VERY LONG BASELINE ARRAY OBSERVATIONAL STATUS SUMMARY

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Contents

List of Tables

List of Figures

2 ANTENNA SITES

Table 1 gives the surveyed geographic locations of the 10 antennas comprising the VLBA, plus the 2-character codes used to identify the antennas (Napier 1995). The antennas are ordered East through West. The SC location refers to the Puerto Rican Datum of 1949. The MK location refers to the Old Hawaiian Datum of 1866. All other locations refer to the North American Datum of 1927. See Napier (1995) for further site information.

Table 1: **Geographic Locations and Codes**

Location	North Latitude [° ′ ″]	West Longitude [° ′ ″]	Elevation [m]	Code
Saint Croix, VI	17:45:30.57	64:35:02.61	16	SC
Hancock, NH	42:56:00.96	71:59:11.69	309	HN
North Liberty, IA	41:46:17.03	91:34:26.35	241	NL
Fort Davis, TX	30:38:05.63	103:56:39.13	1615	FD
Los Alamos, NM	35:46:30.33	106:14:42.01	1967	LA
Pie Town, NM	34:18:03.61	108:07:07.24	2371	PT
Kitt Peak, AZ	31:57:22.39	111:36:42.26	1916	KP
Owens Valley, CA	37:13:54.19	118:16:33.98	1207	OV
Brewster, WA	48:07:52.80	119:40:55.34	255	BR
Mauna Kea, HI	19:48:15.85	155:27:28.95	3720	MK

3 ANTENNAS

The main reflector of each VLBA antenna is a 25-m diameter dish which is a shaped figure of revolution with a focal-length-to-diameter ratio of 0.354. A 3.5-m diameter Cassegrain subreflector with a shaped asymmetric figure is used at all frequencies above 1 GHz, while the prime focus is used at lower frequencies. The antenna features a wheel-and-track mount, with an advanced-design reflector support structure. Elevation motion occurs at a rate of 30 degrees per minute between a hardware limit of 2 degrees and a software limit of 90 degrees. This software limit will eventually be lifted, allowing over-the-top elevation motion to 125 degrees. Azimuth motion has a rate of 90 degrees per minute between limits of −90 to 450 degrees. Antennas will be stowed to avoid operation in high winds. Snow or ice accumulation will also be avoided. See Napier (1995) for further antenna

These were obtained from averages of right circularly polarized (RCP) and left circularly polarized (LCP) values from 10 antennas, measured at the frequencies in column [4] by VLBA operations personnel during regular pointing observations.

The typical zenith $SEFD$s can be used to estimate root-mean-square (RMS) noise levels on a baseline between 2 VLBA antennas (ΔS for a single polarization; see Equation 2) and in a VLBA image ($\Delta I_{\rm m}$ for a single polarization; see Equation 3). Characteristic values for $\Delta S^{128,2{\rm m}}$ assuming a fringe-fit interval of $\tau_{\rm ff} = 2$ minutes and for $\Delta I_{\rm m}^{128,8{\rm h}}$ assuming a total integration time on source of $t_{\rm int} = 8$ hours also appear in Table 2. The tabulated baseline sensitivities for 90 cm and 7 mm assume a fringe-fit interval of 1 minute, since 2 minutes is unrealistically long. All the baseline and image sensitivities in the table, except for 3 mm, assume an aggregate recording bit rate equal to the "sustainable" limit of 128 Mbits per second (Mbps) (see Section 5.16). This rate is commonly achieved by recording a total bandwith $\Delta\nu$ of 32 MHz with 2-bit (4-level) sampling (see Section 5.14). No baseline or image sensitivities are given for 50 cm at the sustainable limit, because adequately wide bandwidths cannot be obtained. For 3 mm, it is assumed that twice the sustainable recording rate is used, that the fringe-fit interval is 30 seconds, and that an image is made from 5 hours of integration with 6 antennas; contact Vivek Dhawan (see Section 26.3) for further information.

Opacity-corrected zenith gains are needed for current techniques for amplitude calibration. These zenith gains vary from antenna to antenna, and will be monitored by VLBA operations and communicated to users (see Section 14). The typical values appearing in Table 2 are meant to be illustrative only.

RFI is known to be problematic at VLBA sites at 90, 50, 20, and 13 cm (Thompson 1995; Hronek & Walker 1996). The AOC frequency coordinator, Raul Armendariz (see Section 26.3), can be consulted for details. Thompson (1995) discusses RFI levels harmful to VLBI.

5 VLBA SIGNAL PATH

This section describes the devices in the signal path at a VLBA antenna site. Devices in Sections 5.1-5.6 and 5.8-5.11 are located at the antenna; all others are in the site control building. More information on the VLBA signal path is provided by Napier (1995), Thompson (1995), and Rogers (1995).

the front end synthesizers (see Section 5.9) and the pulse cal system (see Sections 5.4 and 15.2). The 5 MHz output is the reference for the base band converters (see Section 5.13), the formatter (see Section 5.15), and the antenna timing.

5.8 Local Oscillator Transmitter and Receiver

The local oscillator (LO) transmitter and receiver multiplies the 100 MHz from the maser to 500 MHz and sends it to the antenna vertex room. A round trip phase measuring scheme monitors the length of the cable used to transmit the signal so that phase corrections can be made for temperature and pointing induced variations.

5.9 Front End Synthesizer

The front end synthesizer generates the reference signals used to convert the receiver output from RF to IF. The lock points are at $(n\times\ 500) \pm 100$ MHz, where n is an integer. The synthesizer output frequency is between 2.1 and 15.9 GHz. There are 3 such synthesizers, each of which is locked to the maser. One synthesizer is used for most wavelengths, but two are used at 1 cm, at 7 mm, and for the wide band mode at 4 cm described in Section 5.10.

5.10 IF Converter

The IF converter mixes the receiver output signals with the first LO generated by a front end synthesizer. Two signals between 500 and 1000 MHz are output by each IF converter, one for RCP and one for LCP. The same LO signal is used for mixing with both polarizations in most cases. However, the 4 cm IF converter has a special mode that allows both output signals to be connected to the RCP output of the receiver and to use separate LO signals, thereby allowing the use of spanned bandwidths exceeding 500 MHz. Also, the 90 cm and 50 cm signals are combined and transmitted on the same IFs. The 50 cm signals are not frequency converted, while the 90 cm signals are upconverted to 827 MHz before output.

5.11 IF Cables

There are four of these, labeled A, B, C, and D. Each IF converter normally sends its output signals to A and C, or else to B and D, although switching is available for other possibilities if needed. By convention, the RCP signals over several tape tracks), establishes the barrel roll scheme used to rotate the bit stream/track mapping with time, and sends the output signals to the tape recorders. As many as 32 bit-streams can be formatted, with a bitstream:track multiplexing scheme of 4:1, 2:1, 1:1, 1:2, or 1:4, which allows for very flexible input signal to output tape track switching. VLBA and Mark 3 data formats are supported. Up to 16 pulse cal tones or state counts can be detected simultaneously. Up to 4 Mbits can be captured and sent to the site computer and on to the AOC for various tests, including real time fringe checks.

5.16 Tape Recorders

These are high speed longitudinal instrumentation tape recorders that use 1 inch wide tape on reels 14 inches in diameter. The headstack contains 36 heads, 32 for data and 4 for system information, cross-track parity, or duplicate data. The headstack can be moved under site computer control transverse to the tape motion. The heads are much narrower than the spacing between heads, so multiple pass recording can be used with 14 passes, or more if not all heads are used in each pass.

As many as 32 data tracks can be written to 1 tape drive, with a record rate per track of 8, 4, or 2 Mbps. This can result in an aggregate bit rate of as much as 256 Mbps for 1 tape drive. A doubling of this aggregate bit rate will be possible once appropriate hardware and software are available. However, operational constraints require that a "sustainable" limit of 128 Mbps (averaged over 24 hours) be imposed on the aggregate bit rate. This can be achieved either by recording continuously at 128 Mbps or by arranging that the duty cycle (ratio of recording time to total allocated time) be less than unity. A thin (17600-foot) VLBA tape lasts 10 h 16 m if recorded continuously at 128 Mbps. Rare, particularly meritorious programs may request exemption from the sustainable bit rate limit. The VLBA no longer records (or correlates) thick VLBI tapes.

5.17 Site Computer

A VME site computer running VxWorks controls all site equipment based on commands in the current observing schedule or provided by the array operators or by the site technicians. All systems are set as requested in the current schedule for each new observation.

Each station input comprises 8 parallel "channels" (as defined in Section 5.13), which operate at a fixed rate of 32 Msamples per second, for either 1- or 2-bit samples. Observations at lower sample rates generally can be processed with a speed-up factor of 2 (for 16 Msamples per second) or 4 (for 8 Msamples per second or less) relative to observe time. Special modes are invoked automatically to enhance sensitivity when fewer than 8 channels are observed, or when correlating narrowband or oversampled data. The correlator accepts input data recorded in VLBA, Mark 3, or Mark 4 longitudinal format. Section 18.1 provides further information concerning Mark 4 recordings destined for the VLBA correlator.

Each input channel can be resolved into 1024, 512, 256, 128, 64, or 32 "spectral points", subject to a limit of 2048 points per baseline across all channels. Adjacent, oppositely polarized channels can be paired to produce all four Stokes parameters; in this case correlator constraints impose a maximum spectral resolution of 128 points per polarization state. The user may also specify a spectral smoothing function, or request an "interpolated" spectrum suitable for inversion to a cross-correlation function if further work is required in that domain.

The correlator forms cross-spectral power measurements on all relevant baselines in a given sub-array, including individual antenna "self-spectra". These can be integrated over any integral multiple of the basic integration cycle, 131.072 milliseconds (2^{17} microsec). Adjacent spectral points may be averaged while integrating to reduce spectral resolution. A time-domain transversal filter is available at the output from the integrator to maximize the fringe-rate window while further reducing the data rate.

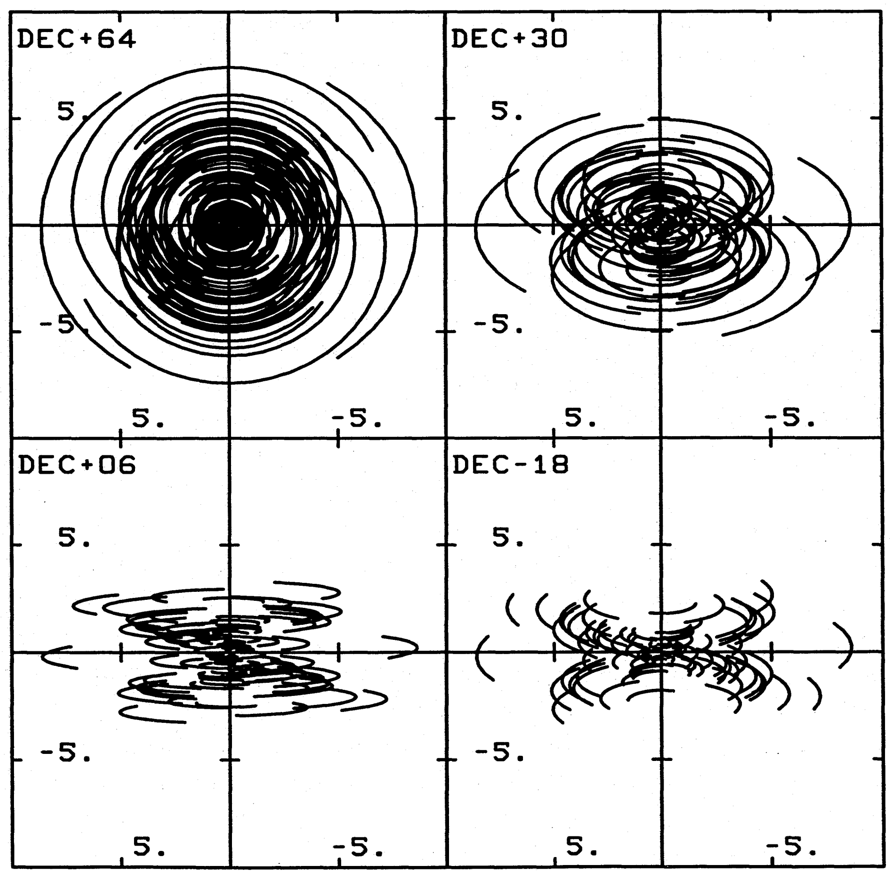
Correlator output is written in a "FITS Binary Table" format, and as of about 1999 April 1 includes editing flags plus amplitude, weather, and pulse calibration data logged at VLBA antennas at observe time (Flatters 1998; Ulvestad 1999a). All results are archived on digital-audio-tape (DAT) cassettes. The output data rate is limited to 0.5 Mbytes per second, which must be shared among all simultaneous correlator sub-arrays. Data are copied from the archive for distribution to users on a variety of media, with DAT and Exabyte currently given primary support.

Operation of the correlator is governed primarily by information obtained from the VLBA control system's monitor data or from foreign stations' log files. A few additional items, all of which have been mentioned above, will be specified by the user prior to correlation. Supervision of the correlation process is the responsibility of VLBA operations personnel; user participation during correlation is not expected nor easily arranged, as explained below.

9 *u-v* PLANE COVERAGE

Plots of the *u-v* plane coverage with the VLBA for sources at declinations of $+64, +30, +06$, and -18 degrees are shown in Figure 1 for horizon-to-horizon tracks and in Figure 2 for single "snapshot" tracks of duration $\frac{1}{2}$ hour approximately when the source transits New Mexico. Similar plots can be generated with the NRAO program SCHED (Walker 2000).

Figure 1: **VLBA *u-v* plane coverage at four declinations. Horizon-to-horizon tracks for an elevation limit of 10°. Plotted range is ± 9000 km.**



11 SPECTRAL RESOLUTION

Spectral resolution is set by the VLBI correlator. With the VLBA correlator each BB channel can be divided into 32, 64, 128, 256, 512, or 1024 spectral points, subject to the limitations specified in Section 7. The spectral resolution is the bandwidth per BB channel divided by the number of spectral points. The VLBA correlator can apply an arbitrary special smoothing, which will affect the statistical independence of these points and thus the effective spectral resolution. Typical continuum programs request averaging to 16 spectral points.

12 BASELINE SENSITIVITY

Adequate baseline sensitivity is necessary for VLBI fringe fitting, discussed in Section 15.3. The following formula can be used in conjunction with the typical zenith $SEFD$s for VLBA antennas given in Table 2 to calculate the RMS thermal noise (ΔS) in the visibility amplitude of a single-polarization baseline between two identical antennas (Walker 1995a; Wrobel & Walker 1999):

$$\Delta S = \frac{1}{\eta_\mathrm{s}} \times \frac{SEFD}{\sqrt{2 \times \Delta\nu \times \tau_\mathrm{ff}}} \ \mathrm{Jy}. \tag{2}$$

In Equation 2, $\eta_\mathrm{s} \leq 1$ accounts for the VLBI system inefficiency (e.g., quantization in the data recording and correlator approximations). Assume $\frac{1}{\eta_\mathrm{s}} \sim 2$ for data from a Mark 3 correlator. Although the system inefficiency for the VLBA correlator has not been determined, Kogan (1995) provides the combination of scaling factors and inefficiencies appropriate for VLBA visibility data. $\Delta\nu$ is the bandwidth [Hz]; use the full recorded bandwidth for a continuum target and use a spectral channel for a line target. τ_ff is the fringe-fit interval [s], which should be less than or about equal to the coherence time τ_atm. Equation 2 holds in the weak source limit and assumes 1-bit (2-level) quantization. About the same noise can be obtained with 2-bit (4-level) quantization and half the bandwidth, which gives the same bit rate. Moran & Dhawan (1995) discuss expected coherence times. The actual coherence time appropriate for a given VLBA program can be estimated using observed fringe amplitude data on an appropriately strong and compact source.

used to convert from $T_{\rm sys}$ to $SEFD$ by dividing by the VLBA antenna zenith gains in K $\rm Jy^{-1}$ provided by VLBA operations, based upon regular monitoring of all receiver and feed combinations. For programs processed on the VLBA correlator after about 1999 April 1, $T_{\rm sys}$ and gain values for VLBA antennas are delivered in TY and GC tables, respectively, in the FITS files archived and distributed by NRAO (Ulvestad 1999a). Single-antenna spectra can be used to do amplitude calibration of spectral line programs (see Section 17).

Post-observing amplitude adjustments might be necessary for an antenna's position dependent gain (the "gain curve") and for the atmospheric opacity above an antenna (Moran & Dhawan 1995). The GC table described above contains gain curves for VLBA antennas. A scheme for doing opacity adjustments is desribed by Leppänen (1993). Such adjustments can be made with AIPS task **APCAL** if weather data are available. For programs processed on the VLBA correlator after about 1999 April 1, VLBA weather data are delivered in a WX table in the FITS files archived and distributed by NRAO (Ulvestad 1999a).

Although experience with VLBA calibration shows that it probably yields fringe amplitudes accurate to 5 percent or less, it is recommended that users observe a few amplitude calibration check sources during their VLBA program. Such sources can be used (1) to assess the relative gains of VLBA antennas plus gain differences among base band channels at each antenna; (2) to test for non-closing amplitude and phase errors; and (3) to check the correlation coefficient adjustments, provided contemporaneous source flux densities are available independent of the VLBA observations. The VLBA gains are measured at the center frequencies appearing Table 2; users observing at other frequencies may be able to improve their amplitude calibration by including brief observations, usually of their amplitude check sources, at the appropriate gain frequencies. Amplitude check sources should be point-like on inner VLBA baselines. Some popular choices in the range 13 cm to 2 cm are J0555+3948=DA 193, J0854+2006=OJ 287, and J1310+3220. Other check sources can be selected from the VLBA Calibrator Survey (see Section 15.6), from major published VLBI surveys such as:

- Caltech-Jodrell Bank survey (Taylor *et al.* 1994; Polatidis *et al.* 1995; Thakkar *et al.* 1995; Henstock *et al.* 1995) available at *http://astro.caltech.edu/~tjp/cj*

- Radio Reference Frame survey (Fey, Clegg, & Fomalont 1996; Fey & Charlot 1997) available at *http://maia.usno.navy.mil/rorf/rrfid.html* system (Thompson 1995) is available at VLBA antennas to overcome this problem. This system, in conjuction with the LO cable length measuring system, is also used to measure changes in the delays through the cables and electronics which must be removed for accurate geodetic and astrometric observations. The pulse cal system consists of a pulse generator and a sine-wave detector. The interval between the pulses can be either 0.2 or 1 microsecond. They are injected into the signal path at the receivers and serve to define the delay reference point for astrometry. The weak pulses appear in the spectrum as a "comb" of very narrow, weak spectral lines at intervals of 1 MHz (or, optionally, 5 MHz). The detector measures the phase of one or more of these lines, and their relative offsets can be used to correct the phases of data from different BBCs. The detector is in the correlator for the Mark 3 system and at the antenna in the VLBA. The VLBA pulse cal data are logged as a function of time during observations with VLBA antennas. For programs processed on the VLBA correlator after about 1999 April 1, such pulse cal data are delivered in a PC table in the FITS files archived and distributed by NRAO (Ulvestad 1999a). AIPS software can be used to load and apply the pulse cal data. However, some VLBA observers may still want to use a strong compact source (see Section 15.1) so they can do a "manual" pulse cal if necessary (Diamond 1995). For example, spectral line users will not want the pulse cal "comb" in their spectra, so they should ensure that their observing schedules both disable the pulse cal generators and include observations suitable for a "manual" pulse cal.

15.3 Fringe Fitting

After correlation, the phases on a VLBA target source can still exhibit high residual fringe rates and delays. Before imaging, these residuals should be removed to permit data averaging in time and, for a continuum source, in frequency. The process of finding these residuals is referred to as fringe fitting. Before fringe fitting, it is recommended to edit the data based on the *a priori* edit information provided for VLBA antennas. For programs processed on the VLBA correlator after about 1999 April 1, such editing data are delivered in an FG table in the FITS files archived and distributed by NRAO (Ulvestad 1999a). The old baseline-based fringe search methods have been replaced by more powerful global fringe search techniques (Cotton 1995a; Diamond 1995). Global fringe fitting is simply a generalization of the phase self-calibration technique (see Section 15.5), as during a global fringe fit the difference between model phases and measured phases are minimized by solving for the antenna-based instrumental phase, its time slope (the plex self-calibration are accomplished with the AIPS task `CALIB` and with program `DIFMAP` in the Caltech VLBI Analysis Programs. Self-calibration should only be done if the VLBA target source is detected with sufficient signal-to-noise in the self-calibration time interval (otherwise, fake sources can be generated!) and if absolute positional information is not needed.

The useful field of view in VLBI images can be limited by finite bandwidth, integration time, and non-coplanar baselines (Wrobel 1995; Cotton 1999b; Bridle & Schwab 1999; Perley 1999b). Measures of image correctness - image fidelity and dynamic range - are discussed by Walker (1995a) and Perley (1999a).

15.6 Phase Referencing

If the VLBA target source is not sufficiently strong for self-calibration or if absolute positional information is needed but geodetic techniques are not used, then VLBA phase referenced observations must be employed (Beasley & Conway 1995). Wrobel *et al.* (2000) recommend strategies for phase referencing with the VLBA, covering the proposal, observation, and correlation stages. A VLBA phase reference source should be observed frequently and be within a few degrees of the VLBA target region, otherwise differential atmospheric (tropospheric and ionospheric) propagation effects will prevent accurate phase transfer. Walker & Chatterjee (1999) have investigated ionospheric corrections using GPS-based models. VLBA users can draw candidate phase calibrators from the source catalog, dated 2000 April 17, in use at the VLBA correlator and distributed with the NRAO program `SCHED` (Walker 2000). Most sources in this catalog are from the Jodrell Bank - VLA Astrometric Survey (JVAS - Patnaik *et al.* 1992; Browne *et al.* 1998; Wilkinson *et al.* 1998), which is being extended to cover the sky north of declination −30 degrees. A VLBA survey of the stronger JVAS sources is in progress, to determine which are compact enough to serve as good VLBA phase reference sources and to obtain improved reference source positions (Peck & Beasley 1998); preliminary results from this VLBA Calibrator Survey are available from the VLBA home page at *http://www.aoc.nrao.edu/vlba/html/VLBA.html* .

16 POLARIMETRY

In VLBA polarimetric observations, BB channels are assigned in pairs to opposite hands of circular polarization at each frequency. Such observations can be recorded in VLBA or in Mark 3 formats. Typical "impurities" of the solving for the RCP-LCP delay; self-calibration and Stokes I image formation; instrumental polarization calibration; setting the absolute position angle of electric vectors on the sky; and correction for ionospheric Faraday rotation, if necessary (Cotton 1995b, 1999a; Kemball 1999). All these post-processing steps can currently be done in AIPS, as can the polarization self-calibration technique described by Leppänen, Zensus, & Diamond (1995).

17 SPECTRAL LINE

Diamond (1995) and Reid (1995, 1999) describe the special problems encountered during data acquisition, correlation, and post-processing of a spectral line program. The spectral line user must know the transition rest frequency, the approximate velocity and velocity width for the line target, and the corresponding observing frequency and bandwidth. The schedule should include observations of a strong continuum source to be used for fringe-finding, "manual" pulse calibration, and bandpass calibration; as well as scans of a continuum source reasonably close to the line target to be used as a fringe-rate and delay calibrator. The pulse cal generators should be disabled.

Post-processing steps include performing Doppler corrections for the Earth's rotation and orbital motion (the correction for rotation is not necessary with observations correlated on the VLBA or any other correlator with antenna based fringe rotators); amplitude calibration using single-antenna spectra; fringe fitting the continuum calibrators and applying the results to the line target; referencing phases to a strong spectral feature in the line source itself; and deciding whether to do fringe rate mapping or normal synthesis imaging and then form a spectral line cube. All these post-processing steps can currently be done in AIPS.

Data reduction techniques for VLBI spectral line polarimetry are discussed by Kemball, Diamond, & Cotton (1995) and Kemball (1999).

18 VLBA/EVN/GLOBAL PROPOSALS

18.1 Preparing a Proposal

After composing the scientific justification and identifying the desired VLBI target source(s), select an appropriate VLBI array. Possibilities include:

Network sessions, has been reserved for joint VLBI programs involving the VLBA and Effelsberg; submit proposals for such joint time both to the NRAO and to the EVN scheduler.

Once the appropriate VLBI array is selected, run the NRAO SCHED program (Walker 2000) to determine the Greenwich Sidereal Time range during which the VLBI target sources are up at the selected antennas. This program can also be used to evaluate the *u*-*v* plane coverage and synthesized beams provided by the selected antennas (see Section 9).

If the proposal requests use of the VLBA correlator, then the proposed observing strategies must adhere to the guidelines summarized by Romney (1999b). Proposed observing modes, whether in VLBA formats or VLBA-compatible Mark 4 formats, can be be selected from modes tabulated by Romney (1999c). Requirements for source position accuracy at correlation time are discussed by Ulvestad (1999b). An accurate source position service is available through NRAO, but requests to it should be made no later than proposal time for positions needed at correlation time (Walker 1999a).

VLBA proposals may also be supplemented with plans for dissertation research and/or requests for long-term acceptance; see the NRAO Newsletter dated 1999 October 1 and posted at *http://www.nrao.edu/news/newsletters* for further details. Any proposal requesting more than about 300 hours of total time, even over the long term, may trigger a "skeptical review" described at *http://www.cv.nrao.edu/~abridle/lpc/lpc.htm* .

18.2 Submitting a Proposal

VLBI proposal cover sheets for VLBA, EVN, or Global proposals can be accessed at *http://www.nrao.edu/administration/directors_office* . That link also describes how to submit completed VLBA proposals by e-mail to "propsoc@nrao.edu" or by regular mail to Director, NRAO, 520 Edgemont Road, Charlottesville, Virginia 22903-2475, USA; and how to submit completed EVN proposals by e-mail to "proposevn@HP.mpifr-bonn.mpg.de" or by regular mail R. Schwartz, EVN Scheduler, MPIfR, Auf dem Hügel 69, D-53121 Bonn, GERMANY. VLBA proposals requesting Effelsberg and Global proposals must be submitted to both the NRAO and the EVN.

Proposals requesting antennas unaffiliated with the VLBA or the EVN must be sent to the directors of those antennas.

21.2 AIPS++

AIPS++ has been publicly released but does not yet offer an end-to-end reduction path for VLBA data. Consult the document "Getting Started in AIPS++" for details on using AIPS++ and an introduction to its capabilties. That document is available from the AIPS++ home page accessed through *http://www.nrao.edu/software* . Section 26.1 gives contact information.

21.3 The Caltech VLBI Analysis Programs

The Caltech VLBI Analysis Programs are a set of programs for the planning and analysis of continuum VLBI observations. These programs are available for VAX/VMS, Sun UNIX, and Convex UNIX. A summary of the major programs can be found in the Bulletin of the American Astronomical Society, volume 23, page 991, 1991. Shepherd (1997) describes the related Caltech program `DIFMAP`. Section 26.1 gives contact information.

22 SPACE VLBI

Some VLBA observing time has been allocated for co-observations with the first dedicated space VLBI mission, VSOP/HALCA. Proposals for co-observations with VSOP are submitted directly to the VSOP mission rather than to the NRAO. For more information on VSOP, see the VSOP home page at *http://www.vsop.isas.ac.jp/* . For a variety of information on the VLBA activities in support of VSOP, see the NRAO Space VLBI Program home page accessed through *http://www.nrao.edu/telescopes* .

VLBA programs using VSOP have some different characteristics from other VLBA programs. First, the observing schedules for the VLBA are prepared by the VSOP Science Operations Group in order to take account of the constraints on the spacecraft observations, and need not be generated by the investigators. Second, the spacecraft frequency reference is provided in series by several of a total of five tracking stations, and the wideband spacecraft data are recorded separately on tapes at each of these tracking stations. This makes the process of correlation, which requires multiple wideband recordings for the spacecraft, as well as multiple clock corrections and the spacecraft ephemeris, considerably more complex. Finally, although the standard VLBA calibration data are available as discussed in Sections 14 and 15, the spacecraft data calibration and fringe-fitting is considerably more complex, owing to (1) the inability to observe fringe-finders for each prouser proposing the observations, this will occur automatically, soon after correlation is complete, provided a medium has been specified. Distributed data will conform to the new FITS binary table standard for interferometry data interchange (Flatters 1998), which is read by AIPS task `FITLD`.

25 PUBLICATION GUIDELINES

Any papers using observational material taken with NRAO instruments (VLBA or otherwise) or papers where a significant portion of the work was done at NRAO, should include the following acknowledgement to NRAO and NSF:

> *The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.*

Further information concerning NRAO preprint requirements and page charge policy can be accessed from the Library home page accessed through *http://www.nrao.edu/library* .

26 RESOURCE LISTS

26.1 Software

The following programs or software packages will be of interest to VLBA users, for planning observations and/or for post-processing VLBA data:

1. NRAO `SCHED`: Contact Craig Walker (see Section 26.3) or consult Walker (2000).

2. NRAO AIPS: Contact AIPS Group, NRAO, 520 Edgemont Road, Charlottesville, Virginia 22903-2475, USA; e-mail "aipsmail@nrao.edu"; AIPS home page accessed through *http://www.nrao.edu/software*

3. AIPS++: Contact e-mail "aips2-request@nrao.edu"; AIPS++ home page accessed through *http://www.nrao.edu/software*

4. Caltech VLBI Analysis Programs: Contact T.J. Pearson, Astronomy Department 105-24, Caltech, Pasadena, California 91125, USA; phone +1-818-395-4980; FAX +1-818-568-9352; e-mail "tjp@astro.caltech.edu"; home page at *http://astro.caltech.edu/~tjp/citvlb*

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26.3 Key Personnel

Table 4 gives the primary work locations, telephone extensions, room numbers, and area of responsibilities and/or expertise of key NRAO personnel who are available to assist the VLBA user community. An individual can be contacted through e-mail via their NRAO username constructed from their first initial followed by their last name, with a maximum of 8 letters. Address e-mail enquiries to "username@nrao.edu". In Table 4, "AOC" refers to the Array Operations Center (phone +1-505-835-extension), "VLA" refers to the Very Large Array (phone +1-505-835-extension), and "CV" refers to Charlottesville (+1-804-296-extension).