NATIONAL RADIO ASTRONOMY OBSERVATORY
VERY LARGE ARRAY

VERY LARGE ARRAY OBSERVATIONAL STATUS SUMMARY
March 15, 1991

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This document summarizes the current instrumental status of the Very Large Array. It is intended as a ready reference for those contemplating use of the VLA for their astronomical research. The information contained herein is in summary form -- those requiring greater detail should consult one of the VLA's staff members, or refer to the manuals and documentation listed in Section 5.0.

This summary consists of a number of sections. Section 1 briefly describes the physical instrument and its major observing modes and capacities. Section 2 is concerned with the instrumental characteristics, including sensitivity, resolution, field of view, pointing accuracy, image fidelity, calibration accuracy, polarization capabilities and spectral line observing modes. Section 3 describes the means of obtaining observing time, the preparation of observing files, the remote observing program, and visitor help at the AOC. Section 4 contains information on the VLA data archive and on publication guidelines, and Section 5 gives a list of documentation relevant to the VLA.

The Very Large Array is a large and complex modern instrument. It is also an extremely flexible instrument, and we are always interested in imaginative and innovative ways of using it. Potential users are reminded that the VLA is not a 'black box', and some familiarity with the principles and practices of its operation are necessary before efficient use can be made of it. Although the NRAO strives to make use of the VLA as simple as possible, users must be aware that proper selection of observing mode and calibration technique is often crucial to the success of an observing program. Inexperienced and first-time users are especially encouraged to enlist the assistance of an experienced colleague or NRAO staff member for advice on, or direct participation in, an observing program. See Section 3.8 for details.

1.0 BASIC PARAMETERS OF THE VLA

The VLA is a 27-element array which can produce images of the radio sky at a wide range of frequencies and resolutions. The basic data produced by the array are the visibilities, or measures of the spatial coherence function, formed by correlation of signals from the array's elements. The most common mode of operation uses these data, suitably calibrated, to form images of the radio sky as a function of space and frequency. Another mode of observing (commonly called "phased array") allows operation of the array as a single element through summation of the individual antenna signals. This mode is used for VLBI observing and for observations of rapidly varying phenomena.

The VLA can vary its resolution over a range exceeding a factor of 100 through movement of its component antennas. There are four basic arrangements, called configurations, whose scales vary by the ratios 1:3.2:10:32 from smallest to largest. These configurations are denoted 'D', 'C', 'B', and 'A' respectively. In addition, there are 3 'hybrid' configurations labelled BnA, CnB, and DnC, which are especially well suited for observations of sources south of δ = -20°. The array completes one cycle through all four configurations in a 15 month period. The configuration schedule for 1991 and the approximate long-term schedule are outlined in Tables I(a) and I(b). Updates to this table are published in the NRAO and AAS Newsletters.

Observing projects on the VLA vary in duration from as short as 1 hour to as long as 3 days. Most observing runs have only one, or perhaps a few, target sources. However, since the VLA is a two-dimensional array, images can be made with data durations of as little as one minute. This mode, commonly called 'snapshot' mode, is well suited to surveys of relatively strong, isolated objects. See section 2.13 for details.

The VLA can be broken into as many as five sub-arrays, each of which can observe a different object at a different band. This mode of operation is especially useful for observing compact objects for which the VLA's full imaging capability and sensitivity are not required.

All antennas are outfitted with receivers for six wavelength bands centered near 90, 20, 6, 3.6, 2.0 and 1.3cm. These bands are commonly referred to as P, L, C, X, U, and K bands, respectively. In addition, eight antennas are equipped with 73.8 MHz (400 cm) receivers. The array can tune to two different frequencies within the same band provided the frequency difference does not exceed approximately 450 MHz. Right-hand (RCP) and Left-hand (LCP) polarizations are received for both frequencies. Observations at more widely separated frequencies can be made within the same run by time switching between the frequencies. This operation takes less than 30 seconds. The array can also simultaneously observe one frequency within L band and one within P band (known as 'LP' band). This is the only currently supported mode in which frequencies within two different bands can be observed simultaneously.

Observations at seven different bandwidths (given by 50 MHz/2^n, with n = 0, 1, ... 6) are possible. A 200 kHz bandpass is also available in spectral line mode. Different bandwidths can be used for each of the two separate frequencies. Wider bandwidths provide better sensitivity, but also increase the chromatic aberration. See Section 2.3.2 for details.

The VLA correlator has two basic modes, Continuum and Line. In Continuum mode, the correlator provides, for each of the two frequencies, the four correlations (RR, RL, LR, LL) needed for full polarimetric imaging. This mode is particularly well suited to high sensitivity, narrow field-of-view projects. The Line mode is a spectrum measuring mode principally intended for observing spectral lines. There are a great many options allowed in this mode. Besides the obvious need for this mode for all spectral line projects, certain continuum projects which require extremely high dynamic range and/or large field-of-view without undue loss of sensitivity will benefit from use of this mode. It is further described in Section 2.11.

2.0 BASIC INSTRUMENTAL PARAMETERS

This section contains details of the VLA's resolution, sensitivity, tuning range, dynamic range, pointing accuracy, and modes of operation. More detailed discussions of most of the observing limitations are found elsewhere. In particular, see Reference 1, listed in Section 5.0.

2.1 Resolution

The VLA's resolution is set by the configuration and frequency of observation. It is important to recall that a synthesis array is 'blind' to structures on scales both smaller and larger than the range of fringe spacings given by the antenna distribution. For the former limitation, the VLA acts like any single antenna -- structures smaller than the diffraction limit are broadened to the resolution of the antenna. The latter limitation is unique to interferometers -- it means that structures on angular scales significantly larger than the fringe spacing formed by the shortest baseline are simply unseen. No subsequent processing can recover this missing information, which can only be obtained by observing in a smaller configuration, or with an instrument which provides this information.

Table II summarizes the relevant information. This table shows the maximum and minimum antenna separations, the approximate synthesized beam size (full width at half-power), and the scale at which severe attenuation of large scale structure occurs.

2.2 Sensitivity

Table III(a) shows the expected VLA sensitivities. The values listed in rows 5 and 6 are the expected r.m.s. fluctuations due to thermal noise on an image made with natural weighting, calculated using the standard formulae with the system temperatures and efficiencies listed. These values are realized in practice except at P-band where the sensitivities are limited by other effects and in imaging very bright objects where the noise is due to baseline dependent errors.

In general, the expected r.m.s. noise in mJy on an output image can be calculated with the following formula:

$$S_{rms} = \frac{K}{\sqrt{N(N-1)n\Delta t\Delta f}}$$

where N is the number of antennas, Δt is the on-source integration time in hours, Δf is the bandwidth in MHz, n is the number of IF pairs (1 or 2), and K is a system constant, equal to 31, 10, 7.4, 5.2, 19 and 33 for P, L, C, X, U, and K bands respectively. This constant K can also be expressed in terms of system temperature and efficiency as:

$$K = .082\ T_{sys}/\eta$$

where T_{sys} is the system temperature, and η is the system efficiency.

The L-band (20 cm) system is currently being replaced by an improved design which will nearly double the sensitivity. For this system, K=6. There are 5 antennas currently equipped. Plans call for a total of 7 antennas by June 1991, and 10 by years end. The entire array should be modified by mid-1994.

These formulae assume natural weighting. For uniform weighting, the achieved sensitivities will be a factor 1.5 to 2.5 worse, depending on the image and (u,v)-cell sizes.

The limiting brightness temperature achievable by an array is a complicated function of the source distribution and array configuration. However, for the simplified case of an object approximately the size of the synthesized beam, the following relation between brightness temperature and flux density can be applied:

$$T_b = F\ S$$

where T_b is the brightness temperature (Kelvins) corresponding to S mJy/beam, and F is a constant depending only upon array configuration: F = 300, 30, 3, 0.3 for A, B, C, and D configurations, respectively. The limiting brightness can be obtained by substituting the rms noise for S. A more detailed description of the relation between flux density and surface brightness is given in Chapter 7 of Reference 1.

The sensitivity varies across each observing band. Table III(b) gives the frequency ranges for each band at which the sensitivity degrades by 10% and by a factor of two. Also included are the maximum ranges over which the VLA receivers remain operative. At these extreme ends, the system sensitivity is typically 10 to 100 times worse than at band center. Furthermore, not all antennas will operate at these frequencies. Consult a VLA staff scientist should you wish to observe near these band edges.

The VLA's sensitivity at 1.3cm is highly weather-dependent. The values given are typical for good conditions -- dry and cold. In summer, sensitivities can be degraded by perhaps 20%.

2.3 Field of View

At least four different effects will limit the field of view. These are: primary beam; chromatic aberration; time-averaging; and non-coplanar baselines. We discuss each briefly:

2.3.1 Primary Beam

The ultimate factor in limiting the field-of-view is the diffraction-limited response of the individual antennas. An approximate formula for the full width at half power in arcminutes is: $\theta_{PB} = 45/\nu_{GHz}$. Objects larger than approximately half this angle cannot be directly observed by the array. However, a new technique known as 'mosaicing', in which many different pointings are taken, can be used to construct images of larger fields. Refer to Reference 1 for details.

2.3.2 Chromatic Aberration (Bandwidth Broadening)

The principles upon which synthesis imaging are based are strictly valid only for monochromatic radiation. When radiation from a finite bandwidth is accepted, aberrations in the image will result. These take the form of radial smearing which worsens with increased distance from the delay-tracking center. The peak response to a point source simultaneously declines in a way that keeps the integrated flux constant. The net effect is a radial degradation in the resolution and sensitivity of the array.

These effects can be parameterized by the product of the fractional bandwidth ($\Delta\nu/\nu$) with the source offset in synthesized beamwidths (θ_0/θ_{FWHP}). Table IV(a) shows the loss of central intensity as a function of this parameter.

2.3.3 Time Averaging Loss

The measures of the coherence function (visibility) for objects away from the phase-tracking center are slowly time-variable due to the changing array geometry, so that averaging them will cause a loss of amplitude. The acceptable loss depends on the expected or required image fidelity. Unfortunately, and unlike the bandwidth loss effect described above, the losses due to time averaging cannot be simply parameterized. The only simple case exists for observations at $\delta = 90$, where the effects are identical to the bandwidth effect except they operate in the azimuthal, rather than the radial, direction. The functional dependence is the same in this case with $\delta\nu/\nu$ replaced with $\omega\delta t$, where ω is the Earth's angular rotation rate, and δt is the averaging interval.

For other declinations, the effects are more complicated and approximate techniques must be employed. Chapter 13 of Reference 1 considers the average reduction in image amplitude due to finite time averaging. The results are summarized in Table IV(b), showing the time averaging in seconds which results in 1%, 5% and 10% loss in the amplitude of a point source located at the half-power point of the primary beam. If the target source extends a fraction 1/f of the half-power from the phase-tracking point, the table entries are multiplied by f.

2.3.4 Non-Coplanar Baselines

The principles by which nearly all images are made in Fourier synthesis imaging are based on the assumption that all the coherence measurements are made in a plane. This is strictly true for E-W interferometers, but is manifestly false for the VLA, with the single exception of snapshots. Analysis of the problem shows that the errors associated with the assumption of a planar array increase quadratically with angle from the phase-tracking center. Serious errors result if the product of the angular offset in radians times the angular offset in synthesized beams exceeds unity. The effects are especially severe at 90cm, where standard 'two-dimensional' imaging can only be done for 'D'-configuration data. This effect is noticeable at L-band in certain instances, but can be safely ignored at all other bands.

We are testing various solutions to this problem, but all are very expensive in computing resources. The simplest solution requires gridding the (u, v, w) data in all three spatial dimensions, and performing a 3-dimensional Fourier transform. At this time, data taken in C and D configurations at 90cm can be properly imaged in this way on the NRAO Convexes with special software available in the test system SDE. Tests are ongoing for techniques of handling B-configuration data at this frequency. Contact Tim Cornwell for further details.

2.4 Time Resolution

The minimum integration time at which all data are written to tape is a function of the total number of channels of data produced by the correlator. This minimum time varies from 1⅔ seconds for the continuum mode to 20 seconds for 512 channel spectral line modes. Times less than these can be selected, but only at the cost of removing antennas from the array. A special 400 ms mode is available in continuum - contact Gareth Hunt (505/835-7213) for details on its use.

The VLA has the potential to produce a great deal of data - as much as 3 GByte per day in some modes. In order to keep the rate manageable, VLA management has set time-averaging guidelines. Table IV(c) shows these averaging times as a function of array configuration and number of channels. Averaging times less than those shown in the table are allowed if either: (a) All data processing is to be done off the NRAO's computers, or (b) Permission has been granted by Miller Goss or Barry Clark.

See Section 2.17 for a description of the High Time Resolution Processor.

2.5 Radio-Frequency Interference

The bands within the tuning range of the VLA which are allocated exclusively to radio astronomy are 1400 -- 1427 MHz, 1660 -- 1670 MHz, 4990 -- 5000 MHz, 15.35 -- 15.4 GHz, 22.2 -- 22.5 GHz and 23.6 -- 24.0 GHz. No external interference should occur within these bands. Experience shows that RFI is a notable problem only within the 20 and 90cm bands, particularly the latter. At 20cm, interference mainly affects the 'D' configuration, as the fringe rates in other configurations are generally sufficient to reduce interference to negligible levels. RFI from satellites is also a problem. In particular, the U.S. and Russian global positioning systems have made observing very difficult near 1575 and 1612 MHz, respectively.

The standard bands chosen for observing at 20cm are 1465 MHz and 1515 MHz. These have been selected on the basis of showing rather little interference. Over a 5 year period, a monthly monitoring program coordinated by Pat Crane has compiled a statistical picture of the RFI environment within the 20cm band. The results of this survey are posted in the data analysts' room, 204 in the AOC. Users who wish to use non-standard frequencies should consult these plots, or call Peggy Perley or Dave Wunker for advice. For general information about the RFI environment call Pat Crane. Fig 1 shows a typical result from this survey. Frequencies to avoid are those whose flux density exceeds ~3 Jy.

At 90cm, the situation is somewhat worse. Interference is relatively infrequent in the evenings and on weekends. However, during the day, very strong interference, sufficient to saturate the receivers, is common. The best advice is to arrange observing to fall outside of regular working hours.

Another important form of RFI are signals which are generated by each antenna. These signals are picked up by nearby antennas, or by the generating antenna's feed, and produce correlated signals in the visibility data. This form of RFI is especially important in the 90 and 400cm bands when in the 'C' and 'D' configurations. They appear at all multiples of 5 and 12.5 MHz - frequencies divisible by these numbers must be avoided. (It is this spectrum of RFI which limits our P-band bandwidth.) Another "family" of RFI occurs at multiples of 100 kHz - these are much weaker, are incoherent between antennas, and can usually be ignored. However, those wishing to experiment with our 400cm system must use the spectral line correlator to allow purging of the 100 kHz signals, which are very strong at this frequency.

These internally generated signals can only be eliminated through RFI shielding of the electronics producing the signals. Currently, five antennas (3, 10, 20, 21 and 26) are shielded. Three more will be added by the end of 1991. We hope to obtain funding to allow completion of this project over the next two or three years.

Within the 6cm band, all observers should avoid using a frequency/bandwidth combination which includes 4800 MHz, where a strong internal birdie exists. The default frequency combinations at this band avoid this birdie.

2.6 Antenna Pointing

The pointing parameters of the antennas are measured monthly under calm nighttime conditions, and are sufficient, under good weather, to allow pointing accuracy of 10 arcsec rms. The pointing accuracy in daytime is a little worse, due to the effects of solar heating of the antenna structures. All key antenna support members have been insulated, so the arcminute deviations noted in the past are believed to have been eliminated.

2.7 Positional Accuracy

The accuracy with which an object's position can be determined is entirely a function of the atmospheric phase stability. Under the best conditions, in 'A'-configuration, accuracies of about 0.05 arcseconds can be obtained. Under more normal conditions, accuracies of perhaps 0.1 arcseconds can be expected. If highly accurate positions are desired, only 'A' or 'B' position code calibrators from the VLA Calibrator List should be used. The positions of these sources are taken from the JPL astrometric survey list.

2.8 Image Fidelity

Under even the best observing conditions, the achieved dynamic range will rarely exceed a few hundred. The limiting factor is the atmospheric phase stability. If the target source contains more than 50 mJy in compact structures (depending somewhat on band), self-calibration can be counted on in improving the images. Dynamic ranges in the thousands can be achieved using these techniques. If the target source is bright enough for dynamic ranges exceeding 10,000 to be conceivable, use of the spectral line correlator mode should be considered.

The interferometer acts as a spatial filter, so that for any given configuration, structures on a scale larger than the fringe spacing of the shortest baseline will be completely absent. Table III(a) gives the largest scale visible to each configuration/band combination. At 90 and 20cm, large numbers of background sources are located throughout the primary antenna beam. Sidelobes from these objects will lower the image quality of the target source. Although bandwidth and time-averaging will tend to reduce the effects of these sources, the very best images will require careful imaging of all significant background sources. The AIPS task 'MX' is well suited to this task at 20cm. The problem at 90cm is much worse, and is greatly complicated by the non-coplanar nature of the array, as described in section 2.3.4. Table III(a) gives the highest flux density expected of these background sources.

Another image-degrading effect is that due to strong nearby sources. Again, the 20 and 90cm bands are especially affected. The active Sun will be visible to any 'D' configuration spectral line observation at these bands. Even with 50 MHz bandwidth in continuum mode, the active Sun can ruin the short spacings of observations within about 20 degrees of the Sun. The quiet Sun poses a lesser threat, so the general rule is to go ahead and observe, even if the target source is close to the Sun.

At 90cm, observations within approximately 5 degrees of Cygnus A, Cassiopeia A, Taurus A, and Virgo A will be greatly degraded.

2.9 Calibration and the Flux Density Scale

The VLA Calibrator List contains information on 806 sources sufficiently unresolved and bright to permit their use as calibrators. Copies of the list are distributed throughout the AOC. The list is also available within the OBSERVE program. An IBM PC program which accesses the VLA Calibrator list can be used to assist in calibrator selection. Copies of these can be obtained by calling Theresa McBride at (505) 835-7000.

Accurate flux densities are obtained by observing one of 3C286, 3C147 or 3C48 during the observing run. These sources are slowly variable, so their flux densities are monitored each year when the VLA is in its 'D'-configuration. The VLA's flux density scale is based on the Baars et al. values for 3C295 at all bands except K-band (23 GHz). For this band, the situation is still unsettled, but it is likely we will adopt the Baars et al. value of NGC7027.

Table V shows the flux densities of these sources in December 1989 at our standard bands.

2.10 Polarization

The continuum mode always provides full polarimetric information. The polarimetric spectral line modes (PA and PB) are also available for observations of linearly polarized spectral lines, or for observations of continuum objects where large field-of-view or high dynamic range is necessary.

Instrumental polarization is easily determined through observations of a bright calibrator source. In nearly all cases, the phase calibrator chosen will double as a polarization calibrator. The minimum condition which will enable accurate polarization calibration is four observations of a bright source spanning at least 90 degrees in parallactic angle. The accuracy of polarization calibration is better than 0.5%. The instrumental polarization is not constant across the beam, so that errors in the source polarization exceeding 1% can be expected when imaging at angles exceeding 10% of the primary beam width. At least one observation of 3C286 or 3C138 is required to fix the absolute position angle of polarized emission.

Ionospheric Faraday rotation is always present at 20 and 90cm. The amount of rotation can exceed 40 degrees at 20cm at solar maximum, and remains notable even through solar minimum. Approximate correction schemes are available within the AIPS task FARAD. This task reads TEC (Total Electron Content) data and computes the appropriate correction. The appropriate data, as complete as possible are automatically available with each AIPS release. More recent values can be obtained through the AIPSSERV facility which is introduced and explained in the 15OCT89 AIPS newsletter. At 90cm, the situation is more difficult. Ionospheric effects are too large to be accurately corrected, and there are no polarized sources which allow fixing the true position angle. The best progress to date has been with objects in which strong, compact polarized emission is found. Each scan can then be corrected to remove the ionospheric rotation, allowing an accurate measure of the polarized flux. However, the problem of fixing the true position angle remains.

Circular polarization measurements are limited by the beam squint -- the RCP and LCP primary beams are separated by 6 percent of the beamwidth. Since circular polarization is determined from the difference between RCP and LCP signals, there results a large and fundamental error in all measurements of circular polarization. This effect can be calibrated out only on-axis, and can be ignored only if the degree of circular polarization exceeds 10%.

2.11 Spectral Line Modes

The VLA correlator is wondrously flexible, and can provide data in many ways. The various spectral line modes currently available are shown in Table VI and described below.

Most modes are distinguished by a code comprising a number followed by zero, one, or two letters. The number refers to the number of spectra being produced, the letters describe which IFs are involved. Recall that each VLA antenna returns four signals: these are the RCP and LCP for each of two separately tuned frequencies. These signal channels are referred to as IFs, and are named A, B, C, and D. The first two represent RCP, and latter two LCP. Channels A and C are at one frequency; B and D are at another.

The single-IF modes provided by the spectral line correlator are known as 1A, 1B, 1C, and 1D. In these modes, only one spectrum is produced. This mode gives the highest spectral resolution at any given bandwidth. The dual-IF modes are denoted 2AB, 2AC, 2AD, 2BC, 2BD and 2CD, and provide spectral information for the two IFs named. Linear polarization measurements are not possible with these modes, but circular polarization can be determined using 2AC, 2AD, 2BC and 2BD modes. The four-IF modes are known as 4, PA and PB. The first of these provides spectra for all four IFs. Again circular, but no linear polarization measurements are possible. The other two modes provide full polarimetric information -- PA provides this for the A and C channels (that is, it performs the correlations AA, AC, CA, and CC, providing a spectrum for each), PB for the B and D channels. Note that for these polarimetric modes, the descriptor '4' is omitted. The characteristics of all of these modes are summarized in Table VI.

It is now also possible to use multiple, independent subarrays in spectral line mode. The correlator modes beginning with '2' or '4' will allow the IFs to be at different bandwidths as well as at different frequencies within the same band. It is not possible to observe simultaneously in line and continuum. Autocorrelation spectra are also now available. There are some restrictions. Contact Eli Brinks (505/835-7209) or Doug Wood (505/835-7398) for further details.

Of central interest to observers is the stability of the spectra. Spectral line dynamic range is commonly defined as the ratio between the weakest believable feature in a spectrum and the total flux density of the continuum in that spectrum. This ratio is limited by instrumental effects which must be calibrated out. The spectral dynamic range depends on bandwidth in a poorly understood way. Applying the on-line autocorrelation only should result in about 50:1 dynamic range but is generally discouraged. Values exceeding 3000:1 at C and X-bands can be achieved with careful bandpass calibration. At L-band spectral dynamic ranges of ~1000:1 can be achieved by observing a suitable bandpass calibrator.

Refer to 'A Short Guide for VLA Spectral Line Observers' for more information.

2.12 VLBI Observations

The VLA supports VLBI observations in either single-antenna or phased array modes using either a Mark II or a hybrid Mark III/VLBA recorder. The hybrid Mark III/VLBA recorder provides narrow-track capability and uses regular thick tapes.

Refer to Section 3.9 for information on absentee observing. For additional information refer to 'VLBI at the VLA I, A Short Guide for Absentee Observers' or call Pat Crane (505/835-7227).

2.13 Snapshots

The unique two-dimensional geometry of the VLA allows a snapshot mode whereby short observations can be used to image relatively bright unconfused sources. This mode is ideal for survey work where the sensitivity requirements are modest. Due to confusion by background sources, this mode is not recommended at 90cm.

Single snapshots with good phase stability should give dynamic ranges of a few hundred. Note that because the snapshot synthesized beam contains high sidelobes, the effects of background confusing sources are much worse than for full syntheses, especially at 20cm in the C and D configurations for which a single snapshot will give a limiting noise of about 1 mJy. This level can be reduced by taking multiple snapshots separated by at least one hour. Use of the AIPS program 'MX' is necessary to remove the effects of background sources.

2.14 Shadowing and Cross-Talk

Observations at low elevation in the C and D configurations will commonly be affected by shadowing. It is strongly recommended that all data from a shadowed antenna be discarded. This can automatically be achieved within the AIPS task 'FILLM'.

Cross-talk is an effect in which signals from one antenna are picked up by an adjacent antenna, causing an erroneous correlation. The effect is important at 20 and 90 cm in the 'D' configuration. Careful editing is necessary to identify and remove this form of interference.

2.15 Combining Configurations

Any single VLA configuration will allow accurate imaging up to a scale approximately 30 times the synthesized beam. Objects larger than this will require multiple configuration observations. Merely ensure that the frequencies used are similar for each configuration. It is not necessary that they be identical, but differences greater than 50 MHz could cause errors due to spectral index gradients.

2.16 High Time Resolution Processor

The High Time Resolution Processor (HTRP) is a 14-channel polarimeter designed for observations of short timescale phenomena such as pulsars and flare stars. The HTRP has been used successfully in pulsar polarimetry, pulsar searches, and pulsar timing. The HTRP receives two, oppositely polarized input signals from the VLA analog sum port through a 14-channel filter bank. The bandwidth of each input channel can be set to either 2.0 or 4.0 MHz. The HTRP provides full polarimetry, producing a total of 56 outputs.

The integration times for each output can be set to between 25 and 5000 microseconds, while the minimum sampling interval, per output channel, is 560 microseconds. The HTRP is controlled by an IBM PC compatible, and the sampled data are currently written to the PC hard disk. Upon completion of an observation, the data are written onto a 40 megabyte cassette tape. In the very near future, we hope to modify the data acquisition scheme such that sampled data are written directly to an Exabyte tape. Current versions of monitor and control software and data acquisition software are adequate for general use; however, data analysis software has yet to be modified for general use. Any observer interested in using the HTRP should plan on investing some time in developing his/her own data analysis software. For further information regarding the HTRP, contact Mark McKinnon at (505) 835-7274.

3.0 OBSERVING WITH THE VLA

3.1 Getting Observing Time on the VLA

The allocation of observing time on the VLA is based upon the submission of a VLA Observing Application Form obtainable at any NRAO office. The form consists of a cover sheet whereon the proposer must summarize all technical details of the observations and an appended, self-contained, scientific justification of the project not to exceed 1000 words in length. Once completed the entire observing request (cover sheet plus appended justification) must be submitted to:

Paul A. Vanden Bout
Director, NRAO
Edgemont Road
Charlottesville, VA 22903-2475

Submissions by Telefax (804-296-0278), although not encouraged, are permitted if they are immediately followed by a mail submission.

Observing requests for specific telescope configurations must be submitted prior to the deadlines listed in Table I(a). The proposal deadline for a particular configuration is the middle of the second month of the preceding term. It is not necessary to submit a proposal in the preceding term, for all proposals will be refereed immediately following the deadline of submission, regardless of the configuration requested. Early submissions - more than one deadline in advance of the relevant configuration deadline - will benefit from referee feedback and the opportunity for revision and additional review if warranted.

All proposals are externally refereed by several experts in relevant subdisciplines (e.g. solar, stellar, galactic, extragalactic, etc.). The referees' comments and rating are advisory to the internal VLA scheduling committee, and the comments of both groups are passed on to the proposers soon after each meeting of the committee (3 times yearly) and prior to the next proposal submission deadline. Scheduling the telescope is a non-exact science, and highly rated proposals are not guaranteed to receive observing time. This is particularly true for programs that concentrate on objects in the LST ranges occupied by popular targets such as the galactic center or the Virgo cluster.

3.2 Observing File Preparation

To use the VLA an observing file must be prepared and submitted to the VLA Operators. This file is generated by the NRAO-supplied program OBSERVE, which is available to all users and can run on a wide variety of machines. We recommend that all users obtain a copy of this program, and periodically check that they have the latest version.

At this time, OBSERVE is available for PCs running under MS-DOS, VAXes under VMS, and for all Sun workstations. We expect a version for IBM R6000 workstations to be available by mid-1991.

OBSERVE can be obtained by one of these routes - listed in order of preference:

1) For users with Internet access; use anonymous FTP from ZIA.AOC.NRAO.EDU (or 192.43.204.7). Contact Wes Young (WYOUNG@NRAO.EDU, or 505/835-7337) for assistance.
2) Telephone Theresa McBride (505/835-7000), and specify the machine type (PC, VAX, SUN, IBM) and medium (disc, floppy, standard tape, Exabyte, or DAT), which she will then mail to you.
3) For VMS users without Internet access, but who have SPAN access (now officially known as NSI), directly copy all files from NRAO::[.OBSERVE]. Then examine READ.ME for directions.

IMPORTANT! A major revision of OBSERVE, version 3.0.1 will be released May 1, 1991. This version implements both LOSER (so frequencies can now be specified directly) and DOPSET (so Doppler tracking is automatically incorporated), improved algorithms for calculating on-source dwell times, and much improved program navigation. All users should obtain a copy of this version.

A considerable training effort is required to become fully conversant with OBSERVE, especially for those accustomed to its Dec-10 predecessor. For help, call Peggy Perley (505/835-7239) or Dave Wunker (505/835-7359), or through E-mail (ANALYSTS@NRAO.EDU).

After your file is prepared, E-mail it to the operators at OBSERVE @NRAO.EDU. Include the program name in the subject line. Always call the operators at 505/772-4251 to confirm receipt of the file. It is in your best interest to complete these operations at least two working days before your observing.

3.3 The Observations and Remote Observing

Observers need not be present at the VLA to obtain VLA data. However, we encourage VLA users to come to Socorro when observing. There is no better way to interact with the data, and to calibrate and to image data quickly. And coming to Socorro is the best way to benefit from discussions with staff members.

We recommend that observers who are coming and who intend to set up their observe files in Socorro arrive two days before their scheduled observations to allow plenty of time to interact with key staff members. See Section 3.7 for information on coming to and staying in Socorro.

For those who choose to process their data at home, the data analysts will mail you a tape (standard ½ inch or Exabyte) containing your data. For some short observations requiring fast turnaround, the data analysts will load your data on disk in FITS format, from where you may transfer the data through ftp to your computer. Contact Peggy Perley (505/835-7239) or Dave Wunker (505/835-7359) to access these services.

3.4 Data Calibration

The only supported software package for data calibration is AIPS. The Convex-specific ISIS package remains available at the AOC, but is not supported, and cannot handle most of the spectral line modes.

3.5 Computing at the VLA

The only data processing computer at the VLA site is a VAX 11/750, with AP. Calibration and imaging within a few hours of observing are possible with this system.

By the end of 1991, we expect to have in place at the VLA a powerful workstation of the Sparc 2 class, with an Ethernet link to the on-line computers. This configuration will allow imaging within a few minutes of observing.

3.6 Computing at the AOC

Until the end of 1991, the main calibration and imaging computers at the AOC will be the two Convex C-1s, each with about 3.5 GBytes of available disk for data. To reserve disk space on these systems, contact Eileen Latasa (505/835-7357) or Jon Spargo (505/835-7305) at least 2 weeks before your visit.

There is also available a SPARC1 workstation with approximately 1.2 GByte of disk. This machine is intended for spectral line projects, and is scheduled by Doug Wood (505/835-7398).

3.7 Reservations for VLA and/or AOC

Advance contact with the Reservationist (Eileen Latasa) at (505) 835-7357 at least 2 weeks prior to your visit to the NRAO/NM is essential in order to optimize the logistics of room occupancy, transportation, computer load, and staff assistance.

First time visiting students will be allowed to come to the NRAO/NM for observations or data reduction only if accompanied by their faculty advisor.

3.8 Help for Visitors to the VLA and AOC

We encourage observers to come to Socorro to calibrate and image their data. This is the best way to ensure the quickest turnaround and best results from their observing. While in Socorro, each observer will interact with members of the AOC staff in accordance with his/her level of experience and the complexity of the observing program. If requested on the original VLA application form, they will be guided through the steps of data calibration and imaging by a prearranged staff "friend" or scientific collaborator. Data Analysts and the computer operations staff are also available for consultation on AIPS procedures and systems questions. During the "off hours", evenings and weekends, visitors have ready access to a roster of On-Call Experts for questions that arise in the areas of astronomy, AIPS, or computer systems. Please seek help if you run into a problem.

3.9 VLBI Remote Observing

The VLA supports absentee VLBI Network observations and absentee observations for VLBA projects. Pat Crane (505/835-7227) supervises all Mark III observations, and Joan Wrobel (505/835-7392) supervises all Mark II observations.

The observer is responsible for providing either Pat or Joan with the necessary scheduling information at least two weeks in advance of the appropriate Network session.

Remote calibration of VLBI data is not provided. For more information refer to 'VLBI at the VLA I, A Short Guide for Absentee Users'.

3.10 VLAPLAN

VLAPLAN and VLAUVPL are PC-based tools to help continuum and line observers prepare VLA observing proposals and observing strategies. VLAPLAN does the main calculations that are required to design a VLA observation to produce a given image quality and sensitivity, within the VLA's hardware and software limitations. It is a worksheet that lets the user adjust the imaging parameters interactively, while reviewing their consequences for VLA configuration choices, total integration times and other critical parameters. VLAPLAN warns about conflicts between your imaging parameters and the VLA's hardware capabilities, and suggests strategies for removing such conflicts. It also plots graphs, scaled to the context of your observing parameters, of the bandwidth and time-average smearing effects, of the primary beam correction, of Gaussian source visibilities and (at L-Band) of known RFI signals. VLAPLAN is based on the approaches to VLA observing strategy and the formulae in Lecture 24 of "Synthesis Imaging in Radio Astronomy".

VLAPLAN recommends which VLA configuration(s) to use for your observing. It chooses the most compact configuration using only the observing frequency and the largest angular size and declination of your source. To do this quickly, it uses a table of the shortest projected baselines in VLA meridian snapshots at ten-degree intervals in declinaton. VLAUVPL is an ancillary worksheet that shows the extreme-baseline coverage in detail, to help you choose VLA configurations for longer, or off-meridian, observations. It computes the full uv tracks at any declination for the VLA's inner or outer antennas at all hour angles consistent with your prescribed elevation limits and offers several displays that will help you to refine your choice of VLA configuration.

VLAPLAN and VLAUVPL are worksheets that will run in MS-DOS PC's under Lotus 1-2-3, Borland Quattro (or any other spreadsheet that reads Lotus worksheet format and macros). Little or no familiarity with the host spreadsheet program is assumed, however. Both VLAPLAN and VLAUVPL can be obtained either on MS-DOS diskette from Meri Stanley at the AOC or by anonymous-ftp from the /ftp/pub/vlaplan subdirectory on the zia server. VLAPLAN contains menu-based documentation about the main VLA imaging parameters, the VLA hardware, and about who to contact at the NRAO for advice about VLA proposal design, submission and scheduling. Paper documentation is also available, as VLA Computer Memo No. 179, from Meri Stanley. Questions and comments about these worksheets should go to Alan Bridle in Charlottesville.

3.11 VLAIS

The NRAO has set up a simple information system on its Zia computer system in Socorro, New Mexico. The information in the system is oriented towards VLA observers and contains data on baseline corrections, system temperatures, list of VLA calibrators and VLA archive sources and other VLA related items. Access to this system is by Internet (address 192.43.204.7) or through the NRAO Socorro terminal switch (505/835-7010). At the login message for Zia type vlais <return> (no password required). A menu will list the major categories available. Choose VLA to get to the VLA specific information.

4.0 MISCELLANEOUS

4.1 VLA Archive Data

A directory of the VLA archive data is available in ten reports, covering the nine years 1981 (09/81-12/81), through 1990. Hardcopy versions are available from Meri Stanley and in all NRAO libraries. There is also an IBM PC program (VLASORS) that can be used to search the archive source list. The data and program are available for IBM Pcs, with at least 4MB disk, from Meri Stanley. A version of the archive list is available on Zia. See Section 3.11.

Archive data taken prior to 1988 cannot be read by the AIPS task FILLM. A general-purpose program is now being developed to reformat all old data. This program has been verified for all continuum data - verification for spectral line data will occur by mid-1991. To obtain reformatted tapes of archive data, call Peggy Perley (505/835-7239) or Dave Wunker (505/835-7359).

NRAO has the following policy on the extent to which an observing team has exclusive use of the raw data obtained as part of their VLA observations. This policy is:

> Eighteen months after the end of a VLA observation the raw (uncalibrated visibility) data will be made available to other users on request. The end of an observation is defined to be after the last VLA configuration requested, either in the original proposal or in a direct extension of the proposal. VLA correlator data taken for VLBI observations are immediately available to all.

4.2 Publication Guidelines

Any papers using observational material taken with NRAO instruments (VLA 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 operated by Associated Universities, Inc., under co-operative agreement with the National Science Foundation."

Preprints

NRAO requests that you submit four copies of all papers which include observations taken with any NRAO instrument or have NRAO author(s) to Ellen Bouton in the Charlottesville Library. NRAO authors may request that their papers be included in the official NRAO preprint series. Multiple author papers will not be included in the series if they are being distributed by another institution. All preprints for distribution should have a title page that conforms to the window format of the NRAO red preprint covers. Note that preprints will be distributed ONLY when the NRAO author so requests; inclusion in the series is not automatic. This action will also cause the paper to be included in NRAO's publication lists.

Reprints

NRAO no longer purchases reprints from the major astronomical journals for distribution. However, NRAO will purchase and distribute reprints in the following cases:

1. The paper is in a publication less likely to be readily available to other astronomers (i.e., IAU symposia/colloquia, IEEE and SPIE proceedings, commercial journals).
2. The paper is likely to be in great demand (i.e., comprehensive catalogs, detection of ETI, etc.).

In such cases, please send copies of the order forms supplied by the publisher to Ellen Bouton in the Charlottesville Library.

NRAO will also order 50 reprints for the personal use of the NRAO author(s) if reprints are requested at the time of submission of page charge information. Orders at a later date should be avoided in order to minimize administrative hassle. Normally, the first author should be responsible for reprint orders and share reprints as appropriate with collaborators. Do not ask NRAO to order reprints in those cases where reprints will be received from a non-NRAO first author.

4.3 Page Charge Support

The following summarizes NRAO's policy:

1) When requested, NRAO will pay the larger of the following:
   a) 33% of the page charges reporting original made with NRAO instrument(s) when at least one author is at a U.S. scientific or educational institution.
   b) 100% of the page charges prorated by the fraction of authors who are NRAO staff members.

2) No page charge support is provided for publication of color plates.

3) To receive page charge support, authors must comply with all of the following requirements:
   a) Include the NRAO footnote in the text: "Operated by Associated Universities, Inc., under cooperative agreement with the National Science Foundation."
   b) Send four copies of the paper prior to publication to Ellen Bouton in Charlottesville. VLA staff members may submit their 4 copies to Julie Lagoyda at the VLA.
   c) Notify Ellen Bouton of the proposed date of publication and apportionment of page charges so that the necessary purchase orders may be initiated. Convenient ways to do this are to send copies of the completed page charge form, send an e-mail message, or call Ellen Bouton.

5.0 DOCUMENTATION

Documentation for VLA data reduction, image making, observing preparation, etc., can be found in various manuals. Those manuals marked by an asterisk (*) can be mailed out upon request. Direct your requests to Theresa McBride (505/835-7000).

1. PROCEEDINGS FROM THE 1988 SYNTHESIS IMAGING WORKSHOP: Synthesis theory, technical information and observing strategies can be found in: "Synthesis Imaging in Radio Astronomy". This collection of lectures given in Socorro in June 1988 has been published by the Astronomical Society of the Pacific as Volume 6 of their Conference Series.
2. INTRODUCTION TO THE NRAO VERY LARGE ARRAY (Green Book): This manual has general introductory information on the VLA. Topics include theory of interferometry, hardware descriptions, observing preparation, data reduction, image making and display. Parts of the 1983 manual are now out of date. Copies of this are found at the VLA and in the AOC, but no new copies are available.
3. THE OBSERVERS REFERENCE MANUAL: This is a general purpose guide to computing at the AOC. It includes sections on ISIS and AIPS calibration, use of the computers for general purposes, and use of the SDE package. This manual is available for use in Socorro only.
4. VLA COOKBOOK: The Cookbook contains some observing strategies and recipes on the initial data reduction of continuum, polarization, spectral line, solar observations, and guides to self-calibration. This manual is available in Socorro only.
5. *A SHORT GUIDE FOR VLA SPECTRAL-LINE OBSERVERS: This is an important document for those wishing to carry out spectral-line observations with the VLA. This guide can also be found in the VLA Cookbook.
6. *AIPS COOKBOOK: The "Cookbook" description for calibration and imaging under the AIPS system can be found in the AIPS terminal rooms in the AOC. The latest version has expanded descriptions of data calibration imaging, cleaning, self-calibration, spectral line reduction, VLBI reductions and a section for CONVEX users. The AIPS COOKBOOK is now produced in a ring binder format for greater ease of updating.
7. *GOING AIPS: This is a two-volume programmers manual for those wishing to write programs under AIPS.
8. *VLA CALIBRATOR MANUAL: This manual contains the list of VLA Calibrators in both 1950 and J2000 epoch and a discussion of gain and phase calibration.
9. VLBI AT THE VLA I, A SHORT GUIDE FOR ABSENTEE OBSERVERS: This manual describes VLBI observing procedures and requirements when the VLA is one of the NUG stations. This documents is contained in the VLA Cookbook.
10. *The Very Large Array: Design and Performance of a Modern Synthesis Radio Telescope, Napier, Thompson, and Ekers, Proc. of IEEE, 71, 295, 1983.
11. *OBSERVE, A GUIDE FOR SPECTRAL LINE OBSERVERS.

6.0 LIST OF KEY PERSONNEL

The following list gives the telephone extensions and AOC room numbers personnel who are available to assist VLA users. In most cases the individuals have responsibilities or special knowledge in certain areas. These are succinctly noted in the right hand column.

You may also contact any of these people through E-mail. The NRAO has adopted a uniform standard for E-mail addresses: first initial followed by last name, with a maximum of eight letters. On BITNET, address your inquiry to USERNAME@NRAO; on Internet, use USERNAME@nrao.edu; and via SPAN use NRAO::USERNAME.

Name	Phone	AOC Room	Notes
	505/835-		
Tim Bastian	7259	373	Solar Observing
Carl Bignell	7242	305	Head of Operations
Eli Brinks	7029	206	Spectral Line Observing
Barry Clark	7268	308	Scheduling
Tim Cornwell	7333	362	SDE Package, Imaging
Pat Crane	7227	356	Radio Frequency Interference
Phil Diamond	7365	306	VLBI, AIPS
Chris Flatters	7209	208	AIPS
Miller Goss	7300	334	VLA Director
Tim Hankins	7326	326	Pulsar Observing
Bob Havlen	7330	330	Visitor Support
Phil Hicks	772-4319	276	VLA Chief Operator
Bob Hjellming	7273	266	Staff Scientist
Gareth Hunt	7213	342	On-Line System, AIPS
Bill Junor	7210	208	AIPS
Eileen Latasa	7357	218	Visitor Registration
Theresa McBride	7000	267	Documentation
Ruth Milner	7282	210	AOC Computing
Frazer Owen	7304	320	Staff Scientist
Bob Payne	7294	378	Head of VLA Computing, ISIS
Peggy Perley	7239	204	Remote Observing, User Support
Rick Perley	7312	368	Calibration, Imaging, Computing
Terry Romero	7300	338	Visitor Support
Ken Sowinski	7299	375	On-Line Systems
Jon Spargo	7305	258	Computer Support
Dick Sramek	7394	328	Electronics Problems
Meri Stanley	7310	340	Documentation
Juan Uson	7237	358	Staff Scientist
Jacqueline van Gorkom	7375	310	Spectral Line Observing (Summer Only)
Craig Walker	7247	314	VLBI
Dave Westpfahl	7225	316	Spectral Line Observing
Doug Wood	7398	309	Spectral Line Observing
Joan Wrobel	7392	302	VLBI
Dave Wunker	7359	204	Remote Observing, User Support
Wes Young	7337	210	OBSERVE, Workstation Support
Tony Zensus	7348	312	VLBI

TABLE I(a)

VLA CONFIGURATIONS FOR 1991/1992

DATES	CONFIG	Proposal Deadline
1991 Feb 26 - 1991 May 28	D	15 Oct 90
1991 Jun 21 - 1991 Sep 16	A	15 Feb 91
1991 Sep 27 - 1991 Oct 14	A/B	15 Jun 91
1991 Oct 18 - 1991 Dec 31	B	15 Jun 91
1992 Jan 10 - 1992 Jan 27	B/C	15 Oct 91
1992 Jan 31 - 1992	C	15 Oct 91

TABLE I(b)

APPROXIMATE LONG TERM VLA CONFIGURATION SCHEDULE

	4-MONTH TERM		
	T1	T2	T3
1991	D	A	B
1992	C	D	A
1993	B	C	D
1994	A	B	C
1995	D	A	B

TABLE II

CONFIGURATION SUMMARY

	A	B	C	D
Maximum Antenna Separation (km)	36.4	11.4	3.4	1.03
Minimum Antenna Separation (km)	.68	.21	.073	.033
Approximate Synthesized Half-Power Beamwidth* (arcseconds):				
90 cm	6	17	56	200
20 cm	1.4	3.9	12.5	44
6 cm	.4	1.2	3.9	14
3.6 cm	.24	.7	2.3	8.4
2 cm	.14	.4	1.2	3.9
1.3 cm	.08	.3	.9	2.8
Approximate Largest Scale Structure "Visible" to VLA **				
90 cm	170"	9'	30'	70'
20 cm	38"	2'	7'	15'
6 cm	10"	36"	2'	5'
3.6 cm	7"	20"	1'	3'
2 cm	4"	12"	40"	90"
1.3 cm	2"	7"	25"	60"

* These numbers are estimates for a uniformly weighted and untapered map produced from full synthesis observations of a source which passes near the zenith.

North-South resolution degrades for southern sources. Sources below -15 degrees NB declination observed with the long north arm hybrid configurations will have resolutions similar to those of the smaller configuration comprising the hybrid.

The approximate resolution for natural weighted map is about 1.5 times these numbers.

The approximate resolution of snapshots is about 1.3 times the listed values.

**These numbers are the largest source size (anywhere in the image) which can be reasonably well imaged in full synthesis observations. For single snapshot observations these numbers should be divided by 2.

TABLE III(a)

VLA SENSITIVITY

Frequency (GHz)	0.3 - 0.34	1.34 - 1.73	4.5 - 5.0	8.0 - 8.8	14.4 - 15.4	22.0 - 24.0
Band Name (approx. wavelength)	90 cm	20 cm	6 cm	3.6 cm	2 cm	1.3 cm
System Temperature (^{o}Kelvins)	150 - 180	60	60	40	120	160 - 210
Antenna Effeciency(%)	40	51	65	63	52	43
RMS Sensitivity (mJy) in 10 minutes (50 MHz bandwidth 27 antennas, 1 IF pair)	-1.6 (3 MHz bw)[1,2]	.13	.095	.067	.24	.42
RMS Sensitivity (mJy) in 12 hours (50 MHz bandwidth - 27 antennas, 1 IF pair)	0.19 (3 MHz bw)[1]	.015	.011	.0079	.028	.050
Untapered brightness (mKelvins) temperature (D configuration, 50 MHz bandwidth, 27 antennas, 1 IF pair)	57 (3 MHz bw)[1]	4.5	3.3	2.4	8.4	15
Antenna Primary Beam Size (FWHP)	156'	30'	9'	5'4	3'	2'
Peak Confusing Source (mJy) Expected in Antenna Primary Beam	10 Jy	195 mJy	7.8	2.0	0.40	0.12

[1] Needs 3-D imaging to reach this level.

[2] Snapshot observations will not usually reach this level, even with 3-D imaging, as the confusion problem is insoluble with only snapshot u,v coverage.

TABLE III(b)
SENSITIVITY RANGES AT VLA BANDS

Band	1.1 x Nominal	2 x Nominal	Extreme Range
90 cm	300 MHz 340 MHz	298 MHz 345 MHz	295 MHz 350 MHz
20 cm	1320 1700	1250 1800	1225 1875
6 cm	4500 5000	4250 5100	4200 5100
3.6 cm	8080 8750	7550 9050	6800 9600
2 cm	14650 15325	14250 15700	13500 16300
1.3 cm	22000 24000	21700 24500	20800 25800

TABLE IV(a)

LOSS OF PEAK RESPONSE DUE TO BANDWIDTH SMEARING
(CHROMATIC ABERRATION)

$\frac{\Delta\nu}{\nu} \cdot \frac{\theta o}{\theta_{FWHP}}$	Peak Response
0	1.0
0.50	0.95
0.75	0.90
1.0	0.80
2.0	0.50

$\frac{\Delta\nu}{\nu}$ = fractional bandwidth

$\frac{\theta o}{\theta_{FWHP}}$ = source offset from delay center in synthesized beams

TABLE IV(b)

AVERAGING TIMES (SECONDS) RESULTING IN VARIOUS AMPLITUDE
LOSSES FOR A POINT SOURCE AT THE ANTENNA HALF POWER

	AMPLITUDE LOSS		
Configuration	1%	5%	10%
A	2.1	4.8	6.7
B	6.8	15	21
C	21	48	67
D	68	150	210

TABLE IV (c)
MINIMUM AVERAGING TIMES IN SEC. FOR VLA OBSERVING

		TOTAL NUMBER OF CHANNELS						
Config	Continuum	8	16	32	64	128	256	512
A & B	10	10	10	10	20	30	60	120
C & D	10	30	30	30	30	30	60	120

FIG. 1

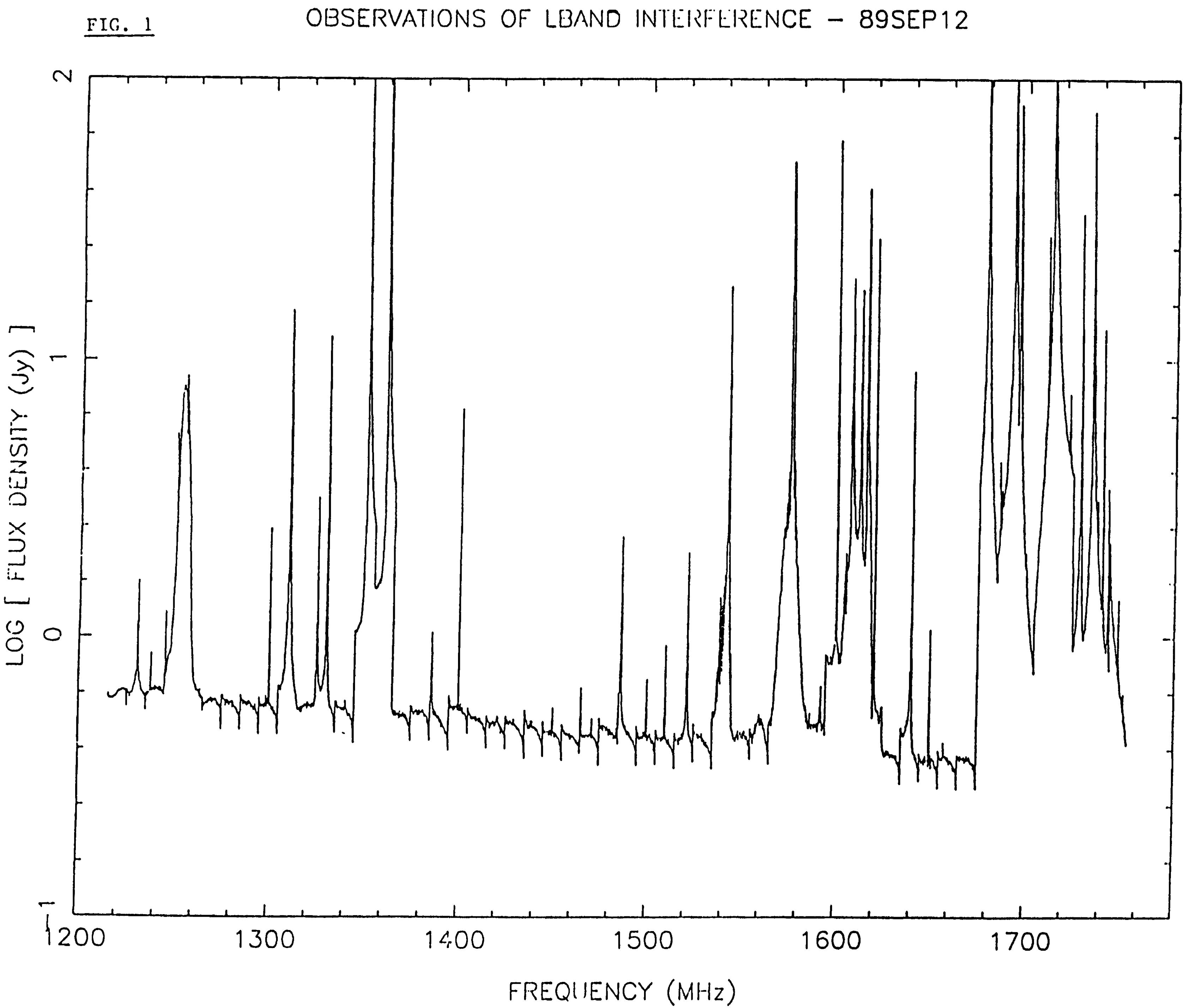
OBSERVATIONS OF LBAND INTERFERENCE - 89SEP12
LOG [FLUX DENSITY (Jy)]
2
1
0
-1
1200
1300
1400
1500
1600
1700
FREQUENCY (MHz)

TABLE V

FLUX DENSITIES OF STANDARD CALIBRATORS FOR DECEMBER 1989

	327.5 MHz	1425 MHz	4866 MHz	8434 MHz	14984 MHz	22460 MHz
3C48	42.7±.3	16.0±.01	5.61±.02	3.29±.01	1.85±.02	1.24±.06
3C147	53.1±.4	21.6±.01	7.78±.02	4.59±.01	2.66±.02	1.81±.09
3C286	26.4±.2	14.7±.01	7.47±.02	5.20±.01	3.42±.03	2.53
3C295	60.4	22.0	6.56	3.42	1.615	------
NGC 7027	-------	1.40±.01	5.49±.02	6.03±.05	5.72±0.1	------

TABLE VI(a)
AVAILABLE BANDWIDTHS AND NUMBER OF FREQUENCY CHANNELS

Normal Mode

Code	Bandwidth MHz	Single IF Mode(1) No. Channels(4)	Single IF Mode(1) Freq. Separ. kHz	Two IF Mode(2) No. Channels(4) per IF	Two IF Mode(2) Freq. Separ. kHz	Four IF Mode(3) No. Channels(4) per IF	Four IF Mode(3) Freq. Separ. kHz
0	50	16	3125	8	6250	4	12500
1	25	32	781.25	16	1562.5	8	3125
2	12.5	64	195.313	32	390.625	16	781.25
3	6.25	128	48.828	64	97.656	32	195.313
4	3.125	256	12.207	128	24.414	64	48.828
5	1.5625	512	3.052	256	6.104	128	12.207
6	0.78125	512	1.526	256	3.052	128	6.104
8	0.1953125	256	0.763	128	1.526	64	3.052
9	0.1953125	512	0.381	256	0.763	128	1.526

Notes:
(1) Observing Modes 1A, 1B, 1C, 1D.
(2) Observing Modes 2AB, 2AC, 2AD, 2BC, 2BD, 2CD.
(3) Observing Modes 4, PA, PB.
The observing mode determines how the hardware combination of the correlator and the four IFs are to be used to handle the data. It is possible to use the output from one, two or four IFs in such a way as to obtain different combinations of number of frequency channels and channel separation. The minimum and maximum number of channels is 4 and 512 respectively.

(4) These are the numbers of frequency channels produced in the AP. Any number of channels that is a power of 2, that is less than or equal to the number in the table and that is greater than or equal to 2 may be selected using the data selection parameters on the DS card.

TABLE VI(b)
AVAILABLE BANDWIDTHS AND NUMBER OF FREQUENCY CHANNELS

On-Line Hanning Smoothing Option(5)

BW Code	Bandwidth MHz	Single IF Mode(1) No. Channels(4)	Single IF Mode(1) Freq. Separ. kHz	Two IF Mode(2) No. Channels(4) per IF	Two IF Mode(2) Freq. Separ. kHz	Four IF Mode(3) No. Channels(4) per IF	Four IF Mode(3) Freq. Separ. kHz
0	50	8	6250	4	12500	2	25000
1	25	16	1562.5	8	3125	4	6250
2	12.5	32	390.625	16	781.25	8	1562.5
3	6.25	64	97.656	32	195.313	16	390.625
4	3.125	128	24.414	64	48.828	32	97.656
5	1.5625	256	6.104	128	12.207	64	24.414
6	0.78125	256	3.052	128	6.104	64	12.207
8	0.1953125	128	1.526	64	3.052	32	6.104
9	0.1953125	256	0.763	128	1.526	64	3.052

Notes:
(1) Observing Modes 1A, 1B, 1C, 1D.
(2) Observing Modes 2AB, 2AC, 2AD, 2BC, 2BD, 2CD.
(3) Observing Modes 4, PA, PB.
(4) These are the numbers of frequency channels produced in the AP. Any number of channels that is a power of 2, that is less than or equal to the number in the table, and that is greater than or equal to 2 may be selected using the data selection parameters on the DS card.
(5) This option MUST be specified on the DS (Data Selection) card.