US/GR BK/

NATIONAL RADIO ASTRONOMY OBSERVATORY

QUARTERLY REPORT

October 1 - December 31, 1999

FEB 0 2 2000

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A. TELESCOPE USAGE

The following telescopes have been scheduled for research and maintenance in the following manner during the fourth quarter of 1999.

	12 Meter	VLA	VLBA
Scheduled Observing (hrs)	1670.25	1672.50	1719.50
Scheduled Maintenance and Equipment Changes	118.50	216.40	247.00
Scheduled Tests and Calibration	347.25	269.10	194.00
Time Lost	262.00	112.50	63.00
Actual Observing	1408.25	1560.00	1215.50

B. 140 FOOT OBSERVING PROGRAMS

The 140 Foot was retired in June 1999 therefore there are no observing programs to report this quarter.

C. 12 METER OBSERVING PROGRAMS

No.	Observer(s)	Program
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.
B693	Butner, H. (Arizona) Charnley, S. (NASA/Ames) Yonekura, Y. (Osaka U.)	Study of the density and velocity structure of the B1 core.
C326	Clancy, R. T. (SSI, Boulder) Sandor, B. (High Altitude Obs)	Thermal and compositional studies of the Mars and Venus atmospheres.
CC11	Colomer, F. (Yebes Obs) Desmurs, J-F. (Yebes Obs) Bujarrabal, V. (Yebes Obs) Alcolea, J. (Yebes Obs)	Study of SiO v = 1 J = 2–1 maser emission from evolved stars.
CD15	Doeleman, S. (Haystack) Londsdale, C. (Haystack) Boboltz, D. (USNO)	Imaging the 3 mm and 7 mm SiO masers towards χ Cygni.
CD18	Doeleman, S. (Haystack) Lonsdale, C. (Haystack) Barvainis, R. (Haystack) Phillips, R. (Haystack) Greenhill, L. (CfA)	86 GHz imaging of the SiO masers in the Orion-KL nebula.

No.	Observer(s)	Program
CK09	Krichbaum, T. (MPIR, Bonn) Klare, J. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Graham, D. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn)	A study of the subluminal kinematics in the inner jet and counter-jet of 3C84.
CK10	Krichbaum, T. (MPIR, Bonn) Graham, D. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn) Greve, A. (IRAM) Ungerechts, H. (IRAM) Terasranta, H. (Metsahovi)	86 GHz VLBI monitoring of BL Lac after multiple optical flares.
CK11	Krichbaum, T. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Graham, D. (MPIR, Bonn) Pauliny-Toth, I. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn)	Imaging the self-absorbed inner jet of 3C 454.3 at 86 GHz.
CK12	Klare, J. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn) Krichbaum, T. (MPIR, Bonn) Ros, E. (MPIR, Bonn) Lobanov, A. (MPIR, Bonn)	Study of the innermost regions of the radio jet in the quasar 3C345.
CL05	Londsdale, C. (Haystack) Boboltz, D. (USNO) Doeleman, S. (Haystack)	The statistical properties of 86GHz SiO masers around evolved stars.
CP06	Phillips, R. (Haystack) Boboltz, D. (USNO)	Monitoring of the 86 and 43 GHz SiO maser emission towards Mira.
F139	Fong, D. (Illinois) Meixner, M. (Illinois) Ueta, T. (Illinois)	^{12}CO observation of IRAS 18576+0341.
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.
G369	Gruendl, R. (Illinois) Gao, Y. (Toronto) Lo, K. Y. (SA/IAA, Taiwan) Hwang, C-Y. (SA/IAA, Taiwan)	Full synthesis imaging of CO (1-0) emission in Arp 244.
H341	Hiroto, T. (Tokyo U.) Yamamoto, S. (Tokyo U.)	A survey of DNC and HN^{13}C lines in dark cloud cores.

No.	Observer(s)	Program
H342	Hatchell, J. (Manchester) Millar, T. (Manchester) Fuller, G. (Manchester) Roberts, H. (Manchester) Buckle, J. (Manchester)	Study of molecular D/H ratios in low mass cores.
H343	Helfter, 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.
K367	Kalenskii, S. (Astro Space Ctr, Moscow)	Study of variability of methanol masers.
L345	Di, L. (Cornell) Goldsmith, P. (Cornell)	Study massive star formation: Density of cold cores in GMCs.
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.
M433	Matthews, L. Gao, Y. (Toronto) van Driel, W. (Paris Obs)	CO observations of low surface brightness.
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. (Korea Astronomy Obs) Williams, J. Tafalla, M. (Madrid Obs) Wilner, D. (CfA)	A deep search for infall wings in contracting starless cores.
P185	Pagani, L. (Paris Obs) Pardo, J-R. (Caltech)	Study of $^{16}O^{18}O$ in L134N.

No.	Observer(s)	Program
P186	Pagani, L. (Paris Obs) Pardo, J-R. (Caltech)	Study of $C^{17}O$ in L134N.
R278	Ridge, N. (Liverpool JMU) Moore, T. (Liverpool JMU)	Study of the Ophiuchus dwarf protostars.
R279	Ridge, N. (Liverpool JMU) Moore, T. (Liverpool JMU)	Study of the dependence of YSO outflow power on cloud core mass.
S447	Sandor, B. (High Altitude Obs) Clancy, R. T. (SSI, Boulder)	Earth atmosphere studies.
S448	Smith, B. (East Tennessee State)	Study of molecular gas in radio-loud and radio-quiet ellipticals.
S449	Smith, B. (East Tennessee State) Struck, C. (Iowa State)	Study of molecular gas and star formation in extragalactic tails and bridges.
T382	Turner, B.	A study of CO^+ in translucent 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.
W421	Webster, Z. (UC, Berkeley) Welch, W. (UC, Berkeley) Mundy, L. (Maryland) Looney, L. (MPIfEP, Garching)	Study of the density profile and kinematics of two regions in NGC 1333.
Z167	Ziurys, L. (Arizona) Savage, C. (Arizona) Highberger, J. (Arizona)	Ion chemistry in photon-dominated regions: examining the $HCO^+/HOC^+/CO^+$ chemical network.
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 $MgNH_2$.
Z170	Ziurys, L. (Arizona)	Study of AlNC in CRL 2688.

D. VERY LARGE ARRAY OBSERVING PROGRAMS

The fourth quarter of 1999 was spent in the following configurations: BnA configuration from October 1 to October 4; B configuration from October 4 to December 31

The following research programs were conducted with the VLA during this quarter:.

No.	Observer(s)	Program
AB879	Becker, R. (UC, Davis) White, R. (STScI) Helfand, D. (Columbia)	FIRST survey. 20 cm
AB908	Brogan, C. (Kentucky) Frail, D. Goss, W. M. Troland, T. (Kentucky)	Zeeman measurements of 1720 MHz OH masers in supernova remnants. 20 cm
AB922	Browne, I. (Manchester) Marlow, D. (Pennsylvania) Myers, S. Wilkinson, P. (Manchester) Fassnacht, C. 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
AB924	Bransford, M. (New Mexico State) Appleton, P. (Iowa State) Gao, Y. (IPAC) Freeman, K. (Mt. Stromlo)	HI observations of Seyfert galaxy Arp 118. 20 cm line
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) Scaramella, R. (OAC)	Sub-mJy observations of VLT VIRMOS Deep Field. 20 cm

No.	Observer(s)	Program
AB929	Black, G. Campbell, D. (Cornell) Nicholson, P. (Cornell)	Radio source occultation by Saturn's ring system. 20, 90 cm
AB930	Beuther, H. (MPIR, Bonn) Menten, K. (MPIR, Bonn) Schilke, P. (MPIR, Bonn) Sridharan, T. (CfA) Wyrowski, F. (Maryland)	Water maser emission in candidate high mass protostars. 1.3 cm line
AC524	Cartwright, J. (Caltech) Taylor, G. Readhead, A. (Caltech) Pearson, T. (Caltech)	Polarization monitoring observations of 3C273. 0.7, 1.3 cm
AC531	Carilli, C. Fan, X. (Princeton) Strauss, M. (Princeton) Rupen, M. Schneider, D. (Penn State) Yun, M.	Search for radio emission from high redshift QSOs from the SDSS. 20 cm
AC536	Carral, P. (Guanajuato U.) Kurtz, S. (Mexico/UNAM) Rodriguez, L.F. (Mexico/UNAM)	Search for new thermal jets from young massive stars. 3.6 cm
AC538	Carilli, C. Menten, K. (MPIR, Bonn) Yun, M.	Imaging the CO Emission from the z=4.4 QSO BRI 1335-0417. 0.7, 3.6 cm
AC541	Cordes, J. (Cornell) Kaspi, V. (MIT) Cordes, J. (MIT) Gaensler, B. (MIT) Hankins, T. (NMIMT) Kern, J. (NMIMT) McLaughlin, M. (Cornell)	Search for pulsations from Cas A neutron star.
AD427	De Breuck, C. (LLNL) Carilli, C. van Breugel, W. (LLNL) Rottgering, H. (Leiden) Miley, G. (Leiden) Stanford, A. (LLNL) Stern, D. (UC, Berkeley)	The most distant radio galaxy. 2 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

No.	Observer(s)	Program
AD431	Dennett-Thorpe, J. (Groningen/Kapteyn) de Bruyn, A. (NFRA)	Determining the structure of microarcsecond sources. 2, 3.6, 6 cm
AF350	Falcke, H. (MPIR, Bonn) Lobanov, A. (MPIR, Bonn) Wright, M. (UC, Berkeley) Bower, G. (MPIR, Bonn) 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
AF365	Faison, M. (Beloit) Churchwell, E. (Wisconsin)	Accretion disk of massive protostar IRAS 20126+4014. 2, 3.6 cm
AG567	Giovannini, G. (Bologna) Treves, A. (Milano Obs) Falomo, R. (Padova) Govani, F. (Padova) Scarpa, R. (STScI) Urry, C. M. (STScI)	Two new gravitational lens candidates. 0.7, 1.3 cm
AG571	Gaensler, B. (MIT) Frail, D. Kulkarni, S. (Caltech)	The Duck and the Mouse—second epoch proper motion measurements. 3.6, 6 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
AG579	Gurwell, M. (Caltech) Butler, B.	Observing C_3H_2 in the atmosphere of Titan. 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
AH669	Hjellming, R. Rupen, M. Mioduszewski, A.	Galactic black hole X-ray transients. 1.3, 2, 3.6, 6, 20 cm
AH678	Horellou, C. (Chalmers, Onsala)	Magnetic fields in the ring galaxy Arp 147. 6 cm
AH685	Haarsma, D. (Haverford College) Hewitt, J. (MIT) Langston, G. Moore, C. (Groningen/Kapteyn)	Time delay monitoring of gravitational lens 2016+112. 3.6, 6 cm
AH687	Hughes, V. (Queens)	An investigation of Class 0 protostars. 0.7 cm

No.	Observer(s)	Program
AH688	Hollis, J. (NASA/GSFC) Pedelty, J. (NASA/GSFC) Koupelis, T. (Wisconsin)	Shock induced polarization of R Aqr Jet. 3.6, 6 cm
AH691	Higdon, J. (Groningen/Kapteyn) Charlton, J. (Pennsylvania)	Interacting/merging pairs with extensive tidal tails. 20 cm line
AI078	Impey, C. (Arizona) Peng, C. (Arizona)	Dark gravitational lenses or binary quasars? 3.6 cm
AJ269	Jamrozy, M. (Jagellonian) Machalski, J. (Jagellonian)	Detection of a radio core in "Giant" radiogalaxy candidates. 6 cm
AJ270	Jura, M. (UCLA) Turner, J. (UCLA) Kahane, C. (Grenoble)	NVSS radio star HD 188037. 3.6, 6, 20 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
AK495	Keenan, F. (Queens U, Belfast) Smoker, J. (Queens U, Belfast) Irwin, M. (Cambridge) Watson, D. (Dublin) Marcha, M. (Lisbon)	Optically detected blue objects in the halo of M31. 6, 20 cm
AK496	Kronberg, P. (Toronto) Sramek, R. Allen, M. (Toronto) Birk, G. (Munich)	Extending the M82 compact source monitoring to 19 years. 2 cm
AK497	Kokkonen, K. (Turku) Lehto, H. (Turku) Johnson, D. (Surrey)	R Aquarii Jet. 1.3, 2, 6 cm
AK500	Kurtz, S. (Mexico/UNAM) Carral, P. (Guanajuato U.) Hofner, P. (NAIC)	Supercompact HII region ON-2 (H_2O). 0.7 cm
AL484	Ledlow, M. (New Mexico) Owen, F.	1 Mpc scale FRI radio galaxy B2 1108+27. 20, 90 cm
AL490	Laine, S. (Kentucky) Kotilainen, J. (Turku) Norris, R. (CSIRO) Reunanen, J. (Turku) Ryder, S. (Hawaii)	Seyfert and starburst galaxies with IR line images. 6 cm

No.	Observer(s)	Program
AL494	Lang, C. Goss, W. M. Rodriguez, L. F. (Mexico/UNAM)	Radio observations of the ionized winds of the massive stars in the arches cluster. 7, 3.5 cm
AL499	Lacy, M. (Oxford) Ridgway, S. (Johns Hopkins)	Radio optical alignments in less luminous radio sources. 3.6, 20 cm
AL500	Laing, R. (Oxford) Parma, P. (Bologna) de Ruiter, H. (Bologna) Bridle, A. Fanti, R. (Bologna)	Decelerating relativistic jets in FRI radio galaxies. 3.6 cm
AL506	Linden-Vornle, M. (DSRI) Norgaard-Nielsen, H. (DSRI) Jorgensen, H. (Copenhagen) Hansen, L. (Copenhagen)	Survey of deep ISO survey area in selected area 57. 20 cm
AL508	Lovell, J. (CSIRO) Jauncey, D. (CSIRO) Edwards, P. (ISAS, Japan) Reynolds, J. (CSIRO) Tzioumis, A. (CSIRO)	CLASS-2: gravitational lens and astrometric southern survey. 3.6 cm
AM603	Morganti, R. (Bologna) Oosterloo, T. (Milano Obs) van Moorsel, G. Killeen, N. (CSIRO) Tadhunter, C. (Sheffield)	HI absorption in radio galaxies. 20 cm line
AM626	Miller, N. (New Mexico State) Owen, F.	Search for dust-obscured star formation in E+A galaxies. 20 cm
AM627	Mirabel, I. F. (Saclay) Dhawan, V. Gerard, E. (Meudon) Hjellming, R. Marti, Josep (Jaen) Ogley, R. (Saclay) Pooley, G. (Cambridge) Rodriguez, L.F. (Mexico/UNAM)	Search for new microquasars. 3.5 cm
AM629	Miranda, L. (IAA, Andalucia) Gomez, Y. (Mexico/UNAM) Lopez, A. (Mexico/UNAM) Rodriguez, L.F. (Mexico/UNAM) Torrelles, J. (IAA, Andalucia)	Jet like features in planetary nebula IC 4997. 0.7 cm

No.	Observer(s)	Program
AM635	Mohan, R. N. (Raman Institute) Rottgering, H. (Leiden) Cimatti, A. (Arcetri) Andreani, P. (Padova) Eisenhardt, P. (JPL) Stanford, A. (LLNL) Elston, R. (Florida) Carilli, C. Anantharamaiah, K. (Raman Institute)	Radio continuum of extremely red galaxies. 20 cm
AM637	McLaughlin, M. (Cornell) Cordes, J. (Cornell) Arzoumanian, Z. (Cornell)	Astrometry of four recently discovered pulsars. 20, 90 cm
AN087	Neff, S. (NASA/GSFC) Ulvestad, J.	HII regions in NGC 4038/9 ("the Antennae"). 2 cm
AO145	Olmi, L. (Massachusetts) Cesaroni, R. (Arcetri) Walmsley, C. M. (Arcetri)	Search for non-thermal continuum towards H_2O masers. 6, 20 cm
AP389	Peck, A. (MPIR, Bonn) Taylor, G. O'Dea, C. (STScI) Giovannini, G. (Bologna)	Searching for HI absorption in two nearby radio galaxies. 20 cm line
AR412	Rottgering, H. (Leiden) De Breuck, C. (LLNL) van Breugel, W. (LLNL) Miley, G. (Leiden)	Search for z=5 radio galaxies from the WISH and NVSS radio surveys. 20 cm
AR419	Rodriguez, L. F. (Mexico/UNAM) Avila, R. (Mexico/UNAM)	Observations of HH 211-millimeter: a "dust only" source. 0.7, 3.6 cm
AR420	Rodriguez, L. F. (Mexico/UNAM) Reipurth, B. (Colorado/JILA) Marti, J. (Jaen)	Do all Class 0 objects have centimeter radio continuum? 3.6 cm
AR422	Rosati, P. (MPIfEP, Garching) Shaver, P. (ESO) Kellermann, K. Fomalont, E.	Radio observations of the deep AXAF X-ray field. 20 cm
AR424	Rupen, M. Fan, X. (Princeton) Strauss, M. (Princeton) Carilli, C. Schneider, D. (Penn State) Yun, M.	High redshift QSOs from the SDSS. 20 cm

No.	Observer(s)	Program
AR425	Roberts, D. (Illinois) Yusef-Zadeh, F. (Northwestern)	Acceleration of high velocity gas in Sgr A West. 3.6 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
AS670	Spangler, S. (Iowa) Mutel, R. (Iowa) McCullough, P. (Illinois)	Faraday rotation variations in the interstellar medium. 6 cm
AS671	Sarma, A. (Kentucky) Troland, T. (Kentucky) Crutcher, R. (Illinois) Roberts, D. (Illinois)	OH zeeman observations toward NGC 6334. 20 cm line
AS673	Skinner, S. (Colorado/JILA) Zhekov, S. (Colorado/JILA)	Radio emission of Wolf-Rayet stars. 1.3, 2, 3.6, 6, 20 cm
AS674	Sage, L. (Maryland) Higdon, J. (Groningen/Kapteyn)	Neutral hydrogen in the ring galaxy Arp 147. 20 cm line
AS675	Saito, M. (CfA) Kawabe, R. (NAO, Japan) Ho, P. (CfA)	Continuum emission toward low mass protobinaries in Taurus. 3.6, 6 cm
AS676	Saito, M. (CfA) Kawabe, R. (NAO, Japan) Beltran, M. (CfA)	Variable thermal emission from low mass Protostars L1551 NE. 3.6, 20 cm
AT232	Thompson, D. (AIP, NY) Fassnacht, C. (Caltech) Soifer, B. (Caltech) Beckwith, S. (STScI)	Extremely red galaxies. 20 cm
AT233	Trigilio, C. (Bologna) Leone, F. (Catania) Umana, G. (Bologna) Leto, P. (Bologna)	Search for coherent emission from Sigma Ori E. 6, 20 cm
AT235	Trinidad, M. (Mexico/UNAM) Curiel, S. (Mexico/UNAM) D'Alessio, P. (Mexico/UNAM) Rodriguez, L.F. (Mexico/UNAM)	Circumbinary disk structures around binary YSOs. 0.7, 3.6 cm
AT236	Troland, T. (Kentucky) Crutcher, R. (Illinois) Plante, R. (Illinois) Roberts, D. (Illinois)	OH zeeman measurements in the central few parsecs of galaxy. 20 cm line

No.	Observer(s)	Program
AU079	Ulvestad, J. Ho, L. (Mt. Wilson)	The Palomar sample of Seyfert galaxies. 6 cm
AW362	White, S. (Maryland)	The stellar activity cycle on active stars. 3.6, 6, 20 cm
AW519	Wilcots, E. (Wisconsin) Bershady, M. (Wisconsin) Jangren, A. (Penn State)	Low redshift, luminous, compact star forming galaxies. 3.6 cm
AW521	Wilson, A. (Maryland) Greenhill, L. (CfA)	Quasars near NGC 1068. 3.6, 20 cm
AW522	Wilner, D. (CfA) Ho, P. (CfA) Rodriguez, L.F. (Mexico/UNAM) Beltran, M. (CfA) Kastner, J. (Haystack)	Continuum studies of T-Tauri disks. 0.7 cm
AW523	van der Walt, J. (Potchefstroom) Churchwell, E. (Wisconsin) Gaylard, M. (HartRAO) Goedhart, S. (HartRAO)	Search for methanol masers around massive protostars. 1.3 cm line
AW524	Wyrowski, F. (Maryland) Schilke, P. (MPIR, Bonn) Menten, K. (MPIR, Bonn) Thorwirth, S. (Cologne) Muller, H. (Cologne) Winnewisser, G. (Cologne)	Vibrationally excited carbon chain molecules in CRL 618. 0.7, 6 cm
AX006	Xu, C. (IPAC) Condon, J.	Intracluster starburst in Stephan's Quintet. 20 cm
AY108	Yusef-Zadeh, F. (Northwestern) Biretta, J. (STScI) Roberts, D. (Illinois)	Proper motion of Sgr A West . 2 cm
AY109	Yan, L. (Carnegie Obs)) Chapman, S. (Carnegie Obs) Owen, F. McHardy, P. (Carnegie Obs) Oemler, G. (Carnegie Obs)) Persson, S.E. (Carnegie Obs)	Deep imaging of the field from Las Campanas near IR survey. 20 cm
AY111	Yin, Q-F. Huang, J. (Nanking) Zheng, W. (Johns Hopkins)	Two newly discovered Wolf-Rayet galaxies. 20 cm
AZ119	Zhao, J. (Shanghai Obs) Goss, W. M.	Proper motions of radio components near Sgr A*. 1.3 cm

No.	Observer(s)	Program
AZ122	van Zee, L. (DAO) Salzer, J. (Wesleyan U.) Skillman, E. (Minnesota)	BCD rotation curves: is the mass distribution centrally concentrated? 20 cm line
BA037	Aller, H.D. (Michigan) Aller, M.F. (Michigan) Hughes, P.A. (Michigan) Wardle, J.F.C. (Brandeis) Homan, D.C. (Brandeis)	Sources with rapidly variable polarization
BB109	Beasley, A. Herrnstein, J. (Renaissance Tech)	VLBA monitoring of WR 140 (HD 193703)
BB112	Benz, A. (ETH) Pestalozzi, M. (Onsala) Conway, J. (Onsala) Gudel, M. (Paul Scherrer) Smith, K. (ETH)	Imaging single T Tau star coronea and the jet/disk interface
BB116	Beasley, A. Herrnstein, J. (Renaissance Tech)	Non-thermal emission from O supergiants
BB117	Beasley, A. Herrnstein, J. (Renaissance Tech)	Monitoring of WR 140. 2, 3.6, 6 cm
BC096	Cohen, A. (MIT) Hewitt, J. (MIT)	Determining a model of gravitational lens 0218+357
BC098	Claussen, M. Wootten, H. A. Marvel, K. (AAS) Wilking, B. (Missouri)	Zeeman measurements o f water masers in YSO jets
BD061	Doeleman, S. (Haystack) Boboltz, D. (USNO) Lonsdale, C. (Haystack)	Imaging of SiO masers around Chi Cygni. 0.7 cm
BD062	Diamond, P. (Jodrell Bank) Kemball, A.	TX Cam: the sequel. 0.7 cm
BF055	Faison, M. (Beloit) Goss, W. M.	Neutral hydrogen absorption towards 3C138. 20 cm with phased array.
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, 20 cm

No.	Observer(s)	Program
BL058	Lonsdale, C. (Haystack) Diamond, P. (Jodrell Bank) Smith, H. (UCSD) Lonsdale, C. (Caltech)	Radio superovae in OH megamaser galaxy Arp 220. 3.6, 6, 20 cm with phased array.
BM108	Moellenbrock, G. (ISAS, Japan) Roberts, D. (Brandeis) Wardle, J. (Brandeis)	Polarization monitoring of gamma-ray blazars. 0.7, 1.3, 2, 3.6 cm
BM120	Mundell, C. (Maryland) Wilson, A. (Maryland) Ulvestad, J. Roy, A. (MPIR, Bonn)	Thermal (?) nuclear emission in NGC 4388. 20 cm with phased array.
BN012	Norbury, M. (Jodrell Bank) Jackson, N. (Jodrell Bank) Browne, I. (Jodrell Bank) Wilkinson, P. (Jodrell Bank) Marlow, D. (Pennsylvania) Myers, S. Rusin, D. (Pennsylvania) Koopmans, L. (Groningen) Readhead, A. (Caltech) Pearson, T. (Caltech) Blandford, R. (Caltech)	Long track observations of top CLASS lens candidates. 6, 20 cm
BP061	Phillips, R. (Haystack) Boboltz, D. (USNO)	Monitoring of 43 GHz SiO maser emission towards MIRA. 0.7 cm
BR057	Roberts, D. (Brandeis) Moellenbrock, G. (ISAS) Wardle, J. (Brandeis) Gabuzda, D. (JIVE) Brown, L. (Connecticut)	Four 3C quasars with VSOP observations. 0.7, 1.3, 2, 3.6 cm
BR063	Ratner, M. (CfA) Bartel, N. (York) Bietenholz, M. (York) Lebach, D. (CfA) Lestrade, J-F. (Meudon) Ranson, R. (York) Shapiro, I. (CfA)	Astrometry of HR 8703 in 1999 for the gravity probe B mission. 3.6, 6 cm
BS076	Strelnitski, V. (Maria Mitchel) Benson, P. (Wellesley) Kogan, L. Salter, D. (Wellesley)	Imaging of VX U Ma in the 1.35 cm H_20 maser line. 1.3 cm

No.	Observer(s)	Program
GB035	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)	Evolving spectral index distribution in images of SN 1993J. 6, 20 cm with phased array.
GP022	Peck, A. (MPIR, Bonn) Taylor, G. Giovannini, G. (Bologna)	HI gas toward the core of 3C 293. 20 cm with phased array.
GP024	Pihlstrom, Y. (Onsala) Conway, J. (Onsala) Vermeulen, R. (NFRA)	HI absorption in the FRII galaxy 3C321. 20 cm with phased array.
GR019	Rioja, M. (OAN) Colomer, F. (OAN) Porcas, R. (MPIR, Bonn) Fomalont, E. Gurvits, L. (JIVE) Schilizzi, R. (JIVE) Sasao, T. (NAO, Japan) Asaki, Y. (NAO, Japan) Mantovani, F. (Bologna)	Phase referencing at L-band using cluster-cluster mode. 20 cm
VC993	Doeleman, S. (Haystack)	VSOP Proposal.

E. VERY LONG BASELINE OBSERVING PROGRAMS

No.	Observer(s)	Program
BA029	Alberdi, A. (IAA, Andalucia) Gomez, J-L. (IAA, Andalucia) Marcaide, J. (Valencia) Perez-Torres, M. (Valencia) Marscher, A. (Boston)	Superluminal source 4C39.25. 0.7, 1.3, 2 cm
BA037	Aller, H. (Michigan) Aller, M. (Michigan) Hughes, P. (Michigan) Wardle, J. (Brandeis) Homan, D. (Brandeis)	Sources with rapidly variable polarization. 0.7, 2 cm
BB109	Beasley, A. Herrnstein, J. (Renaissance Tech)	Monitoring of WR 140 (HD 193793). 2, 3.6, 6 cm

No.	Observer(s)	Program
BB112	Benz, A. (SFIT, ETH) Pestalozzi, M. (Chalmers, Onsala) Conway, J. (Chalmers, Onsala) Guedel, M. (SFIT, ETH) Smith, K. (SFIT, ETH)	Imaging single T Tau star coronae and the jet/disk interface. 3.6 cm
BB114	Bartel, N. (York U) Bietenholz, M. (York U)	Imaging of supernova remnant 41.9+58 in M82. 13 cm
BB116	Beasley, A. Herrnstein, J. (Renaissance Tech)	Non-thermal emission from O supergiants. 3.6 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
BB119	Britzen, S. (NFRA) Vermeulen, R. (NFRA) Taylor, G. Wilkinson, P. (Manchester) Pearson, T. (Caltech) Readhead, A. (Caltech)	Caltech-Jodrell snapshot survey of superluminal motion. 6 cm
BC090	Carilli, C. Taylor, G. Ulvestad, J. Wrobel, J.	BL Lacs. 50, 90 cm
BC091	Clarke, T. Ma, C. (NASA/GSFC) Johnston, K. (USNO) Fey, A. (USNO) Gaume, R. (USNO) Eubanks, T. M. (USNO) Gordon, D. (NASA/GSFC) Vandenberg, N. (Interferometrics) Himwich, E. (Interferometrics) Shaffer, D. (Radiometrics) Boboltz, D. (USNO) Kingham, K. (USNO) Fomalont, E. Walker, R. C.	Geodesy/astrometry observations for 1999. 18 cm
BC092	Coles, W. (UC, San Diego)	Measurements of solar wind speed near the sun using IPS. 2, 3.6, 6 cm

No.	Observer(s)	Program
BC095	Cawthorne, T. (Lancashire) Gabuzda, D. (Lebedev) Reynolds, C. (Lancashire)	Total intensity and polarization structure of BL Lacertae objects on scales between milliarcseconds and arcseconds. 13, 20, 50, 90 cm
BC096	Cohen, A. (MIT) Hewitt, J. (MIT)	Determining a model of gravitational lens 0218+357. 18 cm
BC098	Claussen, M. Marvel, K. (AAS) Wilking, B. (Missouri) Wootten, H. A.	Magnetic fields in YSO jets. 1 cm
BC100	Chatterjee, S. (Cornell) Cordes, J. (Cornell) Arzoumanian, Z. (NASA/GSFC) Goss, W. M. Fomalont, E. Beasley, A. Benson, J. Lazio, T. J. W. (NRL) Xilouris, K. (NAIC)	Gated pulsar astrometry. 18 cm
BD055	Doeleman, S. (Haystack) Barvainis, R. (unaffiliated) Lonsdale, C. (Haystack) Greenhill, L. (CfA) Phillips, R. (Haystack)	SiO msers in Orion nebula. 0.7 cm
BD059	Desai, K. Brisken, W. (Princeton) Chatterjee, S. (Cornell) Fey, A. (USNO) Lazio, T. J. W. (NRL) Lestrade, J-F. (Meudon)	Serendipitous observations of an extreme scattering even towards PSR J1643-12. 2 cm
BD061	Doeleman, S. (Haystack) Boboltz, D. (USNO) Lonsdale, C. (Haystack)	Imaging of SiO masers around Chi Cygni. 0.7 cm
BD062	Diamond, P. (Manchester) Kemball, A.	TX Cam: the sequel. 0.7 cm
BE019	Eisner, J. (Harvard) Greenhill, L. (CfA) Herrnstein, J. (Renaissance Tech) Moran, J. (CfA)	SiO masers and outflow in the W51-IRS2 star-forming region. 7 cm
BF050	Fanti, C. (IRA) Cotton, W. Fanti, R. (IRA) Mantovani, F. (IRA)	Search for CSS and GPS candidates. 6, 20 cm

No.	Observer(s)	Program
BF055	Faison, M. (Beloit) Goss, W. M.	Neutral hydrogen absorption towards 3C 138. 18 cm
BF056	Falcke, H. (MPIR, Bonn) Aller, H. (Michigan) Aller, M. (Michigan) Bower, G. Brunthaler, A. (MPIR, Bonn) Terasranta, H. (Metsahovi)	Monitoring the major radio outburst in the extremely variable spiral galaxy III Zw 2. 7, 21 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. 1, 7 cm
BG093	Gallimore, J. Baum, S. (STScI) O'Dea, C. (STScI)	Flat spectrum sources in Seyfert galaxies: measuring properties of the obscuring Torus. 4, 13 cm
BG095	Gabuzda, D. (NFRA) Aller, M. (Michigan) Aller, H. (Michigan) Hughes, P. (Michigan)	Polarization of BL Lac objects. 2, 3.6, 6 cm
BH054	Hagiwara, Y. (NAO, Japan) Diamond, P. (Jodrell Bank) Herrnstein, J. (Renaissance Tech) Miyoshi, M. (NAO, Japan)	Multi-frequency continuum observations of NGC 5793. 4, 6, 20 cm
BJ028	Jones, D. (JPL) Piner, B. (JPL) Wehrle, A. (JPL)	Measurement of proper motions in the jet and counterjet of NGC 4261. 4 cm
BK068	Kellermann, K. Cohen, M. (MIT) Vermeulen, R. (Dwingeloo) Zensus, J. A. (MPIR, Bonn)	Kinematics of quasars and AGN. 2 cm
BK069	Kaplan, D. (Caltech) Chatterjee, S. (Cornell) Condon, J. Cordes, J. (Cornell) Lazio, T. J. W. (NRL)	High resolution imaging of compact steep spectrum objects. 13 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

No.	Observer(s)	Program
BL058	Lonsdale, C. (Haystack) Diamond, P. (Manchester) Smith, H. (UC, San Diego) Lonsdale, C. (Caltech)	Radio supernovae in OH megamaser galaxy Arp220. 3.6, 6, 18 cm
BL066	Lobanov, A. (MIPR, Bonn) Kraus, A. (MPIR, Bonn) Otterbein, K. (Heidelburg)	0836+710: Jet kinematics related to the broad-band activity. 1, 4, 7 cm
BM108	Moellenbrock, G. Roberts, D. (Brandeis) Wardle, J. (Brandeis)	Polarization monitoring of gamma-ray blazars. 0.7, 1.3, 2, 3.6 cm
BM112	Moran, J. (CfA) Bragg, A. (CfA) Diamond, P. (Jodrell Bank) Greenhill, L. (CfA) Henkel, C. (MPIR, Bonn) Trotter, A. (CfA)	Next generation study of NGC 4258 accretion disk physics from measurement of month-to-month variations. 1 cm
BM116	Marscher, A. (Boston) Cawthorne, T. (Lancashire) Gear, W. (Wales) Stevens, J. (Cambridge) Marchenko, S. (Boston) Lister, M. (JPL) Gabuzda, D. (NFRA) Yurchenko, A. (St. Petersburg) Forster, J. (UC, Berkeley)	Monitoring millimeter-bright AGN. 0.7 cm
BM120	Mundell, C. (Maryland) Wilson, A. (Maryland) Ulvestad, J. Roy, A. (MPIR, Bonn)	Thermal (?) nuclear emission in NGC 4388. 18 cm
BN008	Nagar, N. (Maryland) Falcke, H. (MPIR, Bonn) Wilson, A. (Maryland)	Investigating the parsec-scale jets in the LINERs NGC 4278 and NGC 6500. 2, 4, 6, 20 cm
BN012	Norbury, M. (Manchester) Jackson, N. (Manchester) Browne, I. (Manchester) Wilkinson, P. (Manchester) Marlow, D. (Pennsylvania) Myers, S. Rusin, D. (Pennsylvania) Koopmans, L. (Groningen/Kapteyn) Readhead, A. (Caltech) Pearson, T. (Caltech) Blandford, R. (Caltech)	Long track observations of top CLASS lens candidates. 6, 18 cm

No.	Observer(s)	Program
BP055	Peck, A. Taylor, G. Vermeulen, R. (NFRA)	HI in compact symmetric object J1816+3457. 18 cm
BP057	Piner, B. (JPL) Piner, G. (JPL) Edwards, P. (ISAS, Japan)	Multi-epoch observations of the TeV source 1ES 2344+514. 2 cm
BP061	Phillips, R. (Haystack) Boboltz, D. (USNO)	Monitoring of 43 GHz SiO maser emission towards Mira. 0.7 cm
BR057	Roberts, D. (Brandeis) Moellenbrock, G. (ISAS, Japan) Wardle, J. (Brandeis) Gabuzda, D. (NFRA) Brown, L. (Connecticut)	Four 3C quasars with VSOP observations. 0.7, 1.3, 2, 3.6 cm
BR063	Ratner, M. (CfA) Bartel, N. (York U.) Bietenholz, M. (York U.) Lebach, D. (CfA) Lestrade, J-F. (Paris Obs) Ransom, R. (York U.) Shapiro, I. (CfA)	Astrometry of HR 8703 in 1999 for the gravity probe B mission. 3.6, 6 cm
BR066	Reid, M. (CfA) Davis, J. (CfA)	Proper motion of Sgr A*. 0.7 cm
BS065	Sasao, T. (NAO, Japan) Asaki, Y. (NAO, Japan) Imai, H. (NAO, Japan) Kameya, O. (NAO, Japan) Miyoshi, M. (NAO, Japan) Mochizuki, N. (NAO, Japan) Okudaira, A. (Kagoshima, Japan) Omadaka, T. (Kagoshima, Japan) Manabe, S. (NAO, Japan) Kameya, O. (NAO, Japan)	Towards determination of outer rotation curve of the Milky Way galaxy. 1.3 cm
BS076	Strelnitski, V. (Maria Mitchel) Benson, P. (Wellesley) Kogan, L. Salter, D. (Arecibo)	Imaging of VX UMa in the 1.35 cm H_20 maser line. 1.3 cm
BS077	Spangler, S. (Iowa) Mutel, R. (Iowa)	Measurement of solar wind acceleration using VLBI phase scintillation. 3.6, 6 cm

No.	Observer(s)	Program
BT044	Taylor, G. Beasley, A. Frail, D. Kulkarni, S. (Caltech)	Observations of gamma-ray bursters. 4 cm
BU013	Ulvestad, J. Bower, G. 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. 1, 2, 4 cm
BU015	Ulvestad, J. Antonucci, R. (UCSB) Kinney, A. (STScI) Pringle, J. (STScI) Schmitt, H. (IoA, Cambridge)	Parsec-scale cores, jets, and millihaloes in Seyfert galaxies. 20 cm
BU018	Ulvestad, J.	Gravitational lens candidate J1605+3029. 2, 4, 6, 13, 20 cm
BV037	Vlemillimeterings, W. (Leiden) Baudry, A. (Bordeaux) Diamond, P. (Jodrell Bank) Habing, H. (Bordeaux) Schilizzi, R. (JIVE) van Langevelde, H. (JIVE)	Fundamental data for a sample of enshrouded AGB stars. 20 cm
BW045	Hewitt, J. (MIT) Schechter, P. (MIT)	Milliarcsecond imaging of new gravitational lens candidates. 6 cm
GB035	Bartel, N. (York U.) Rupen, M. Bietenholz, M. (York U.) Beasley, A. Conway, J. (Chalmers, Onsala) Altunin, V. (JPL) Graham, D. (MPIR, Bonn) Venturi, T. (Bologna) Umana, G. (Bologna)	Evolving spectral index distribution in images of SN 1993J. 6 cm
GD013	Diamond, P. (Manchester) Booth, R. (Chalmers, Onsala) van Langevelde, H. (NFRA) Vlemillimeterings, W. (Leiden)	Global VLBI of the 1612 MHz masers towards OH127.8-0.0. 18 cm
GP022	Peck, A. Taylor, G. Giovannini, G. (Bologna)	HI gas toward the core of 3C 293. 18 cm

No.	Observer(s)	Program
GP024	Pihlstrom, Y. (Chalmers, Onsala) Conway, J. (Chalmers, Onsala) Vermeulen, R. (NFRA)	HI absorption in the FRII galaxy 3C321. 18 cm
GR019	Rioja, M. (Yebes Obs) Colomer, F. (Yebes Obs) Porcas, R. (MPIR, Bonn) Fomalont, E. Gurvits, L. (NFRA) Schilizzi, R. (NFRA) Sasao, T. (NAO, Japan) Asaki, Y. (NAO, Japan) Mantovani, F. (Bologna)	Phase referencing at L-band using cluster-cluster mode. 18 cm
VT762	Fomalont, E.	0528+134. 6 cm
VT763	Fomalont, E.	0528+134. 6 cm
W044	Krichbaum, T. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Kraus, A. (MPIR, Bonn) Lobanov, A. (MPIR, Bonn) Zensus, J. A. (MPIR, Bonn)	Intraday variables. 6 cm
W096	Murphy, D. (JPL) Canizares, C. (MIT) Coppi, Y. (Yale) Edwards, P. (ISAS, Japan) Lister, M. (JPL) Marshall, H. (MIT) Piner, G. (JPL) Preston, R. (JPL)	Gamma-ray quasar 0836+710 simultaneous observation with Chandra. 6, 18 cm

F. SCIENCE HIGHLIGHTS

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.

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; M-H. Rhee (Yonsei University); M. S. Yun; 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%. 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/H2CO 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).

Socorro

Collimation Region of M87 Jet Revealed – Global VLBI observations at 7 mm wavelength have revealed the inner regions of M87 at unprecedented resolution. The new image shows a remarkably broad jet with an "opening angle" of about 60 degrees near the center, with strong collimation of the jet occurring at 30-100 Schwarschild radii from the black hole. This work supports the hypothesis that jets are formed by an accretion disk around the black hole and collimated by magnetic fields. These observations are thought to be the first to show that AGN jets do not reach their final, collimated configuration until many tens of Schwarzchild radii from the black hole. The VLBA, along with telescopes in Europe, was used for this work.

Investigators: W. Junor (UNM); J. Biretta and M. Livio (STScI).

G. 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.

H. CHARLOTTESVILLE ELECTRONICS

Amplifier Development, Design, and Production

Four K-band amplifiers were shipped to the Array Operations Center (AOC) in Socorro, completing the scheduled 1999 commitment for that band. The machine shop delivered 15 K-band amplifier chassis and flange assemblies to the assembly group, and that production run will begin delivering amplifiers in early January 2000. Additionally, a set of six Ka-band amplifiers are in production. Four Q-band amplifiers were delivered to the AOC during the quarter, with the shipment of one additional amplifier in early January required to meet the 1999 production commitment. Two Q-band amplifiers, tuned for optimal performance in the lower portion of the frequency range, were delivered to Tucson for use in an ALMA prototype receiver. Plans have been generated to continue production of K- and Q-band amplifiers for the VLA and W-band amplifiers for the VLBA.

Prototyping of the 8-12 and 12-18 GHz InP amplifiers was completed, and testing has proven the amplifiers to meet or exceed all design goals for noise, gain, and bandwidth performance. Additional development and prototyping work has continued to make a wideband prototype amplifier for millimeter-wave receivers. This work resulted in a 3-13 GHz prototype amplifier with average noise of 6.5 K and gain of 33 dB. Our goal is to complete the designs of production-version InP amplifiers for frequencies of NRAO interest below 8 GHz to complement those already developed for 18-118 GHz.

In addition to ongoing amplifier production, the amplifier group provided ALMA support in the form of both manpower and equipment, was involved in the maintenance and repair of test sets and lab equipment, and repaired a number of failed or damaged amplifiers returned from the various field sites.

Superconducting (SIS) Millimeter-Wave Mixer Development

During this quarter work has focused on the following: (i) completion of the 600-720 GHz SIS mixer design, (ii) design of a balanced sideband separating SIS mixer for the 230 GHz band, (iii) design of an IF preamplifier with 8 GHz bandwidth, (iv) development of an automated mixer/receiver test system including software and construction of mixer test instrumentation, and (v) fabrication and measurement of low-loss vacuum windows. We also completed a study and report on waveguide flange standardization for ALMA.

SIS Mixers

The design of the 600-720 GHz building block SIS mixer is complete and will be sent to SUNY for fabrication in the next quarter. This mixer has no adjustable tuners, and is designed with low IF parasitic capacitance and inductance as required for wide IF bandwidth.

Having successfully demonstrated single-chip balanced and sideband-separating mixers in the 210-270 GHz band, we are now combining these to make a single-chip balanced sideband-separating mixer. This design will be completed and fabricated at UVA in the next quarter.

The Hertzberg Institute in Canada has completed two 230 GHz SIS mixers for use on the antenna test receivers.

During the last quarter we built (or rebuilt) and tested a total of six SIS mixers using Nb circuits fabricated at UVA.

Automatic SIS Mixer Testing

Work continues on automating SIS mixer testing. This is crucial to production of SIS mixers at the required rate during ALMA construction. During this quarter, automated testing in the 230 GHz band using the chopper wheel to switch the receiver input between hot and cold loads suggested that the optical system requires improving to reduce beam scattering. The new optical system has been designed and it will be tested in the next quarter. An optical bench has been set up for measuring horns and lenses in the 230 GHz band.

We have almost completed the design of the input optical components for the 600-720 GHz laboratory test receiver. This will be written up as an ALMA memo.

A gas cell has been built which will permit measurements of a narrow-band source at known temperature in one sideband to confirm receiver performance deduced from the usual simpler but indirect measurement methods.

Three IF amplifier bias supply chassis are under construction for use in the two mixer test systems and for development of broadband IF pre-amps. The five printed circuit board designs in each chassis were updated to incorporate as-built changes and additional connectors were added to minimize point-to-point wiring and simplify maintenance.

Design work has begun on new mixer bias supplies that will simultaneously control the four mixers in the balanced sideband-separating design. The design will be completed and its construction will commence in the next quarter.

Broadband IF Development

Following the recent successful results in our amplifier group using InP HFET's to make stable, low-noise amplifiers in the band 4-12 GHz, we are adapting their design for use as an IF preamplifier to be situated in the SIS mixer block. Simulations with an optimized preamp circuit driven from an SIS mixer indicate that low overall receiver noise temperature and flat gain are achievable over the 4-12 GHz band, with an acceptably low impedance presented to the SIS mixer.

Work continues on the 4 K, 4-12 GHz IF test plate for the mixer test Dewars. This plate holds an IF selector switch, directional coupler, and a balanced amplifier consisting of two quadrature hybrids and two amplifiers.

Vacuum Windows

The need for extremely low-loss, low-leakage, vacuum windows on the ALMA has let to the development of solid dielectric windows with multiple matching layers. These are tuned for a single receiver band and must be assembled with considerable precision to achieve the desired pass band. This work was on hold for twelve months following the loss of the key technician, and is now being continued by our engineering staff.

We had planned to use expanded PTFE manufactured by Gore as one of the layers in these windows. However, our measurements indicate that the material purchased recently has a significantly higher relative dielectric constant than earlier samples measured independently at NRAO and SAO ($\varepsilon_r = 1.3$ *vs* 1.2 measured on earlier samples). This will require a re-design of the vacuum windows being made for the 12 Meter Telescope and for lab use.

To measure low-loss windows and window materials accurately in the 68-950 GHz range, we have been looking into the possibility of using a Fourier transform spectrometer. We have visited several laboratories with commercial FTS's and find that the sensitivity of most instruments below ~300 GHz is insufficient for our needs. This is because of the low output of broadband sources at the lower frequencies. We have been given time on the National Synchrotron Light Source at Brookhaven, whose far-IR port is equipped with two FTS's. It is quite probable that the NSLS is the only facility where sufficiently accurate FTS measurements can be made in the 68-300 GHz range.

An alternative method for measuring windows and materials is to use the HP8510 vector network analyzer. We have built an optical bench for operation with the 8510 for measurements up to 110 GHz. Measurements made with the 8510 in the usual (frequency domain) mode were far too noisy for accurate determination of loss and dielectric parameters; this "noise" arises from multiple reflections at low level from the optical components and from surrounding obstacles. By employing the time-domain gating option on the 8510, both the transmitted and reflected signals can be filtered in the time domain to eliminate components not originating in the measurement pass of the signal. The limited frequency coverage of the 8510 results in significant errors at the band edges when the frequency response is measured with time gating, but over the central 80 percent of the band we find that accurate reflection and loss measurements are obtained. This method can be used to 330 GHz with commercial frequency extenders for the VNA, but beyond 330 GHz it will probably be necessary to rely on FTS measurements.

Miscellaneous

We completed a study of waveguide flange standards for the ALMA. The report (see Publication section below) is available at the ALMA web site. In many waveguide bands, more than one MIL-Spec standard flange is available. Flat and anti-cocking flanges, compatible with certain MIL-Spec flanges, are increasingly widely used. Alignment tolerances on standard flanges are acceptable for most practical applications, except when a flange is used with a smaller waveguide size than originally intended; then tighter tolerances are needed. The report discusses the relative merits of these flange types and examines the effects of flange misalignment. The effect of differential contraction between steel screws and brass flanges is considered. Recommendations are made for flange standardization on the ALMA.

Publication

A. Kerr, E. Wollack, and N. Horner, "Waveguide Flanges for ALMA Instrumentation," ALMA Memorandum No. 278, 9 Nov. 1999. Available in PDFformat at http://www.alma.nrao.edu/memos/html-memos/abstracts/abs278.html.

Electromagnetic Support

The original proposal for the GBT Q-band (40-52 GHz) receiver has a layout of four feeds in a square. Two flat tertiary reflectors are used to steer the beams from the four feeds onto the subreflector. One of the two reflectors is a chopping mirror and will be used for atmospheric noise suppression and fast pointing corrections. The fixed reflector is 36 inches in cross-section. A new optics scheme is being developed in which curved reflectors will be used in place of flat reflectors. The curved reflectors will be smaller in size. An electromagnetic analysis is being carried out, with the goal of providing a final design suitable for use on the antenna.

The design of the optics for a 600-720 GHz laboratory receiver was completed. This receiver will be used for evaluating SIS mixers. The receiver will have provision for a Martin-Puplett Interferometer (MPI) for LO injection/sideband separation, external to the dewar. The optics use two parabolic metal mirrors, separated by 9 inches, to couple the feed beam waist to the telescope beam waist. The MPI will be conveniently positioned between the mirrors, where the beam waist is large, for effective coupling. The optics were designed by Gaussian mode analysis and then checked with Physical Optics analysis.

Production and test of K-band wideband polarizers for the VLA continued.

Spectrometers/Correlators

During this quarter, most of the time was dedicated to working on the design of the ALMA correlator. During this period, the correlator group made several major changes to the correlator design plan that resulted in a considerable amount of redesign of previously completed logic cards. These changes were required in order to improve the reliability of the signal interfaces.

A *Request for Quote* for the design of the ALMA correlator chip was prepared during this quarter and a successful vendor was selected as a result.

A small amount of time was spent in support of the GBT and Tucson spectrometers.

Accomplishments of the correlator group during this quarter include:

1. Completion of the design and layout of a digital filter card for the ALMA correlator. The filter card was actually sent out for PCB manufacturing before being made unusable by a decision to change the FPGA family to be used in the correlator. This PC card will now be used for signal quality testing. Redesign of this card was started and should progress much faster than the original card because of the work already done.
2. Completion of the design and layout of the digital station card that serves as the delay line and the data packetizer card in the ALMA correlator. The change made in the FPGA family also left this card in need of fundamental changes but, as above, the redesign should benefit substantially from the original design work.
3. Initial design of a test fixture to test both filter and station cards.
4. Completion of a detailed specification for the ALMA correlator chip. A survey of potential companies for the design and development of this chip was done, resulting in the RFQ noted above.
5. Substantial progress on the design of the correlator printed circuit card. The design of a FPGA to do analog summation on the card was mostly completed.
6. Defining the interface between the correlator card and the long-term accumulator. Definition of the interface between the long-term accumulator and the read time computer system was completed as far as is possible at this time.
7. Design of the long-term card itself (about 30% complete). The design of a FPGA chip for this card is complete.
8. Completion of the design and layout of a test card to test the proposed 125 MHz digital interface standard.

Goals for the next quarter include:

1. To use the test card mentioned above to validate the high-speed interface method planned for the correlator.
2. To complete the design and layout of the digital filter and station cards.
3. To start on the actual design of the correlator chip.
4. To continue the design of the correlator and long-term accumulator cards.

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.

An important technical challenge associated with the array is the development of a low-noise sampling element. We chose a configuration consisting of special sinuous antennas integrated with low-noise balanced amplifiers. During this quarter, 38 room temperature balanced amplifiers for 1.0-2.0 GHz were fabricated, evaluated, and mated with the antennas to form the 19 elements. Various tests were performed to characterize the completed elements, including a short period test run on the 140 Foot Telescope. These tests indicated that the measured noise was considerably higher than expected from theory. It appears that impedance mismatch and possibly amplifier oscillation may be the causes of the higher noise, but more laboratory tests are required to confirm this hypotheses.

Some time was spent this quarter detailing a long-range plan to transform the current proof-of-concept system into a complete astronomical imaging instrument. This achievement will require significant development work to find an optimum beam forming system, explore efficient cryogenic cooling techniques, interface the system with AIPS++ software, and understand the calibration techniques.

Our goals for next quarter include performing a series of laboratory experiments to isolate the noise problem with the sampling elements. In addition, we plan to redesign the low-noise elements for variable ground plane spacing and perform associated impedance measurements. We will also compute the magnitude of the signal processing requirements for cross-correlation and direct beam forming digital techniques.

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 back-end electronics and is capable of canceling interference from both terrestrial and satellite sources, thus opening new spectral windows for astrochemistry and highly redshifted HI measurements. We are currently in the first phase of our proof-of-concept system.

During this quarter, a laboratory experiment was performed to verify the RFI attenuation as a function of interference-to-noise ratio (INR) as predicted in the paper by Barnbaum and Bradley (1998, *Astron. J.*, vol. 116, p. 2598). We also measured the noise added by the reference channel for a range of INRs in the main and reference channels. Finally, we measured the noise spectrum distortion caused by the frequency-dependent attenuation of noise in the reference channel by the tapped-delay filter. All these measurements were performed on our prototype adaptive canceler.

Also, time was spent this quarter examining the long-range plans for transforming the proof-of-concept system into a working instrument for astronomical applications. This transformation will require a significant development effort in utilizing fast, clean analog-to-digital conversion, adopting modern DSP processors for this application, and quantifying the effectiveness of several adaptive canceling techniques on real RFI-corrupted astronomical data. We are writing a NSF MRI proposal to be submitted next quarter that will address this specific development task.

The goals for next quarter include making relatively minor improvements to the current hardware. A series of laboratory measurements will be performed on the improved system to explore filter coefficient stability, attenuation versus interference-to-noise ratio, injected noise spectral properties, and broadband noise cancellation.

Balanced Low-Noise Amplifiers

This project 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. Cryogenic amplifiers covering the 290-395, 385-520, 510-690, 680-920, and 910-1230 MHz GBT bands have already been developed.

During this quarter, an oscillation was discovered and removed in our 910-1230 MHz series amplifiers. A 385-520 MHz amplifier was sold to Yale for laboratory experiments. Three 290-395 MHz amplifiers were partially assembled for delivery to NAIC early next quarter. Intermodulation distortion tests were performed on our 910-1230 MHz balanced amplifier at cryogenic temperatures.

The primary goal for next quarter is to develop a pair of low-noise, GaAs balanced amplifiers covering 800-1200 and 1200-2000 MHz for the MIT/LLNL axion search project in accordance with our development contract.

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.

We developed phase noise working specifications and a phase noise budget for ALMA LO sources and multipliers. We developed measurement techniques and measured critical components of the proposed LO system and verified by experiment the validity of the proposed YIG-tuned source concept with respect to phase noise. This included measurements of a YIG-tuned oscillator, a 100 mW power amplifier, and a 31/93 GHz tripler.

We established a collaborative arrangement with S. Weinreb at Caltech/JPL for the design and fabrication of MillimeterIC chips for W-band power amplifiers. JPL has shipped us the first lot of packaged amplifiers for test and we will be testing these at 80 GHz within the next 30 days. We have mounted and tested commercially-available MillimeterIC chips for the lower frequency amplifiers.

The major thrusts for the next quarter are to characterize the amplitude noise of the YIG-tuned sources at frequencies 4 to 12 GHz from the local oscillator frequency and to compare the YIG-tuned oscillator with a Gunn-effect oscillator.

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 to support semiconductor device research.

Work last quarter centered on modifying a 55/110 GHz doubler and refurbishing an old 31/93 GHz MillimeterIC tripler for laboratory use. Design of a 81/243 GHz tripler continues. We began to study the underlying nature of spurious signals from frequency multipliers using modern nonlinear dynamical theory. We participated in a meeting of the JPL HIFI LO group to exchange ideas and explore collaborations. As part of our contract with the University of Virginia group, spiral inductor test structures were fabricated and evaluated in a specially designed test fixture. A problem with the air bridge height was found. These inductors will be used in future multiplier designs, including the 81/243 GHz tripler. Varactors for the 110/220 GHz doubler were redesigned.

Our goals for the next quarter include the following: fabricate varactors for the 110/220 GHz doubler, fabricate and evaluate new spiral inductor test structures, finalize the design of the 81/243 GHz tripler chip, and complete the design of an 80 K cryostat for cooled multiplier evaluation. We will be gold-plating 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.

I. GREEN BANK ELECTRONICS

GBT Spectrometer

Programming support was rendered in the form of document generation describing the details of the setup and operation of the duty-cycle counters, which are used to monitor and set the input levels to the samplers. Software was written to read the duty-cycle counters. Another document was generated describing the location of the lags for each configuration, so that the data could be unscrambled. Firmware and software programming and programming support will continue into the next two quarters.

Drawings were reviewed and the proper revision as reflected in hardware has been archived.

One of the Long Term Accumulator modules has been found to have an intermittent failure that causes the module to fail to produce data for the VME computer. This card has been removed from the system pending repairs when time allows.

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.

Both the 100 MHz and 1600 MHz samplers need to be calibrated. The sampler test jig was obtained from Charlottesville, supplies, sources and a terminal were set up, and the test procedure was refined. The task of calibrating the 35 samplers is ready to be handed off to a technician, and will be completed in the next quarter.

Other GBT Back-ends

The Spectral Processor was moved to the GBT Equipment room from the 140 Foot Telescope this quarter. It has been reanimated and is ready for initial debugging use. Some upgrades to the system for RFI detection are being readied.

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.

Mechanical mounts are being constructed for the holography receiver to allow it to be used in either the original Prime Focus configuration, or in the Gregorian focus position. In addition to this, the back-end is being moved to the receiver room to allow better performance.

The GBT VBLA terminal has been moved and installed in the Tape Room. Software integration remains to be completed.

GBT Fiber IF System

The additional seven channels of the Fiber IF system are being manufactured. These should be finished in January, 2000.

GBT Servo System

The servo monitor system is being developed actively. This will assist in acceptance testing and performance monitoring of the antenna. All hardware is complete, except for cabling, and most of the software is complete. This will be used during the February preliminary servo tests.

A meeting is held regularly between NRAO, Comsat and RSi/PCD to address the current Servo issues.

GBT Receivers

The GBT Gregorian receivers are all complete, with the exception of the Q-Band receiver. Several of these receivers have been in use at the 140 Foot Telescope for several years. All the receivers are being refurbished and tested to await installation in the GBT. This process is nearly complete.

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 for the next quarter is testing and connecting the actuator cables. This will require at least 6 NRAO Electronics personnel 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

Due to lower than expected costs, we were able to build a four beam receiver with the available funding. The additional two beams should be ready by March of 2000. Design of a tertiary mirror system in underway, and should be completed in 2000.

GBT Cryogenics

The previously installed cryogenic tubing on the GBT has all been replaced with the fully-welded runs of tubing. About 80 percent of the tubing installation is complete. All runs up the vertical feed arm and the alidade tower are complete. Work remains in connecting up the feed arm runs to the receiver room and the alidade runs to the compressor room. Work is underway to determine the optimal oil separation configuration for the compressors.

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.

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.

OVLBI

Our OVLBI engineer has departed, and has been replaced by two technicians. Before he left he started a number of upgrades to the station. With the help of the digital lab, and the new OVLBI technicians, we are currently implementing a number of them. These include centralizing control at the Jansky Lab, adding intercoms to the station, 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 is being added.

A future upgrade to the antenna is replacement of the Antenna Control Unit and the motors that drive the axes with modern brushless motors. This activity is currently on hold due to manpower restrictions.

20 Meter

Normal maintenance issues have been taken care of. A second VLBA recorder was connected to the formatter to allow unattended operation of twice the duration. Several minor tape drive problems were corrected. Our previous cryogenics problems with this system have been resolved.

85-3 and the GB Interferometer

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 the 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.

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 Electronics division lent its support to the efforts to get our backup generator installed and operating in the Jansky Lab Control Rooms. Plant Maintenance is installing wiring to connect the generator to mission-critical loads in the control rooms.

J. TUCSON ELECTRONICS

1mm 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, our goal being to complete this project during the first quarter of 2000. We will then use the experience gained with automating the 1mm Array system to modify the tuning procedure for all receivers on the 12 Meter Telescope.

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 is currently being 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, multi-beam 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 June 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.

K. SOCORRO ELECTRONICS

Overview

The essential goal of the Electronics Division is to maintain electronic and cryogenic assemblies at the VLA and VLBA instruments and to provide on-site operation of all VLBA sites; a secondary mission of the Division is to enhance the function of both instruments through a variety of projects.

Preventive Maintenance Program

Division technicians helped implement a new maintenance tracking system this quarter. When fully implemented during the upcoming quarter, the program is expected to permit improved repair tracking to identify problem areas. An important goal for 2000 is to reduce observing downtime, especially that resulting from repetitive problems. Another important goal in this area is to improve checkout procedures for replacement modules sent to the VLBA sites and for VLA antennas after a move. 870 Division maintenance actions were tracked by the existing maintenance management system this quarter.

The Division assisted in the overhaul of two VLA antennas last quarter. In its fifth cycle, the VLA overhaul schedule is an essential part of the instrument PM program. Some project work is done as part of the overhaul cycle, such as rewiring the F racks to accept the new receiver controls. Two overhauls are scheduled for each quarter in 2000.

For the VLBA, overhaul PM is conducted during maintenance visits, and the Division will assist with three such visits in 2000. An internal technician training program was initiated this quarter to better support the VLBA maintenance visits.

There is a steady stream of preventive maintenance, but some significant or at least illustrative activities are given below.

Hydrogen Maser #4 was returned from the vendor after factory repair and its performance appears to be stable. Maser #11 is being tested to see if an IF degradation problem has been corrected after replacement of the hydrogen purifier and Pirani Gauge Assemblies. An essential goal for the next quarter is to complete the repair of Maser #11 or return the equipment for factory repair. Once #11 and #4 are both working, the maser at VLBA Owens Valley, #5, 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) led to removing the instrument from service. A replacement VCO is being procured and developed for use in the API, but the failure brought attention to other debilities in the instrument that must be corrected to produce a reliable instrument. An important goal is to rebuild the instrument in 2000; the API will be out of service until then.

The FFT for the VLA correlator is performed in the FPI array processor (AP). A failure of the AP this quarter caused three and a half days of lost observing time leading to essential goals for 2000 to replace the AP and to provide working spares for the existing AP in the interim. Though the AP is supported by the Computer Division, the Electronics Division must provide significant assistance.

The replacement for the AP, called the correlator controller, consists of four new interface circuit cards for the correlator and a VME chassis with three COTS circuit cards and one in-house card. All but two of the cards have been fully constructed or procured. The goal is to complete the boards, design, and build a text fixture for debugging the in-house VME card, and debug the entire assembly by the second quarter. The new controller replaces the Spectre Modcomp computer, the current correlator controller, and the AP. A study of other possible single-point failures uncovered another essential goal for 2000, to construct a spare VLA L28 5 MHz reference module.

Late in the quarter an intermittent problem developed in the IF B Delay/Recirculator system of the VLA correlator. As of this date, the problem appears to be a mechanical problem in the back plane. Since the problem is so sporadic and requires taking the whole array out of service to troubleshoot, work on the problem is limited to maintenance time.

Heads for the 49 magnetic tape drives are expensive and have an expected lifetime of only 5,000 hours. Since head wear is thought to be proportional to relative humidity, dry air kits have been installed on drives at Saint Croix, North Liberty, and Hancock. In addition, the head assembly pre-amps and cabling are susceptible to failure from broken wires and shorts as the assemblies age. Desirable goals are to install additional dry air kits at all VLBA sites and to repackage the head pre-amps and cabling to reduce failure from broken wires. However, the need for replacement headstacks, refurbished capstan motors, and new idler rollers is expected to preempt additional dry air kits and head pre-amp upgrades in 2000, because of budget limitations.

In response to reports that some VLBA magnetic data tapes work better on certain tape drives, an important goal for the next quarter is to establish an improved tape path calibration of all drives using a single master tape.

VLBA antenna drive motors have a failure rate significantly higher than VLA antenna drive motors. A study of brush wear and of improved air filtering are intended to reduce the problems. An important goal for 2000 is to reduce drive motor failures.

Flexible stainless steel lines are used on both instruments to supply compressed helium to the 180+ cooled receivers used on the VLA and VLBA. A replacement 12 foot flex line costs $400; but with a TIG welder procured in 1999, the lines can be repaired in-house at a fraction of the procurement cost. An important goal for 2000 is to modify helium lines in the Cryo Shop to facilitate testing of new receivers.

The Solar calibration procedure for the VLA was improved and tested during the quarter. With the improved procedure, a single person can calibrate and test solar calibration noise levels more quickly and more accurately. A desirable goal for 2000 is to test and calibrate the C, U, and K-band front-ends on the four antennas which have external solar calibration noise systems installed, and do the same for the X- and L-band front-ends on all 28 antennas.

A firmware fix to provide accurate rotational control of the VLBA subreflectors over short distances was tested successfully at VLBA Hancock during this quarter. As a result, the firmware has been installed at all VLBA sites. An important goal for the next quarter is to complete testing of subreflector positioning at 7 millimeter and prepare a test memo. The tests may lead to better understanding of a problem in which the subreflector rotation changes in proportion to telescope elevation angle.

After a power failure in 1999, operators were not able to re-program the VLA International Atomic (IAT) Clock because the 1PPS from the GPS receiver had inadvertently been left disconnected. An LED to indicate the presence of the 1PPS has been added to one of the IAT clocks this quarter and an important goal is to add the indicator to the other clock in the coming quarter.

Infrared transmitters in five of the VLBA weather stations have been replaced, fixing all sites with evident problems. An important goal is to complete all sites in 2000.

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 for 2000 is to provide sufficient remote status information or control so that the correct repair personnel can be dispatched.

VLBA site techs received training on a variety of topics at a workshop held in Socorro this quarter. Three of the group foci were problems with the VLBA drive motors, questions about the new HVAC proportional controls being installed by the ES Division, and safety training for doing station electrical work. An important goal is to repeat the workshop in 2001.

Premature failure of main power breakers at VLBA sites may result from generator PM procedures which now require periodic operation of the breaker. A desirable goal for the next quarter is to decide between less frequent generator PM or installation of a main power switch.

Tests show that the "notches" (gain loss) in the low frequency end of L-band on the VLA are a problem with the feed horns. No corrective action is planned at this time.

This quarter the Division investigated five VLA site and four VLBA site radio frequency interference reports by finding the likely sources of most disturbances and suggesting observation file changes to help mitigate the interference for future observations. More than two dozen military frequency coordination requests were processed, in part the result of schedules sent to military frequency coordinators around the country. Nearly a half dozen scheduled VLA and VLBA observers were warned of likely radio frequency interference (RFI) during their observations. The warnings allowed time for the observers to modify their observation files or anticipate RFI effects during data reduction. An important goal is to continue the RFI mitigation effort.

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 need to be addressed after installation of the new front-end filters. The filters are discussed under projects.

Correction of VLA sync detector variations and DC offsets at the back-end and a study of subreflector rotation and offset at K- and Q-bands are two maintenance activities which would be desirable to schedule in 2000. Repair of the 12 dozen+ VLBA baseband converters ties up nearly one FTE because of the need to tune with hand-selected soldered-in components. A desirable goal is to redesign and rebuild the BBC for lower maintenance costs.

VLBA PT Link

All four IFs on the PT fiber optic link were tested successfully on December 14, 1999, demonstrating that the link meets specifications agreed on two years ago. The goals of this quarter were to complete the digital optical transceiver, modify the high power analog laser module, upgrade the analog optical receiver unit, install two additional F4 modules, install the PT rack input switch plate, and solve the noise source driver problem. All of these goals were met. The essential goal for 2000 is to provide the link for observing at high resolution during the VLA "A" configuration in October 2000. Tasks to meet this goal are being scheduled: construction of spares, modifications to some of the link modules, a switch to bring the link into use without moving cables, and documentation.

New Receivers

This quarter the Division installed three 7 millimeter (Q-band) receivers, and two 1.3 cm (K-band) receivers on the VLA. The K-band receivers are the new low noise 18 - 26.5 GHz design. There are now 18 Q-band receivers available at the VLA and 11 low noise K-band receivers. The system performance and local oscillator power levels of all 18 Q-band receivers have been characterized; an important goal for next quarter is to release the results in a test memo. An essential goal is to assemble and install an additional seven Q-band and five low noise K-band receivers on the VLA in 2000. Doing so will require the construction of five F14 receiver control modules and rewiring the associated F racks. Six existing F14 modules will be upgraded over the same period. Altogether, sixteen F14s remain to be built and 32 to be modified.

The VLA F3 LO modules in their current configuration must be adjusted to extend the stable operating frequency range for use with Q band. A YIG bias customizing test bed was fixed to use with the procedure. A desirable goal for 2000 is to study the replacement of the F3 module because of its limited bandwidth and stability. Actual replacement will require special budgeting.

During this quarter, three of the four 3 mm (W-band) receivers were temporarily installed for tests on the Fort Davis, Pie Town, and Mauna Kea VLBA antennas. An important goal is to fix suspected window leaks and bad noise diodes on the existing receivers, preferably before a CMVA run in April 2000. To address problems with ripple in the bandpass, high system temperature, and failed noise diodes, an important goal is to investigate changes to the LO oscillator chain, a Y-adapter and calibration coupler, and isolators during the next quarter. With the planned modifications, the frequency range of the W-band receivers will be extended to 95 GHz. An essential goal is to add two more W-band receivers to the VLBA system before the end of the year.

Upgrade for the Pulsar High Time Resolution Processor (HTRP)

A New Mexico Tech project, the HTRP upgrade has been supported in part by the NRAO. This quarter, a prototype of the Fast Analog to Digital Converter (FADC) assembly was produced for software development. Schematic drawings were released for board layout design by an outside contractor. The FADC is expected to be completed next quarter, an important goal. Another important goal for 2000 is to rework the VME timing card and to provide spares which together are expected to complete the hardware phase of the project. A desirable goal for 2000 is to remove 60 Hz interference to the HTRP.

Expanded Very Large Array Project

A major design consideration for the Expanded Very Large Array Project is the location of data sampling. Though sampling at the antenna is simpler and may well be the method chosen for the ALMA instrument, there must be proof at the VLA that RFI produced by the high speed sampling can be suppressed below at least harmful and perhaps detectable levels. The decision impacts the design of the fiber transmission system and configuration of hardware at the antenna and control building. An important goal for 2000 is to study the sampling location issue and to develop a system block diagram for the antenna. As an example of the impact of the sampling location dilemma, the existing Fluke tuneable frequency synthesizers are in need of replacement. Replacement synthesizers must be procured in the next several years, but will not be used on the expanded VLA if sampling is located at the antenna. An important goal for 2000 is to identify and cost replacement synthesizers.

An important goal for the first quarter is to assist the Computer Division in implementing a two-port serial line controller (SLC). The SLC is the communication link between the on-line computer and the digital control system (DCS). The second port on the SLC will allow developmental software testing during VLA maintenance time in preparation for replacement of the existing on-line computer.

A 10 Gbps fiber optic link is being developed for the ALMA project with the rationale that the work will transfer to the Expanded Very Large Array project. An important goal for 2000 is to complete the link and begin other studies related to both projects such as a monitor and control system.

Another important goal in 2000 is to extend the existing 200 MHz VLA IF to 300 MHz by means of wider front-end filters. The BW increase is not part of the Expanded Very Large Array Project, but is mentioned here to bring attention to the need to expand the IF. The filter bodies and changes to the back-end are complete; construction and installation will begin next quarter.

K-band Water Vapor Radiometer (WVR)

Tests of the two 3-channel WVRs this quarter show noise in the signal considerably in excess of the 0.1 percent requirement, despite re-work of isolation and shielding. An important goal for next quarter is to determine design changes necessary to bring the instruments within specification, and for 2000, to produce two functioning WVR instruments installed on the VLA. It may be possible, for example, to copy the BIMA multichannel design being developed for the ALMA project.

VLBA Panel Adjustments

The VLBA main reflector panels must be adjusted to achieve the best possible efficiency at W-band. Studies and demonstrations of metrology systems by the ES Division in 1999, have led to renewed interest in holographic methods for adjusting panels. To maintain phase reference, the reference antenna for holography must be adjacent to the antenna being measured. An important goal for the next quarter is to develop a plan for a portable "outrigger" antenna for holography using a beacon from a geostationary earth satellite. A cost of $10K is expected by using COTS equipment and copying the API, which will require funding over the usual operating budget.

High Density Recording Rates

To improve the SNR of faint objects, a formatter expansion at the Los Alamos, Pie Town, Kitt Peak, and Owens Valley VLBA sites has permitted successful testing of a 512 Mbps recording rate by using two tape recorders simultaneously. Though some software problems remain, the hardware produced acceptable error rates at the standard recording speed of 160 ips. An important goal for 2000 is to install the formatter expansion at the remaining VLBA sites. The project has been on hold for six months because of a frozen job opening.

At the request of the OVLBI program, a proof of concept for a 1 Gbps system is under construction and a report is planned for the next quarter. The concept being studied is to use two head assemblies on each of two drives for a total of 128 tracks recording simultaneously. A drawback of the scheme at the current 160 ips tape speed is that the magnetic tapes will fill up in 2 hours and 15 minutes.

Interference Monitoring

Results of a 6-band RFI survey at the VLA and an all-station, 7-band VLBA RFI survey were placed on the NRAO web page for use by array users in planning their observations. A desirable goal for 2000 is improved methods of alerting VLA and VLBA array users to known RFI problems. Four additional military surplus receivers were received for use with the VLA Environmental Monitoring Station (EMS). The receivers cover a frequency range from a few hundred kilohertz to 18 GHz. An important goal for 2000 is to complete the repair and calibration of the "new" and existing receivers and to place the entire monitoring system into routine use.

Using surplus equipment and a NM Tech student, a satellite tracking system (STS) is being added to the arsenal of antennas to be used with the EMS. The system consists of a 10' parabolic dish with fast drives capable of tracking low earth orbit (LEO) satellites. The antenna and antenna gimbal were mounted, the electrical control hardware and servo systems were installed, and the tracking and control algorithms were tested this quarter. The high-gain antenna and precision tracking system of the STS will be used with the EMS for direction finding and satellite power measurement capabilities. For example, the STS/EMS can be used to verify emissions limits of the agreement with Iridium. The desirable goal is to produce a working STS during the next quarter.

VLBA Correlator

A desirable goal for 2000 is to replace the Sun 3 computer used for diagnostics on the VLBA correlator with a PC running Linux. The hardware is on hand for the update, but a requirement for CCC to compile software must first be removed.

Presently there are a number of personal computers running terminal emulator programs to communicate with over 100 embedded microcomputers in the VLBA correlator. A desirable goal for 2000 is 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, assuming funding is available.

Ionosphere Testing

A dual-frequency GPS receiver to be used for ionosphere studies at the VLA site has exhibited software problems. A desirable goal for 2000 is to repair the receiver and begin the study.

Video Monitoring

Video monitoring at four VLBA sites accessible via the Web enable the Socorro Operator to monitor weather conditions at the sites. A desirable goal for 2000 is to complete installation of video surveillance at the remaining sites.

Other Work

Desirable projects for 2000 are deployable 74 MHz dipoles, installation of filters for the OH Radio Astronomy band at 1612 MHz to block spurious radiations from adjacent bands used by GLONASS and the IRIDIUM LEO communication satellite constellation, installation of PCAL on the VLBA for Q- and W-band receivers, snow detectors for the VLBA antennas, and installation of telephones at the VLA to replace the existing intercom system. Progress on most of these items is expected to be constrained by the budget for 2000, though an important goal is to test prototype *IRIDIUM* filters on three antennas in 2000.

ES Division

Emergency repairs on VLBA azimuth drives involved unplanned trips to the St. Croix and Brewster, Washington, antennas. In St. Croix, a bearing in an azimuth drive motor failed catastrophically. Fortunately, the antenna was removed from service and the drive motor was replaced before it was damaged beyond repair. The Brewster VLBA antenna suffered from a fatigue failure in an Azimuth Drive Axle resulting in almost three weeks of down time. A new axle was designed, fabricated in the machine shop and installed on an emergency basis.

New procedures for the reconditioning and alignment of encoders have been implemented. Preliminary pointing results show that these changes have increased the pointing accuracy of the last three antennas overhauled (antennas #17, #23, & #24). Prototype encoder electronics were also installed on antenna 24. The new circuits promise to be more reliable, easier to repair, more stable, and capable of far greater resolution. A goal of 6 arc seconds RMS was established in Test Memo #218. We expect these procedures and modifications will contribute significantly in achieving this goal.

A site-wide energy survey was also completed this quarter (VLA test Memo #223). The survey identified several places where substantial energy cost savings could be realized by upgrading or replacing older inefficient equipment. Some of the more cost effective projects with paybacks of around three to four years are Control Building chiller motor replacement, replacement of old wall A/C units, upgrade lighting, Tech Service heat pump, and waste oil heaters. The basic KWH rate from 1992-1999 has increased 3.7 percent, the overall KWh rate is up 8.2 percent, while the VLA consumption in KWh is down 15 percent. The Socorro Electric Cooperative (SEC) cost has been relatively flat during this period. A plan between ES division and Business division on acquiring new equipment is underway. The possibility of financing this equipment with energy savings was discussed with the SEC.

Long line potential measurements over the waveguide were begun. These measurements are done every three years and are critical for proper setting of the corrosion protection system that protects the waveguide. The potential measurement cycle and waveguide inspections are to be revised to improve confidence in waveguide integrity.

This year 4,300 ties were replaced requiring more than 17,000 spikes. The bulk of the replaced ties were located on the section of track between DN-9 and highway 60. By year end, the track crew will have completed leveling all but one stretch of track on the west arm and two on the north arm. The track crossing highway 60 also had to be rebuilt. This crossing repair had to be coordinated with the state highway department as traffic was detoured around the track crossing during the replacement. A trip to St. Louis was made to inspect a Rail Tamper. NSF has approved the trade of a Rail Grinder for a Rail Tamper. The Tamper will be a valuable addition to our track repair equipment. This equipment will alleviate much of the laborious work of Lining and leveling track. We hope to eliminate most manual leveling and tamping.

In addition to the fabrication of VLBA azimuth drives and the multitude of other smaller parts, the machine shop also completed the phase shifters and dewars required for next year's K-band installations.

Completed Work Orders –Machine Shop Man Hours By Division

Electronics	1,982
Cryogenics	13
E & S	707
Tucson	0
Charlottesville	0
Operations	19
Total Hours	**2,721**

The Auto shop was busy refurbishing two surplus dump trucks that are required for the ongoing track repairs and railroad tie replacements. The dump beds on both trucks were shortened and tarp rolls were installed so that the trucks would meet legal highway requirements. Both trucks also were painted. The valves on both VLA auxiliary (CAT) generators were adjusted and the generators were serviced.

Several initiatives were undertaken to protect our workforce. The first of these initiatives involved a meeting with state OSHA personnel to bring our lockout/tagout procedures into compliance with state and federal laws. A prototype fall arrest system was also designed, fabricated, and tested. This system will protect our workers as they ascend the ladder to the antenna apex on both VLA and VLBA antennas. A guardrail system also was designed to protect employees working at the antenna apex. Prototype guardrails are being evaluated on both the VLA and the VLBA antennas. The control building fire alarm system was completely rewired to improve reliability and decrease the incidence of false alarms.

Efforts to protect our visitors were also undertaken. During thunderstorms visitors tend to seek shelter in the visitors picnic area. In order to decrease their exposure to lightning, a lightning protection system was installed over the picnic area.

Tests were conducted to investigate our ability to recover from a major power failure. These tests involved switching off power to the control building and waiting until the UPS batteries were run down so that all computer systems lost power. Our power recovery procedures were then rehearsed and refined where required. It has been agreed upon by Operations, Computing, Electronics, and ES Divisions to make this exercise an annual event.

Several building maintenance projects were undertaken, including refurbishing the visitors center and the repair of a broken water main that supplied the control building, VSQs, and visitors center. On October 10, 1999 the water main broke underneath the control building foundation. Therefore, a large hole had to be excavated under the building foundation to repair the line. A new Visitor Center front door, damaged by high winds, was replaced. A complete new interior paint job and repairs to carpet and displays were made. Visitors to the VLA have subsequently been more favorable about the visitor center. We contacted the New Mexico state property division and negotiated Visitor center roof repairs, which the state will pay for. Bids are being reviewed by the state at this time. The second Control Building chiller was brought on-line and is being tested.

Effective November 1, 1999, Lew Serna and Jon Thunborg became the new ES Division Head and ES Deputy Division Head, respectively.

Engineering Services Division - Goals and Objectives 1st Quarter 2000

- Array reconfiguration to C-array, a task that consumes relative manpower otherwise used during other tasks listed.
- Perform antenna overhaul of 5, 20, and 26.
- Perform semi-annual VLA antenna lubrication maintenance of drives, AZ/EL gears and FRM.
- Perform installation of K- and Q-band receivers (6) on VLA antenna.
- VLBA tiger team's visit to St. Croix - will perform an exchange of the azimuth drive #1 wheel assembly and reposition the FRM as needed, along with several other maintenance tasks.
- Repair Visitor Center roof.
- Continue Fall Arrest device testing - an in-house design requires extensive testing per ANSI standards to prove worthiness before actual use.
- Decide on VLA handrail. Develop alternatives if not approved.
- Design and build optical telescope for a VLA antenna to measure antenna-pointing precision.
- Design and fabricate ladder hatch grab bar for VLA antenna - a safety item that will improve access to dish surface.
- Modify transporter truck to increase stroke - designed to allow much needed clearance of rail while turning truck 90 degrees.
- Install remote start/stop function onto VLA Operation touch screen console - allows Operators to remotely start or stop VLA power generators during commercial outages.
- 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.
- Preventive maintenance of Control Building chillers - this is a three year maintenance cycle item due this quarter.
- Antenna drive motor tach generator replacement - a prototype design development to improve operation and reduce failure rate of motors due to brush wear.

- VLA antenna encoder overhauls - during antenna overhaul, encoders are disassembled and rebuilt replacing worn parts, then bench tested to meet original specification.
- VLA encoder upgrade - developing an executable plan to modify VLA antenna encoders and data converter to improve performance, reliability, and serviceability.
- VLA antenna elevation motor junction box modification - a shop task during antenna overhaul to improve disconnection of power and control cabling from motors when removed for repair.
- VLA antenna elevation cable wrap modification - an overhaul task to improve disconnection of power and control cabling at the elevation axis.
- VLBA contempo unit upgrade - preparing for the last VLBA installation at North Liberty due in April. In addition, assembling vertex and pedroom hvac modifications to install during tiger team visits.
- Test transporter limp pump system - designed to recover from main hydraulic pump failure of transporter. Evaluation of improvements made on the system continues.
- Transporter maintenance - includes truck rotations, drainage, and inspection of hydraulic reservoir, major oil, and filter changes per reconfiguration.
- Welding shop fabrication - includes feedcone segments (3), encoder enclosures (3) to better insulate antenna units from condensation and dust, VLBA apex handrail (3), modifying VLA antenna elevation encoder mount to improve alignment settings, prefabrication of elevation hardstops and antenna structural modifications during overhauls and tiger team visits.
- Machine shop fabrication - includes component builds for new K, Q and W-band receivers, related electronic modules and parts, components for VLBA azimuth wheel assembly spares, and general repairs as needed.
- Revise Confined Space safety procedures for summer work period.
- Resume north arm drainage repair.
- Perform long-line potential measurements - coincident to waveguide anode corrosion and lightning protection.
- Prepare antenna-painting equipment - will overhaul water-blaster (1) and paint gun system (1) and assemble VLBA azimuth wheel assembly (1).
- Redistribution of administration, janitorial, and emergency services duties - preparing for retirement of department supervisor.
- Monthly staff coordination and projects meetings - division heads, supervisors, and engineers meet to plan, schedule, and review ongoing work effort.
- Complete alignment of main line track from CN-5 to CN-8.
- Install old crossing planks at Highway 60 for "on-off" location.
- Rebuild crossing between CN-6 & CN-7.
- Complete long line potential measurements on all arms.
- Check LPS over wave guide on all arms.
- Continue anode bed maintenance.
- Continue grounds maintenance (roads, landfill, etc.).
- Build fence around satellite dish behind VSQs.
- Assist carpenter as needed.
- Replace/repair ceiling & floor tile in machine shop.
- Open inspection hole in roof of visitor center for contractor when repairs begin.
- Remove lime build-up on slump block at cafeteria.
- Build shelves in room 7 of at SLOB.
- Locate & repair roof leaks at servo shop.
- Install sound soak in room 301 at AOC. (Need help from Grounds)
- Install carpet in operator area at AOC. (Need help from Grounds)
- Continue PMs.
- Repair work on equipment & vehicles.
- Build, install, & paint one dump truck bed modification (1 of 3).
- Build, install, & paint one dump truck tarp roll & wind deflector.
- Build, install, & paint one dump truck cab (1 of 1).

L. COMPUTING AND AIPS

Observatory-wide Computing

Computer Security - Policy: During the past several months, the Computing Council and a group of NRAO staff developed a formal policy on computer and network security which went into effect on November 10, 1999. The primary goal of the policy is to improve the security of our computing environment without compromising services that are fundamental to our role as a user facility. Changes will be phased in during the first half of 2000, with the schedule determined by a Computing Security Committee composed of representatives from the four major sites, the NRAO wide-area networking manager, and a Computing Security Manager as chair.

The policy mandates a slightly different approach to computer security than we have taken in the past, when only services which were known to be a problem were blocked from the Internet. By contrast, once the policy has been implemented, only services known to be needed outside of NRAO will be allowed, and only for those systems which need to provide them. This will minimize potential intrusion paths and help to make the problem of monitoring network service usage tractable. Virtually all of the break-ins at the NRAO during the past year involved a small number of services which were not actually needed externally. To complement the tighter access controls, we will also increase efforts to detect intrusion attempts.

A number of computing staff have received training in computer security issues to ensure that we understand our options and their potential impact. The enhanced education in computer security will also extend to our computer users, including visitors to NRAO, as appropriate.

Remote Access: To reduce the risks associated with remote access, the NRAO has strongly recommended, and may eventually require, the use of the secure shell (*ssh*) package for login connections between NRAO sites and our users' home systems. ssh encrypts the transmitted data, including passwords, and thus hides account information from "sniffer" programs. ssh, which is available for both UNIX and Windows in free and commercial versions, is supported at all NRAO sites, and we continue to urge NRAO's user community to install ssh on the computers that they will use to connect to our systems.

Viruses: Computer viruses are detected on NRAO systems at a rate of about two incidents per month. Nearly all of these are received via email messages to NRAO staff from external sources. Propagation has been virtually nil, however, due in large part to the use of anti-virus software on essentially all networked Windows PCs at the NRAO. In late 1999, an update and support contract was purchased for this software, to ensure that our virus detection capability remains current across the Observatory.

Hardware - Computers: The budget for hardware acquisition and refurbishment was small in 1999. Highest priority was given to hardware needed for the upgrade to the VLA on-line system, to wide-bed printers required for engineering design and large-format astronomical presentations, and to computer-driven projectors.

Approximately 50 upgrades must be done each year to sustain even a five-year lifetime for UNIX workstations; in 1999 we were able to do less than 20, with the drastic reduction affecting both staff desktops and facilities for visiting observers. 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 that has been available for the upgrade effort has not permitted us to keep up with replacement of aging hardware; as a result, there are still more than a hundred systems in daily use around the Observatory which are at least five years old.

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). Networking bandwidth has been increased observatory-wide, both to support videoconferencing and to provide faster data transfer. The increased bandwidth between Charlottesville and Green Bank has also enhanced Green Bank's connectivity to the Internet, which will be required to support remote observing with the GBT. Most of the necessary equipment was delivered in late 1999. Systems will be installed first in Charlottesville and Green Bank for testing, and then in Socorro and Tucson. The facilities should be available for general use in the spring of 2000. The NRAO equipment will use 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.

Y2K - Final 1999 Preparations: By the last quarter of 1999, only a few tasks remained to be done to prepare for the Y2K rollover. These included further testing and a database upgrade for VLBA operations, and the application of recently-released Y2K fixes on the Fiscal computer system. UNIX workstation operating system/patch upgrades were completed, as was a minor update to the voicemail system on the Charlottesville PBX. A checklist was developed to ensure that necessary updates had been applied to all Windows PCs.

As a precaution against escalated computer hacker activity, more restrictive router filtering was put in place before New Year's Eve, and one NRAO site opted to disconnect from the Internet for 24 hours around the rollover.

All sites arranged for key support staff to be either on-site or readily available over the holiday weekend in case of serious problems as a result of the date change.

Early 2000 Results: As of January 6th, no problems have been seen with critical systems. Communications, Fiscal computing, and telescope observing are all proceeding normally. The VLBA successfully observed on New Year's Eve through midnight UT and the VLA through both midnight UT and midnight local time. No unusual computer hacker activity was noticed during the holiday period at the sites that remained connected to the Internet, and no new viruses have been detected. No NRAO site has reported problems with outside providers such as electricity, water, financial services, and transportation.

A small number of non-critical PC systems and in-house scripts reported the date incorrectly. None of these affected fundamental operations, and all were immediately corrected. A few users of a very old email client have had to change to newer ones.

Future Plans: Our uneventful transition to year 2000 operation suggests that further problems will also be minor, but we recognize that some issues may take time to manifest themselves. We will continue to monitor our Y2K situation carefully over the next few months, particularly in such areas as payroll, benefits, supplies, and the leap day.

AIPS

Versions - The current test version of AIPS is 31DEC99, and this is currently planned to be the final "release" of AIPS. 31DEC99 will be available from our ftp site continuously, and will continue to be patched and developed where necessary over the next several years. The last standard release of AIPS is 15OCT99, which is currently being shipped. AIPS is currently distributed nightly to all NRAO sites and to a number of non-NRAO sites in the US, Europe and Japan. In the future we expect the nightly distribution list to grow as the "Midnight Job" becomes the standard method for obtaining AIPS. Full support for SVLBI processing has been available since 15APR98.

The 15APR98 version of AIPS was distributed to over 344 non-NRAO sites, running Solaris, Linux, DEC Alpha, HP and SGI versions. The overall number of AIPS installations has continued to grow over the last two years. The majority (75%) of AIPS distributions are now received by ftp, although the CD-ROM distribution is still in strong demand. Demand for 15OCT99 has been strong.

Late in Q4 Ketan Desai announced he would be leaving the AIPS group in early 2000; the AIPS group wishes him the best of luck in his new career. Efforts at replacing him have begun.

General Issues -

- The main imaging task IMAGR was changed to restart deconvolutions more efficiently when possible. A new option to deconvolve the image with multiple-width Gaussian models was introduced. This may be a major step forward in Cleaning extended sources.
- A simplified interface MAPPR to IMAGR was released.
- SCIMG is a new task, a multi-field version of SCMAP, to image and self-calibrate a data set iteratively.
- The graphical interactive editing tasks were upgraded to allow the option of displaying and editing all polarizations and IFs at the same time. Several other options to aid usability were added.
- Continued support of GPS external calibration information.
- The tasks CONFI and UVCON have been evolved to assist in configuration optimization and simulation for ALMA.
- Tasks to study single-dish, beam-switched imaging techniques were introduced and upgraded.
- Another round of reconcilitation between the USNO/GSFC and NRAO versions of the radio astrometry routines was completed.
- KRING now chooses the FFT method for model division instead of insisting on DFTs.
- Issues concerning the Linux compiler and round-off errors were investigated.
- A patch addressing an error in the VLBA saturation correction that was introduced in Version 10.5, and that could lead to errors of the order of ten percent in auto-correlation amplitudes, was released.
- A number of changes/additions were made to FILLM (the main VLA data loading routine) including support for the new link to the Pie Town VLBA antenna.

Goals for Q1 2000 -

- Continuing maintenance and user support.
- A new installation/registration wizard for 31DEC99

- Low-level code development in support of NRAO instruments.
- Updating of user documentation.
- Additional data editing and weighting tools.
- Streamline loading and calibration of VLBI data.

Socorro Computing

Y2K Preparations - During the fourth quarter of 1999, activities in the Systems Support Group of the Computer Division concentrated on completing the preparations for Y2K. NRAO-NM has finished its OS upgrades and Y2K patching. All Linux machines have been upgraded to Redhat 6.0, and all Suns except for a few special cases have been upgraded to Solaris 2.6. The special case Suns now run a patched version of Solaris 2.5.1. All of the non-Y2K compliant PC motherboards have been replaced.

Also the Array Support Group saw major Y2K preparation activity during the last quarter of 1999. Databases and operating systems were upgraded to Y2K compliant versions, which in turn required software testing and a few fixes.

A staffing and user support plan was drawn up to ensure proper support over the January 1 weekend; all users were informed of the important details of this plan. In order to guard against possible shortages, a repository of essential computer supplies had been created to see us through the first two months of 2000.

Thanks to good preparation the Y2K transition was relatively uneventful at the AOC and the VLA. Planned systems staffing in the first days of the new year was reduced. In VLBA operations one script, which could not easily be tested in advance, showed some date problems, but this was easily fixed and had no adverse effects on observing.

New Hardware - We purchased a number of hardware items, which, because of the Y2K efforts, will have to wait until the new year before being installed:

A new high capacity black-and-white printer will be placed in the new West Wing addition at the AOC. This printer will alleviate the increased printer load and allow staff in the new wing to have printer facilities nearby.

Increasingly, posters at conferences and meetings are being made using large format color printers. To enhance the professional appearance of NRAO posters, we have ordered such a printer for the AOC. This will most likely will be located in the public room AOC-260.

A Windows-NT/Redhat Linux PC will be placed in AOC Room 260; this machine will be available for general public use and will have a CD-R(W) writer installed. This will offer users an alternative to tapes as a data backup and transportation medium for modestly sized datasets.

Finally, we will replace two DAT drives on public machines by newer drives which accept the DDS3 format. This will be a welcome addition to the sole public DDS3 drive we have available, and will allow us to offer DDS3 access to each AOC corridor with public workstations. For the year 2000, we intend to further upgrade most of our tape drives, both Exabyte and DAT, offering increased capacity and reliability.

Correlator - A new version of the VLBA correlator software was installed. This version has an improved nutation model, writes status information into a database as part of the VLBA Operations Management System (OMS) project, and has support for a delay model server so that the burden of computing delays can eventually be moved off the real-time system.

A Linux PC which will compute and return delay values upon request has just arrived and will be installed on the VLBA correlator subnet in January. Developed for both the VLBA and the Expanded Very Large Array projects, this prototype will help test the distributed controls model of the Expanded Very Large Array .

Operations Management System (OMS) - The OMS dynamic scheduling system was used heavily by the new VLBA data quality analyst. The schedule viewing tools were adapted to show dynamic and conditional schedules, and to show maintenance type work. These tools will be released to a larger test group next quarter. The OMS interface to the correlator status reports is being tested, and will be released to beta testers next quarter.

VLA Online System Upgrade - Development and testing of the VLA correlator controller replacement continues. The system has been successfully connected to both the VLA network and the VLA correlator. When work on the interface card to the correlator is completed, testing will resume.

We managed to secure another five years of hardware maintenance for our Modcomp computers. This allows us sufficient time to rebuild the online system while relying on the Modcomps in the meantime.

As part of the Expanded Very Large Array , development of an interface to the current VLA monitor and control system was began. Hardware has been ordered and software design has started.

In December, a report on the current status of the VLA online system rebuild was presented to the VLA Computing Oversight Committee.

Mainsaver - The Computer Division further managed 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. MAINT and Mainsaver are now in use in parallel by all divisions at all sites; by January 1 we intend to use Mainsaver exclusively.

Projects to be Completed -

- Finish VLA-AOC communications project.
- Install and make available to users the new wide-bed color printer.
- Helpdesk: reduce open ticket count by 50%.
- Make improved work break-down plan for VLA online system rewrite.
- Resolve outstanding bugs in jobserve
- First draft of operational Expanded Very Large Array computing system requirements
- Initial evaluation of hardware for VLA monitor & control interface
- VLBA recorder track test
- Deliver OMS schedule views to beta testers
- OMS correlator log and queue in alpha test
- Prototype OMS reports and OMS correlator queue resolution
- Deliver Expanded Very Large Array computing chapter (with Cornwell)
- Move track and vlbamon databases to new database server oort
- Transparent support of Pie Town in VLA
- Allow VLA fast switching mode for planetary bodies

Projects to Receive Serious Attention -

- Remove old servers zia and arana from service
- Install new printing system
- Redesign VLA-based workstations banshee and miranda in order to improve robustness
- Further progress on computer division web pages rewrite
- Installation of video-conferencing equipment
- Begin serious testing redesigned correlator controller at VLA

Green Bank Computing

We have continued our program to replace our old Unix machines and to upgrade the revisions of the operating systems. As part of the Observatory-wide computer upgrade, we earlier purchased five PCs. We have also moved the computers which were used for the 140 Foot Telescope into general service. As a result, we were able to retire nine Sun computers originally purchased in 1990-92. Because of lack of manpower, we have fallen behind on upgrades to the operating systems. We embarked on a program to address this aggressively. Present plans call for all Suns to be at least at revision 2.6 of Solaris by April 2000.

We were also able to purchase a more modern dual-processor Sun as a general purpose workstation to replace the central compute server (arcturus). It has been configured for general use, and should be in full service by January 2000.

It was not surprising that tests showed that 64 MB is totally inadequate memory for a Sun Ultra computer to support AIPS++ applications for the GBT, especially when they have to coexist with other major applications requiring a large amount of memory. Since all public machines in Green Bank and all computers used by the GBT scientific support staff are Ultras, we have completed the upgrade of all Sun Ultra computers to have at least 256 MB main memory.

We are continuing our major effort to apply all recommended security patches to the Linux and Solaris operating systems. Although this is a job that is never complete, by the end of the year we had installed all security patches recommended by the vendors on all but a few of our Linux systems, which are still a little out of date. This was due to lack of manpower and our emphasis on the upgrades on the Solaris systems.

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 80 percent of the upgrades were complete. The rest should be complete by February 2000.

The major new piece of equipment implemented in the last year was a Hewlett-Packard printer capable of printing D, E, and A0 formats. This was installed at the end of the year and will be fully deployed in January 2000. It has already revolutionized the preparation of poster papers for scientific and technical conferences. We expect it also to facilitate the production of engineering drawings by the drafting and technical staff.

Consistent with the rest of the world, our efforts in upgrading computers and testing software turned the *Y2K problem* into a smooth transition.

M. AIPS++

Our major goal for the last quarter was to issue and support the first public release of AIPS++. The actual release was made on October 12 at the Astronomical Data Analysis Software and Systems meeting in Hilo, Hawaii. The capabilities of the release are described in the release notes (http://aips2.aoc.nrao.edu/docs/project/releasenotes12). Since the release, we have distributed about 1100 CDROMs covering Linux and Solaris operating systems. Defect reports for the release have been submitted at the rate of about 30-50 per month.

Immediately after the release, we produced a development plan (http://aips2.nrao.edu/docs/notes/222/222.html) for the next release, which is scheduled for April 2000. Most of the work in 1999Q4 was as described in this development plan. The main exception is in synthesis development where staffing problems have forced a deferment of VLBA processing support to the October 2000 release.

An end-to-end test of software readiness for the GBT was conducted in early December using the GBT mockup. The data analysis was performed in AIPS++. Overall, the test was a considerable success (as reported elsewhere). For AIPS++, we learned a number of small problems that must be addressed, but no showstoppers were found. Thus AIPS++ is in good position to support the commissioning of the GBT during 2000.

Various Outreach activities occurred in the last quarter. A series of talks were given at the Array Operations Center in Socorro, introducing scientists to the use of AIPS++. A similar series was started in Charlottesville. We conducted a tour of radio observatories in Europe giving brief presentations and demonstrations to local scientists. These outreach activities are planned to continue for the next year.

Goals for 2000

E 1. Support the existing release (1.2) of AIPS++ by NRAO, consortium, and astronomical users.

E 2. Support GBT commissioning and first scientific observations

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

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

E 5. Coordinate development of calibration and imaging pipelines within AIPS++

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.

I 7. Complete AIPS++ such that processing of mainstream VLA and VLBA observations can be accomplished entirely within AIPS++

I 8. Coordinate with the VLA Upgrade Project, the use of AIPS++ facilities with the upgraded VLA

I 9. Develop a prototype calibration and imaging pipeline for the VLBA with the goal of simplifying use of the VLBA by non-experts.

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.

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

D 12. Conduct outreach initiative to publicize AIPS++ and to educate new users

E: Essential, I: Important, D: Desirable

Currently all the Essential items (1-6) are being actively pursued at high priority, items 7 and 8 are in progress, 9 is awaiting developments of VLBA fillers and a fringe fitter, we are in the process of hiring staff for item 10, item 11 is scheduled for the summer, and item 12 is ongoing.

N. GREEN BANK TELESCOPE

Construction Schedule

The panel manufacture and acceptance has been delayed, but should be completed in January 2000. Final approval has been given for 86 percent of the panels. More than 70 percent of the panels are now in place on the telescope. The pace of installation has slowed with the onset of winter weather. All work was stopped during the period December 24, 1999, to January 3, 2000. The contractor is currently deciding how large a crew to retain at the site during the winter. If the weather is favorable, a sufficiently large crew might be able to complete the installation of the panels by the end of April, at which point acceptance tests can begin.

Panel Fabrication, Acceptance, and Delivery to Green Bank

Fabrication and inspection of the GBT panels is continuing at the RSI facility in Sterling, VA. The manufacture of the innermost panels, those of tiers numbered one to five, has begun, and substantial progress has been reported for panels in tiers four and five. One additional panel for each of the tiers two to five will be made. These will be kept in Green Bank as spares, to be used if one of the inner panels should be damaged by ice falling from the feed arm. The NRAO continues to go to Sterling as needed for inspections to confirm that the surfaces of the panels meet the smoothness specification.

The painting of the panels has proceeded steadily, and NRAO personnel typically go twice each week to perform the acceptance tests on the painted panels.

After the inspection trip by NRAO to Sterling on December 21, 1999, the total number of panels with final acceptance stands at 1,732 (86%).

The total number of manufactured panels as of December 21, 1999, is 1,968 (98%). The total number of tiers manufactured is 39, this total includes all tiers 4 to 44.

Panels accepted for RMS as of December 10, 1999, is 1,868 (93%). Tiers 7-10, and 12-44, are complete for a total of 37 tiers. Tier 11 has 34 panels, 32 of which are acceptable. It was a tier which was manufactured early in the process, and the panels have required a lot of rework. We have asked for a new set of CMM measurements on the last two panels. COMSAT has approved the additional measurements.

The total number of panels painted and accepted as of December 21, 1999, is 1,732 (86%). Completed tiers are 15-44 for a total of 30 tiers. The number of completed panels is 1,538, partial tiers are Tier 12, 13, and 14 for a total of 194 panels. The number of panels shipped to Green Bank as of the GB site report for December 12, 1999, is 1596. Unfortunately two panels were damaged during the installation and have been returned to RSI for rework. New measurements have been made for these panels and the results are being examined.

Installation of the Panels on the Telescope

The process of installing the panels is now well underway. The contractor is using two metrologists, each with a total station. One instrument is applied to the alignment of the actuators which support the panels. The other instrument is assigned to the installation of the panels. The first panels installed were from tiers 26 and 27. The installation of panels on the outer edge (away from the vertex; tier 44) is complete, and work now proceeds in the direction of the vertex. The crew is currently on tier 17.

The progress as of December 12, 1999:

Actuators Aligned	2099	(95% of 2209 total)
Actuators Welded	1951	
Panels Installed	1434	(72% of 2004 total)

Activity at the Telescope Site

The site crew totaled about one hundred persons through most of this reporting period. Of these, 70 are iron workers. The iron workers not involved with the panels are employed on numerous other tasks.

The large S-70 derrick crane and supporting tower, a feature of the Green Bank skyline for many years, has now been taken down. Most of it as already been returned to the equipment rental agency. The ringer crane used to reach the high structure has also been dismantled and returned to the leasing agent.

Other activities include the alignment of the elevation gear segments, the installation of conduit and wiring, and the ongoing painting. The work on the gear segments will accelerate now that the alignment of the azimuth wheels has been completed, since the crew on the second shift is now working in this area. During much of the period eleven painters were on the job, and are trying to get as much done as possible before the advent of cold weather.

NRAO Activity

This report does not usually include the GBT-associated NRAO activity, but it is worth noting that an important end-to-end test of the hardware and software was made on December 1. An antenna simulator was coupled with actual hardware (front-end, IF, back-end) and GBT monitor and control software to make a "pointing calibration" run of several hours duration. The test exercised both the Observers' interface and the Operators' interface software and display screens, and the system output (albeit noise!) was studied with the AIPS++ single-dish software. The test was very successful. The system came up with few problems, and ran very well, although a number of bugs were identified.

A Pragmatic Schedule

The contractor currently is installing panels with two crews and two cranes during times of good weather. The construction site was shut down for a holiday break between December 24 and January 3, inclusive. After the break work started up, but with a reduced crew. The contractor is at this time reviewing the work that needs to be completed, and will soon decide the size of the crew which will be kept through mid-March. One scenario is to cut the crew approximately in half, and shut down one of the two cranes. This saves costs of maintaining crew size in bad weather and allows for the servo to be tuned, since the azimuth motion can not be fully tested with two cranes in place. The servo tuning will be done at night. During the day the single crew either puts in panels or does other work (cables, odds and ends of structure, etc.). Of particular emphasis will be the completion of the installation of the gear segments on the elevation drive, and the installation and testing of the actuator cables. The actuator cables are installed in the structure, but have been coiled and stored in sheltered places while the welding of the actuators is done, in order to avoid damage to the cables from weld splatter. In this scenario, the program of panel installation during the best weather coupled with other work during the poorer weather would continue through January and February. Full panel installation, with two crews if necessary, would follow in the spring, with the goal of completing the work by the end of April. At that point there are few post-panel installation tasks left to be done and the first steps in the acceptance test procedure could begin.

Quarterly Project Summary

The SAO maser was moved from the 140 Foot Telescope to the GBT Electronics Room. All GBT equipment that was installed at the 140 Foot has now been moved to the Jansky lab.

Purchases of the components for the Q-band receiver were completed well within budget. The savings are being used to complete the 4-beam receiver that was originally planned and to build a simple tertiary reflector. The receiver dewar has been fabricated in the machine shop, and the dewar end plates are nearly complete. The pacing items for the completion of the receiver are now the CDL low noise amplifiers. The tertiary reflector has been designed.

Group leaders reevaluated the cost to complete the GBT in view of extending the project through the first quarter of 2000.

A budget account was established for spare equipment for the GBT. The budget allocation for spares is $200K, and $114K has been committed to spare servo boards, surface panels, and gear reducer. The remaining $86K will allow the purchase of approximately 92 items identified as critical spare parts. Quotations have been received on 66 of the items, and purchase orders have been issued on 26 of them. The spares budget is insufficient to cover all components that have been identified as single point failures.

Rangefinder measurements of a retroreflector on the GBT feedarm on October 15 revealed multiple modes of structural oscillation. The modes occurred at the frequencies and in the directions predicted by structural analysis. The frequencies of the oscillations were also verified by an independent measurement with accelerometers. Point-to-point measurements of 12 ground rangefinders were postponed to support alignments at the elevation bearings. The measurements were rescheduled for the end of January 2000.

Repeater antennas for the new GBT radio communications system were installed on November 5, and the radio system became operational on November 12. The repeaters comply with NRQZ power density limits. Operations and maintenance personnel are evaluating the system to see if it provides the radio coverage they need.

The drawing of the GBT site was revised to reflect current plans for outfitting the telescope. Revisions to the drawing include the relocation of the site road, the addition of a dirt road and fence around the perimeter of the ground laser rangefinders, the removal of the local control building, and the addition of a variety of cables, including optical fiber, 4160 V power lines, and telephone lines.

An end-to-end test of GBT software was successfully carried out on December 1. During the test, an all sky pointing observation was simulated with an antenna simulator. The software evaluated during the test included the monitor and control software, the operator/engineer graphical user interface (GUI), the observer's GUI, and the commissioning tools in AIPS++. The hardware used during the test included the Ku-band receiver, IF electronics, and the digital continuum receiver (DCR). A few minor problems, such as memory leaks and inadequate disk space, were identified during the test. Staff astronomers and telescope operators will continue to run these tests to familarize themselves with the software and to identify any additional problems.

The feed support for the C-band receiver was completed in the machine shop on December 16. With the exception of the feeds for the L-band, S-band, and prime focus receivers which are self-supporting, all GBT receiver feeds require supports. The feed supports, which resemble inverted cans, also serve as RFI and weather seals. All feed supports have now been fabricated.

At the contractor's request, NRAO staff completed a two week trial period of setting panel corners with the corner setting tool. Additional corner setting will not take place until the contractor agrees to use the tool.

The contractor is just now completing the disassembly of the S70 derrick. Contractor personnel who disassembled the derrick were also slated to test actuator cables; therefore, cable testing and outfitting of the actuator control room has been significantly delayed.

Project Budget (as of Nov 31, 1999).

Category	Allocation ($K)	Expended ($K)	Balance ($K)
Electronics	191	171	20
Surface/Pointing	197	118	79
Monitor/Control	120	20	100
Total	508	309	199

Project Major Milestones

Milestone	Original Date	Revised Date	Completed
Complete S-band feed	05-07-99	06-08-99	06-08-99
Complete S-band Rx	06-18-99	08-11-99	08-11-99
Remove VLBA-DAR from 140	06-17-99	07-22-99	07-22-99
Remove X-band from 140	07-21-99	07-23-99	07-23-99
Remove C&K-band from 140	06-23-99	06-23-99	06-23-99
Remove SP from 140	07-27-99	09-15-99	09-15-99
Remove SAO maser fr. 140	07-27-99	10-15-99	10-15-99
Install GBT/lab IF fiber	05-28-99	08-09-99	08-09-99
Install GBT radio system	08-31-99	11-12-99	11-12-99
Fab. feed support/seal	05-31-99	12-16-99	12-16-99
Complete Q-band Rx	03-31-00		
Complete Q-band tertiary	04-15-00		
Complete IF rack	07-14-99	03-31-00	
Complete 290/395 feed	08-16-99	04-30-00	
Fiberglass S-band feed	07-16-99	02-28-00	
Fiberglass 800MHz feed	07-16-99	02-28-00	
Fiberglass PF-5 feed	07-16-99	02-28-00	
Modify holography Rx	12-01-99	03-31-00	

Complete act.surf. soft.	05-31-99	06-15-99	06-15-99
Install subrefl. retros	05-17-99	07-14-99	07-14-99
Complete panel set tool	06-14-99	10-15-99	10-15-99
Install 3 ground lasers	06-28-99	01-31-00	
Repeat ground laser meas.	06-28-99	01-31-00	
Develop retro calib proc.	01-21-00		
Calibrate surface retros	02-25-00		
Complete hydro. level	09-08-99	11-31-99	11-31-99
Measure az track profile	09-15-99	03-01-99	
End-to-end software test	12-01-99	12-01-99	12-01-99
Complete commission. plan	02-29-00		
Complete act. cable test	04-01-00		
Complete ACR outfitting	06-01-00		
Complete panel corner set	06-01-00		

O. MILLIMETER ARRAY PROJECT

In the past three months, the U.S. side of the ALMA Project has made substantial progress in making the transition from the U.S.-only Millimeter Array Project to the joint U.S.-European ALMA Project. A joint Project Team is being formed by consolidating the management and oversight people and committees for each major Project task. In the joint Project there are nine major tasks, or "level-1 Work Breakdown Structure" elements. For each of these tasks the respective U.S. Division Heads and their counterpart European Team Leaders have been meeting to establish mechanisms for working together. In many cases, advisory committees have been set up that are made up of individuals from both European and U.S. institutions. For example, an ALMA Science Advisory Committee (ASAC) has been established and is functioning to provide advice to the Project management. Membership of all the joint committees can be found on the ALMA web pages (which are now mirrored in Europe). In the Design and Development Phase (referred to as Phase 1), through December 2001, the Project Management is provided by the ALMA Executive Committee, two representatives from the U.S. and two from Europe.

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

Antenna

Best-and-final proposals for the design and fabrication of a prototype antenna were received from two contractors. The proposals were competitively evaluated by three proposal evaluation committees set up for this purpose and a selection was made. At the end of the quarter detailed contract negotiations were in progress with that vendor. It is hoped that the contract can be signed in January. Meanwhile, the European procurement of a second prototype antenna of another design, from another vendor, but done to the same technical specifications, continued to proceed on the same schedule as the U.S. procurement.

Receiver

A Joint Receiver Design Group (JRDG) was formed comprised of five representatives from European institutions and five representatives from U.S. institutions. The JRDG met twice in person during the quarter and agreed on overall specifications for the front-end receiver package. Competitive engineering design concepts for the receiver were received by the JRDG and assessed by that group in the expectation that an agreed concept could be established early in the next quarter.

Meanwhile at the NRAO CDL work on an internal amplifier (contained within the SIS mixer block) required to achieve 8 GHz bandwidth from an SIS mixer is proceeding on three fronts. First, as a step down in frequency from previous amplifiers, the new Indium Phosphide amplifier optimized for 12-18 GHz has been refined and shows >28 dB of gain from 12-18 GHz, a minimum noise temperature of 6K at the center of the band, and less than 9K of noise across the whole band. New designs for 8-12 and 4-12 GHz relying on the information obtained from the 12-18 GHz amplifier are under way. Second, a design for a 4-12 GHz amplifier using Gallium Arsenide is nearly complete; this will be somewhat higher noise than the Indium Phosphide amplifier, but it may work better in an SIS mixer block because it will be easier to stabilize. Third, an Indium Phosphide MillimeterIC chip designed by Dr. S. Weinreb is being prepared for test in a special test fixture. Although this chip could reduce the assembly effort for an internal IF amplifier, it is not clear that the overall performance will be equal to that of a design using discrete components, and it may be difficult to stabilize it. In a preliminary measurement, it was determined that the Tantalum Nitride material used in the MillimeterIC chip to form resistors changes resistance by only 4 percent when cooled from room temperature to the 4K temperature of a mixer; this is an encouraging result.

A 200-300 GHz balanced SIS mixer from a new UVA wafer was tested during this period; the I-V characteristic of the junction is very good. Typical receiver noise temperature of this mixer is about 50 to 100 K between 210 to 290 GHz, similar to the ones tested from previous wafers. The plan is to evaluate the rest of the devices (with different tuning circuits) as soon as possible.

Work continued on the development of a broadband fully-integrated (MillimeterIC) SIS mixer for the 602-720 GHz band. This design uses superconducting capacitively-loaded coplanar waveguide (CLCPW) as the low-loss transmission line medium and a twin-junction tuning circuit to tune out the junction capacitance. Special design considerations have been given to minimize the mixer output capacitance and the inductance so that the design will be compatible with the 4-12 GHz IF proposed for the Atacama Large Millimeter Array (ALMA). At present, designs of the suspended microstrip line to CLCPW transition, the CLCPW line, low-pass filter and the CLCPW to superconducting microstrip transition have been completed. Initial design of the waveguide to suspended microstrip transition has been done and will be optimized again before the mixer circuit is finalized.

Local Oscillator System

There was an ALMA LO PDR and workshop in Tucson which was attended by many U.S. and European participants.

The goals for driver chain and multiplier development and test became much clearer as a result of the PDR, at which the official decision to adopt the "photonic reference" or Option II was made. This led to a close examination of the near-term goals and alternative approaches for the drivers and multiplier designs. The availability of certain commercial and experimental power amplifiers channeled the development effort toward early tests of the effects of amplifier and multiplier noise on overall LO noise. MillimeterIC amplifiers covering 20-40, 32-42, 36-47, 50-60, and 103-109 GHz will be tested in conjunction with existing multipliers covering 40-80 and 55-110 GHz. Further experiments with the phase lock loop for the YIG-tuned oscillator, including a third order loop. Plans were made in conjunction with the SIS group for performing amplitude noise measurements in the 4-12 GHz ALMA IF band using a YTO driver, frequency multipliers, and an SIS mixer.

Work on the development of a photonic LO distribution system was focused on clarifying interface specifications for local oscillator portions of the test interferometer with the ALMA Systems group. In addition, issues were explored related to the long term service and availability of the lasers needed in the system. A vendor was located that sells photomixer chips that appear to satisfy the requirements of the photonic LO distribution system.

Correlator

All FPGA "personalities" for the test correlator were completed. Newly-written software for the correlator control computer was used to perform end-to-end tests of the test correlator and produced results completely free from hardware and software errors on the very first try!

The ALMA correlator station logic card was completely routed and it will go out for prototype fabrication shortly. The design of a logic card for the FIR filter test fixture was completed and it will go into layout soon.

The four new samplers built for the test correlator were evaluated for their analog response in the frequency range above 1.6 GHz, which is the natural output range available from the ALMA baseband conversion system which best fits the test correlator. It had been thought previously from tests on earlier samplers that the frequency response would not be useful above 2.2 GHz, but it was determined that the response is useful to beyond 2.6 GHz. This means that the desired frequency range of 1.6-2.4 GHz can be used directly, simplifying the test interferometer configuration and allowing the use of more ALMA prototypes during antenna evaluation.

Computing

In late November the NRAO and ESO successfully tested antenna motion software on the NRAO 12m telescope using its optical telescope. This software was written with a portable API that abstracts the azimuth and elevation, so it would also be capable of driving the real ALMA prototype antennas. Besides sidereal tracking and deriving pointing models, the software has some capabilities of driving the telescope in more sophisticated patterns, for example a "figure 8" pattern which might be useful for holography.

System Integration

A system block diagram of the test interferometer complete at the module level was finished and released. It includes fallback options in the event some development areas fall behind the prototype antenna delivery schedule, and it identifies an individual with responsibility for delivery of each module. Draft lists of required devices exist for the test setups for (a) single-dish continuum observations; (b) single-dish spectroscopic observations and (c) interferometric observations. Laboratory *zero-baseline* tests were included as a necessary engineering assessment in the baseline plan for the test interferometer.

A document summarizing the specifications adopted by the U.S. side for the ALMA receivers was completed and distributed to the U.S. Project for review. This document highlighted a number of system inconsistencies that need to be resolved in the joint ALMA project. In addition, draft specifications were distributed for ALMA bins, rack and modules; comments on these draft specifications will be reviewed by the joint US-European system group.

A detailed draft plan for antenna evaluation using the test interferometer at the VLA site was distributed for comment to all the Division Heads.

Science, Calibration, and Imaging

In October the first joint US-European ALMA Science Meeting, *Science with the Atacama Large Millimeter Array,* was held in Washington, DC. Three days of science talks by scientists from Europe, the US, and Japan highlighted the enormous *discovery space* to be opened for science by ALMA. The meeting also provided a forum for astronomers from all over the world to begin to work together on confirming the science requirements and technical specifications for ALMA.

Data rate standards were adopted, viz. 30 Mbyte/s peak rate and 3 Mbyte/s sustained rate. Considerable progress was made in array configuration design. Strong emphasis is being placed on incorporating the actual site topographical constraints on the proposed array configurations. Imaging simulations are used to assess the configurations proposed. Other design issues being investigated include definition of a procedure by which the antenna foundation locations can be established that minimizes the total number of foundations required in all the array configurations. This means optimizing the array configurations for re-use of foundations in more than one array configuration and minimizing the length of roads and utility trenches required.

Personnel

At the end of the quarter 48 full-time equivalent staff were assigned to the ALMA Project at the NRAO. An important addition to the Project staff, the appointment of a new ALMA Project Manager was made in December. The Project Manager is Dr. Marcus Rafal, who joins the NRAO after working at the Space Telescope Science Institute. Dr. Rafal will provide experienced management leadership in the next, very demanding, stages of the ALMA Project.

P. PERSONNEL

New Hires

Armendariz, Raul	Electronics Engineer II	10/04/99
Clarke, Tracy	Research Associate	11/29/99
Durand, Steven	Electronics Engineer I	10/04/99
Shepherd, Deborah	Assistant Scientist - Socorro Operations	10/01/99
Thilker, David	Research Associate	11/29/99

Terminations

Anantharamaiah, Kuduvali	Visiting Scientist	11/09/99
Barnes, Peter	Assistant Scientist - Research Support	12/31/99
Cortes, Paulo	Junior Engineering Associate	11/12/99
Fagg, Henry	Electronics Engineer I	12/03/99
Hoyle, Simon	Visiting Scientific Programmer Analyst	11/19/99
Pedtke, Daniel	Electronics Engineer I	12/29/99
Vaccari, Andrea	Electronics Engineer III	11/15/99
Xiluri, Kiriaki	Scientific Associate I	12/23/99

Promotions

Medcalf, David	to VLBA Operations Supervisor	11/01/99
Serna, Lewis	to Head of Engineering Services. Division	11/01/99
Thompson, Steven	to VLBA Correlator Operations Supervisor	11/01/99
Thunborg, Jon	to Deputy Head of Engineering Services	11/01/99

Change in Title

Hicks, Philip	to VLA Operations Supervisor	11/01/99

Other Changes

Lilie, Paul	to Leave for Professional Advancement	11/18/99*

*Incorrect information reported last quarter.

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