull gear were aligned, and the telescope was tipped to 5 degrees elevation for the first time on February 29.

The testing of the actuator control cables on the telescope began on January 18. Approximately 1,770 of the 2,209 actuator cables have been tested. Despite the installation of protective coverings over the cable connectors, water accumulated in about a third of the connectors, causing these cables to fail their insulation resistance test. Cables with wet connectors are hung out to dry after they are tested instead of being permanently attached to an actuator. These cables will be retested to insure that their insulation resistance is acceptable. The retesting of the cables will delay the outfitting of the actuator control room by two months.

Preliminary tests of the GBT servo system began in January. The azimuth and elevation encoders were installed in late March, and the NRAO servo monitor was installed in early February. The Kollmorgen motors that position the subreflector were returned to the manufacturer for warranty work. Servo tests of the subreflector motors have been delayed due to the failure of a transformer that provides electrical power to the motors.

The NRAO staff reviewed and returned comments on COMSAT's Servo Site Test Procedure, Operations and Maintenance Manual, Site Restoration Plan, Optics Alignment Procedure, and Final Testing and Acceptance Plan.

The assembly of the four beam, dual polarization Q-band receiver is essentially complete. The Green Bank machine shop fabricated the receiver's four feed horns, and the Central Development Laboratory delivered the receiver's eight low noise amplifiers. The initial cool-down and testing of the receiver will begin in April.

A calibration procedure for the surface retroreflectors was developed, and 1,437 of the 2,209 retroreflectors have been calibrated. The remainder of the retroreflectors will be calibrated by mid-April. The mount that supports a retroreflector actually suspends the retroreflector below the telescope surface. The calibration procedure is needed to determine the normal distance between the telescope surface (the face of the mount) and the retroreflector's reflecting point. These normal distances must be subtracted from the rangefinders' measurements of the surface to give the true distance to the surface.

A two-element, 100-meter baseline, 12 GHz interferometer was placed into operation the week of March 6 to measure atmospheric phase stability. The measurements will be used to study anomalous refraction, which can adversely affect telescope pointing at high frequencies. The interferometer is a replica of the device used for ALMA site monitoring. This project was a cooperative effort between NRAO Tucson and Green Bank.

The feed horns for low frequency receivers on the GBT are fabricated by alternately stacking aluminum hoops and rings. After the hoops and rings are welded together, the exterior of the resulting structure is reinforced with fiberglass. The fiberglass reinforcement of the feeds for the S-band, 800 MHz, and 1070 MHz receivers was completed over the last quarter. All feeds requiring fiberglass reinforcement are now complete.

Project Budget
(as of February 29, 2000)

The project budget was revised to reflect the extension of the project through the third quarter of 2000. Overruns caused by the project extension were covered by diverting funds from the project's Monitor and Control budget. The resulting shortfall in the Monitor and Control budget was covered by a $75k supplement from the Observatory's research equipment budget. An additional $80k for data analysis computers will be sought from a Sun Microsystems grant. The Observatory's research equipment budget also supported allocations for the Q-band tertiary mirror ($10k) and prime focus receiver 2 ($20k). The remaining money to be spent in the Electronics and Monitor and Control budgets is earmarked for an array of computer disks (RAID) and a data access workstation. The remaining money to be spent in the Surface and Pointing budget is for the installation of the laser access platforms on the GBT feed arm, the installation of cardinal point weld plates on the GBT structure, and the wiring of the feed arm lasers.

Category	Allocation ($k)	Expended ($k)	Balance ($k)
Antenna	9	25	(16)
Electronics	30	3	26
Surface/Pointing	74	3	71
Monitor/Control	56	0	56
Project Management	153	27	126
Total	322	58	263

Project Major Milestones

Milestone	Original Date	Revised Date	Completed
Complete Q-band Rx	03-31-00	04-07-00	04-07-00
Complete Q-band tertiary	04-15-00	12-01-00	
Complete IF rack	07-14-99	04-28-00	
Complete 290/395 feed	08-16-99	05-31-00	
Fiberglass S-band feed	07-16-99	02-15-00	02-15-00
Fiberglass 800 MHz feed	07-16-99	02-23-00	02-23-00
Fiberglass PF-5 feed	07-16-99	02-23-00	02-23-00
Modify holography Rx	12-01-99	05-15-00	
Install ground lasers	06-28-99	04-14-00	
Repeat ground laser meas.	06-28-99	04-19-00	
Develop retro calib. proc.	01-21-00	03-01-00	03-01-00
Calibrate surface retros.	02-25-00	04-12-00	
Measure az. track profile	09-15-99	06-05-00	
Complete commission schd.	02-29-00	05-10-00	
Complete act. cable test 1	04-01-00	04-24-00	
Complete act. cable test 2	05-31-00		
Complete ACR outfitting	06-01-00	08-01-00	
Complete panel corner set	06-01-00	06-15-00	
Install servo monitor	02-15-00	02-07-00	02-07-00
Install 12 GHz interfer.	03-06-00	03-06-00	03-06-00
Install L & S-band feeds	06-15-00		
Measure all Rx feeds	07-03-00		
Assemble all cryo. comp.	07-14-00		
Feed arm servo tests	06-30-00		
Az/El servo tests	08-18-00		

GBT Software

General

We have begun a major push to make the GBT Metrology system more readily available to investigators from other groups. We will provide an interface from the Glish command language to the Metrology ZIY computer to enable both the selection of laser rangers and targets and also the acquisition of the range measurements. When this effort is complete, a repeat of the successful laser test measurements of June 1999 from a general purpose workstation. In addition to the laser ranging measurements, we should also be able to collect coordinated accelerometer and weather data. We presently plan to be able to make the first observations of this type by June.

Personnel

We are pleased to welcome Richard Prestage, who will join the software group in June. He will take over the management of GBT software development from Gareth Hunt in September.

Several people from NRAO associated with the GBT (Brandt, Fisher, Hunt, Jewell, Prestage) gave presentations at the SPIE conference on Astronomical Telescopes and Instrumentation in Munich.

Monitor and Control

To consolidate the experience gained on the integration tests, we created version 3.0 of the M&C software. In this release, we corrected as many of the reported bugs as possible in order to create as reliable an environment as possible for the ongoing integration tests. It is certified to run on the Solaris 2.6 and Linux 6.0 operating systems with the corresponding new compilers and software libraries. The code used on the single board computers is still being built using an older release of the Free Software Foundation g++ compiler.

The M&C general libraries, i.e., those which contain no device-specific software are also available on the Windows NT platform. This is needed for the metrology control software to access the antenna commanded track, and also other ancillary information such as the weather information.

The software to control the spectral processor back-end is included in the new release. A few enhancements were needed to the holography back-end to improve the high speed operation. We now have three of the four GBT back-ends fully supported.

Although we have made progress on the spectrometer, it has not been as nearly as much as hoped. We have made progress on the multi-tasking on the Sparc-based spectrometer controller. The primary reason for the lack of progress was that several hardware problems precluded software development. These have now been addressed, and we still plan to have the spectrometer software complete by the summer.

Coding to reflect the hardware changes in the IF rack are complete. It cannot be fully tested, however, until the hardware modifications are complete and the rack re-installed. However, we did take the time to create an IF rack simulator to test as much as possible. The testing should be complete in May.

Work is in progress to complete the software control of the LO system, including switching signals to the frontends and backends. The basic functions are operational, and we expect the work to be complete in June.

GBT Operations Documentation

Completed in the first quarter of 2000 were Operations Descriptions of the VLBI, Spectral Processor, Spectrometer and DCR subsystems. Drafts for the Operations Description of the Servo System and Radio Communications were also completed. The operations manual will be available in both hard copy and on the web for easy access. The evaluation of which commercial tool to use for this purpose will be completed in the second quarter of 2000.

GBT Preventative Maintenance

A detailed assessment of the preventative maintenance requirements for the GBT was completed in the first quarter. A realistic estimate of the manpower and telescope downtime is now possible. The list of required lubrications and their cost estimates will be completed in the second quarter.

GBT Operator Training

Operator familiarization training on the LO/IF, Spectrometer, Digital Continuum Receiver and VLBI subsystems was completed in the first quarter. Operator familiarization training on the Comsat control devices for the GBT, HVAC, and Cryo sub systems will be completed in the second quarter.

GB Maintenance Bookkeeping

The assessment of and decision to use a commercial software tool (Mainsaver) to manage PM scheduling and track repair of failures was completed in the first quarter. A preliminary attempt at setting up the software for use on GB telescope systems will be completed in the second quarter of 2000.

GBT Operations Outfitting Contribution

In the first quarter, the GBT Operators have assisted in GBT corner setting, testing of actuator cables, and calibration of the more than 2,000 surface retro reflectors. This effort (especially corner setting and cable testing) will increase in the second quarter to such an extent that majority of the GBT Operator pool will be tied up in these tasks.

Use and Testing of the GBT M&C Software System

Whenever possible and practical, GBT operators have assisted and become involved with testing and use of the M&C software system. This effort will continue into the second quarter and will increase as the system becomes more usable.

D. CENTRAL DEVELOPMENT LABORATORY

Amplifier Design and Development

Design and development work concentrated in two areas: balanced amplifiers below a frequency of 2 GHz using GaAs transistors, and the use of InP transistors below a frequency of 18 GHz.

Balanced amplifier development is aimed at developing a series of low-noise cryogenic amplifiers covering the 290-2000 MHz frequency range for use on the GBT. The simultaneous power and noise match characteristics of balanced amplifiers over an octave or more bandwidth without the need for bulky input isolators make them attractive for low-noise receiver applications.

The administrative details of a contract with MIT/LLNL for the development of a pair of low-noise GaAs balanced amplifiers covering 800-1200 and 1200-2000 MHz for an axion search project was completed. Preliminary design work on this project also began this quarter with the goal of delivering a pair of amplifiers toward the end of next quarter.

Two amplifiers were developed and refined using InP transistors below 18 GHz: the first is optimized for the frequency range 12-18 GHz, and achieves a receiver noise temperature of about 6 K over this range; it is useful as low as 8 GHz. This amplifier is intended to replace the existing narrow-band 15 GHz amplifiers in VLA receivers and to serve as the first IF amplifier in the new W-band VLBA receivers. The second design is optimized for the frequency range 8-12 GHz, and achieves a receiver noise temperature of about 5 K over this range; it is useful as low as 3 GHz. This amplifier was integrated with a SIS mixer to achieve an 8-12 GHz bandwidth as described in the SIS mixer design section. It is also intended to replace an old-design 4-6 GHz amplifier which has been a workhorse in many past and existing receivers.

The two low-frequency InP amplifiers exhibit a higher noise temperature than is predicted by present models, although their performance is better than any other amplifier in these frequency bands. Work is continuing to try to understand what effects are causing the increased noise, and to determine how to overcome it and achieve even lower receiver temperatures.

As part of continued development, we are staying informed about the status of MMIC amplifier work using InP transistors, which is being done primarily by JPL, TRW, and HRL (Hughes). At the present time, the NRAO amplifiers using discrete devices and chip-and-wire construction techniques show superior performance and consistency compared to MMIC amplifiers, but they require a generous amount of highly-skilled labor to produce. We have studied the possible economic advantages and performance implications of the present state-of-the-art in MMIC (as opposed to discrete transistor) technology, and will continue to evaluate this technology in order to determine if and when NRAO should become involved in this effort.

Amplifier Production

A total of 27 low-noise amplifiers, using InP transistors, in frequency ranges from 12 to 45 GHz was produced. In addition, three balanced 290-395 MHz amplifiers were produced and delivered to NAIC for use in Arecibo receivers.

A total of 12 K-band (18-26 GHz) amplifiers was produced. Four K-band amplifiers were shipped to the AOC for their receiver upgrade program. Two K-band amplifiers went to OVRO for support of their ALMA-related water vapor radiometry program. An additional six K-band amplifiers are in the final stages of test and documentation.

Three Ka-band amplifiers have been completed and are awaiting initial test and evaluation.

A total of 12 Q-band (37-45 GHz) amplifiers was produced. Five Q-band amplifiers were sent to the AOC for the ongoing receiver construction program. One of the amplifiers is to be used experimentally to boost the injected switched cal signal on a Q-band receiver to facilitate observations of the active sun. Four Q-band amplifiers were provided to the GBT to complete their amplifier requirements for the eight-beam receiver. Three additional Q-band LNA's are in the final stages of test and documentation.

Amplifiers currently in production are K, Ka, Q, and W, along with the new style 8-18 GHz amplifiers for IF service in W-band receivers. The machine shop is completing a build of K-band chassis and will begin its first production run of W-band bodies shortly. Previous W-band machining work for the MAP project had been contracted outside of NRAO.

Superconducting (SIS) Millimeter-Wave Mixer Development

SIS Mixer Development

We have completed the design of a 211-275 GHz single-chip balanced sideband separating mixer for ALMA. The masks have been ordered. The mixer will be fabricated at UVA.

The design of the 602-720 GHz mixer has been completed and it is being fabricated at SUNY. This single-ended mixer will also serve as a building block for balanced and sideband-separating mixers. In collaboration with S. Srikanth, we have completed the electrical design of the mixer block which has an integrated scalar feed horn. We have been working with a commercial machine shop on the mechanical design of this mixer, whose waveguide size is 0.007" x 0.014".

Continued work on balanced and sideband-separating mixers using waveguide hybrids indicates that this approach should be practical for all ALMA bands up to at least 720 GHz. The reduced LO power requirement and inherent LO noise rejection of balanced mixers are likely to make them crucial to receivers that will cover the full ALMA frequency bands. Our collaboration with Hertzberg Institute continues and HIA should demonstrate a 230 GHz balanced mixer using this technology with our building block mixers later this year.

SIS Mixer Testing

Software was completed to generate a real-time strip-chart display of the Y-factor with 7.5 screen updates per second when using a chopper wheel to switch between hot and cold calibration sources. To obtain the measurement standard deviation of about 0.01 dB, each screen update requires averaging 512 samples from the chopper wheel. This approach is now used for manual mixer optimization, and is essential for the next development phase, which will allow rapid system noise temperature measurements while various parameters are varied under computer control.

Initially, we developed interim noise measurement software to replace the manual measurements used previously. This semiautomatic software still requires manual determination of the optimum mixer bias point, after which the program automatically measures operating parameters and noise temperature data and stores the results in a spreadsheet. The software is now being enhanced to find the optimum operating point automatically by collecting noise temperature data as a function of bias, LO frequency, magnetic field, and intermediate frequency.

During this quarter, the measurement database has been restructured to support both an unlimited number of mixers and an unlimited number of dependent measurement variables while minimizing the database file size. During the next quarter, we will complete software for measuring and plotting mixer noise temperatures as a function of bias voltage, magnetic field, and IF frequency.

The second 4 K JT test Dewar was completed and successfully cooled. It remains to instrument this dewar.

The room temperature part of the 4-12 GHz IF system for testing ALMA receiver components has been completed. This contains amplifiers, filters, programmable attenuators, switches, a wideband tunnel diode detector, and a control unit.

The first of the three IF amplifier bias supplies was completed during this quarter and used for the evaluation of integrated mixer-preamps. The remaining two supplies will be completed during the next quarter.

Design of the new bias supplies for the balanced sideband separating mixers was delayed and resources redirected to development of the mixer noise temperature data acquisition software and optimization routines.

During this quarter, we built (or rebuilt) and tested a total of four balanced or single-ended SIS mixers fabricated at UVA and SUNY.

Broadband IF Development

As a first step towards integrating an IF preamplifier with a SIS mixer, a 3-13 GHz InP HFET amplifier of established design (M. Pospieszalski) was attached to an existing 230 GHz SIS mixer. The amplifier was modified to include a bias circuit for the mixer, and the mixer block was modified to allow direct connection to the amplifier without a connector. We measured a minimum DSB receiver noise temperature (including the optics) of 55 K at 4 GHz IF, but the performance degraded at higher IF's. Simulations of the mixer-preamp using MMICAD showed a flat response in noise performance across the 4-12 GHz IF bandwidth, so we are now investigating the discrepancy. The initial results are encouraging.

Vacuum Window Development

Prototype PTFE/crystal quartz/PTFE vacuum windows for ALMA, which were being tested on the VLBA's 3 mm receivers, were reported leaking. This was found to be a result of the Viton o-ring bearing against the PTFE surface of the window. The windows were modified so the o-ring contacted the quartz, which was found to give acceptable vacuum integrity.

We have been investigating the use of Zytex to replace the hard-to-obtain Gortex RA7957 as the outer layer in a 5-layer broadband vacuum window. A prototype 5-layer window will be ready for testing during the next Brookhaven run. It is expected that low-loss windows can be made using Zytex for all the ALMA bands up to at least 300 GHz. We are measuring the properties of Zytex and Gortex RA7957 using capacitance measurements and Fourier transform spectroscopy.

We visited the National Synchrotron Light Source at Brookhaven National Laboratory, which has Fourier transform spectrometers capable of measurements at wavelengths of 3 mm and longer. Several measurements of vacuum windows and materials were made, and the existing beamline equipment was evaluated in preparation for future work there. We also visited UCLA to evaluate their Specac FTS.

Publications

S. Srikanth and G. Ediss, "Optics for the 600-720 GHz Mixer Test Receiver," ALMA Memo No. 284, 24 January 2000. Available in pdf format at www.alma.nrao.edu/memos/html-memos/abstracts/abs284.html.

G. Ediss, A. Kerr, D. Koller, "Measurements of Quasi-Optical Windows with the HP 8510," ALMA Memorandum 295, 10 March 2000. Available in pdf format at www.alma.nrao.edu/memos/html-memos /abstracts/abs295.html.

Electromagnetic Support

GBT

The Short Backfire Antenna feed for the 510-690 MHz band has been built and measured. The measured return loss is better than -14.0 dB for one polarization and better than -12.9 dB for the other polarization. There is good match between the principal plane patterns up to 630 MHz. Sidelobes are present in the H-plane patterns in the -15 dB level at and above 660 MHz. The taper at the edge of the main reflector varies between -9.0 dB and -13.0 dB across the 510-690 MHz band. The phase center of the feed travels 20 inches in the frequency band. The cross-polarization level is -23 dB at the worst.

Work on the Q-band optics continues. The reflector on top of the feeds has been designed. The second reflector is being analyzed.

General

Two different versions of the feed for the 600-720 GHz test receiver have been designed. The feed will be an integral part of the mixer block. One version will have variable depth corrugations while the second version will have both variable depth and width corrugations. Drawings have been sent to manufacturers to study the feasibility of manufacture and for obtaining quotations.

Spectrometers/Correlators

During this quarter, most of the time was spent working on the design of the ALMA correlator. The two most important events during this period were the correlator preliminary design review and the award of a purchase order for the design of the ALMA correlator chip.

A small amount of time was spent in support of the GBT and Tucson spectrometers, including two trips to Green Bank.

The ALMA correlator PDR presented the system design to the scientific community for review and criticism. Some substantial changes (mostly performance enhancements) to the Long Term Accumulator (LTA) section of the correlator resulted from the PDR but, for the most part, the design was accepted as presented.

Work has now started on the design of the 4096 lag ALMA correlator chip; however, budget concerns forced the abandonment of several attractive alternatives for the chip design.

Some time was spent in hardware support of the ALMA test correlator(which is based on the GBT spectrometer design). Software development for this system continued during the quarter.

Accomplishments -

1. Near completion of the redesign of the ALMA digital filter card using a newer Field Programmable Gate Array (FPGA) family, including the redesign of the tap weight multiplier FPGA chip.
2. Completion of the new LTA design up to the point of a formal design review.
3. Completion of the design, layout, and construction of a test card with the intention of investigating methods of on-card and off-card interconnects of 125 MHz logic signals.
4. Final review and release of the ALMA correlator chip specification and the start of the ALMA correlator chip design.
5. Successful end-to-end testing of the ALMA test correlator, including extraction of station spectra.

Goals -

1. Complete the design of the filter and LTA cards, and completion of the PC card layout for both. Continue redesign of the station card.
2. Complete system rack layout now that a final decision for the location of the digital filter card has been made.
3. Continue the design phase of the correlator chip.
4. Complete FPGA chip designs for the filter card, the station card, and the LTA.

ALMA LO Source

The purpose of this project is to develop a series of electronically-tunable, phase-locked sources operating near 100 GHz. These sources will be used to drive millimeter- and submillimeter-wave frequency multipliers that produce the first-LO signal for the ALMA receivers.

During this quarter we evaluated the amplitude and phase noise performance of a proof-of-concept phase-locked LO chain which included the 80 GHz power amplifier from JPL, a 40/80 GHz frequency doubler fabricated at NRAO, a commercial YIG-tuned oscillator, and a commercial MMIC power amplifier packaged at NRAO. The amplitude noise was measured indirectly by measuring the noise temperature of a SIS mixer as pumped by the LO source. The experiment was configured such that the noise added by the YIG-based LO chain could be directly compared with that of a Gunn oscillator. We established that the amplitude noise levels in the sidebands located at 1.5 GHz from the LO source frequency were sufficiently low enough to meet the ALMA specifications.

The phase noise of the YIG-based LO chain was measured using a commercial measurement system. It was found that the phase noise of the LO on time scales of less then one second was suitable to provide 90 percent interferometric coherence at 950 GHz, in accordance with the ALMA specification.

Also during this quarter a biasing circuit for the MMIC-based power amplifiers was developed. We are currently building three power amplifiers with associated power supplies for use by the SIS mixer development group.

ALMA Frequency Multipliers

The purpose of this project is to develop millimeter- and submillimeter-wave frequency multipliers for use in laboratory experiments and receiver systems associated with ALMA. A series of multipliers using varactor and varistor circuits operating in the 50 to 950 GHz range are being developed. We have an ongoing contract with the Semiconductor Device Laboratory at the University of Virginia (UVA) to support semiconductor device research.

During this quarter a new wafer of varactors suitable for the 110/220 GHz doubler design was fabricated by the UVA group. The diode characteristics were measured on-wafer and found to be adequate for this circuit. The wafer will be diced into individual varactor circuits early next quarter. Evaluation of the 110/220 GHz doubler will begin shortly thereafter.

As part of our contract with the UVA group, a second wafer of spiral inductor test structures was fabricated and then evaluated in a specially designed test fixture. A fabrication problem which resulted in the incorrect air bridge height was identified and corrected. These inductors are required for the 81/243 GHz tripler which is currently in development.

Also in collaboration with the UVA group we are developing capacitors that are suitable for integration with GaAs circuit processing. We are encouraged by the working properties of Chemical Vapor Deposition-grown oxide for use as the dielectric. Test structures were fabricated with the correct capacitance per unit area needed for the 81/243 GHz multiplier circuit. We also eliminated spin-on glass dielectric due to metal adhesion problems. We plan to investigate sputtered (amorphous) quartz early next quarter.

Also in collaboration with the UVA group, we have successfully molded a polyurethane (PUR) replica of the 55/110 GHz doubler. We are currently addressing metallization problems associated with sputtering a uniform layer of gold into the deep narrow channels. Sputtering may be suitable after some adjustments, but we are also exploring electroless nickel plating of the plastic followed by gold electroplating to the appropriate thickness. We plan to build and evaluate a molded 55/110 GHz doubler sometime next quarter.

We have developed a procedure for measuring the thermal properties of the molded plastic and the associated metallization at cryogenic temperatures. All of the preliminary work is completed (wiring of temperature sensors, making mounting brackets, etc.) and we are now ready to begin measurements. Understanding the thermal properties of the PUR is essential for adapting this technology for the fabrication of ALMA frequency multiplier blocks which are being designed for use at 80 K.

We have completed the design of an 80 K cryostat for cooling the frequency multipliers for evaluation. The cryostat is currently being fabricated at NRAO.

We have also completed copper plating and gold plating on the inside wall of stainless steel waveguide structures for use by N. Erickson at the University of Massachusetts in the development of a calorimeter-based power meter. The calorimeter is needed for accurate evaluation of frequency multiplier performance at submillimeter wavelengths. The success of this plating operation required the development and fabrication of a special waveguide holding fixture.

Fully-Sampled, Focal Plane Array Feed

The purpose of this long-term development project is to explore the technical challenges associated with the development of a "radio camera" for imaging applications on single-dish telescopes. The camera consists of a two-dimensional array of receiving elements located on the telescope's focal plane. These elements sample the focal plane electromagnetic field distribution, yielding complex signals that are processed using both analog and digital techniques to synthesize the desired number of telescope beams. We are currently working on the third generation of the 19-element proof-of-concept system.

During this quarter we began our detailed analysis of the current low-noise sampling element configuration in order to understand why the measured noise temperature was higher than expected.

Our first step was to calculate the impedance of the element antenna structure (currently a sinuous antenna). We made use of HP HFSS, a finite-element analysis software package, to simulate the structure. However, we found that the accuracy of the calculation which is primarily bounded by our current computing resources was insufficient for this project. An accurate value of this impedance is important for proper matching of the antenna to the low-noise amplifier. We decided to abandon the use of HFSS for this application, and focus our attention to measuring the antenna impedance using a network analyzer and the use of the Green Bank anechoic chamber. This we plan to accomplish during the next quarter.

The signal processing requirements for the array feed were analyzed this quarter in preparation for developing the complete imaging instrument. There are three general categories of signal processors: analog signal phasing and addition, digital phasing and summation, and digital cross-correlation followed by phasing and summation. The focus of the current study was on the latter two methods for both continuum and spectral line applications. The current generation of both FPGA's and DSP chips were found suitable for handling the processing requirements over a bandwidth of a few megahertz.

Advanced Radio Frequency Interference Canceling System

The purpose of this long-term development project is to apply modern digital signal processing technology to the ever-growing problem of radio interference. Modern adaptive signal canceling methods are currently being analyzed and applied to system-noise-limited measurements of very weak cosmic signals. Our long-term goal is to develop an RFI excision system that is integrated with the GBT backend electronics and is capable of canceling interference from both terrestrial and satellite sources, thus opening new spectral windows for astrochemistry and highly red-shifted H I measurements. We are currently in the first phase of our proof-of-concept system.

During this quarter we began making improvements to the current hardware-based, proof-of-concept system. The A/D converter boards are now being modified to reduce stray noise pickup, and new pre-filters for the analog baseband inputs to the A/D converters were designed. Noise associated with the dc power supplies was also reduced through filtering. A series of laboratory measurements using this system is being planned for next quarter to explore adaptive filter coefficient stability, attenuation versus interference-to-noise ratio, injected noise spectral properties, and broadband noise cancellation.

Work began on the development of a fast, clean analog-to-digital converter. The converter, which consists of two complex sampling channels (80 MS/sec each), will be built on a specially designed circuit board with attention paid to proper component layout to reduce unwanted noise. This board will be followed by an interface board to both PC and DSP-based processing systems. The converter board is currently under development.

The NSF MRI proposal for the development of a complete adaptive RFI canceling instrument for astronomical applications has been submitted.

E. GREEN BANK ELECTRONICS

GBT Spectrometer

Firmware and software programming and programming support will continue into the next two quarters. Pulsar features have not been addressed yet, and will probably take longer than two quarters to finish up.

There is a loss in serial communication between the computer and the system monitor card when the system power is enabled. We have not solved this problem to date, and will address it next quarter as time allows. This should not affect operation of the spectrometer, it is merely a nuisance.

The 1600 MHz samplers need to be calibrated. The 100 MHz samplers were finished this quarter. The calibration of the 1600 MHz samplers will be done in the second quarter.

A large amount of time was spent debugging the hardware. The Long Term Accumulator (LTA) board #3 has failed twice. We believe this is due to poor pin contact on one of three IC's.

Some decoupling caps are on order for the sample distributor cards. The three machine-wrapped cards do not work, while the hand-wrapped card does. It appears that the hand wrapped card has better decoupling than the machine wrapped version.

Enhancements to the system to allow better isolation of faults and integration of software have been designed. One such modification will equip all LTAs with LEDs to indicate the status of various key bits on the cards. Another modification will buffer key signals on the VME interface board and bring them out to front panel test points for easy access with a logic analyzer or scope.

Other GBT Backends

The Spectral Processor has been used this quarter for debugging and RFI measurements. The system was connected to 85-3 for some measurements. Some software enhancements remain to be completed.

The Digital Continuum Receiver has been in regular use in the GBT Mockup to test receivers and other equipment for gain stability, temperature stability, etc. It is ready for general use.

It has been decided that we wish to do holography from the Gregorian focus, as well as from the prime focus. A Gregorian feed is being designed and fabricated. Changes to the IF portion have been completed.

The GBT VBLA terminal remains to be integrated into the system. It has been hooked up to the IF spigots, and the network and timing signals are being installed in preparation for software integration efforts.

GBT Fiber IF System

The additional seven channels of the Fiber IF system are finished. Integrating all the fiber IF components into the IF rack continues. This should be finished in April, 2000.

GBT Servo System

The servo monitor system has been installed in the GBT alidade servo room. Preliminary Az-El servo tests are continuing, with NRAO providing engineering help to debug the systems.

A meeting is held regularly between NRAO, COMSAT, and RSI/PD to address the current Servo issues.

GBT Receivers

The GBT Gregorian receivers are all complete. All the receivers have been refurbished and are being tested to await installation in the GBT. This process is nearly complete. A change is being made in the calibration signals. This modification will be completed this quarter.

GBT Active Surface

The Active Surface software is in good shape. Some work remains in the interface between the Active Surface and the Metrology systems to allow calibration of the actuator using rangefinder data.

The major activity underway this quarter is testing and connecting the actuator cables. The NRAO is supplying six people to assist the contractor in the cable testing.

Once the cables are all tested, the active surface room can be outfitted, providing that COMSAT finishes the environmental controls for that room.

Q-Band Receiver

The construction of the receiver was finished this quarter. Testing and characterization of the receiver will be done over the next quarter.

GBT Cryogenics

Very little work was done on the cryogenics during the winter. Work is beginning again since the weather is better. The remaining tubing will be installed this quarter. Compressor construction will begin this quarter, and should be done by the beginning of next quarter.

GBT Outfitting

The outfitting of the antenna is beginning to take shape. The cables for the networks, telephone, intercoms, and other NRAO systems are in hand, and ready for installation at our first opportunity. Detailed plans have been made for these installation jobs. Outfitting the receiver room, the active surface room, and the servo room will have to wait for environmental controls in these rooms, and for COMSAT to vacate the rooms.

GB Earth Station (OVLBI) 45 Foot

This quarter we completed a number of upgrades to the OVLBI tracking station. These include centralizing control at the Jansky Lab, and adding a more sophisticated automatic call-out system to the station to allow for more unattended tracking passes. An oscillation detector to detect Antenna Control Unit failure was designed and built. An additional MCB interface was built and added to the system to allow for automated S2 recorder tape copying. Several S2 recorder problems were fixed.

One of the two dedicated operators resigned in the first quarter of 2000 thus reducing, by almost a factor of 2, operator support. This coupled with previous changes in OVLBI personnel have led to the decision of running mostly in an unattended mode. The gradual change to this mode of operations was started late in the first quarter and will be completed in the second quarter.

USNO 20 m Operation

The reduction in the USNO budget for this year has led to a reduction of the permanent operator pool for the 20 m from two to one. Some readjustment and reduction of services were necessary to accommodate the reduced level of support.

Normal maintenance issues have been taken care of. A hot air kit was installed in the tape drives by Signatron, who is building a Mark IV upgrade for the recording system.

85-3 and the GB Interferometer

Both software and hardware upgrade effort continues in preparing for moving control of these systems to the Jansky Lab. The control of these systems will use the basic GBT M&C software system and user interface. The final move of the control of these systems will be completed late in the second quarter. This opportunity affords real experience controlling telescope systems using the GBT M&C software system significantly in advance of its use on the GBT.

The control system on the Interferometer and 85-3 is being replaced with equipment identical to that in the GBT control system. This will allow all the telescopes to utilize the same pool of spares, and allow the technicians charged with maintaining them to be able to work on both. The Interferometer control equipment will be moved to the Jansky Lab to eliminate the interference that equipment would cause to the GBT. The system is particularly noisy at 1400 MHz. The control system for 85-3 is also being upgraded to the same hardware and software.

The hardware and software drivers for this upgrade were completed this quarter. Testing has been completed with all the subsystems. Integrated testing will be completed during the month of April, with a two-week shakedown run before the plug is pulled on the venerable DDP-116 control system. Once this shakedown run is successfully completed, we will fit 85-1 and 85-2 with the electronics to allow remote control via fiber optics. This will take a few weeks.

In addition to these upgrades, normal maintenance and repair was provided. Studies were started to make the focus/rotation mounts usable again.

General Site Support

The fire alarm system was repaired. A site radio communications system that meets the NRQZ limits was installed and tested for operations use. Support for the 40 foot educational instrument was provided.

F. SOCORRO ELECTRONICS

Preventive Maintenance Program

Hydrogen Maser #11 was returned to the factory in Tuscaloosa, Alabama, for repair after in-house trouble shooting revealed that the maser's physics package was no longer functioning properly. The instrument is due back during the next quarter. Once Maser #11 is working, Maser #5 at VLBA Owens Valley will be updated, an important goal for 2000.

Problems with the voltage controlled oscillator (VCO) and the phase lock loop bandwidth in the API (Atmospheric Phase Interferometer) were corrected this quarter, primarily through improved temperature regulation, and the instrument returned to regular use. An important goal is to rebuild the instrument in 2000, in order to improve reliability and to provide a spare.

Failure of the VLA FFT Array Processor last quarter (end 1999) spurred interest in completion of a new VLA correlator controller. Construction of all circuit boards for the controller has now been completed, including a test fixture for the VME control card. Checkout and at least partial implementation of the new controller is an essential priority for 2000. The new controller will replace the Spectre Modcomp computer, the current correlator controller, and the AP.

A study of other possible single point failures led to another essential goal for 2000: to construct a spare VLA L28 5 MHz reference module. A new L28 was built this quarter, but final checkout is scheduled for next quarter.

A failure in the IF B Delay/Recirculator system of the VLA correlator seen during the fall quarter of 1999 has not recurred but presumably remains latent since nothing explicit was repaired.

An ASIC failure in the VLBA correlator FFT engine was remarkable only in that most of the ASIC failures are in the MAC cards which are easier to troubleshoot. The failed ASIC had an older date code; fortunately, most of the older circuits are in the MACs. A second VLBA correlator problem was traced to a bad crimp connection, apparently brought to light by thermal cycling during a power outage.

Heads for the 49 magnetic tape drives are expensive and have an expected lifetime of only 5000 hours. New "triple-cap" head stacks were ordered last year with the expectation that the revised design might extend head life, but many of the new stacks have exhibited high error rates after only 200 hours of use. Except in one case, all failed stacks have been returned to use after "shuttling" which re-contours the head surfaces. The necessity of doing so is cause for more study.

An essential goal for 2000 is to identify the head wear process, perhaps through procurement of a "profilometer" which uses a laser interferometery measuring technique to make fine non-contact, non-invasive mechanical measurements.

Desirable goals are to install additional dry air kits at all VLBA sites and to repackage the head preamps and cabling to reduce failure from broken wires; however, in the face of budgetary limitations, that work is pre-empted by the need for replacement headstacks, refurbished capstan motors, and new idler rollers. A procedure to test replacement capstan motors has improved repair reliability.

In response to reports that some VLBA magnetic data tapes work better on certain tape drives, an important goal for this quarter was to establish an improved tape path calibration. To that end, the Computer Division conducted tests to show that tape offsets are tape speed related. To correct for the problem, separate forward and reverse offsets are to be provided for each tape speed in the on-line drive control. In addition, a master alignment tape has been recorded and is being used to calibrate all drives. The old and new calibration values will be recorded. Then the change in calibration can be measured during a second round of calibrations scheduled for next quarter.

VLBA antenna drive motors have a failure rate significantly higher than VLA antenna drive motors. A study of brush wear by the ES Division led to selection and testing of an alternate brush design for the drive motors. The test units are in use at Hancock and Los Alamos with good results so far. In addition to the better brushes, improvements in air filtering may reduce the motor problems. An important goal for 2000 is to reduce drive motor failures.

Flexible stainless steel lines are used on both the VLA and VLBA to supply compressed helium to the 180+ cooled receivers used on the VLA and VLBA. A replacement 12' flex line costs $400, but the lines are now being repaired successfully in-house at a fraction of the procurement cost. Re-plumbing the Cryo Shop with larger diameter helium lines will not take place this year, however, because of budgetary constraints.

The Cryo Shop rebuilt 43 cold heads this quarter in addition to compressor repairs, silver brazing and cleanup of waveguide assemblies, and rework of helium lines to accommodate new receivers.

A computer used for the VLA solar calibration procedure was repaired and used to test one of the four VLA all-band solar-cal antennas. The data are being incorporated into a new, more comprehensive solar-cal table. A desirable goal for 2000 is to complete testing and calibrating the C-, U-, and K-band frontends on the four antennas which have external solar calibration noise systems installed, and for the X- and L-band frontends on all 28 antennas. Also, some solar noise source calibration must be accomplished in time for solar maximum observing in the third quarter of 2000.

After a power failure in 1999, operators were not able to re-program the VLA International Atomic Time (IAT) Clock because the 1PPS from the GPS receiver had inadvertently been left disconnected. An LED to indicate the presence of the 1PPS has now been added to both IAT clocks.

Unplanned power outages continue to cause downtime of the VLA, now mainly due to warm-up of the dewars and tripped circuit breakers. Circuit breakers on the helium compressors are thought to trip when power is restored while the compressor piston is in the compress cycle. Startup current in this case can be close to 65A, an excessive amount.

Infrared transmitters in all of the VLBA weather stations have been replaced, and improved calibration procedures for dewpoint/temperature implemented, completing the upgrade of all sites. An important goal for 2001 is to produce a Technical Report on the VLBA weather system.

A loss of airflow in the VLA vertex room shuts down power to the B rack to avoid overheating, but current status information is insufficient for remote diagnosis. A desirable goal is to provide sufficient remote status information or control so that the correct repair personnel can be dispatched; however, budgetary limitations have pre-empted progress on this work so far.

Premature failures of main power breakers at VLBA sites are expected to be reduced as a result of less frequent generator PM requiring disconnect of the breaker.

The UPS was replaced at VLBA-Pie Town after the original unit was damaged during a power utility problem last year.

Notifications of USAF use of 1381 MHz continue. A weekly coordination and notifications scheme was worked out with Melrose EMC test range where activities can impact VLA and VLBA-Los Alamos observing. Potential RFI in radio astronomy bands from proposed new or changed broadcast TV licenses was identified and the licensees notified. An important goal is to continue the RFI mitigation effort, though some of the work will be curtailed to address Expanded VLA (EVLA) RFI issues as explained later.

Equalization of receiver outputs on the VLA and a study of receiver instability problems uncovered during recent maintenance time at the VLA are two maintenance problems that are to be addressed after installation of the new frontend filters. The filters are discussed under Projects. Correction of VLA sync detector variations and DC offsets at the backend, a study of subreflector rotation and offset at K- and Q-bands, and redesign of the VLBA BBC modules are three desirable maintenance goals which will be delayed because of budgetary constraints.

Projects

VLBA PT Link

The essential goal for 2000 is to provide the link to VLBA-Pie Town for observing at high resolution during the VLA A configuration in October 2000. Tasks to meet this goal are being accomplished during the second quarter: two M32 spares are under construction, parts are being procured for a spare L6 module, and key optical component spares have been requisitioned. A problem with low total power in three of the four IFs was traced to a kinked optical fiber on a transceiver board and corrected. The discovery that loss of sync on the L8 module is a function of the drift slope of the VLA EFOS maser should lead to a solution or at least a work-around in the next quarter. Automatic switching equipment between VLA and PT Link was completed and installed.

New Receivers

This quarter the Division installed one 7 mm (Q-band) receiver, and two 1.3 cm (K-band) receivers on the VLA, the last of the 1999 receiver build. There are now 19 Q-band receivers available at the VLA and 12 low noise K-band receivers. The system performance and local oscillator power levels of the new K- and Q-band receivers have been characterized and the information made available on a web page. An essential goal is to assemble and install an additional six Q-band receivers and four low noise K-band receivers on the VLA in 2000, starting with one of each this quarter. The first Q-band receiver build will include solar calibration noise injection circuitry to support solar maximum observing in the third quarter this year.

A desirable goal is to replace the F3 LO module used with both K- and Q-band receivers because of its limited bandwidth and stability, but budgetary constraints will limit F3 work in 2000 to routine maintenance and to adjustments required to accommodate the new receivers.

Problems last year with failed noise diodes on two of the W-band receivers were traced to a coupling flange internal to the dewar having been damaged in shipment. Both flanges were fixed, but one of the diodes also was damaged and has been returned to the vendor for repair. CV removed the Teflon layer from the quartz windows to repair or at least reduce the window vacuum leaks. A faulty mixer in Receiver #2 was repaired by cannibalizing Receiver #3. As a result of this work, three W-band receivers are anticipated to be available at Fort Davis, Pie Town, and Los Alamos for the CMVA run next quarter of 2000. Receiver #3 needs new LNAs, but must be rebuilt to accommodate a new LNA design.

To address problems with ripple in the bandpass and high system temperature in the current W-band receiver design, an important goal is to replace the Y-adapter and calibration coupler, and add isolators in the next two receiver builds scheduled for 2000. A Y-adapter tested this quarter demonstrated higher than desirable insertion loss, so a second design is being fabricated and will be tested in the second quarter.

Upgrade for the Pulsar High Time Resolution Processor (HTRP)

A New Mexico Tech project, the HTRP upgrade has been supported in part by NRAO. The circuit board designs for the FADC are complete, and the boards will be released for manufacture after successful software checkout of the prototype by NM Tech. The prototype was provided last year. Remaining important goals for 2000 are to rework the VME timing card and to provide spares.

A desirable goal for 2000 is to remove 60 Hz interference to the HTRP, possibly by breaking a ground loop with an optical fiber transmission line.

VLA Expansion Project

The overall goal for the EVLA project is to produce a functional block diagram in 2000. RFI from the digitizer, the 10 Gbps fiber link transceiver, control computers, and other electronic equipment proposed for the antenna all impact major design considerations so that an essential goal for this quarter is to write an RFI test plan. Identifying acceptable levels of RFI and developing mitigation techniques such as shielding are goals for the third quarter.

Another essential goal for this quarter is to inventory monitor and control points based on scientific, operational, and technical needs and a preliminary specification written for a "field bus" at the antenna. The transition from old to new antennas will be addressed in the specification. Also, a specification for the LO will be prepared. A study of the ALMA wide bandwidth conversion will lead to initial planning for receivers to cover the receiving range 1 GHz -

50 GHz with possible provisions for up to 86 GHz. With assistance from the ES Division, a mock up of the proposed new vertex room may be designed and constructed.

The Computer Division has procured the two-port serial line controller (SLC) hardware for use in developing on-line control software. Installation and initial tests are important goals for this quarter.

Another important goal in 2000 is to extend the existing 4x50 MHz VLA IF to 4x75 MHz by means of wider frontend filters. The BW increase is not part of the VLA Expansion Project, but is mentioned here to bring attention to the need to expand the IF. Filters were successfully tuned and installed on Antenna 26 during this quarter; the expectation is to modify half of the VLA antennas in 2000.

K-Band Water Vapor Radiometer (WVR)

The two 3-channel WVRs were successfully modified this quarter for a factor of 10 improvement in stability and by 2 in linearity. Both WVRs were installed on VLA antennas this quarter. An important goal for next quarter is to cooperate with scientific tests to determine if the current design will provide useful data. If not, a new design will have to be selected, which would be a goal for 2001.

VLBA Panel Adjustments

The VLBA main reflector panels must be adjusted and the subreflector surfaces corrected to achieve the best possible efficiency at W-band. A plan has been developed to use a one meter diameter reference reflector antenna mounted on the main dish for phase-referenced holography using a beacon from a geostationary earth satellite. An important goal for the next quarter is to conduct tests of satellite signal strength to verify the viability of the design and then to procure parts. The cost is expected to be reduced from initial estimates of more than $10k by using the existing converter, IF, and base band converter circuits of the VLBA antenna.

High Density Recording Rates

To improve the SNR of faint objects, a formatter expansions at the Los Alamos, Pie Town, Kitt Peak, and Owens Valley VLBA sites have permitted successful testing of a 512 Mbps recording rate by using two tape recorders simultaneously. Work on the project is expected to resume as early as the end of the next quarter after training of new personnel and be completed in 2000.

At the request of the OVLBI program, a proof of concept was constructed and a report submitted for using two head assemblies on each of two drives for a total of 128 tracks recording simultaneously. The resulting 1 Gbps system could be used to look at even fainter sources, an important asset for W band receivers.

Interference Monitoring

The priority of the Interference Monitoring has shifted during the quarter to serve the EVLA design. As a result, some projects of the group, such as improving methods of alerting VLA and VLBA array users to known RFI problems, are being set aside and some services, like monthly RFI surveys at the VLA and VLBA, are being curtailed.

Surplus receivers that cover a frequency range from a few hundred kilohertz to 18 GHz are being repaired and calibrated for possible use as an Environmental Monitoring System (EMS) but only to the extent that the EMS will support EVLA environmental monitoring goals from 1 to 18 GHz. The essential goal is to provide an RFI test plan and necessary monitoring equipment for EVLA by the end of the quarter.

Installation and testing of a high-gain antenna and precision satellite tracking system (STS) is complete and the system available to the EMS for direction finding and satellite power measurements.

VLBA Correlator

A desirable goal for 2000 is to replace the Sun 3 computer (CCC) used for diagnostics on the VLBA correlator with a PC running Linux; however, the Sun is still used for compiling parts of the correlator real-time software.

Presently there are a number of personal computers running terminal emulator programs to communicate with more than 100 embedded microcomputers in the VLBA correlator. Parts are on order to install a multi-serial I/O system for the new diagnostic computer (CCC replacement) to remove the terminal emulators and make the diagnostics available on the network.

Video Monitoring

Video monitoring at four VLBA sites accessible via the web enables the Socorro Operator to monitor security and weather conditions at the sites. A desirable goal for 2000 is to complete installation of video surveillance at the remaining sites in time to use the system for snow detection next winter. Since the video is used only for capturing occasional frames, not continuous monitoring, the current plan calls for replacing the video cameras with digital cameras so the photographic equipment can be used for a wider variety of purposes.

Iridium Filters

Interest has waned in installing and testing iridium filters for the OH band since the satellite system is scheduled to be removed from use.

Engineering Services

Accomplishments

Array reconfiguration to C-array has been completed along with the overhaul of Antennas 20 and 26. During overhauls we retrofitted the access platforms to pedestal room a/c unit; installed EL hardstops; modified EL encoder mount and added weather enclosure; relocated AZ limit switches; installed feedcone segments and new receiver mounts; enlarged holes on Transporter lift pads. We installed elevation cable wrap modifications to improve disconnection of power and control cabling at the elevation axis. VLA encoders were disassembled and rebuilt replacing worn parts, then bench tested to meet original specification. Also we initialized and finished fabrication of VLA L-band covers. The covers are being replaced on an as needed basis.

Antenna 26's Focus Rotation Mount (FRM) was removed due to a repeatability test failure. A careful inspection for wear on FRM's was also performed. It had been 12 years since it was last overhauled, but inspection revealed minimal wear. A bad bearing was found and is believed to have caused the test failure. The bearing was replaced along with several internal gears; repeatability test results were excellent. Due to minimal wear and the likelihood of a complete redesign of the FRM during EVLA (Phase II), the FRMs will not be overhauled. They will be removed from the Apex if they fail repeatability tests during the normal antenna overhaul cycle or when a failure warrants its removal.

Antenna 1 preempted Antenna 5 in the overhaul schedule because of a major problem with gearbox #2 welds breaking. A weak weld in combination with the gearbox backlash at the high end of the specification caused a crack at the weld. Separation of Antenna 1 was required to make repairs, which is ongoing. Installed K-band receivers on Antennas 20 and 23 as well as a Q-band on Antenna 28. In addition, we have made preparations for the next three antennas scheduled for overhaul.

We disassembled and rebuilt Transporter I's #2 truck and completed a successful modification to increase its stroke by ¾ inch in order to clear the tracks during 90 degree turns. In addition, all post reconfiguration transporter maintenance was completed including Transporter II's 140 hour service. Cummins batteries on Transporter II were relocated to improve access for bolting. The antenna to the transporter during moves, and a problematic fuel pump was repaired. A hydraulic flow meter was built in house, which will be used to troubleshoot the transporter limp system.

A decision was made to proceed with installation of the VLA and VLBA Apex handrails. A design for a handrail rolling mill, to form a round handrail, has been completed and construction is expected next quarter. It's planned to do all installations in conjunction with the Fall Arrest prior to the A-Array moves in the fourth quarter of 2000. An improvement to the Fall Arrest trolley brake mechanism on an in-house Fall Arrest device has precipitated a successful testing per ANSI standards of the new Fall Arrest system. The Safety Officer has recommended an outside independent test. The design and fabrication of a ladder hatch grab bar for VLA antenna access hatch to improve access to dish surface has been completed. It will be installed on Antenna 1 and tested through the third quarter of 2000.

A successful St. Croix Tiger Team visit performed an exchange of the Azimuth drive #1 wheel assembly, installed the VLBA apex handrail and reposition the FRM. Along with repairing a hole in subreflector, several other maintenance tasks were completed. All preparations including preparation for the last VLBA contempo unit upgrade are complete for the North Liberty Tiger Team visit in April 2000. In addition, other preparations such as handrails, disassembling and rebuilding drive motors and EL platform extension for the Fort Davis, and Kitt Peak Tiger Team visits have been made. Fabrication of the prototype lexan snow cover for VLBA subreflectors has been slowed, but completion is schedule in the second quarter of 2000. We installed the 3mm-receiver mount on the Los Alamos telescope.

A commitment to proceed with the VLA encoder upgrade was made. The prototype encoder has performed flawlessly for over six months and should improve performance, reliability and serviceability. Minor changes are being made and several major components have been ordered. We hope to begin manufacturing the boards in-house midway into the third quarter (2000) and begin cycling modified encoders through antennas in the field and during overhauls in the fourth quarter of 2000. We hope to complete this modification by the end of 2001.

Several preventive maintenance tasks were completed this quarter, including monthly inspections of antennas, HVAC and electrical systems, vehicles and the AAB overhead crane. The semi-annual lubrication of VLA azimuth and elevation gears, and FRM drives was completed. A spare VLA azimuth gearbox was also overhauled this quarter. The 3-yr maintenance PM of the Control Building chiller was also completed this quarter. We located underground power and wyecom cables for SEC casement in preparation for the ALMA antenna test site. Ran inner duct for fiber optic connection to the PC repair trailer. Repaired VSQ Sidewalk lighting Installed high pressure sodium light fixtures outside Tech Services, Auto Shop and Cafeteria buildings.

The alignment of mainline track from CN5 to CN8 was completed. A rail vehicle on/off platform was constructed at Highway 60. Rebuilt the crossing between CN-6 and CN-7. We resumed north arm drainage repair in mid March when moisture in the ground permitted, and expect to be completed in the second quarter of 2000. We acquired a Track Tamper, which should make lining, leveling and tamping a more efficient and safe operation.

The long line potential measurements of the waveguide system was completed along all three arms of the VLA. A plan is being considered to complete at least one arm each year and to make monthly tests at stations during the remainder of the year. The waveguide Lightning Protection System (LPS) inspection is approximately 33 percent complete and plans are being made for repairs. A security fence was constructed around the satellite monitoring station (IPG). The continuation of anode bed and general ground maintenance was performed.

We replace/repaired ceiling tile in the Machine Shop. We built storage shelves in Room 7 of the SLOB, remedied the areas around the pine trees to improve water and oxygen getting to the root system. We made improvements to the visitors' walking path between the two listening posts and installed Visitor Center Displays. Lime buildup was removed on slump block walls of the cafeteria and we fixed roof leaks over Servo Shop. We completed one dump truck modifications: revised bed, installed tarp roll, wind deflector and cab cover. Also, an existing trailer for site use was modified. At the AOC: relocated static sensor for Unit #31; installed two dampers for controlling the air flow to auditorium and shell spaces and we installed a 40hp motor on unit #31 air handler; performed noise survey of the auditorium; replaced carpeting in the Operations area of the AOC and sound soaked two rooms. We rewired the VLBA Operations lighting.

Components for the new K- and Q-band receivers were fabricated in the Machine Shop. The Machine Shop also fabricated parts for five W-band (3 mm) card cages, a prototype hi-pass filter for W-band testing, and several recorder parts for the Recorder Group (electronic modules). Several components for VLBA azimuth wheel assemblies and parts for six Q-band card cages were fabricated. Two hydraulic cylinders used to lift the transporter trucks while making right angle turns were modified by the Machine Shop, greatly increasing the piston travel. The Machine Shop was also used extensively for emergency repairs of equipment and tools used on the VLA site.

A proposal to upgrade outdated equipment with newer energy conserving equipment was submitted by the Engineering Group. The proposal outlined cost savings and pay back schedules for each of these upgrades. An optical telescope was specified and ordered. This telescope will be used to identify antenna pointing problems for the VLA. This optical telescope system will be assembled and implemented by a summer student during the next quarter of 2000. Another summer student was recruited to work on an antenna ray tracing program that will be used for VLBA holography.

We developed the work scope and issued contract to paint the St. Croix antenna in 2000. We performed OSHA test for machining of BeCu. Test indicated no presence of BeCu in the breathing zone of worker. We worked on ALMA general layouts. Began design work on the Control Building outside staircase repairs. The Engineering Group also researched alternative materials for building the dichroic panels.

The Drafting Group continued converting drawing files to the electronic database in addition to providing drafting support to the engineering groups. The Drafting Group is currently completing a 3D view of the STS/RFI tower area. ALMA/AT modules (as well as other current drawings) were placed on a web page.

The redistribution of administrative duties in Janitorial and Emergency Services has been made. P. Lindsey will assume administrative duties, C. Chavez will head the janitorial/security duties, while K. Lakies becomes the Fire Chief and G. Morris becomes the EMT Chief. A retirement ceremony was conducted for A. Patrick on 3/31/00. Three Newsletters were published. Several employees were sent for training in Heavy Equipment Operation and First Time Supervision. Several individuals were enrolled in a computer training class. Annual personnel evaluations were completed and budgets were prepared. We conducted monthly staff coordination and projects meetings with division heads, supervisors and engineers to plan, schedule and review ongoing work effort.

Work continues on paint crew job safety analysis, completion expected in the second quarter of 2000. We completed development of the safety awareness plan for 2000. Provided ergonomics training on office work station. We performed semi-annual site safety inspection. Several employees attended a performance technology seminar on Behavior Based Safety. A summary report will by issued early in the second quarter of 2000.

Second Quarter Goals and Objectives

1. Prepare antenna-painting equipment - will overhaul water-blaster (1) and paint gun system (1). (VLA)
2. Repair of the Visitor Center roof will continue into the second quarter. Bids received by the state of New Mexico were too high: $10,000 being the limit and $13,000 the lowest bid received. A letter has been sent to the State to reaffirm our need and we expect the state to complete repairs in June 2000.
3. Continue installation of K- and Q-band receivers (3) on VLA antennas as they become available.
4. Fire alarm system repairs - an earlier study reveals several dysfunctional building panels needing repair or maintenance to return to proper operating conditions. This task coincides with the recent relocation of the main fire alarm control panel in Operations at the VLA.
5. Design and build optical telescope to measure antenna-pointing efficiency. (VLA)
6. Design and install remote start/stop function onto VLA Operations touch screen console which will allow Operators to remotely start or stop VLA power generators during commercial outages.
7. Antenna drive motor tach generator replacement - a prototype design development to improve operation and reduce failure rate of motors due to brush wear. (VLA/VLBA)
8. Test transporter limp pump system - designed to recover from main hydraulic pump failure of transporter. Evaluation of improvements made on the system continues. (VLA)
9. VLBA Tiger Team visit to North Liberty.
10. Build next VLBA Axle.
11. Give a Fall Arrest presentation at the ASSE conference.
12. Move antennas to DnC array. (VLA)
13. Start handrail installations. (VLA/VLBA)
14. Assign summer students optical telescope and subreflector measurement projects. (VLA)
15. Attend Fire Inspection Techniques training at the Fire Academy.
16. Begin work on VLA Vertex Room mock-up.
17. Revise Confined Space safety procedures.
18. Continue anode bed maintenance. (VLA)
19. Continue grounds maintenance (roads, landfill, etc.). (VLA)
20. Open inspection hole in roof of VC for contractor when repairs begin. (VLA)
21. Continue Site & Wye related PM's. (VLA)
22. Continue repair work on equipment & vehicles. (VLA)
23. Continue monthly staff coordination and project meetings to plan, schedule and review ongoing work.
24. Developed D-array reconfiguration schedule. (VLA)
25. Overhaul Antennas 1 and 5. (VLA)
26. Assemble and troubleshoot handrail rolling mill to form round Apex handrails (VLA/VLBA)
27. Initialize L-band cover fabrication. (VLA)

28. Research alternative material for building spare dichroic panels. (VLBA)
29. Continuing drawing vectorization - two completed this month.
30. Converting drawing files to electronic data base, on-going.
31. Complete waveguide LPS check and order material for repairs.
32. Complete LPS checkout and begin repairs.
33. Continue tree salvage. (VLA)
34. Assist as needed on Guest House maintenance. (Socorro)
35. Continue roof repairs as needed. (VLA)
36. Schedule guards as needed. (VLA)
37. Assist as needed for ALMA prep work. (VLA)
38. Get Jackson tamper operational (work out bugs). (VLA)
39. Level and align track CN8 to BN-6 & BW5 to BW6. (VLA)
40. Complete French drain CN8 to CN9. (VLA)
41. Continue vehicle PM's. (VLA)
42. Vehicle and equipment repairs as needed. (VLA)
43. Adapt grader for plowing LPS cable over waveguide. (VLA)
44. VLA 20th Anniversary support. (VLA)
45. Prepare all three buses for use during 20th Anniversary. (VLA)
46. Redo exterior stucco on Guest House. (Socorro)
47. Provide safety awareness sessions on First Aid and CPR. (VLA)
48. Paint Antenna 3 structure. (VLA)
49. Install motor starter on Transporter1. (VLA)
50. Perform VLA site power recovery tests.
51. Check out power distribution system for Paint Crew work. (VLA)
52. Perform site wide lighting Pms. (VLA)

G. TUCSON ELECTRONICS

1 mm Array, 220-250 GHz Receiver

This receiver is now in routine use. Several early operational problems have been identified and solved. We have identified two faults in this system which may be the source of the problems with baseline stability which sometimes affects wide-bandwidth measurements. This receiver is the ideal candidate for the development of automatic tuning of receivers, and the software to realize this has been developed and implemented. Although all of our receivers are tuned remotely over the computer network at the telescope site (or even tuned over the Internet from our downtown offices), the precise tuning still relies on the telescope operator closing the loop. The receiver characteristics are such that a simple lookup table of tuning parameters is not adequate to ensure optimum performance. With eight receivers to tune, this clearly puts considerable demand on the operator and can lead to inefficiency in the setup time needed for a new observer, even though the individual receiver channels are less complex to tune than our regular single-beam systems. systems. We continue to develop the automated tuning system for the 1 mm Array, with the intention of this development work being used in the receiver tuning design for ALMA.

The 8-channel, 4-beam, 3-millimeter System

A commercially available frequency tripler for the LO has been tested and works well at 4 K. This validates the concept of using coaxial lines to input the LO to the dewar at one third of the LO frequency. The dewar has been built and is currently being tested. The design and fabrication of the basic receiver insert has been completed. A crossed-grid polarization diplexer designed to operate at 4 K has also been constructed and tested. A prototype 2-channel system continues to be tested in the lab.

Planned Wideband Continuum Receiver

The availability of HEMT amplifiers covering the frequency range from 70–90 GHz raises the possibility of building a continuum receiver with a sensitivity of around 50 mJy per root sec; the extraordinarily high sensitivity comes from the very wide bandwidths. The major problem to be overcome is the "1/f" noise which has been reported from early experiments. Although not necessarily worse in this system than in other HEMT amplifiers, the extremely large (bandwidth times integration time) product means that much lower levels of "1/f" gain modulation can dominate the residual noise in the detected output from the receiver. Progress with this project is dependent on available manpower, and has been given lower priority than the multibeam systems mentioned above.

New Phase-Lock Control

One of the most efficient observing modes, generally applicable to relatively narrow bandwidth observations, is frequency switching. Unlike other switching schemes, in this observing mode the object of interest is in the telescope beam and in the spectrometer passband for 100 percent of the time. At present we are limited in our ability to frequency switch, in both switching rate and in total frequency throw, by the analog phase-lock system. We have designed, tested, and installed a digital phase-lock system into our 2/3 millimeter receiver that combines both frequency and phase control and provides faster, reliable switching over a broader frequency range. We can now routinely switch by as much as ±35 MHz, making frequency switching useable for a wide variety of research projects. We are currently producing digital phase-lock systems for all of our receivers for installation during the first half of 2000.

Another capability which will become practical thanks to the enhanced digital phase-lock is "sideband smear" operation. This is a powerful technique of reducing confusion in spectral line observations from features appearing in the unwanted sideband. The principles have been established during some ad hoc test observations performed at the 12 Meter Telescope, and have been described in conference proceedings. The practical implementation of a usable system at the 12 Meter has been hampered by the performance of the phase-lock system; fast switching times over a relatively large bandwidth are required. The digital phase-lock should solve these problems.

Receiver Component Servo Systems

Given the importance of the accuracy and reliability of the servo drivers for the components of the 12 Meter receivers, we have investigated these aspects on our 1 millimeter array system. By implementing a periodic test and maintenance procedure for all of the mechanical systems in these servo drivers, we have dramatically improved the accuracy, reliability, and repeatability of these systems. This will have direct impact on our ability to quickly and automatically tune all of the 12 Meter receivers.

Cryogenics

All receivers on the 12 Meter Telescope rely heavily on reliable operation of cryogenic systems. A new cryogenic compressor system has been developed for our closed-cycle 4 K refrigerator. The individual compressor units for the Gifford-McMahon refrigerator and the Joule Thomson expansion valve have been combined into a single unit, resulting in a smaller installation with lower power consumption. All four of these units have been fabricated, tested, and installed on the telescope.

Quadrant Detector and Thermal Sensors

One of the main contributions to pointing changes on the 12 Meter Telescope is lateral movement of the subreflector, with respect to the main telescope surface. This is caused by unbalanced thermal effects on the subreflector support structure. We have installed a system on the 12 Meter to sense these changes; we have a laser quadrant detector to measure the lateral motion of the subreflector mount, with respect to the telescope central hub structure, and we have thermistors continuously monitoring the temperature of the feed legs and other parts of the telescope structure. We are currently trying to build up statistics to enable us to understand the detailed relationship between the thermal distribution of the telescope and telescope pointing offsets. At a later date we hope to incorporate the thermal data into our telescope pointing model to give real time pointing corrections.

New Digital Spectrometer

A new digital spectrometer, called the Millimeter Auto Correlator (MAC), has been in routine use at the 12 Meter Telescope for the 18 months. The MAC, which is a GBT correlator clone, has twice the instantaneous bandwidth currently available for our multibeam systems, and uses a single wideband sampler for each IF channel. This new design avoids the persistent platforming problems experienced with our now decommissioned hybrid correlator spectrometer. The MAC supports the existing 1.3 millimeter and 3 millimeter, and any future, multibeam systems on the telescope.

Software

Continuum On-The-Fly Analysis

Eric Greisen has added tasks to the AIPS package which allow the analysis of continuum On-The-Fly (OTF) data. By employing the Emerson, Klein, Haslam deconvolution algorithm, these analysis tasks add greatly to our complement of OTF analysis software. This development has also expanded the scientific capabilities of the 12 Meter by adding continuum OTF to its complement of observing modes. Further development of this software is concentrating on a streamlining of the user interface. We anticipate a completion of this project by July 2000.

ALMA

The ALMA receiver system development, laser local oscillator, and cryogenics, and antenna design are all based in Tucson. The current site testing activities and logistics support are managed out of Tucson. It is important to put effort into these activities, but until ALMA resources become available the staff involved are shared between ALMA development and 12 Meter support. This has been a major factor in delays with the new 8-feed 3-millimeter receiver, for example.

H. COMPUTING AND AIPS

Computer Security

Support staff at the NRAO sites have made good progress this past quarter in implementing the requirements of the Computer Security Policy which was issued in November 1999. Three areas were given highest priority by the Computer Security Committee at its first meeting late last year:

1. Network router filters - These are used to restrict network access from outside of the NRAO to services and systems known to be needed. Final analysis of data logged by our routers is currently underway, to verify that all key services have indeed been explicitly permitted.
2. Centralized access logging - Using a well-secured central server to record information from all systems facilitates identification of potential security problems. This is now in place for UNIX systems at all four major sites. Similar information is also being kept for the NRAO Windows NT domain where applicable.
3. Provision of security-related information for users - A significant amount of documentation, covering both computer security and Observatory-wide Computing in general, has been created on NRAO's internal web pages, including meeting minutes, incident alerts, and access restriction information. In March, a presentation on the use of *ssh* was given via videoconference from Charlottesville to Green Bank and Socorro.

In addition, NRAO system administrators have coordinated service aliases and access to security logs across sites, performed scans for known vulnerabilities on all computers connected to the local networks, and taken steps to document and simplify the general use of encryption software such as *ssh* and PGP.

We had originally intended that all four major sites would be essentially compliant with the policy by the middle of 2000. With the loss of all computer support positions in Tucson, and a reduction in this area at the Charlottesville site, this schedule may be delayed, particularly as it is not yet clear how computer security will be handled in Tucson. However, at a minimum we will complete the router filtering configuration, substantially increase the amount of security-related information available to users (particularly "how-to" documents on useful utilities), and investigate log monitoring/intrusion-detection software.

Software

AIPS

Versions - The current test version of AIPS is 31DEC99, the final "release" of AIPS. 31DEC99 is available from our ftp site continuously, and will continue to be patched and developed where necessary over the next several years. AIPS is currently distributed nightly to all NRAO sites and to a number of non-NRAO sites in the U.S., Europe, and Australia. We expect the nightly distribution list to continue to grow as the Midnight Job becomes the standard method for obtaining AIPS. Full support for SVLBI processing has been available since 15APR98. The majority (75%) of AIPS distributions are now received by ftp, although the CD-ROM distribution of 15OCT99 is still in strong demand.

The last standard release of AIPS is 15OCT99, which is still available from the NRAO. The 15OCT99 version of AIPS has been distributed to over 270 non-NRAO sites, running Linux, Solaris, DEC Alpha, HP, and SGI versions. The overall number of AIPS installations has continued to grow over the last two years. At present, 31DEC99 (AIPS for the Ages) has been installed at 74 sites. We expect all sites to eventually migrate to the 31DEC99 version.

In February, K. Desai left the AIPS group to work in the computing industry. E. Greisen will be making an extended visit to the AOC to address the programming shortfall; he will be in Socorro from early April until October. We are currently advertising for a replacement programmer/user support person in Socorro. AIPS support has reached a critical level.

General Issues -

1. UVCON - a task to generate a uv database for a given array configuration was greatly enhanced this quarter. The array geometry can be specified in a number of different coordinate systems. Use of this task to simulate ALMA configurations is underway.
2. IMAGR - multi-resolution clean has been added to IMAGR. It takes advantage of the multiple field capabilities to model the source simultaneously as a collection of Gaussian objects of different widths. Options to make restarts more efficient were also added.
3. New task SCIMG - simple single-field image and self-calibrate a dataset.
4. Editing tasks EDITR, EDITA modified to allow rapid editing of multi-IF multi-polarization data via the CROWDED adverb.
5. Phase re-referencing - underlying routines re-referencing solutions to reference antennas were rewritten, correcting a number of long-standing bugs. Error reporting has been improved.
6. FILLM and DOCALIB=2 - FILLM now has the option of using the nominal sensitivities to set the data weights (CPARM(2)). Throughout all of AIPS, the option of applying calibration tables to both the data AND weights is now available thru DOCALIB=2.
7. New task FGPLT to display times when uv-samples are flagged.
8. New installation wizard is approaching completion; using a Perl script the installation of AIPS will be significantly simplified.
9. Improvements to DBCON to allow the combining of disparate datasets.
10. Subtle bugs in the Linux compiler concerning roundoff were addressed.
11. Errors in UVCOP/UVFIX/UJOIN/CALIB/TI2HA/UVMTH/TBIN/SPFLG/SETFC corrected.

Patches for 15OCT99 - Patches for the AIPS tasks DBCON and IMAGR for the 15OCT99 distribution are available from the AIPS web page.

Goals for Q2 2000 -

1. Continuing maintenance and user support.
2. Complete installation/registration wizard for 31DEC99.
3. Low-level code development in support of NRAO instruments.
4. Continue updating user documentation.
5. Additional data editing and weighting tools (some completed, others under consideration).
6. Streamline loading and calibration of VLBI data.

PCs

Prior to the February release of Microsoft Windows 2000, it became increasingly clear that while the new operating system has the potential to improve our Windows environments and to simplify PC administration, it also contains features that can introduce serious incompatibilities with existing systems on our networks. Before any Windows 2000 systems can be installed on our existing networks, support staff will need time for training and testing the new features in a trial environment, and then to determine the best configuration for Windows 2000 networking across the Observatory. The NRAO, like many other institutions with mixed environments, has therefore adopted the policy that, until this training and evaluation program is complete, there will be a moratorium on the deployment of Windows 2000 on computers which are installed on NRAO networks. Most PC support staff will receive formal training during the spring and summer of 2000, and we hope to have a test network set up by July. For budgetary reasons, it is unlikely that we will be able to begin a general upgrade of existing systems to Windows 2000 before next year.

System Support

In 1999, the NRAO held a very successful meeting for all staff involved in real-time computing. The attendees felt strongly that the information exchange and, especially, the personal contact and discussion, were valuable to their work. A modest allocation has been made from the Observatory-wide Computing budget in 2000 to support a similar meeting for NRAO computer support staff, which is tentatively scheduled to take place in Socorro in August. A number of issues affecting all NRAO sites require extensive discussion, including security-related procedures, software configuration standards, Windows 2000 testing, and the increasing network interaction of Windows and UNIX; this meeting is therefore very timely.

Hardware

UNIX Upgrades

The Observatory-wide Computing budget for hardware and software has again been cut in 2000. Less than 10 percent of our UNIX desktops can be upgraded this year, essentially the same as in 1999. Most of this equipment will be ordered during the second quarter of 2000.

Five years is the longest that a system can be considered useful in the face of vendor support restrictions and the steady increase in resources required by operating systems and applications. The limited budget available in 1999 and 2000 for the upgrade effort has not permitted us to keep up with the 20 percent annual turnover rate which is required to achieve this goal. As a result, there are still more than a hundred systems in daily use around the Observatory which are at least five years old; roughly half of these are no longer supported by the current version of their operating system.

Networking

The installation of videoconferencing capability, which is funded by a special grant from the NSF, continues to progress at all four major NRAO sites (Charlottesville, Green Bank, Socorro and Tucson). The equipment was installed during January and February as planned. Initial tests by technical staff went smoothly, with only minor modification of equipment settings required. The facilities have since been used quite successfully for several internal meetings. Experience thus far suggests that larger meetings and presentations by video will be more effective with a few improvements, such as wiring for audio pickup in the AOC and Green Bank auditoriums. These enhancements will be planned during the spring of 2000.

Videoconference participation from outside of the NRAO requires ISDN; this capability will be configured and tested this quarter, and should be available before summer. The equipment we have purchased uses H.323 protocol, with a gateway to H.320 (ISDN). Because of this adherence to common standards, we expect our facilities to interoperate well with most popular videoconferencing equipment.

Planning

Significant planning efforts have been conducted for the improvement of the final data products offered to users of NRAO telescopes. We are considering how best to bring the data products from NRAO telescopes in line with those from other telescopes operating in different wavebands. To improve the accessibility of our facilities, we would like to be able to provide initial calibration and imaging for all observations, both from synthesis arrays and single dish radio telescopes. This goal is achievable, but requires integration of all aspects of the software used in NRAO telescopes. A proposal for accomplishing this has been prepared and circulated, and is now under discussion throughout the Observatory. The key element is the establishment of a Data Management and Operations Division charged with the overall responsibility for improving our data products.

Green Bank Computing

Because of lack of manpower, we had fallen behind on upgrades to the operating systems of the Unix computers. We embarked on a program to address this aggressively. With two planned exceptions, we have now been able to upgrade all of the Suns to be at revision 2.6 of Solaris, and for all PCs running Linux to be at revision 6.0 of the RedHat distribution.

The dual-processor Sun Ultra 60 purchased in 1999 is in full service as the compute server and as the repository of all third party software served to the other Sun computers.

To provide a more uniform environment for our Windows users, we have embarked on a program to upgrade all of the Windows 95 computers to Windows NT. By the end of the year, approximately 90 percent of the upgrades were complete. The rest should be complete in April.

The major new piece of equipment implemented in the last year was a Hewlett-Packard printer capable of printing D, E, and A0 formats. It has now been fully configured for use by all staff members from both Unix and Windows platforms. It has already revolutionized the preparation of poster papers for scientific and technical conferences, for example at the AMERICAN ASTRONOMICAL SOCIETY meeting in Atlanta in January and the SPIE meeting in Munich in March. It is being used more and more to produce engineering drawings by the drafting and technical staff.

Despite the fact that Green Bank has very clean and reliable power, it still suffers occasional interruptions. We now have all of the servers (Unix and Windows NT) and the essential computers to operate the GBT on modern Uninterruptible Power Supplies.

Socorro Computing

Y2K - The AOC and VLA site computer systems passed the Y2K transition well. All of our important services had been moved to new servers with Y2K-compliant operating systems. Even so, older servers (old zia, arana) with non-compliant operating systems did not die completely in 2000; at this time they are limping along with limited functionality, and will be shut down for good very soon. Computer Division support staff was on-hand on January 1, 2000, but left within a few hours when it became apparent that all important systems were running well.

New Hardware - Testing of the new poster-size color laser printer was concluded successfully; it is already available for general use. A guide to its use is currently nearing completion; as soon as that is done the availability of the printer will be announced officially.

A new high volume laser printer was installed in the west wing, allowing better printing access to staff in this new wing, while at the same time relieving pressure on the central laser printer next to the old computer floor.

We are gradually upgrading our tape drives on public machines; each of the three corridors with public workstations now has access to one DDS-3 DAT drive; funds permitting, we plan to further improve the tape situation of both DATs and Exabytes during the remainder of this year.

The new video conferencing equipment was installed, and already is seeing frequent use.

We ordered 13 new PCs (5 high-end and 8 mid-range) to replace the obsolete Sun IPXs that are still in wide use around NRAO-NM. This choice of computers was aimed at maximizing the number of systems we could afford with limited funds without compromising their usefulness in the coming years.

Operations Management System (OMS) - The OMS dynamic scheduling system was released to a wider group of beta testers—until then it had only been used by the VLBA data quality analyst. Schedule views were delivered to beta testers, as were prototype OMS reports and the OMS correlator queue management.

VLA Online System Upgrade - The division heavily contributed to the computing chapter in the EVLA proposal document, and an improved manpower plan for the VLA expansion computing system was prepared. This plan predicts the FTEs needed each year until 2007 for VLA, VLBA, and EVLA. A first draft of the operational VLA Expansion computing system requirements was produced; Blachman will further expand this to its final version. Successful tests of a new serial line controller concluded the initial evaluation of the hardware for the EVLA monitor and control system.

In close cooperation with the Electronics Division, more testing of the correlator controller components was conducted. We expect the remaining hardware to be available by mid-April, after which we will intensify the tests. First realistic tests on the actual array may be started as early as July 2000; dedicated test time for this purpose has been requested and assigned.

VLBA Support - The "track" database was moved to the new database server Oort; work on making support of the Pie Town antenna in the VLA transparent is 90 percent complete. A VLBA recorder track test was developed which should help in optimally calibrating the VLBA recorders.

VLA Support - A VLA fast switching mode for planetary bodies was developed and implemented. Though it already has been used on a small number of occasions, the data have not been reduced yet and we are unable to gauge the level of success.

During the first quarter, a number of the known bugs in *jobserve* were eliminated, and the few remaining ones are being addressed currently. Though officially jobserve has not been released outside the NRAO, we have shipped it to sites that asked for it, which has resulted in a number of helpful comments. We are aiming at a first release late May, 2000. This version will support VLA observing with the Pie Town antenna.

Mainsaver - The Computer Division finalized the transition from our locally developed maintenance system MAINT to the commercial PC-based Mainsaver. Mainsaver is intended to be the primary means of managing inventory, entering work orders, and scheduling preventive maintenance for the AOC, the VLA, and the VLBA sites. Since January 1, Mainsaver has been used exclusively, and support of MAINT has stopped entirely.

User Support, Miscellaneous - A concentrated effort is under way to update the Socorro-based computer web pages. The structure was redesigned and most of the content has been completely rewritten. We plan to bring these new web pages online some time during the second quarter of 2000.

Due to various circumstances, the unresolved problem count of our help desk system had risen above 100. In a concentrated effort this count was reduced by 50 percent, and we are committed to prevent the number of open tickets from rising above this level again.

Computer Division Goals for Second Quarter, 2000 - To be completed:

1. VLA-AOC communications upgrade complete.
2. Bring new division web pages online.
3. Install new PC hardware (initially) in summer student areas.
4. Order equipment for upgrade majority of PC network.
5. Order and install new tape drives on public systems.
6. Exhaustive clean-up of system files.
7. Release "jobserve" with support for Pie Town.
8. Draft of VLA Expansion computing system requirements document ready to go to reviewers.
9. More detailed project plan for EVLA software rewrite including improved manpower plan.
10. Perform initial tests of CORBA.
11. Study *use cases* for EVLA observing model (proposal, scheduling).
12. Perform connectivity test of the serial line controller.
13. Perform bench testing of correlator controller hardware.

To receive serious attention:

14. Further rewrite and redesign of all division Web pages.
15. Prepare to relocate VLA computing lab for ALMA control room.
16. Train Technical Specialist in Windows support.
17. Install new printing system.
18. Remove old servers zia and arana from service.

I. AIPS++

In the last quarter our major goals were to support the first public release of AIPS++ (version 1.2), and to issue the second release (version 1.3). The second release is now pending and will be made in the next few weeks. The capabilities of version 1.3 are described in the release notes http://aips2.aoc.nrao.edu/docs/project /releasenotes13.

Immediately after the first release, we produced a development plan (http://aips2.nrao.edu/docs/notes/226/226.html). Most of the work in 2000Q1 was as described in this development plan, with the addition that we devoted several weeks at the end of the development cycle to fixing defects.

As described in the last quarterly report, the AIPS++ Goals for 2000 are as follows:

E 1. Support the existing release (1.2) of AIPS++ by NRAO, consortium, and astronomical users.
This continues. The total number of defect reports submitted now approaches 1300, of which we have fixed about 1100. The remainder are postponed until the next development cycle that is now starting. In the version 1.3, there were no unresolved important defects (severity level 1 or 2).

E 2. Support GBT commissioning and first scientific observations.
This continues. We now have data conversion programs for all of the possible output formats from the GBT. The single dish analysis program and the GBT commissioning tool continue to be improved. We believe that we are well situated for the expected commencement of GBT commissioning in August 2000.

E 3. Issue two main releases (1.3 and 1.4) of AIPS++, improving the completeness of scientific capabilities and thus broadening the user community.
Version 1.3 is now undergoing final testing and duplication to CDROMs and is expected to be released in April. We hold the planning meeting for version 1.4 in late April. The number of AIPS++ users continues to increase steadily.

E 4. Provide simulation capabilities for ALMA within AIPS++, including construction of data sets with simulated errors, calibration and imaging, and evaluation of imaging performance
This is concluded for the moment. We are in advance of the capability of ALMA scientists to use the existing functionality. Once they have investigated use of the package, we will continue with the next goal of adding simulation of antenna pointing errors.

E 5. Coordinate development of calibration and imaging pipelines within AIPS++
A coordination meeting was held in Socorro in late January. This served to align the work going on at different AIPS++ sites. Further coordination will continue throughout the year.

E 6. Develop a plan for constructing an NRAO-wide Data Management System based on AIPS++, designed to deliver complete data products that make NRAO telescopes more accessible to astronomers, and incorporating the university community into the production, analysis, and archiving of these data.
A plan for the establishment of a Data Management Division with these goals has been completed, and is under discussion at the Observatory. A presentation of this plan was made to the AUI Board of Trustees, and received support.

I 7. Complete AIPS++ such that processing of mainstream VLA and VLBA observations can be accomplished entirely within AIPS++
This is ongoing. For the VLA, the major work needed is to complete some areas of calibration, and to improve data editing capabilities. For the VLBA, a data conversion program (a filler) must be written, and we need a fringe-fitting capability. We are in the process of hiring a scientist/programmer to aid with the development in this area.

I 8. Coordinate with the EVLA Project the use of AIPS++ facilities with the EVLA
We contributed a section on computing for the EVLA proposal to address these issues.

I 9. Develop a prototype calibration and imaging pipeline for the VLBA with the goal of simplifying use of the VLBA by non-experts.
This activity is still in the planning stage. As a first step, we are developing scripts for the reduction of known data sets.

I 10. Develop visualization capabilities inside AIPS++ using already secured NSF grant, with the goal of aiding processing of radio-astronomical observations into scientific results.
We have hired one scientist into Green Bank, effective April 3, to work on visualization, and continue a search for a visualization software developer to be located in Socorro.

D 11. Issue developer's prerelease of AIPS++ for development of new AIPS++ on limited and controlled platform, thereby expanding the pool of available developers outside the existing consortium
This is in the planning phase. We expect the major work here to be in documentation. We expect a pre-release will be issued in mid 2000. The pressure for a developer's release is quite high.

D 12. Conduct outreach initiative to publicize AIPS++ and to educate new users.
For item 12, we continue internal workshops on the use of AIPS++ in various applications. We also conducted outreach at the AMERICAN ASTRONOMICAL SOCIETY meeting in Atlanta. We plan to continue this at various meetings throughout the year. We also visited Arecibo in February to consult with NAIC scientists on the use of AIPS++. This has led to an ongoing informal collaboration.

E = Essential; I = Important; D = Desirable.

J. TELESCOPE USAGE

The following telescopes have been scheduled for research and maintenance in the following manner during the first quarter of 2000.

	12 Meter	VLA	VLBA
Scheduled Observing (hrs)	1932.50	1635.80	1685.00
Scheduled Maintenance and Equipment Changes	73.25	224.80	240.00
Scheduled Tests and Calibration	178.25	316.00	272.00
Time Lost	165.75	103.00	38.00
Actual Observing	1766.75	1532.80	1647.00

K. VERY LARGE ARRAY OBSERVING PROGRAMS

No.	Observer(s)	Title
AA245	Arzoumanian, Z. (NASA/GSFC) Yusef-Zadeh, F. (Northwestern)	Survey of 1720 MHz OH masers in the inner Galaxy. 20 cm
AB876	Bietenholz, M. (York U.) Frail, D. Hester, J. (Arizona State)	Time-variability in the radio structure of the Crab nebula. 6 cm
AB879	Becker, R. (UC, Davis) White, R. (STScI) Helfand, D. (Columbia)	FIRST survey. 20 cm
AB917	Blundell, K. (Oxford) Close, L. (Oxford) Leahy, P. (Manchester) Beasley, A.	Multi-frequency high resolution study of hotspots. 0.7, 1.3, 2, 90 cm

No.	Observer(s)	Programs
AB922	Browne, I. (Manchester) Marlow, D. (Pennsylvania) Myers, S. Wilkinson, P. (Manchester) Fassnacht, C. (Caltech) Readhead, A. (Caltech) Xanthopoulos, E. (Manchester) Rusin, D. (Pennsylvania) Biggs, A. (Manchester) Blandford, R. (Caltech) de Bruyn, G. (NFRA) Jackson, N. (Manchester) Koopmans, L. (Groningen/Kapteyn) Norbury, M. (Manchester) Pearson, T. (Caltech)	Gravitational lens monitoring combined program. 3.6, 6, 20 cm
AB925	Bondi, M. (Bologna) Gregorini, L. (Bologna) Vettolani, G. (Bologna) Parma, P. (Bologna) DeRuiter, H. (Bologna) Zamorani, G. (Bologna) Ciliegi, P. (Bologna) LeFevre, O. (Marseille Obs) Mazure, A. (Marseille Obs) Guzzo, L. (Milano Obs) Arnaboldi, M. (OAC, Italy) Scaramella, R. (OAR, Italy)	Sub-mJy observations of VLT VIRMOS deep field. 20 cm
AB927	Brogan, C. (Kentucky) Troland, T. (Kentucky)	H I Zeeman observation toward W49. 20 cm line
AB931	Blundell, K. (Oxford) Kassim, N. (NRL) Owen, F. Lazio, T. J. W. (NRL) Rawlings, S. (Oxford)	A 74 MHz survey. 90 cm
AB935	Butler, B. Stern, S. A. (SWRI)	Observations of Pluto/Charon and Triton. 0.7 cm
AB937	Bohringer, H. (MPIfEP, Garching) Schuecker, P. (MPIfEP, Garching) Feretti, L. (Bologna) Giovannini, G. (Bologna) Govoni, F. (Bologna)	Search of radio halos in REFLEX clusters. 20 cm
AB938	Bower, G. Falcke, H. (MPIR, Bonn) Backer, D. (UC, Berkeley)	Circular polarization in Sgr A*. 0.7, 1.3, 2, 3.6 cm

No.	Observer(s)	Programs
AC524	Cartwright, J. (Caltech) Taylor, G. Readhead, A. (Caltech) Pearson, T. (Caltech)	Polarization monitoring observations of 3C273. 0.7, 1.3 cm
AC528	Caccianiga, A. (Lisbon) Della Ceca, R. (Brera Obs) Maccacaro, T. (Brera Obs) Wolter, A. (Brera Obs) Gioia, I. (Bologna)	Radio/x-ray selected BL Lacs and radio galaxies. 6, 20 cm
AC532	Cowan, J. (Oklahoma) Stockdale, C. (Oklahoma) Rupen, M. Chu, Y. (Illinois)	Observations of SN 1961V: supernova or not? 6 cm
AC538	Carilli, C. Menten, K. (MPIR, Bonn) Yun, M.	Imaging the CO emission from the z=4.4 quasi-stellar object BRI 1335-0417. 0.7, 3.6 cm
AC540	Clarke, T.	Faraday rotation in extended radio sources in Abell clusters. 6, 20 cm
AC544	Castelletti, G. (IAFE) Golap, K. Dubner, G. (IAFE) Goss, W. M.	CTB80. 90 cm
AC549	Cram, L. (Sydney) Mobasher, B. (Imperial College) Ellis, R. (Cambridge) Sullivan, M. (Cambridge) Treyer, M. (Marseille Obs) Hopkins, A. (Pittsburgh)	Continuum emission from UV selected star forming galaxies. 20 cm
AD428	Dallacasa, D. (Bologna) Stanghellini, C. (Bologna) Fanti, R. (Bologna) Centonza, M. (Bologna)	High frequency peakers. 1.3, 2, 3.6, 6, 20 cm
AD433	Di Matteo, T. (CfA) Fabian, A. (Cambridge) Carilli, C. Magorrian, J. (CITA) Allen, S. (Cambridge)	X-ray emitting elliptical galaxies. 0.7, 1.3, 3.6 cm
AE132	Estalella, R. (Barcelona) Beltran, M. (CfA) Ho, P. (CfA) Anglada, G. (IAA, Andalucia)	Thermal radio jet in B335. 3.6 cm

No.	Observer(s)	Programs
AF350	Falcke, H. (MPIR, Bonn) Lobanov, A. (MPIR, Bonn) Wright, M. (UC, Berkeley) Bower, G. Aller, M. (Michigan) Terasranta, H. (Helsinki) Patnaik, A. (MPIR, Bonn)	Monitoring extremely variable spiral III Zw 2. 1.3, 2, 3.6, 6, 20, 90 cm
AF368	Filho, M. (Groningen/Kapteyn) Barthel, P. (Groningen/Kapteyn) Ho, L. (DTM/Carnegie)	Searching for central engines in composite LINER/H II galaxies. 3.6 cm
AF370	Falcke, H. (MPIR, Bonn) Brunthaler, A. (MPIR, Bonn) Bower, G. Aller, M. (Michigan) Aller, H. (Michigan) Terasranta, H. (Helsinki)	III Zw 2, a superluminal jet in a spiral galaxy. 0.7, 1.3, 2, 3.6, 20, 90 cm
AG575	Greenhill, L. (CfA) Chandler, C. (Cambridge) Herrnstein, J. (Renaissance Tech) Reid, M. (CfA)	Orion BN/KL: the maser shell around source I. 0.7 cm line
AG580	Govoni, F. (Bologna) Taylor, G. Dallacasa, D. (Bologna) Feretti, L. (Bologna) Giovannini, G. (Bologna)	Faraday rotation in clusters A2255 and A514. 3.6, 6 cm
AG586	Gaensler, B. (MIT) Gotthelf, E. (Columbia) Vasisht, G. (JPL) Slane, P. (CfA)	Anomalous x-ray pulsars. 20 cm
AH669	Hjellming, R. Rupen, M. Mioduszewski, A. (ATNF)	Galactic black hole x-ray transients. 1.3, 2, 3.6, 6, 20 cm
AH672	Harris, D. (CfA) Walker, R. C. Leeuw, L. (Hawaii)	25" knot in the radio jet of 3C 120. 2 cm
AH685	Haarsma, D. (Haverford College) Hewitt, J. (MIT) Langston, G. Moore, C. (Groningen/Kapteyn)	Time delay monitoring of gravitational lens 2016+112. 3.5, 6 cm

No.	Observer(s)	Title
AH689	Hofner, P. (NAIC) Cesaroni, R. (Arcetri) Rodriguez, L. (Mexico/UNAM) Marti, J. (JAEN)	High mass protostar IRAS 20126+4104. 0.7, 1.3 cm
AH690	Hill, G. (Texas) Croft, S. (Oxford) Rawlings, S. (Oxford) Gay, P. (Texas)	TEXOX high-redshift cluster survey. 20 cm
AH695	Hunter, D. (Lowell Obs) Hunsberger, S. (Lowell Obs)	H I in irregulars without ordered rotation. 20 cm
AH699	Ho, P. (CfA) McGary, R. (CfA) Coil, A. (UC, Berkeley)	1720 OH masers near Sgr A. 20 cm
AH704	Hibbard, J. Higdon, J. (Groningen/Kapteyn) Charlton, J. (Pennsylvania)	H I in the tidal tail of NGC 3921. 20 cm
AI081	Irwin, J. (Queens) Chaves, T. (Queens)	Edge-on galaxy NGC 2613 - possible supershells. 20 cm
AJ269	Jamrozy, M. (Jagellonian) Machalski, J. (Jagellonian)	Detection of a radio core in "giant" radiogalaxy candidates. 6 cm
AJ271	Jamrozy, M. (Jagellonian) Machalski, J. (Jagellonian)	Detection of radio cores in candidate "giant" radio galaxies. 3.6 cm
AJ272	Jones, D. (JPL) Preston, R. (JPL)	Low frequency images of Pearson-Readhead AGNs. 90 cm
AJ275	Jaffe, W. (Leiden) Ford, H. (Johns Hopkins) Tran, H. (Johns Hopkins) Davies, J. (Johns Hopkins)	Nearby AGNs with nuclear disks. 3.6 cm
AK485	Kulkarni, S. (Caltech) Frail, D. Bloom, J. (Caltech) Djorgovski, S. (Caltech) Harrison, F. (Caltech)	Radio afterglows of gamma-ray bursts. 2, 3.6, 6, 20 cm
AK500	Kurtz, S. (Mexico/UNAM) Carral, P. (Guanajuato U.) Hofner, P. (NAIC)	Supercompact H II region ON-2 (H_2O). 0.7 cm

No.	Observer(s)	Programs
AK503	Kolpak, M. (Boston) Jackson, J. (Boston) Bania, T. (Boston) Clemens, D. (Boston) Simon, R. (Boston) Heyer, M. (Massachusetts) Dickey, J. (Minnesota) McClure-Griffiths, N. (Minnesota)	H I absorption toward sources from the BU/UMass Galactic Ring Survey. 20 cm line
AK507	Koopmans, L. (Groningen/Kapteyn) de Bruyn, A. G. (NFRA) Fassnacht, C. (Caltech)	Radio micro lensing in the gravitational lens B1600+434? 1.3, 2, 3.6 cm
AK508	Kurtz, S. (Mexico/UNAM)	Hot molecular core in W75N. 1.3 cm
AK514	Kenny, J. (Yale) van Gorkom, J. (Columbia)	H I mapping of ongoing ICM/ISM stripping in NGC 4522. 20 cm line
AL507	Lazio, T. J. W. (NRL) Kassim, N. (NRL)	Unidentified ultra-steep spectrum source. 20 cm
AL509	Lim, J. (SA/IAA, Taiwan) Ho, P. (CfA)	H I in low-redshift quasars. 20 cm line
AL511	Lang, C. Goss, W. M.	Intrinsic magnetic field orientation and H II environment of the Snake. 3.6, 6 cm
AM626	Miller, N. (New Mexico State) Owen, F.	Search for dust-obscured star formation in E+A galaxies. 20 cm
AM647	Minter, A. Reynolds, R. (Wisconsin) Balser, D.	Faraday rotation observations to measure turbulence in the WIM. 20 cm
AM648	Monnier, J. (CfA) Greenhill, L. (CfA) Tuthill, P. (Sydney) Danchi, W. (UC, Berkeley)	Spectra of IR bright Wolf-Rayet stars. 1.3, 2, 3.6, 6 cm
AN087	Neff, S. (NASA/GSFC) Ulvestad, J.	H II regions in NGC 4038/9 ("the Antennae"). 2 cm
AN090	Neff, S. (NASA/GSFC) Ulvestad, J.	Star formation processes in a galactic merger sequence. 3.6, 6 cm
AN091	Neumann, D. (CNRS, France) Kassim, N. (NRL) Roettiger, K. (Missouri)	On the origin of radio halos in clusters of galaxies. 90 cm

No.	Observer(s)	Programs
AO144	Owen, F. Eilek, J. (NMIMT)	High dynamic range imaging of the M87 halo. 20 cm
AO147	Ogley, R. (CNRS, France) Mirabel, I. F. (CNRS, France) Chaty, S. (Open University) Marti, J. (Jaen) Rodriguez, L. (Mexico/UNAM) Stirling, A. (Lancashire)	Super-soft X-ray white dwarf binaries. 3.6, 6 cm
AO148	Oosterloo, T. (NFRA) Morganti, R. (NFRA) van Moorsel, G.	H I rotation curves of early-type galaxies. 20 cm
AO149	Owen, F.	Cluster radio halo candidates. 20 cm
AP380	Pooley, G. (Cambridge) Hardcastle, M. (Bristol, UK) Riley, J. (Cambridge) Alexander, P. (Cambridge) Gilbert, G. (Cambridge)	Radio jets of FRII radio sources. 3.6, 6 cm
AP387	de Pater, I. (UC, Berkeley) Butler, B. Perley, R.	Jupiter's flux density at 74 and 330 MHz. 90 cm
AP390	Perley, R. Condon, J. Cotton, W. Yin, Q-F. Wall, J. (Oxford) Kassim, N. (NRL) Erickson, W. (Maryland)	74 MHz all sky survey: test observations.
AR402	Rudnick, L. (Minnesota) Treichel, K. (Minnesota) Katz-Stone, D. (USNA) Giovannini, G. (Bologna)	Non-relativistic sheaths around extragalactic jets. 3.6, 6, 20 cm
AR411	Reipurth, B. (Colorado/JILA) Rodriguez, L. (Mexico/UNAM)	New thermal jets in the OMC-2 region. 3.6, 6 cm
AR418	Richards, E. (Arizona State) Cowie, L. (Hawaii) Barger, A. (Hawaii) Fomalont, E. Kellermann, K. Partridge, R. B. (Haverford College) Windhorst, R. (Arizona State)	A 20 cm deep field. 20 cm

No.	Observer(s)	Programs
AR423	Rawlings, S. (Oxford) Croft, S. (Oxford) Kennefick, J. (Oxford)	Thirty-two z>4 quasars. 20 cm
AR428	Reynaud, D. (CNRS, France) Downes, D. (IRAM) Roussel, H. (CNRS, France) Vigroux, L. (CNRS, France) Beck, R. (MPIR, Bonn)	Magnetic fields in the barred spiral NGC 1530. 3.6, 6 cm
AR430	Rupen, M. Fan, X. (Princeton) Strauss, M. (Princeton) Carilli, C. Yun, M. Schneider, D. (Penn State) Bertoldi, F. (MPIR, Bonn)	High redshift quasi stellar objects from the SDSS. 6 cm
AR431	Rand, R. (New Mexico) Higdon, J. (Groningen/Kapteyn) Duric, N. (New Mexico) Lacey, C. (NRL)	Thermal and non-thermal emission in the barred spiral galaxy M83. 3.6, 6, 20 cm
AR432	Rosenberg, J. (Massachusetts) Schneider, S. (Massachusetts)	H I imaging of low surface brightness galaxies. 20 cm line
AS568	Sramek, R. Weiler, K. (NRL) Van Dyk, S. (UCLA) Panagia, N. (STScI)	Properties of radio supernovae. 1.3, 2, 3.6, 6, 20 cm
AS677	Scheuer, P. (Cambridge) Laing, R. (Oxford)	How do hot spots talk to each other? 20 cm
AS679	Snellen, I. (Cambridge) Mack, K. (Bologna) Schilizzi, R. (NFRA) Tschager, W. (Leiden)	Luminosity function of nearby GPS sources. 2, 3.6, 6 cm
AS686	Saikia, D. (NCRA, India) Ishwara-Chandra, C. (NCRA, India)	Giant radio sources. 6, 20 cm
AT229	Taylor, G. Fabian, A. (Cambridge) Allen, S. (Cambridge) Govoni, F. (Bologna)	Faraday rotation study of the 3C129 cooling flow cluster. 3.6, 6 cm

No.	Observer(s)	Programs
AT235	Trinidad, M. (Mexico/UNAM) Curiel, S. (Mexico/UNAM) D'Alessio, P. (Mexico/UNAM) Rodriguez, L. (Mexico/UNAM)	Circumbinary disk structures around binary YSOs. 0.7, 3.6 cm
AT237	Thomas, H. (Cambridge) Green, D. (Cambridge) Alexander, P. (Cambridge) Eales, S. (Wales)	H I observations of galaxies in the JCMT/SCUBA galaxy survey. 20 cm
AT243	Thompson, M. (Kent)	Line rich and line poor UC H II regions. 1.3 cm
AV246	Venturi, T. (Bologna) Dallacasa, D. (Bologna)	Sources in Abell A3528.
AW362	White, S. (Maryland)	The stellar activity cycle on active stars. 3.6, 6, 20 cm
AW518	Wall, J. (Oxford) Blundell, K. (Oxford) Kassim, N. (NRL) Lazio, T. J. W. (NRL) Peck, A. (MPIR, Bonn)	Search for 74 MHz halos around CSO/GPS sources. 400 cm
AW522	Wilner, D. (CfA) Ho, P. (CfA) Rodriguez, L. (Mexico/UNAM) Beltran, M. (CfA) Kastner, J. (Haystack)	Continuum studies of T-Tauri disks. 0.7 cm
AW525	Wilcots, E. (Wisconsin) Sparke, L. (Wisconsin) Noordermeer, E. (Wisconsin)	Dynamics of barred Magellanic spirals. 20 cm
AW527	Willson, R. (Tufts) Lang, K. (Tufts)	Nonthermal radio emission from solar bursts and CMEs. 90 cm
AW533	Wyrowski, F. (Maryland) Schilke, P. (MPIR, Bonn) Menten, K. (MPIR, Bonn) Walmsley, C. M. (Arcetri)	Vibrationally excited cyanoacetylene in G10.47+0.03. 0.7 cm line
AY110	Yun, M. Sanders, D. (Hawaii) Kawara, K. (Tokyo U.) Taniguchi, Y. (Tohoku)	Radio identification of ISOPHOT Lockman Hole survey sources. 20 cm
AZ121	van Zee, L. (DAO) Salzer, J. (Wesleyan U.) Taylor, C. (Ruhr U.) Norton, S. (UC, Santa Cruz)	H I in compact dwarf irregular galaxies. 20 cm

No.	Observer(s)	Programs
AZ124	Zwaan, M. (Groningen/Kapteyn) van Dokkum, P. (Caltech) Verheijen, M. Briggs, F. (Groningen/Kapteyn)	H I imaging of galaxy cluster Abell cluster 1689 at z=0.181. 20 cm
AZ125	Zabludoff, A. (Arizona) Mulchaey, J. (Mt. Wilson) Wilcots, E. (Wisconsin) Williams, B. (Delaware) van Gorkom, J. (Columbia)	The H I content of loose groups of galaxies. 20 cm
BA036	Augusto, P. (Madeira) Browne, I. (Jodrell Bank) Wilkinson, P. (Jodrell Bank)	B2114+022, a gravitational lensing candidate. 90 cm
BB117	Beasley, A. Herrnstein, J. (Renaissance Tech)	Monitoring of WR 140. 2, 3.6, 6 cm
BD062	Diamond, P. (Jodrell Bank) Kemball, A.	TX Cam: the sequel. 0.7 cm
BF058	Falcke, H. (MPIR, Bonn) Reid, M. (CfA) Henkel, C. (MPIR, Bonn) Brunthaler, A. (MPIR, Bonn)	Towards measuring proper motions of local group galaxies. 1.3 cm
BG095	Gabuzda, D. (NFRA) Aller, M. (Michigan) Aller, H. (Michigan) Hughes, P. (Michigan)	Polarization of BL Lac objects. 2, 3.6, 6 cm
BG096	Gomez, J-L. (IAA, Andalucia) Agudo, I. (IAA, Andalucia) Alberdi, A. (IAA, Andalucia) Cawthorne, T. (Lancashire) Marscher, A. P. (Boston)	Multi-frequency polarimetric VLBA observations of conical shocks in the inner jet structure of 3C371. 1.3, 2 cm
BH042	Herrnstein, J. (Renaissance Tech) Moran, J. M. (CfA) Greenhill, L. (CfA)	Are quasars being ejected from the nucleus of NGC 4258? 20 cm
BK071	Kowatsch, P. (MPIR, Bonn) Krichbam, T. P. (MPIR, Bonn) Roy, A. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Fricke, K. J. (Gottingen)	Two-sided jet in Seyfert 2 galaxy NGC 3079. 3.6, 6, 20 cm

No.	Observer(s)	Programs
BK073	Kellermann, K. Biretta, J. (STScI) Owen, F. Junor, W. (New Mexico)	Kinematics of parsec and subparsec structure of M87 jet. 2 cm
BP055	Peck, A. (MPIR, Bonn) Taylor, G. Vermuelen, R. (NFRA)	H I in compact symmetric object J1816+3457. 20 cm
BP061	Phillips, R. (Haystack) Boboltz, D. (USNO)	Monitoring of 43 GHz SiO maser emission towards MIRA. 0.7 cm
BP065	Peck, A. (MPIR, Bonn) Taylor, G.	Jet and hotspot velocities in compact symmetric objects. 3.6 cm
BS073	Stanghellini, C. (IRA) Bondi, M. (IRA) Dallacasa, D. (Bologna) Xiang, L. (Urumqi)	Kinematics of parsec and subparsec structure of M87 jet. 3.6, 2 cm
BW043	Walker, R. C. Kellermann, K. Romney, J. Vermeulen, R. (NFRA) Alef, W. (MPIR, Bonn) Benson, J.	Changes in the 3C84 accretion region. 1.3, 2, 3.6, 6 cm
GB034	Bartel, N. (York) Rupen, M. Bietenholz, M. (York) Beasley, A. Conway, J. (Onsala) Altunin, V. (JPL) Graham, D. (MPIR, Bonn) Venturi, T. (Bologna) Umana, G. (Noto)	Detailed high resolution image of supernova 1993J in M8. 3.6 cm
GG042	Greenhill, L. (CfA)	Maser accretion disk in NGC 1068. 1.3 cm
GM036	Momjian, E. (Kentucky)	High velocity H I absorption against 3C84. 20 cm
W068	Zensus, J. A. (MPIR, Bonn) Carrara, E. (Sao Paulo) Abraham, Z. (Sao Paulo) Lobanov, A. (MPIR, Bonn) Unwin, S. (JPL)	Quasar 3C 273. 6 cm

No.	Observer(s)	Programs
W094	Hirabayashi, H. (ISAS, Japan) Wehrle, A. (JPL) Unwin, S. (JPL) Makino, F. (ISAS, Japan) Kii, T. (ISAS, Japan) Kobayashi, H. (NAO, Japan) Edwards, P. (ISAS, Japan) Okayasu, R. (ISAS, Japan) Valtaoja, E. (Turku)	3C279. 6 cm

L. THE VERY LONG BASELINE ARRAY OBSERVING PROGRAMS

No.	Observer(s)	Programs
BA036	Augusto, P. (Madeira) Browne, I. (Manchester) Wilkinson, P. (Manchester)	B2114+022, a gravitational lensing candidate. 18 cm
BB104	Bignall, H. (Adelaide) Tingay, S. (JPL) Tzioumis, A. (MPIR, Bonn)	Monitoring of SAX x-ray AGN. 1, 4, 13 cm
BB107	Butler, B. Campbell, D. (Cornell) Ostro, S. (JPL)	Radar observations of newly discovered near-earth objects in 1999. 13 cm
BB111	Brisken, W. (Princeton) Dewey, R. (Princeton) Thorsett, S. (Princeton) Beasley, A. J. Benson, J.	Proper motions of pulsars in supernova remnants. 18 cm
BB117	Beasley, A. Herrnstein, J. (Renaissance Tech)	Monitoring of WR 140. 2, 3.6, 6 cm
BB118	Brisken, W. (Princeton) Benson, J. Fomalont, E. Goss, W. M. Thorsett, S. (Princeton)	Parallaxes of ten nearby radio pulsars. 18 cm
BB120	Boboltz, D. (USNO) Gaume, R. (USNO) Fey, A. (USNO) Hajian, A. (USNO) Hummel, C. (USNO) Johnston, K. (USNO)	Simultaneous VLBA/NPOI observations of radio stars. 3.6 cm

No.	Observer(s)	Programs
BC104	Chatterjee, S. (Cornell) Cordes, J. (Cornell) Goss, W. M. Fomalont, E. Beasley, A. Benson, J. Lazio, T. J. W. (NRL) Arzoumanian, Z. (NASA/GSFC)	High frequency VLBA pulsar astrometry. 6 cm
BD062	Diamond, P. (Manchester) Kemball, A.	TX Cam: the sequel. 0.7 cm
BD064	Desai, K. (Renaissance Tech) Golap, K. Anantharamaiah, K. (Raman Institute)	Scattering in the solar wind at large elongations. 2, 3.6, 18 cm
BF049	Fanti, C. (Bologna) Dallacasa, D. (Bologna) Fanti, R. (Bologna) Gregorini, L. (Bologna) Pozzi, F. (Bologna) Stanghellini, C. (Noto) Vigotti, M. (Bologna)	VLBI structure of a new sample of CSS/GPS. 20 cm
BF058	Falcke, H. (MPIR, Bonn) Reid, M. (CfA) Henkel, C. (MPIR, Bonn) Brunthaler, A. (MPIR, Bonn)	Toward measuring proper motions of local group galaxies. 1.3 cm
BG073	Gomez, J-L. (IAA, Andalucia) Alberdi, A. (IAA, Andalucia) Marscher, A. (Boston)	Comparison of observed and simulated relativistic jets: 22 and 43 GHz monitoring observations of the radio galaxy 3C120. 0.7, 1 cm
BG094	Giovannini, G. (IRA) Cotton, W. Feretti, L. (IRA) Lara, L. (IAA, Andalucia) Taylor, G. Venturi, T. (IRA)	VLBI observations of unbiased sample of radio galaxies: II-VLBA Observations of 24 sources. 6 cm
BG096	Gomez, J-L. (IAA, Andalucia) Agudo, I. (IAA, Andalucia) Marscher, A. (Boston) Alberdi, A. (IAA, Andalucia) Cawthorne, T. (Lancashire)	BL Lac object 3C 371. 0.7, 1.3, 2 cm

No.	Observer(s)	Programs
BG102	Gallimore, J. Pedlar, A. (STScI) Baum, S. (STScI) Kukula, M. (Edinburgh) Murray, C. (UNM) O'Dea, C. (STScI) Pedlar, A. (NRAL) Thean, A. (Bologna)	Observations of the CfA Seyferts. 13 cm
BH042	Herrnstein, J. (Renaissance Tech) Moran, J. (CfA) Greenhill, L. (CfA)	Are quasars being ejected from the Nucleus of NGC 4258? 18 cm
BH056	Ho, P. (SAO) Anglada, G. (IAA, Andalucia) Curiel, S. (UNAM) Gomez, J-L. (LAEFF) Patel, N. (SAO) Rodriguez, L. (UNAM) Torrelles, J. (IAA, Andalucia)	Proper motion studies of circumstellar water masers in NGC 2071 and W75N. 2 cm
BH065	Hong, X. (SAO) Jiang, D. (SAO) Wang, W. (SAO) Zhou, J. F. (SAO)	Polarization observations for a sample of 15 EGRET AGNs at 18cm. 20 cm
BJ030	Jiang, D. R. (Shanghai) Zhou, J. F. (Shanghai) Hong, X. Y. (Shanghai) Chen, Y. J. (Shanghai)	Is there a twin jet in the nucleus of 1624+416? 1 cm
BJ032	Johnston, J. (USNO) Fey, A. (USNO) Gaume, R. (USNO) Clark, T. (NASA/GSFC) Ma, C. (NASA/GSFC) Eubanks, T. M. (USNO) Kingham, K. (USNO) Boboltz, D. (USNO) Vandenberg, N. (Interferometrics) Himwich, E. (Interferometrics) Shaffer, D. (Radiometrics) Gordon, D. (NASA/GSFC) Fomalont, E. Walker, R. C.	Geodesy/astrometry observations for 2000. 3.6 cm

No.	Observer(s)	Programs
BK068	Kellermann, K. Cohen, M. (Caltech) Vermeulen, R. (NFRA) Zensus, J. A. (MPIR, Bonn)	Kinematics of quasars and AGN. 2 cm
BK071	Kowatsch, P. (MPIR, Bonn) Krichbaum, T. (MPIR, Bonn) Roy, A. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Fricke, K. (Gottingen)	Two-sided jet in Seyfert 2 galaxy NGC 3079. 3.6, 6, 18 cm
BK073	Kellermann, K. Biretta, J. (STScI) Owen, F. Junor, B. (New Mexico)	Kinematics of parsec and subparsec structure of M87 jet. 2 cm
BL077	Lister, M. (JPL) Piner, B. (JPL) Preston, R. (JPL) Tingay, S. (JPL)	Pearson-Readhead survey at 43 GHz. 0.7 cm
BL080	Lobanov, A. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn) Ros, E. (MPIR, Bonn) Klare, J. (MPIR, Bonn) Geisecke, A. (MPIR, Bonn)	Multi-frequency monitoring of the parsec scale jet in 3C345. 0.7, 1.3, 2, 3.6, 6 cm
BL086	Lobanov, A. (MPIR, Bonn) Ros, E. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn)	Monitoring the ongoing flare in the VLBI core of 3C345. 0.7, 1, 2 cm
BM110	Mutel, R. (Iowa) Denn, G. (Iowa)	Monitoring BL Lac. 0.7, 1.3, 2 cm
BM112	Moran, J. (CfA) Bragg, A. (CfA) Bragg, A. (Manchester) Diamond, P. (Manchester) Greenhill, L. (CfA) Henkel, C. (MPIR, Bonn) Herrnstein, J. (Renaissance Tech) Trotter, A. (CfA)	Next generation study of NGC 4258 accretion disk physics from measurement of month-to-month variations. 1 cm

No.	Observer(s)	Programs
BM116	Marscher, A. (Boston) Cawthorne, T. (Lancashire) Gear, W. (Wales) Stevens, J. (Cambridge) Marchenko, S. (Boston) Lister, M. (JPL) Gabuzda, D. (NFRA) Yurchenko, A. Forster, J. (UC, Berkeley)	Monitoring millimeter-bright AGN. 0.7 cm
BM130	Monnier, J. (CfA) Danchi, W. (NASA) Greenhill, L. (CfA) Tuthill, P. (Sydney)	Interacting stellar winds in WR 112? 4, 6, 13, 20 cm
BN009	Norbury, M. (NRAL) Blandford, R. (Caltech) Browne, I. (NRAL) Jackson, N. (NRAL) Koopmans, L. (Groningen) Marlow, D. (Pennsylvania) Myers, S. Pearson, T. (Caltech) Readhead, T. (Caltech) Rusin, D. (Pennsylvania) Wilkinson, P. (NRAL)	Long-track observations of top CLASS lens candidates. 20 cm
BP053	Polatidis, A. (NFRA) Conway, J. (Chalmers, Onsala) Murphy, D. (JPL)	Continued coordinated monitoring of 1928+738. 0.7, 2 cm
BP055	Peck, A. (MPIR, Bonn) Taylor, G. Vermeulen, R. (NFRA)	H I in compact symmetric object J1816+3457. 18 cm
BP056	Piner, B. (JPL) Jones, D. (JPL)	15 GHz observations of the compact radio-intermediate quasar PG 2209+184. 2 cm
BP057	Piner, B. (JPL) Edwards, P. (ISAS)	Multi-epoch observations of the TeV source 1ES 2344+514. 2 cm
BP059	Patel, N. (SAO) Greenhill, L. (CfA) Herrnstein, J. (Renaissance Tech) Ho, P. (SAO) Moran, J. (CfA) Zhang, Q. (CfA)	Kinematics of gas within a few AU around IRAS 21391+5802. 1 cm

No.	Observer(s)	Programs
BP061	Phillips, R. (Haystack) Boboltz, D. (USNO)	Monitoring of 43 GHz SiO maser emission towards MIRA. 0.7 cm
BP062	Piner, B. (JPL) Edwards, P. (ISAS)	Multi-epoch 15 GHz observations of the TeV sources 2155-304 and 1ES 1959+650. 2 cm
BP065	Peck, A. (MPIR, Bonn) Taylor, G.	Jet and hotspot velocities in compact symmetric objects. 3.6 cm
BR057	Roberts, D. (Brandeis) Moellenbrock, G. Wardle, J. (Brandeis) Gabuzda, D. (NFRA) Brown, L. (Connecticut)	Four 3C quasars with VSOP observations. 0.7, 1.3, 2, 3.6 cm
BR066	Reid, M. (CfA) Davis, J. (CfA)	Proper motion of Sgr A*. 0.7 cm
BS073	Stanghellini, C. (Bologna) Dallacasa, D. (Bologna) Xiang, L. (Urumqi) Bondi, M. (Bologna)	Motion in the radio source OQ208. 2, 3.6 cm
BS074	Sarma, A. (Kentucky) Romney, J. Troland, T. (Kentucky)	VLBA Zeeman measurement of the magnetic field in 22 GHz H_20 masers in W3(2). 1 cm
BT038	Tingay, S. (JPL) Jauncey, D. (ATNF) Jones, D. (JPL) Meier, D. (JPL) Murphy, D. (JPL) Preston, R. (JPL) Reynolds, J. (ATNF) Tzioumis, A. (ATNF)	Continued 8.4 GHz monitoring of Centaurus A, the closest active radio galaxy. 4 cm
BT044	Taylor, G. Beasley, A. J. Frail, D. Kulkarni, S. (Caltech)	VLBA observations of Gamma Ray Bursters. 3.6 cm
BT048	Taylor, G.	Imaging extreme Faraday rotation measures in quasar cores. 0.7, 1.3, 2 cm
BT049	Tarchi, A. (RAIUB) Neininger, N. (RAIUB) Greve, A. (IRAM)	Nature of the central radio source of NGC 2146. 20 cm

No.	Observer(s)	Programs
BU013	Ulvestad, J. Falcke, H. (MPIR, Bonn) Krichbaum, T. (MPIR, Bonn) Roy, A. (MPIR, Bonn) Wilson, A. (Maryland) Wrobel, J. Zensus, J. A. (MPIR, Bonn)	Component motions in two Seyfert galaxies. 4,2,1 cm
BU016	Ulvestad, J. Antonucci, R. (UCSB) Barvainis, R. (Wootton Institute)	Disks, jets, and thermal material in radio-quiet quasars. 20,13, 6 cm
BV033	Vlemmings, W. (Leiden) Baudry, A. (Bordeaux) Diamond, P. (Manchester) Habing, H. (Leiden) Schilizzi, R. (JIVE) van Langevelde, H. (JIVE)	Phase referencing of nearby OH masering stars. 20 cm
BW043	Walker, R. C. Kellermann, K. Romney, J. Vermeulen, R. (NFRA) Alef, W. (MPIR, Bonn) Benson, J.	Changes in the 3C84 accretion region. 1.3, 2, 3.6, 6 cm
BW047	Winn, J. (MIT) Hewitt, J. (MIT) Patnaik, A. (MPIR, Bonn) Schechter, P. (MIT)	Snapshot survey of gravitational lens candidates. 6 cm
BY011	Yakimov, V. (ASC) Gabuzda, D. (JIVE) Vetukhnovskaya, Y. (JIVE)	5 and 15 GHz polarization observations of gamma ray sources. 6, 2 cm
GA018	Augusto, P. (Madeira) Browne, I. (Manchester) Wilkinson, P. (Manchester) Jackson, N. (Manchester)	B2114+022 - a unique and puzzling gravitational lensing candidate. 18 cm

No.	Observer(s)	Programs
GB034	Bartel, N. (York U.) Rupen, M. Bietenholz, M. (York U.) Beasley, A. J. Conway, J. (Chalmers, Onsala) Altunin, V. (JPL) Graham, D. (MPIR, Bonn) Venturi, T. (Bologna) Umana, G. (Bologna)	Detailed high resolution image of supernova 1993J in M81. 3.6 cm
GD014	Dennett-Thorpe, J. (Groningen/Kapteyn) de Bruyn, A. G. (NFRA)	Peaked spectrum sources with their spectral peak above 5 GHz. 1.3 cm
GG038	Giovannini, G. (Bologna) Feretti, L. (Bologna) Venturi, T. (Bologna) Cotton, W. D. Lara, L. (IAA, Andalucia) Taylor, G.	Symmetrically expanding FRI radio galaxy 3C338. 2, 3.6 cm
GG042	Greenhill, L. (CfA)	Maser accretion disk in NGC 1068. 1.3 cm
GK020	Koopmans, L. (Groningen/Kapteyn) de Bruyn, A. G. (NFRA)	Scatter broadening in edge-on disk gravitational lens 1600+434. 18 cm
GM036	Momjian, E. (Kentucky) Romney, J. Troland, T. (Kentucky) Goss, W. M.	High velocity H I absorption against 3C 84. 18 cm
GP025	Paragi, Z. (FOMISGO) Fejes, I. (FOMISGO) Vermeulen, R. (NFRA) Schilizzi, R. (NFRA) Spencer, R. (Manchester) Stirling, A. (Lancashire)	Anomalous equatorial emission region of SS 433. 18 cm
GS016	Snellen, I. (Cambridge) Mack, K. (Bologna) Schilizzi, R. (NFRA) Tschager, W. (Leiden)	Complete sample of GPS sources. 6, 18 cm
GX006	Xanthopoulos, E. (Manchester) Browne, I. (Manchester) Wilkinson, P. (Manchester) Porcas, R. (MPIR, Bonn) Patnaik, A. (MPIR, Bonn)	JVAS gravitational lens B1030+074. 2, 3.6, 18 cm
TF015	Foley, L.	Fringe Finders. 20, 13, 6, 4, 2, 1, 7 cm

No.	Observer(s)	Programs
W022	Reid, M. (CfA) Greenhill, L. (CfA) Argon, A. (CfA) Moran, J. (CfA)	Nuclear jet in M87. 18 cm
W040	Junor, W. (New Mexico) Biretta, J. (STScI)	Proper motion in the Vir A jet. 6 cm
W068	Zensus, J. A. (MPIR, Bonn)	Quasar 3C273. 5 cm
W088	Roberts, D. (Illinois) Moellenbrock, G. Wardle, J. (Brandeis) Gabuzda, D. (NFRA) Brown, L. (Connecticut)	Polarization monitoring of four bright quasars at 5 and 1.6 GHz. 18 cm
W094	Hirobayoshi, H. (ISAS, Japan)	6 cm

M. 12 METER OBSERVING PROGRAMS

No.	Observers	Programs
A143	Arce, H. (CfA) Goodman, A. (CfA)	Study of the interaction between giant Herbig-Haro flows and their surroundings.
B691	Butner, H. (Arizona) Lada, C. (CfA) Alves, J. (CfA) Lada, E. (Florida) Charnley, S. (NASA/Ames)	Tracing the density profile of starless cores: CS versus dust extinction.
B692	Butner, H. (Arizona) Charnley, S. (NASA/Ames)	Understanding deuterium fractionation chemical pathways: Class 0 sources.
B697	Buckle, J. (Manchester) Fuller, G. (Manchester) Hatchell, J. (Manchester)	Study of sulphur chemistry in protostellar outflows.
C326	Clancy, R. T. (SSI, Boulder) Sandor, B. (High Altitude Obs)	Thermal and compositional studies of the Mars and Venus atmospheres.
G368	Gao, Y. (Toronto) Gruendl, R. (Illinois) Lo, K. Y. (SA/IAA, Taiwan) Hwang, C-Y. (SA/IAA, Taiwan)	Study of the widely separated ultraluminous infrared galaxies.
G374	Gensheimer, P. (Arizona) Wilson, T. (Arizona)	$C^{34}S$ observations of ρ Ophiuchi B1.

No.	Observer(s)	Programs
G375	Gallimore, J. Thornley, M.	Are the nuclei of Seyfert galaxies gas-rich compared to normal galaxies?
H343	Helfer, T. (Arizona) Thornley, M. (MPIR, Bonn) Regan, M. (DTM/Carnegie) Sheth, K. (Maryland) Vogel, S. (Maryland) Harris, A. (Maryland) Wong, T. (UC, Berkeley) Bock, D. (UC, Berkeley) Blitz, L. (UC, Berkeley)	Continuing program: Total-power data for BIMA SONG.
K365	Kuan, Y-J. (ASIAA, Taiwan) Charnley, S. (NASA/Ames) Rodgers, S. (NASA/NRC) Butner, H. (Arizona) Snyder, L. (Illinois)	Search for azaheterocyclic interstellar molecules.
K366	Koo, B-C. (Seoul National U.) Rho, J. -H. (IPAC) Reach, W. (IPAC) Mangum, J.	Observations of the shocked molecular gas in supernova remnants.
L346	Lubowich, D. (Hofstra) Turner, B.	Study of mass loss from super-Li-rich AGB stars.
L347	Lubowich, D. (Hofstra)	A comparison between the DCN/HCN, D/H, and DCO^+/HCO^+ ratios in the 20 km/s and 50 km/s Sgr A molecular clouds.
L348	Lim, J. (ASIAA, Taiwan) Dinh, V-T. (ASIAA, Taiwan) Kwok, S. (Calgary) Lee, T-H. (Calgary)	Study of the molecular structure of the Egg proto-planetary nebula (CRL 2688).
M434	Marston, A. (Drake U.) Appleton, P. (Iowa State) Norris, R. (CSIRO) Heisler, C. (Mt. Stromlo) Dopita, M. (Mt. Stromlo)	Study of molecular gas associated with compact objects in low-powered AGNs (COLAs) – Part II.
M435	Myers, P. (CfA) Lee, C. W. (Korea Astronomy Obs) Williams, J. Tafalla, M. (Madrid Obs) Wilner, D. (CfA)	A deep search for infall wings in contracting starless cores.
M436	Mochizuki, K. (ISAS, Japan)	CO line toward the central kiloparsec of M31: thermal balance of molecular gas in galactic centers.

No.	Observer(s)	Programs
M437	Mangum, J. Emerson, D. Payne, J.	A multi-beam imaging survey of the CO in M31.
P182	Petitpas, G. (McMaster U.) Wilson, C. (McMaster U.)	Do gas properties determine the nuclear structure of barred galaxies?
P184	Pagani, L. (Paris Obs) Pardo, J-R. (Caltech)	Study of the physical structure of L134N.
P185	Pagani, L. (Paris Obs) Pardo, J-R. (Caltech)	Study of $^{16}O^{18}O$ in L134N.
P186	Pagani, L. (Paris Obs) Pardo, J-R. (Caltech)	Study of $C^{17}O$ in L134N.
P188	Promislov, V. (Lebedev)	Study of methanol masers.
R280	Rizzo, R. (OAN, Spain) Martin-Pintado, J. (OAN, Spain) Mangum, J.	Searching for the molecular emission in WR environments.
S447	Sandor, B. (High Altitude Obs) Clancy, R. T. (SSI, Boulder)	Earth atmosphere studies.
S450	Strelnitski, V. (Maria Mitchell Obs.) Gordon, M. Jisonna, L. (Arizona)	Monitoring of MWC 349 in H30α and H35α recombination lines.
S451	Shah, R. Wootten, H. A.	Study of ionization fraction in protostellar clusters.
T380	Turner, B.	Study of deuterium in translucent clouds.
T382	Turner, B.	A study of CO^+ in translucent clouds.
T383	Turner, B. Rosner, S. (Western Ontario) Scholl, T. (Western Ontario) Cameron, R. (Western Ontario)	A search for SiO^+.
T385	Turner, B. Heiles, C. (UC, Berkeley)	A search for the CN Zeeman effect in molecular clouds.
V91	Verheijen, M. Rhee, M-H. (Yonsei U., Korea) Yun, M. Chung, A. (Yonsei U., Korea)	Study of a $z = 0$ calibration of the CO Tully-Fisher relation.

No.	Observer(s)	Programs
V93	Verheijen, M. Rhee, M-H. (Yonsei U.) Chung, A. (Yonsei U.) Yun, M. Byun, Y. I. (Yonsei U.)	CO mapping of spiral galaxies in the Ursa Major cluster.
W423	Willliams, J. Richer, J. (Cambridge) Fujiyoshi, T. (Cambridge) Chandler, C. (Cambridge)	Study of the structure and kinematics of starless dense cores.
Z168	Ziurys, L. (Arizona) Savage, C. (Arizona) Highberger, J. (Arizona)	Is IRC+10216 unique? Searches for metal-bearing species towards other late-type stars.
Z169	Ziurys, L. (Arizona) Sheridan, P. (Arizona) Savage, C. (Arizona) Highberger, J. (Arizona)	A search for interstellar/circumstellar $MgNH_2$.
Z171	Ziurys, L. (Arizona)	Study of AlNC in CRL 2688.
Z172	Ziurys, L. (Arizona) Highberger, J. (Arizona) Savage, C. (Arizona) Mangum, J.	Study of vibrationally-excited CS in circumstellar shells: A new maser?
Z173	Ziurys, L. (Arizona) Savage, C. (Arizona) Highberger, J. (Arizona) Guélin, M. (IRAM) Cernicharo, J. (SCIC, Spain)	Confirmation of AlNC in IRC+10216.

N. PERSONNEL

New Hires

Chandler, C.	Assistant Scientist - Socorro Operations	01/01/00
Damodaran, A.	Visiting Assistant Scientist	01/20/00
Field, S.	Junior Engineering Associate	01/10/00
Ray, J.	Junior Engineering Associate	01/04/00*
Schmidt, R.	Junior Engineering Associate	01/17/00
Sumner, M.	Junior Engineering Associate	02/14/00*

Terminations

Bagri, D.	Systems Engineer I	02/18/00**
Beresford, R.	Visual Systems Engineer I	01/14/00
Cohen, A.	Junior Engineering Associate	01/14/00

Desai, K.	Assistant Scientist - Socorro Operations	02/25/00
Mares, J.	Junior Engineering Associate	01/07/00
Smith, S.	Field Inspection Engineer I	01/31/00**
Vance, B.	Scientific Programming Analyst	01/01/00**
Wang, C.	Electronics Engineer III	02/07/00**
Waddell, M.	Electronics Engineer I	01/05/00
Williams, J.	Research Associate	01/21/00

Promotions

Brown, R.	to Deputy Director	02/07/00
Fisher, J. R.	to Scientist, Tenure	01/01/00
Goldman, M.	to Resident Engineer	01/01/00

Other

Brown, D.	to 50% Part-time	03/01/00**
Campbell, J.	to 50% Part-time	03/01/00**
Uson, J.	to Professional Leave	01/01/00
Yin, Q.	to 50% Part-time	03/01/00**
Zensus, J. A.	return from Leave of Absence	01/01/00

* Rehire
** Reduction in Force

O. PUBLICATIONS

Attached as Appendix A is a listing of all preprints received in the NRAO Charlottesville library during the reporting period authored by NRAO staff or based on observations on NRAO telescopes.

PREPRINTS RECEIVED, JANUARY - MARCH 2000

BAUER, F.E.; CONDON, J.J.; THUAN, T.X.; BRODERICK, J.J. RBSC-NVSS Sample. I. Radio and Optical Identifications of a Complete Sample of 1500 Bright X-ray Sources.

BIETENHOLZ, M.F.; BARTEL, N.; RUPEN, M.P. A Stationary Core with a One-Sided Jet in the Center of M81.

BRAGG, A.E.; GREENHILL, L.J.; MORAN, J.M.; HENKEL, C. Accelerations of Water Masers in NGC4258.

BRAVO-ALFARO, H.; CAYATTE, V.; VAN GORKOM, J.H.; BALKOWSKI, C. VLA H I Imaging of the Brightest Spiral Galaxies in Coma.

BROGAN, C.L.; FRAIL, D.A.; GOSS, W.M.; TROLAND, T.H. OH Zeeman Magnetic Field Detections Toward Five Supernova Remnants Using the VLA.

CALLAWAY, M.B.; SAVAGE, B.D.; BENJAMIN, R.A.; HAFFNER, L.M.; TUFTE, S.L. Observational Evidence of Supershell Blowout in GS 018-04+4 The Scutum Supershell.

CARILLI, C.L.; BERTOLDI, F.; MENTEN, K.M.; RUPEN, M.P.; KREYSA, E.; FAN, X.; STRAUSS, M.A.; SCHNEIDER, D.P.; BERTARINI, A.; YUN, M.S.; ZYLKA, R. Dust Emission from High Redshift QSOs.

CARILLI, C.L.; TAYLOR, G.B. The Extreme Compact Starburst in MRK 273.

CECIL, G.; GREENHILL, L.J.; DEPREE, C.G.; NAGAR, N.; WILSON, A.S.; DOPITA, M.A.; PEREZ-FOURNON, I.; ARGON, A.L.; MORAN, J.M. The Active Jet in NGC 4258 and Its Associated Shocks.

CHENG, J. Design of Carbon Fiber Composite Antenna Dishes.

CROSTHWAITE, L.P.; TURNER, J.L.; HO, P.T.P. Structure in the Neutral Hydrogen Disk of the Spiral Galaxy, IC 342.

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DUMKE, M.; KRAUSE, M.; WIELEBINSKI, R. The Interstellar Medium in the Edge-on Galaxy NGC 5907. Radio Continuum Emission and Magnetic Fields.

ESCOFFIER, R.P.; WEBBER, J.C.; D'ADDARIO, L.R.; BROADWELL, C.M. A Wideband Digital Filter Using FPGAs.

FALCKE, H.; WILSON, A.S.; HENKEL, C; BRUNTHALER, A.; BRAATZ, J.A. Hubble Space Telescope and Very Large Array Observations of the H2O Gigamaser Galaxy TXS 2226-184.

FEY, A.L.; CHARLOT, P. VLBA Observations of Radio Reference Frame Sources. III. Astrometric Suitability of an Additional 225 Sources.

FRAIL, D.A.; KULKARNI, S.R.; SARI, R.; TAYLOR, G.B.; SHEPHERD, D.S.; BLOOM, J.S.; YOUNG, C.H.; NICASTRO, L.; MASETTI, N. The Radio Afterglow from GRB 980519: A Test of the Jet and Circumstellar Models.

GOMEZ, J.-L.; MARSCHER, A.P. Space VLBI Observations of 3C 371.

JEWELL, P.R. The Green Bank Telescope.

KELLERMANN, K.I. Angular Resolution, Confusion, and Dynamic Range Constraints on the Design of Next Generation Radio Telescopes for Centimeter Wavelengths.

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LANGSTON, G.; MINTER, A.; D'ADDARIO, L.; EBERHARDT, K.; KOSKI, K.; ZUBER, J. The First Galactic Plane Survey at 8.35 and 14.35 GHz.

LISZT, H.; LUCAS, R. The Structure and Stability of Interstellar Molecular Absorption Line Profiles at Radio Frequencies.

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MATTHEWS, L.D.; VAN DRIEL, W. An H I Survey of Highly Flattened, Edge-On, Pure Disk Galaxies.

MCCUTCHEON, W.H.; SANDELL, G.; MATTHEWS, H.E.; KUIPER, T.B.H.; SUTTON, E.C.; DANCHI, W.C.; SATO, T. Star Formation in NGC 6334 I and I(N)

MOORE, C.B.; RUTLEDGE, R.E.; FOX, D.W.; GUERRIERO, R.A.; LEWIN, W.H.G.; FENDER, R.; VAN PARADIJS, J. Identification of a Likely Radio Counterpart of the Rapid Burster.

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PIHLSTROM, Y.; CONWAY, J.E.; BOOTH, R.S.; DIAMOND, P.J.; KORIBALSKI, B.S. VLBA H I Absorption Observations of the Water Megamaser Galaxy NGC 5793.

POSPIESZALSKI, M.W.; WOLLACK, E.J.; BAILEY, N.; THACKER, D.; WEBBER, J.; NGUYEN, L.D.; LE, M.; LUI, M. Design and Performance of Wideband, Low-Noise, Millimeter-Wave Amplifiers for Microwave Anisotropy Probe Radiometers.

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SASLAW, W.C. Chandrasekhar and Astrophysical Style: An Essay Review of 'From White Dwarfs to Black Holes: The Legacy of S. Chandrasekhar', ed. by G. Srinivasan.

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SHEPHERD, D.S.; YU, K.C.; BALLY, J.; TESTI, L. The Molecular Outflow and Possible Precessing Jet from the Massive Young Stellar Object IRAS 20126+4104.

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THORNLEY, M.D. Molecular Gas and Star Formation in nearby Galaxies.

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WELLS, D.C. The FITS Experience: Lessons Learned.

WHITE, S.M.; JANARDHAN, P.; KUNDU, M.R. Radio Detection of a Rapid Disturbance Launched by a Solar Flare.

WROBEL, J.M.; HERRNSTEIN, J.R. Accretion Rates onto Massive Black Holes in Four Quiescent Elliptical Galaxies.

YUN, M.S.; CARILLI, C.L. Redshift Distribution of Faint Submm Galaxies Inferred from Their Radio-to-Submm Spectral Index.