

Interoffice

**National Radio Astronomy Observatory
Charlottesville, Virginia**

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To: VLBA Memo Series

From: J. D. Romney

Subject: VLBA Specification Summary

The attached edition of the VLBA Specification Summary represents a distant descendant of the original document distributed as VLBA Memo 557. Numerous intermediate updates have been available over computer networks from CVAX and, more recently, via the VLBI file server 'VLBI-SERVER' at Caltech. Up-to-date paper editions have also been distributed at various scientific meetings.

VLBA design and construction have now progressed sufficiently that most of the Summary has become static. This memorandum is intended, therefore, to bring the information available through this series up to date.

For those preferring an incremental correction, the following outlines the major changes since Memo 557 —

⊙ **GENERAL:** Former document split into separate Specification and Status Summaries; both available over computer networks.

⊙ **SITES:** "Northeast" site selected; Hawaiian site moved (back) to Mauna Kea; new "final" station codes (superseding Memos 626 and 627); precise coordinates for almost all stations; revised construction order; new availability target dates.

⊙ **FREQUENCIES:** Receiver noise temperatures now (generally) measured rather than predicted; HEMT amplifiers now used in all receivers above 1 GHz, with SIS option at 43 GHz.

⊙ **SIGNALS:** Sample rates extended down to 0.5 Msmp/s; bitstream:track multiplexing extended to 4:1 and 2:1; fewer passes per tape; longer duration per pass.

⊙ **CORRELATOR:** Extensive changes in specifications arising from exploitation of 'FX' architecture and practical design of fringe delay and phase tracking.

VLBA SPECIFICATION SUMMARY

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INTRODUCTION

This document summarizes the essential specifications of the Very Long Baseline Array (VLBA) project in a concise list for quick reference. It is compiled from the much more detailed "VLBA Book", and various general and specialized Array memoranda, which should be consulted for definitive information. For the sake of brevity, however, no references are given.

Progress in construction of the Array is outlined in a companion report, the VLBA Status Summary, which is kept current through frequent updates.

Both documents are maintained in plain ASCII text in NRAO's computer network, in directory 6654::UMA3:[VLBA] under file names SPECS. and STATUS., respectively. They are also available from the VLBI-SERVER bulletin board on node DEIMOS at Caltech, as VLBA-SPECS and VLBA-STATUS.

SITES

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Code	Location *1*	N Latitude [o, ', "]	W Longitude [o, ', "]	Elev. [m]	Avail- able
PT	Pie Town, NM	34 18 03.61	108 07 07.24	2371	88/5
KP	Kitt Peak, AZ	31 57 22.39	111 36 42.26	1916	89/4
LA	Los Alamos, NM	35 46 30.33	106 14 42.01	1967	90/2
FD	Fort Davis, TX	30 38 05.63	103 56 39.13	1615	91/2
NL	N. Liberty, IA	41 46 17.03	91 34 26.35	241	90/4
OV	Owens Vly., CA	37 13 54.19	118 16 33.98	1207	90/11
BR	Brewster, WA	48 07 52.80	119 40 55.34	255	90/8
SC	St. Croix, VI	17 45 30.57	64 35 02.61	16	91/6
MK	Mauna Kea, HI	19 48	155 28	3725	91/10
HN	Hancock, NH	42 56 00.96	71 59 11.60	309	92/3

Note: *1* Listed in planned order of construction.

ANTENNAS

Main Reflector --

Diameter 25 m
f/D 0.354
Surface Shaped figure of revolution
Accuracy (see below)

Cassegrain Reflector *1* --

Diameter 3.5 m
Surface Shaped asymmetric figure
Accuracy 0.150 mm

Structure --

Type Wheel-and-track, with advanced-design reflector support structure.
Elevation Motion 0 -> 125 deg; 30 deg/min
Azimuth Motion -90 -> +450 deg; 90 deg/min

Operating Conditions:

	Precision	"Normal"	Survival
Temperature [C]	-18 -> +32	-30 -> +40	
Temp. Change [C/hr]	2	--	
Temp. Diff'l. [C]	3.5 *2*	--	
Wind [m/s]	6	18	50
Gusts [m/s]	1	2.5	
Rain [cm/hr]	None	5	
Snow or Ice	None	None	20 psf, OR 1 cm

Accuracy --

Main Surface (panel manufacturing RSS)		0.125 mm
Main Surface (total RSS)	*3* *4*	0.282 mm
Pointing (repeatable)	*4*	3'
Pointing (non-rep., short term)	*4*	8"
Pointing (non-rep., long term)	*4*	14"

Notes: *1* Not used for all bands; see "Frequencies".
2 This condition to be met for 95% of observations.
3 See "Frequencies" for corresponding aperture efficiencies.
4 Under precision operating conditions.

FREQUENCIES

Band Designation *1*	Frequency Range [GHz]	Aperture Efficiency *2*	Noise Temp. [K] *3*	Rcvr. System
330 P	.312 - .342	.50	30	104
610	.580 - .640	.49	30	64
1.5 L *4*	1.35 - 1.75	.63	7	25
2.3 S	2.15 - 2.35	.70	8	28
4.8 C *4*	4.6 - 5.1	.72	10	25
6.1 *5*	5.9 - 6.4	.72	12	32
8.4 X	8.0 - 8.8	.71	16	37
10.7 *5*	10.2 - 11.2	.71	20	36
15 U	14.4 - 15.4	.69	30	48
23 K *4*	21.7 - 24.1	.66	60	87
43 Q	42.3 - 43.5	.51	90	125
89 W *5*	86? - 92?	.18	?	?

- Notes: *1* MHz/GHz frequency, to 2(+) significant figures; Conventional radio (and VLA) letter codes.
 2 Total aperture efficiency, including all known effects.
 3 Receiver noise temperature based on lab measurements; Estimated system temperature, including all effects.
 4 Initial complement, installed as antenna is completed; All standard VLBA bands except 43 GHz installed at PT.
 5 Optional receivers, not included in basic Array budget. (6.1-GHz receiver would share 4.8-GHz feed; one 10.7-GHz receiver already installed at PT.)

Feeds / Foci --

Below 1 GHz: Crossed dipoles / Prime focus
 Above 1 GHz: Corrugated horn / Cassegrain focus;
 Compact corrugated horn at L-band.

Amplifier Types --

Below 1 GHz: Ambient-temperature GaAsFET amplifiers.
 Above 1 GHz: Cooled (15K) HEMT amplifiers (43 GHz may possibly be SIS Mixer at 3.5K).

Dual-Frequency Pairs --

Planned: S/X bands.
 Options: C/U, C/K, U/Q, U/W bands.

SIGNALS

IF Processing --	
Number of IFs	4
IF Frequency Range	500 - 1000 MHz
Baseband Conversion --	
Number of Converters	8 (expandable to 16)
Number of Channels	16 -- USB and LSB from each converter
Bandwidths	16, 8, 4, 2, 1, .5, .25, .125, .0625 MHz
LO Quantization	10 kHz
Aggregate Bandwidth	256 MHz
Sampling --	
Number of Samplers	16
Sample Rates	32, 16, 8, 4, 2, 1, 0.5 Msamp/s
Level Quantization	2 or 4 levels
Aggregate Data Rates	512 Msamp/s, 1024 Mbit/s *1*
Formatting --	
Number of Bitstreams	32
Multiplexing	4:1, 2:1, 1:1, 1:2, 1:4 bitstream:track
Format	Programmable, including Mark 3
Framing	Transparent or data-replacement
Aggregate Bit Rate	512 Mbit/s (expandable to 1024 Mbit/s)
Recording --	
Number of Data Tracks	64 (expandable to 128) -- on 2 recorders
Record Rate per Track	8, 4, 2 Mbit/s (plus 9/8 parity) *2*
Duration per Pass	1 hour *2*
Passes per Tape	16
Duration per Tape	16 hours *2*
Capacity per Tape	7.37 Tbit
Aggregate Bit Rates	128 Mbit/s sustainable *2* 512 Mbit/s peak

- Notes: *1* Maximum aggregate bandwidth/sampling capacity cannot be formatted or recorded without expansion.
2 Durations refer to "sustainable" 4 Mbit/s track record rate which allows unattended operation for 24-hour period.

CORRELATOR

Basic Dimensions --

Stations	s = (10), (15), 20	*1* *2*
Channels	c = 1, 2, 4, 8	
Spectral Points	l = 32, 64, 128, 256, 512, 1024	*3*

Other Capabilities --

Oversampled Input Data	f = 1, 2, 4, ...	
Interleaving	n = 1, 2 (n <= f)	
Overlapping	v = 1, 2, 4, ...	
Interpolation	z = 1, 2	
Polarization	p = 1 (Normal), 2 (Polarized)	*3*
Polarized Resol'n Factor	y = 1, EXCEPT p=2 & l=256 ==> y = 2	

Mode Limits --

"F" (FFT section)	s c n v z y / f <= 160	*1*
"X" (XMult/Acc section)	s (s+1) c p l / 2 <= 262,144	*2*

Timing --

Sample Rate	32, 16, 8, 4, 2 Msamp/s
Speedup Factor	1, 2, 4 -- constant, full-speed playback
Integration Time Quantum	131.072 ms
Integration Time, max.	134 s
Archive Data Rate	0.5 Mbyte/s, maximum

Tracking --

Delay Range	Unlimited, via playback offset
Delay Switching Range	6000 samples
Coarse Delay Rate Range	+/- 50 sample/s
Fine Delay Range	+/- 1/2 sample
Fine Delay Accuracy	0.001 sample
Phase Accuracy	0.002 turn
Fringe Rate Range	Unlimited (+/- full bandwidth)
Fringe Acceleration Range	+/- 10.4 Hz/s

Pulsar Gate --

Gate Profile	Arbitrary
Pulse Phase Resolution	1024 points/period
Pulse Timing Resolution	Equal to FFT length

Simultaneous Correlation --

Sub-Arrays	10
Switched Models	> 8
Switching Interval Quantum	100 ms

Notes: *1* For "F" mode limits, s = 10, 20 only.
 2 For "X" mode limits, s = 15, 20 only.
 3 l <= 256 for polarized correlation (p = 2).