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NATIONAL RADIO ASTRONOMY OBSERVATORY
SOCORRO, NEW MEXICO
VERY LARGE ARRAY PROGRAM

VLA OBSERVATIONAL STATUS REPORT

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The capabilities of the VLA array vary with time because of the rapid changes during construction. There is currently no regular or formal means of communicating the current observational limitations of the VLA to either "insiders" or "outsiders". To overcome some of these difficulties we suggest a bimonthly or quarterly report which very briefly summarizes the most recent estimates of the sensitivity, resolution and observational limitations of the VLA as well as convey the most recent information on calibrators and software changes. The motivation for this report is to supply the user or potential user of the array with information on its capabilities which can be used as guidelines in proposing and planning observational programs. The document will not contain detailed descriptions of, or detailed progress reports on, array problems. Nor will it contain schedules and dates for enhanced capabilities.

The hardware configuration as well as the best estimates of the sensitivity of the VLA at the end of September are briefly outlined. More current estimates of the array status or information not covered in this report may be obtained directly from the VLA staff.

1.0 HARDWARE CONFIGURATIONS

Continuum observations at the four separate wavelengths 1.3 cm, 2 cm, 6 cm, and 20 cm are supported. Observations at three separate bandwidths, 50, 12 and 1.5 MHz, are possible. Circularly polarized feeds are used at all bands except 20 cm where linearly polarized feeds are in use.

There were a total of twelve antennas operating at the close of the month. The location of these antennas from the array center are approximately 0.5, 0.7, 1.3, 1.6, 3.2, 5.2, 7.7, and 10.5 km along the West arm and 0.1, 0.5, 1.0, and 1.6 km along the East arm. The West arm is populated principally in the A configuration and the East arm in the B configuration. The approximate minimum and maximum baselines are

0.2 and 12 km respectively.

With as many as three antennas assigned to the test array for testing purposes, there were observing periods with fewer than 12 antennas devoted to astronomical observations.

2.0 OBSERVATIONAL LIMITATIONS

The best estimates of the sensitivity and resolution of the VLA are summarized in Table I. Unless otherwise stated, these parameters assume 12 antennas, a maximum baseline of 12 km and an observing bandwidth of 50 MHz. In general the parameter estimates are conservative.

Mapping of sources is restricted to small diameter sources until more antennas become available at shorter spacings. Sources with extended errors in regions larger than 2', 45", 15", and 10" at 20, 6, 2, and 1.3 cm respectively, will be missing major fractions of flux density unless spacings of 50 to 400 m can be included in the observations.

The poorly understood large daytime single antenna pointing errors of 1 arcminute or more will influence observational strategy to the extent that synthesis observations at the high frequencies may necessitate several pointing checks during the run.

2.1 Dynamic Range

The dynamic range, loosely defined to be the ratio of the maximum source brightness to the minimum believable source brightness, is limited by phase stability. Many of the synthesized maps generated from VLA observations are limited by dynamic range and not noise.

2.2 Side Lobes

Since the array is populated only to 1.6 km along the East arm and to 12 km along the West arm the side lobe levels for sources at low declination can be greater than 20 percent. The clean algorithm is available to lessen the effects of the synthesized beam.

2.3 Interference

Externally and internally generated radio interference has had a variable influence on past observations taken in the 20 cm band. The amount of interference noticed in observational data has diminished recently.

2.4 Positions

Source position can be determined to approximately 0.05 arcseconds for sources in the north and about 0.2 arcseconds for sources south of -20 degrees declination.

2.5 Polarization

Circular polarization measurements are not presently possible because of the large circularly polarized side lobes.

Linear polarization observations are possible at 6 cm. The on-axis instrumental polarization can be determined to an accuracy of about 0.5 to 1.0 percent. This poor accuracy is partly a result of known pointing problems. Mapping the polarization of sources more than one arcminute away from the beam center may be subject to uncertainties greater than one percent because of the large linear polarized side lobes. Polarization observations in the 20 cm band are not supported and observations at the short wavelengths, particularly 1.3 cm, are severely hampered by pointing problems.

2.6 Spectral Line Capabilities

Not possible.

3.0 VLA CALIBRATORS

The general philosophy adopted by the VLA staff towards the measurement and compilation of "unresolved" radio sources used to calibrate the gain and phase of the VLA is (a) to find and monitor the flux density of about two dozen unresolved, unconfused, and relatively quiescent sources at the

TABLE I

VLA SENSITIVITY AND RESOLUTION *

Frequency (GHz) Wavelength (cm)	1.34 - 1.73 20	4.5 - 5.0 6	14.4 - 15.4 2	22.0 - 24.0 1.3
RMS Sensitivity (mJy) in 10 minutes (50 MHz bandwidth-12 antennas)	1.1	0.8	8	11
RMS Sensitivity (mJy) in 12 hours (50 MHz bandwidth-12 antennas)	0.13	0.1	1.7?	2-5?
Dynamic Range **	100	50	10-20?	10?
Synthesized Beam (arcseconds) (12 antennas-max. baseline:12 km)	3.3	1.0	0.4	0.2
Antenna Beam Size (FWHP-arcsecs)	1800	540	220	120
Field-of-View (FWHP-arcsecs) with 50 MHz bandwidth (max. baseline:12 km)	200	200	150	80
Brightest Source (mJy) Expected in Antenna Beam	100	2.3	<.1	<.01
Brightest Source (mJy) Expected in Field-of-View with 50 MHz bandwidth with 12 km array	3.5	0.4	<.04	<.004

* Table entries are the best estimates as of September 30, 1978.

** Extremely dependent on declination, time of day, season, and frequency of calibration.

four primary frequencies and (b) to determine the accurate (<0".03 arcseconds) positions for about 50 unresolved sources well distributed over the sky.

The list of flux density calibrators and primary phase calibrators as of September 30 are presented in Tables II and III. These lists are by no means complete and will be updated at approximately one or two month intervals. There exists larger lists of secondary phase and gain calibrators which have a more limited use and can be used in conjunction with the primary calibrators. As the VLA staff collects more data, the primary list of calibrators will grow and become more complete. Furthermore the flux density calibrators will at some future time become a subset of the primary list of phase calibrators.

There are currently a limited number of sources used for polarization calibration at 6 cm. The instrumental polarization can be calibrated using 0316+413, 0552+398, 0923+398, 1328+307, and 2005+403. 1328+307 is currently used to establish the absolute position angle. The list of polarization calibrators will be expanded in the near future.

4.0 SOFTWARE STATUS

The current on-site VLA software capabilities for converting raw visibility data into well-calibrated maps are best summarized by briefly listing the various tasks presently implemented at the different stages of data processing. No attempt is made to list the complete set of either the software options or its limitations.

The on-line computers, the Modcomps, automatically (a) change the LO phase to compensate for differential atmospheric refraction; and (b) correct the visibility phases for variations in the effective electrical length of the waveguide and some of the antenna LO paths (this latter correction is often termed the "round-trip phase correction"). In addition, gain variations caused by changes in the system temperature are corrected by using real time measured system temperatures. The latter correction may be turned on or off at the astronomer's option and by default is turned on at 6 cm only.

All further processing required to take the initially corrected visibility data from the Modcomps through calibration to the final maps is accomplished using the DEC-10 general purpose computer. The software is quite extensive and employs an antenna-by-antenna calibration technique.

For the calibration of data there exist programs to (a) flag data good or bad, (b) correct phases for known source position errors, antenna position errors and time errors, and (c) correct amplitudes for general zenith angle dependent effects such as atmospheric absorption. First order antenna shadowing corrections and system temperature corrections for all bands utilizing the measured system temperature data are possible. The antenna gain, phase and polarization characteristics are calculated from calibrator source observations, interpolated in time and stored with the visibility data. It is possible to undo some of the corrections applied by the Modcomps; these currently include the round-trip phase corrections at all bands and the system temperature correction at 6 cm. There is additional software which allows the observers to calculate baseline and pointing errors from calibrator observations.

The tasks for conversion of calibrated data to maps include sorting, gridding, fast Fourier transform, source subtraction in the u,v plane and the clean algorithm. Both u,v plane convolution (to aid in reducing the aliasing problems) and tapering are supported. Map display formats include: character display on computer terminals and line printer output; contours with or without polarization on the Tektronix storage tube terminal and the Versatec dot matrix plotter; and gray scale and color images on the Comptal graphics terminal attached to the PDP-11/40.

TABLE II

FLUX DENSITY CALIBRATORS

0116+319	0538+498	1519-273	2134+004
0134+329	0552+398	1730-130	2352+495
0224+671	0727-115	1749+096	
0229+132	0923+392	1749+701	
0237-233	1127-145	1921-293	
0316+413	1245-197	2005+403	
0537-441	1328+307	2021+614	

These calibrators are unresolved to the 3 percent level at 20 and 6 cm wavelength and to the 5 percent level at 2 and 1.3 cm over most of the baseline range currently available at the VLA. The exceptions include:

0224+671, 0229+132, 0316+413, 0923+392, and 1749+096 must not be used as short baselines at 20 and 6 cm.

0134+329, 0538+498 and 1328+307 must not be used at long baselines at all bands except 20 cm.

0134+329 and 0538+498 must not be used at 2 and 1.3 cm on any baselines.

0923+392 and 1730-130 must not be used at 20 cm on any baselines.

TABLE III

PRIMARY PHASE CALIBRATORS

[illegible]	0814+425	1328+254	[illegible]
0224+671	0831+557	1328+307	[illegible]
0316+413	0851+202	1404+286	1741-038
0333+321	0923+392	1502+106	1807+698
0336-019	0953+254	1555+001	2005+403
0355+508	1155+251	1611+343	2021+614
0430+052	1245-197	1638+398	2200+420
0552+398	1253-055	1641+399	2230+114
0742+103	[illegible]	1730-130	2251+158
			2345-167
			2352+495