3 SYSTEM INTEGRATION

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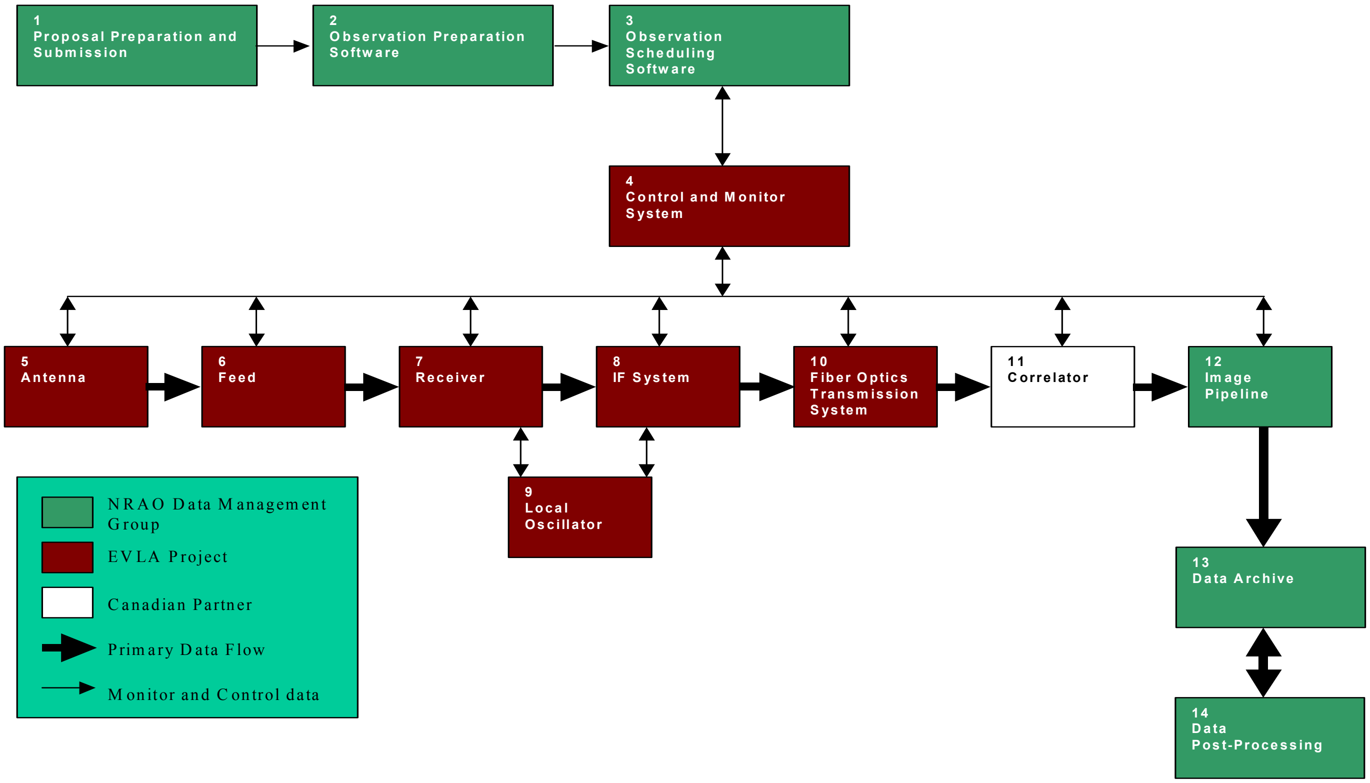
Revision History
2001-Sep 04: Initial release
2001-Sep 27: Changed LO/IF Frequencies
2001-Oct 16: Numerous Revisions
2001-Nov 3: Added RFI text
2001-Nov 8: Added Software Sections
2001-Nov 15: Updated 2nd LO synthesizer Spec
2001-Nov 26: Added Subsystem Diagram, modified order of some headings

Summary

3.1 Introduction

In this chapter we present a summary of the performance, engineering and test specifications for the EVLA project. Figure 3-1 shows the principal subsystems of the EVLA.

Figure 3-1 Principal EVLA Subsystems



3.2 Specifications and Requirements

3.2.1 Antennas

The EVLA re-utilizes the existing twenty-eight E-Systems 25-meter parabolic antennas that make up the current VLA system. Modifications are made as necessary to support the new feeds, front ends, electronics and fiber optics systems.

3.2.2 Frequency and Polarization Coverage / Receiver Specifications

The EVLA system is designed for complete frequency coverage between 1 and 50GHz. Both Left and Right Hand Circular Polarizations are available ever this entire frequency range. In addition, the EVLA system continues to support the existing 74 MHz and P-Band capabilities of the VLA. The following table shows the operational frequency bands along with the Tsys, Efficiency, and polarizations of each band.

VLA Band	Freq	Freq. Range	Tsys (K)	Eff	Polarization
4	74 MHz	73.5-74.5 MHz	1000-10000		RHCP/LHCP
P	327 MHz	300-340 MHz	150-180		RHCP/LHCP
L	1.5 GHz	1.2 – 2.0 GHz	26	0.50	RHCP/LHCP
S	3.0 GHz	2.0 – 4.0 GHz	29	0.62	RHCP/LHCP
C	6.0 GHz	4.0 – 8.0 GHz	31	0.60	RHCP/LHCP
X	10.0 GHz	8.0 – 12.0 GHz	34	0.56	RHCP/LHCP
U	15.0 GHz	12.0 – 18.0 GHz	39	0.54	RHCP/LHCP
K	22.0 GHz	18.0 – 26.5 GHz	54	0.51	RHCP/LHCP
Ka	33.0 GHz	26.5 – 40.0 GHz	45	0.39	RHCP/LHCP
Q	43.0 GHz	40.0 – 50.0 GHz	66	0.34	RHCP/LHCP

3.2.3 System Temperatures

The spreadsheet on the following page shows calculations for estimated system temperatures**. This data will be updated with new estimated receiver temperatures shortly. It will be available at the EVLA system PDR on 4-5 December 2001.**

Figure 3-2 Systems temperatures

System Temperature Calculations

		Unvarying					Galactic and 3°bb (corrected for absorbtion)					Atmospheric Emission			T_{sys} (corrected for atmospheric absorbtion)		
υ_g	BAND	T_{amp}	T_{loss}	T_{cal}	T_{spill}	T_o	T_{gal}	T_{bb}	T_{bg}	τ	$T_{bg}e^{-\tau}$	T_{atm}	$1-e^{-\tau}$	$T_{atm}(1-e^{-\tau})$	Σ_T	e^{τ}	T_{sys}
0.075	U6					50	1200	3	1203	0.008	1193	280	0.008	1242	5	1.008	1252
0.150	U5					50	200	3	203	0.008	201	280	0.008	2	253	1.008	255
0.240	U4					50	65	3	68	0.008	67	280	0.008	2	134	1.008	135
0.370	U3					40	25	3	28	0.008	28	280	0.008	2		1.008	70
0.550	U2					30	9	3	12	0.008	12	280	0.008	2		1.008	46
0.825	U1					20	3	3	6	0.008	6	280	0.008	2		1.008	28
1.000	L	2		2	11	20	1	3	4	0.008	5	280	0.008	2	28	1.008	27
1.450	L	2		2	11	20	0	3	3	0.008	4	280	0.008	2	28	1.008	26
3.000	S	3		2	8	23	0	3	3	0.009	3	280	0.009	3	29	1.009	29
6.000	C	5		2	6	25	0	3	3	0.010	3	280	0.010	3	31	1.010	31
10.000	X	8		2	5	28	0	3	3	0.012	3	280	0.012	3	34	1.012	34
15.000	Ku	10		3	5	30	0	3	3	0.017	3	280	0.017	5	38	1.017	39
22.000	K	10		4	4	30	0	3	3	0.065	3	280	0.063	18	51	1.067	54
34.000	Ka	14		3	4	35	0	3	3	0.020	3	280	0.020	6	44	1.020	45
45.000	Q	18		4	4	40	0	3	3	0.070	3	280	0.068	19	62	1.070	66
49.000	Q	18		4	4	40	0	3	3	0.250	3	280	0.221	62	105	1.250	131
80.000	W	32		8	3	60	0	3	3	0.200	2	280	0.181	51	113	1.220	138

T_{amp} = Amplifier Temperature

T_{loss} = Loss from Polarizer, Horn, Waveguide, Etc..

T_{cal} = Injected Cal Signal

T_{spill} = Ground Radiation Scattered into Feed

Assumptions:

- > Elevation = 90°
- > Coldest Part of Galaxy
- > Dryest Typical Atmosphere
- > Winter Temperatures

$$T_{sys} = T_o + T_{bg}e^{-\tau secz} + T_{atm}(1-e^{-\tau secz})]\ e^{\tau secz}$$

3.2.4 Tuning Capabilities / LO-IF System Specifications

The EVLA system has the ability to tune two different frequency/polarization pairs anywhere within one, or two, frequency bands, with each pair providing up to 4 GHz of bandwidth in each polarization – a maximum total bandwidth of 16 GHz. In addition, the Local Oscillator system has the flexibility to function with both the new EVLA front ends and the existing VLA front ends.

Sky Frequencies and Sub-Bands

Sky Frequency Band:	1.2-2	2-4	4-8	8-12	12-18	18-26	26-40	40-50
Feed:	L	S	C	X	Ku	K	Ka	Q
Delta F:	1	2	4	4	6	8	14	10
Bandwidth of Sub Band:	1	2	4	4	4	4	4	4
Number of Sub-Bands:	2	2	2	2	2	2	2	2

1'st Local Oscillator and Downconversion Stage

1st LO Synthesizer	13	13	16	N/A	12-13	15-18	12-16	17-20
Multiplier	1	1	1	N/A	2	2	3	3
Actual 1st LO	13	13	16	N/A	24-26	30-36	36-48	51-60
Step Size (MHz)	512 +/- F_{fts}	512 +/- F_{fts}	512 +/- F_{fts}	N/A	1024 +/- $2F_{fts}$	1024 +/- $2F_{fts}$	1536 +/- $3F_{fts}$	1536 +/- $3F_{fts}$
IF-1	11-10	10-8	12-8	8-12	12-8	12-8	12-8	12-8

2'nd Local Oscillator and Downconversion Stage

LO-2 (Synthesizer)	14.8	14.55	14-14.8	10.8-14.8	10.8-14.8	10.8-14.8	14.8-10.8	12-14
Step Size (MHz)	128 +/- F_{fts}	128 +/- F_{fts}	128 +/- F_{fts}	128 +/- F_{fts}	128 +/- F_{fts}	128 +/- F_{fts}	128 +/- F_{fts}	128 +/- F_{fts}
IF-2	2-3	2-4	2-4	2-4	2-4	2-4	2-4	2-4

(All Frequencies in GHz)

Four independently tuneable 2nd LO synthesizers are used allowing greater tuning flexibility.

4-Band and P-Band capabilities continue to exist in the EVLA. These capabilities are the same as the current VLA bands except they can utilize the 8 bit samplers. These bands are upconverted to L-Band and processed thru the same IF chain. They can be used independently, together or in conjunction with any other frequency band.

An additional 4.096 GHz fixed LO and conversion can be switched into each downconverter channel when using the higher resolution, lower bandwidth samplers. This LO is also used during the transition period. During the transition the existing VLA Correlator requires Fringe rotation and in the final system, the WIDAR EVLA Correlator requires frequency offsets. These functions, along with the finer tuning steps, are provided by the Fine Tuning Synthesizers in the first and second LO synthesizers.

3.2.4.1 Local Oscillator Specifications

1st LO Synthesizer: 12-20 GHz, Steps: Nx512 +/- $F_{\text{FINE TUNING SYNTHESIZER}}$
2nd LO Synthesizer: 10.8-14.8 GHz, Steps: Nx128 +/- $F_{\text{FINE TUNING SYNTHESIZER}}$
Fine Tuning Synthesizer: Direct Digital Synthesizer, F_{CENTER} and F_{RANGE} TBD

Detailed designs and specifications of both main LO synthesizers and the Fine Tuning Synthesizer are described in detail in Chapter 6.

3.2.4.2 Downconverter Stage

All receiving bands in the EVLA are converted to X-Band by some combination of their respective front ends and/or two up-converter modules - one 4/P-Band to L-Band and the other L/S/C-Band to X-Band.

In each antenna there are four main X-Band IF down converter modules, each driven by an independent LO synthesizer. Each has a single 4 GHz wide input that is split into two IFs. These IFs are each up to 2 GHz wide and are in the passband from 2 to 4 GHz. An alternate passband is provided for low bandwidth signals that may require higher resolution digitizers.

The two IF outputs from each of the four downconverters are harmonic sampled by a pair of 3-bit 4 Gsps digitizers. Alternatively, a single IF from each downconverter is digitized by an 8-bit 2Gsps digitizer. It is also possible to use a mixture 3-bit and 8-bit digitizers – the only limitation being that each downconverter can drive only one type of digitizer at a time.

The input and output noise power spectral distribution is nominally flat over the passband. The down converter module provides for total power measurement of each split IF as well as the total IF. Internal filters and external filter connections are provided to either narrow the desired passband or notch out undesired areas within the passband.

3.2.5 Digitizers

The EVLA system digitizes data in the antenna vertex room. Data is sampled by high speed Analog to Digital (A/D) converters. Two sets of converters are available to users. The first is a wide bandwidth device with lower bit resolution that is used for most observing modes of the EVLA. Current plans call for the use of the 4 Gsps 3-bit devices currently being developed for ALMA. The second is a narrower bandwidth device with higher bit resolution that is used for observing in bands with higher levels of Radio Frequency Interference (RFI). Current plans call for the use of an 8-bit 2 giga-sample per second device made up of one or two commercial A/D converters.

During the transition period, this narrow bandwidth 8-bit digitizer is also used to provide compatibility between antennas with the new electronics and the existing VLA Correlator. The IF signal is filtered to a bandwidth of 1GHz, digitized, and transmitted to the CEB over fiber as a digital signal. In the CEB, the data is filtered using digital FIR filters, decimated, spectrally inverted (in the digital domain) if required, then converted back to analog using a D/A converter. This analog signal is then fed into the VLA Correlator using the existing VLA Baseband electronics and samplers.

3.2.5.1 Wideband Digitizer Specifications

The EVLA system has wideband digitizers to be used in normal operation of most frequency bands. These digitizers have the following specifications:

Sampling Rate: 4.096Gsps
Bit resolution: 3 bits
Quantization Levels: 8 levels

Aperture Time: ~50 ps
Jitter: a few ps
Threshold Indecision Region: a few mv
Analog Band width: >4GHz
Sampling Bands: Baseband 0-2 GHz, Passband: 2-4 GHz
Output Demultiplexing: 1:16
Output Data Word Width/Rate: 48(16x3)bits / 256 MHz
Output Logic: Low Voltage Differential Signaling (LVDS)

The EVLA system is currently planning to use the 3-bit samplers being designed for the ALMA project. The specifications above are the current published goals for the ALMA devices.

3.2.5.2 Narrow Band Digitizer Specifications

Sampling Rate: 2.048 Gsps
Bit resolution: 8 bits
Quantization Levels: 256
Aperture Time: TBD (~50 ps ?)
Jitter: TBD (a few ps ?)
Threshold Indecision Region: TBD (a few mv?)
Analog Bandwidth: >2 GHz
Sampling Bands: Baseband 0-1GHz, Passband: 1-2 GHz
Output Demultiplexing: 1:8
Output Data Word Width/Rate: 64(8x8) bits / 256 MHz
Output Logic Levels: Low Voltage Differential Signaling (LVDS)

The EVLA system is being designed for the sampler specified above but currently, the best device available is a 1.5 Gsps, 8-bit device from Maxim. Two of these devices running at 1.024 Gsps can be multiplexed to form a single unit running at 2.048 Gsps. Tests and simulations are being run to test the validity of this idea.

3.2.6 External RFI

The EVLA system is being designed to operate in the presence of ever increasing levels of Radio Frequency Interference. The design of the Widar Correlator, as well as the use of three and eight bit quantization in the digitizers plays a major roll in the systems immunity to external RFI. A Further discussion of RFI is located in section 3.8

3.2.7 Self Generated RFI

The EVLA system is also susceptible to RFI generated on site and within the EVLA's own systems. Sources of this RFI include:

- High speed digital electronics in the antenna pedestal and vertex rooms
- The LO/Reference systems in the EVLA antennas and central building
- High speed computers and networks covering the entire VLA site
- High speed digital electronics in the existing and new correlators
- Electronics systems in the ALMA test interferometer
- Site 2-way radio communications.

All of these systems must be built and tested to minimize RFI emission levels.

3.2.8 Monitor and Control

The Monitor and Control (M&C) system of the EVLA is based entirely on a TCP/IP based Ethernet. Fiber based Gigabit Ethernet is being used for the antenna field and major computer systems. A combination of fiber and shielded twisted pair based 100 megabit Ethernet is used in the antenna electronics systems and between some computing systems in the CEB.

3.2.9 Correlator

The WIDAR Correlator being built in Canada for the EVLA is designed to the following specifications:

- In wideband mode, provide 16384 spectral channels across 16Ghz of total Bandwidth (consisting of 8 x 2 GHz analog bands) on every baseline. The number of bands used and number of spectral channels per band is flexible.
- In narrowband modes (e.g. many programmable 8 MHz bands), provide up to 0.25 million spectral channels per baseline. Mixed narrowband and wideband modes are possible.
- Provide 1 Hz spectral resolution in narrowband radar mode.
- Simultaneous, fully digital, phased-VLA operation for VLBI.
- Spectral dynamic range > 105 even in the presence of powerful narrowband signals.
- Digital Filters to eliminate costly narrowband analog filters from the antenna electronics
- Multiple sub array-capabilities
- 32 station capability (installed racks for 40, expandable to 256)
- Pulsars: fast (<100 usec) phase binning, >1000 bins

3.2.10 Computing Systems

In order to provide facilities expected of a modern astronomical instrument, there will be completely new computer systems. An “end-to-end” implementation philosophy will track observations from proposal to archive. At the completion of an observation, the archive will include proposal cover sheets, telescope schedules, observation status information, the observed data, an automatically generated ``reference image," and information entered during the data reduction.

3.2.10.1 Computer System Requirements

More sophisticated scheduling algorithms will be needed to allocate observations based on prevailing weather and interference conditions. Observations will be initiated and tracked by a modern Monitor and Control (M&C) system. In particular, the M&C system will have the task of configuring the correlator and directing the output into a data pipeline.

In order to produce images and spectra from observations as soon as they are taken, the correlated data will be passed though an image pipeline. The pipeline will calibrate and image the data using canned procedures. The procedures will contain heuristic methods driven by the goal-oriented descriptions of the observation supplied by the observer. A Data archive will be an integral part of the pipeline.

The requirements for proposal handling, data analysis, and archiving are being developed by the Data Management End-to-End (E2E) group. These are being developed in the E2E project book. See, for example, the requirements sections in:

http://www.nrao.edu/e2e/documents/e2eprojectbook.pdf

The scientific requirements of the monitor and control system can be found in Benson, J. & Owen, F., “Scientific Requirements for the EVLA Real-Time System,” EVLA Memo 15, 2000.

http://www.aoc.nrao.edu/doc/vla/EVLA/Memos/Sci_Req.ps

M&C requirements for the use by operations and electronics are being separately developed. The initial operational requirements may be found at:

http://www.aoc.nrao.edu/vla/EVLA/Computing/WorkingDocs/index.shtml

3.2.10.2 Monitor and Control

The M&C System will provide a complete and well-integrated tool suite to test, control, monitor, maintain, and calibrate the instrument. It will provide facilities for use by observers, by operations staff, and by scientific, computing, and engineering support personnel. It will be a distributed computing architecture. It will be possible to monitor and control all hardware from a remote location via an authorized, secure network connection. Where possible, the system will use commercial, off-the-shelf (COTS) equipment. The main network infrastructure will be TCP/IP over Ethernet, using single mode fiber to the antennas. It is extremely desirable to reduce the radio frequency interference (RFI) in the antennas themselves, so fiber will also be used there if cost permits.

3.2.10.3 Data Processing

AIPS++ will provide the software necessary to reduce all data from the EVLA. AIPS++ already contains a complete suite of applications for reduction of radio aperture synthesis data, including editing, calibration, image, image enhancement, and displays of image and all intermediate products. This will be the environment in which development of new processing techniques will be done, including, for example, bandwidth synthesis.

A detailed analysis of the scope and nature of data processing that will be needed by deployment of the full EVLA shows that there will be a spectrum of data processing needs. With reasonable predictions for the growth in the computer industry (e.g., Moore's Law continuing to the end of the project in 2009 - see [1] and references therein), we expect to be able to process the data from the most demanding observations with the EVLA using a moderately parallel cluster for reasonable costs. Many more typical observations will be entirely processable using a desktop computer.

The numerically intensive parts of AIPS++ are able to take advantage of parallel and distributed computing environments in order to support the data processing requirements of the EVLA. A collaboration between NCSA and NRAO has led to AIPS++ parallel codes for the most demanding parts of synthesis data reduction: spectral line imaging, wide-field imaging, and mosaicing.

3.2.10.4 Image Pipeline

In order to produce images and spectra from observations as soon as they are taken, the correlated data will be passed though an image pipeline. The procedures will contain heuristic methods driven by the descriptions of the observation supplied by the observer. The heuristic methods will make use of the status information about all EVLA components to provide a “reference image” from the data. For many observations, this will be sufficient for use by the observer, or at the very least will serve as a starting point for subsequent additional processing by the observer. The pipeline will be implemented using the extensive scripting and synthesis data reduction capabilities of the AIPS++ package. The development of pipeline processing is also being developed for other NRAO telescopes.

3.2.10.5 Data Archive

In the majority of cases, the reference image produced by the pipeline and stored in the archive will constitute a scientific result that does not require further data reduction. After an observation has been stored in the archive, it will be possible to retrieve the data to apply data post- processing tools to the data in the archive to produce additional scientific results. It will be possible to treat the data in the archive as if it were being provided by the telescope in real-time. All data that affect the production of scientific data products are to be archived along with the visibilities. The analysis of EVLA computing needs estimates that typically the average data rate from the EVLA will be from 50 to 100 Terabytes per year. Although this is very large by today's standards, we expect that at the end of construction, the cost of such storage will be in the range \$50k to \$100k per year. It is likely that the data will be stored in a heterogeneous array of computers, rather than on a single, large computer. The design and implementation of the archive will be leveraged on other efforts presently in place (e.g., HST, IPAC, Sloan) and in development (the National Virtual Observatory) in the wider astronomical community. If appropriate, the archive will be out-sourced to an organization that already serves large databases to the community. The archive will enable EVLA results to be used (after the usual proprietary period) in the National Virtual Observatory initiative, thus enhancing the scientific impact of the array. This work is also being developed for other NRAO telescopes.

3.2.10.6 Software Practices

The AIPS++ group, which will provide the underpinning for the pipeline data processing, has good professional practices that we will use as a model for all software developed for the EVLA. These include peer review of newly submitted code, a test procedure for each class submitted to the libraries, weekly discussions, weekly targets and reports for all engineers, periodic and fixed release dates, etc.

Software will be developed and requirements refined periodically based on operational experience.

3.2.10.7 Standards

When the overall requirements are complete, we will decide on the necessary platforms, tools, and standards to implement the software. This will not be until after the computing PDRs.

3.2.10.8 Data Requirements

Special attention must be paid to the data integrity throughout the system. The data must be adequately sampled and keyed so that assembling a complete data stream (observing request parameters, observed parameters, correlation fragments, etc.) is available without undue complexity and delay, especially for pipeline processing and archiving.

3.3 System Block Diagrams

The following Block Diagrams are available on-line as PDF and MS-Visio files.

3.3.1 Antenna System Diagram

To be included in a future edition

3.3.2 Antenna RF/LO/IF Electronics

Antenna Block Diagram

3.3.3 CEB LO/IF Electronics

CEB Block Diagram

3.3.4 Correlator

Please refer to Figure 8-2

3.3.5 Monitor Control System

Please refer to Figure 3-1

3.3.6 Computing System

Please refer to Figure 3-1

3.4 Acceptance Testing

3.4.1 Test Definition

TBD

3.4.2 Test Procedure Development

TBD

3.4.3 System Testing

TBD

3.4.4 Test Result Documentation & Reporting

TBD

3.5 Hardware Development

With the exception of the Correlator, the vast majority of the EVLA electronics hardware is being developed in the labs at the NRAO Array Operation Center in Socorro, New Mexico. The NRAO/AOC labs are set up to:

- Construct prototypes for all EVLA hardware.
- Manufacture low-volume production components.
- Repair and maintain EVLA components for the life of the system.

To accomplish this, substantial investments are being made in Computer Aided Design / Computer Assisted Engineering (CAD/CAE) software, modern analog and digital test equipment, surface mount soldering equipment and the personnel training. Manufacture of bare printed circuit boards and larger volume production components is outsourced to contractors in the United States, Canada and Mexico.

3.5.1 Test and Laboratory Equipment

Due to the greatly enhanced requirements of the EVLA electronics, advanced test and laboratory equipment is required for the development and maintenance of the EVLA hardware over the life of the system. The following table shows the equipment required for the EVLA.

Equipment	Systems	Purchase/Existing
High Speed Digital Scope (2.5GHz)	DTS, LO/IF, Digitizers, Correlator	E (Pie Town Link)
Digital Scopes (min 500 MHz BW)	DTS, LO/IF, Front Ends, Systems, M&C	P
Optical Spectrum Analyzer	DTS, LO/IF	E (Pie Town Link)
Microwave Spectrum Analyzers (x)	LO/IF, RFI, Digitizers, Front Ends	P
Vector Network Analyzer	LO/IF, Front Ends, DTS, RFI	P
OC192 Communication Analyzer	DTS	E (ALMA)
High Speed Logic Analyzer	DTS, Digitizers, M&C	E (ALMA)
Phase Noise Test Set	LO/IF	E (VLA/VLBA)
Signal Generators (x)	LO/IF, Front Ends, DTS	

3.5.2 Engineering Design and Test Software

Design, development and testing of EVLA hardware is being performed largely using commercially available software packages. These include (but are not limited too):

Microsoft Visio 2002 or AutoCad 2000i (or later) for Block diagrams and other system documentation.

Protel 99SE (or later) or OrCad v9.1 (or later) for schematic and PCB design,

Xilinx Foundation-Classic or Foundation-ISE v 4.1 (or later) for FPGA and CPLD development.

AutoCad 2000i (or later) for mechanical designs.

LabView 6.0i (or later) for bench testing and integration, as well as for test fixtures to be used for maintenance over the life of the EVLA system.

3.5.3 Hardware Design Standards

3.5.3.1 Units and measurements:

All units and measurements in the EVLA systems are imperial to maintain compatibility with existing VLA standards

3.5.3.2 VLA Electronics Rack, Bin, Module, and Connector Numbering System

A numbering system based on the existing VLA system is used to identify EVLA racks, bins, modules and connectors. This numbering system is defined in EVLA specification number A23010N0001.

3.5.3.3 Expanded VLA Drafting Numbering System

The Expanded VLA Drafting number in system is outlined in EVLA specification number A23010N0002. The numbering system(s) described in this document is used for all work in the NRAO Electronics Division, Computing Division and Central Development Lab (CDL). In addition, it is used for all NRC/DRAO based EVLA work.

The NRAO Engineering Services division is continuing the use of their current numbering system, originally defined by the VLA antenna vendor.

3.5.4 Hardware Environmental Requirements

3.5.4.1 Antenna Vertex Room Electronics

These specifications are for survivability. Individual modules or components may have tighter requirements to maintain certain operational specifications (gain, phase stability, etc..). These additional requirements are listed with the applicable equipment

Operating Temperature:	0 to +50 C
Storage Temperature:	-20 to +70 C
Humidity:	0 to 95% non-condensing
Altitude:	7200 ft AMSL
Operational Orientation:	Any position *
Storage Orientation:	Any Position
Shock:	TBD G
Vibration:	TBD G
ESD Protection	?

* Modules may have to remain at a fixed position relative to the rack/bin for cooling purposes.

3.5.4.2 Antenna Pedestal Room Electronics

These specifications are for survivability. Individual modules or components may have tighter requirements to maintain certain operational specifications (gain, phase stability, etc..). These additional requirements are listed with the applicable equipment

Operating Temperature:	0 to +50 C
Storage Temperature:	-20 to +70 C
Humidity:	0 to 95% non-condensing
Altitude:	7200 ft AMSL
Operational Orientation:	Upright
Storage Orientation:	Any Position
Shock:	TBD G
Vibration:	TBD G
ESD Protection	?

3.5.4.3 Antenna Apex Electronics

These specifications are for survivability. Individual modules or components may have tighter requirements to maintain certain operational specifications (gain, phase stability, etc..). These additional requirements are listed with the applicable equipment

Operating Temperature:	-20 to +70 C

Storage Temperature: -20 to +70 C

Humidity: 0 to 100% condensing
Altitude: 7200 ft AMSL
Operational Orientation: Any position
Storage Orientation: Any Position
Shock: TBD G
Vibration: TBD G
ESD Protection ?

3.5.4.1 Control Building Electronics

These specifications are for survivability. Individual modules or components may have tighter requirements to maintain certain operational specifications (gain, phase stability, etc..). These additional requirements are listed with the applicable equipment

Operating Temperature: 0 to +50 C
Storage Temperature: -20 to +70 C
Humidity: 0 to 70% non-condensing
Altitude: 7200 ft AMSL
Operational Orientation: Upright
Storage Orientation: Any Position
Shock: N/A
Vibration: N/A

3.5.5 Antenna Racks, Bins and Modules

The EVLA uses a modified version of the VLA antenna rack, bin and module specifications. This allows reuse of racks and some system components, particularly during the transition period. It also allows for the cannibalization of some existing system hardware to reuse costly, machined custom hardware.

These specifications are modified as necessary to meet RFI/EMC and cooling requirements of the new EVLA electronics system. The connectors are being updated to eliminate obsolete, hard-to-find or excessively expensive components.

3.5.6 CEB Racks, Bins and Modules

The EVLA uses a modified version of the VLA rack, bin and module specifications for the LO systems in the Central Electronics Building. This is done to allow reuse of racks and some system components, particularly during the transition period. It also allows for the cannibalization of some existing system hardware to reuse costly, machined custom hardware.

These specifications are modified as necessary to meet RFI/EMC and cooling requirements of the new EVLA electronics system. The connectors are being updated to eliminate obsolete, hard-to-find or excessively expensive components.

The Correlator, Fiber Optic and Computing systems are using completely new hardware.

3.6 System Software Development

3.6.1 Software Design Standards
To be included in a future edition

3.6.2 Computing Platform(s)
To be included in a future edition

3.6.3 Computer/Network Security
To be included in a future edition

3.7 System Power Supplies

3.7.1 Antenna Electronics Systems
Antenna Vertex room, Pedestal Room and Apex electronics are powered from N+1 redundant 48 Volt DC power supplies. Final voltage regulation occurs at the module or bin level. Final regulators can be linear type devices, switching (PWM) type devices, or a combination of the two depending on RFI and thermal requirements. As an option, backup power is provided for by the addition of 48 Volt DC Gel Cell type batteries. Commercial equipment such as computers, networking equipment and test equipment can be powered from 120VAC commercial power. Computers, network routers, voice communication equipment and any alarm/safety related equipment is provided with battery backup for (TBD) minutes of operation in the event of a power failure.

3.7.2 CEB Electronics Systems
LO/IF electronics in the Central Electronics building are powered from N+1 redundant 48 Volt DC power supplies. Final voltage regulation occurs at the module or bin level. Final regulators can be linear type devices, switching (PWM) type devices, or a combination of the two depending on RFI and thermal requirements. As an option, backup power is provided for by the addition of 48 Volt DC Gel Cell type batteries. Commercial equipment in the LO/IF racks such as computers, networking equipment and test equipment can be powered from 120VAC commercial power.

The Hydrogen MASER and other critical time standard devices are to have battery backup for (TBD) minutes of operation in the event of a power failure.

3.7.3 Correlator
The correlator and digital IF fiber optic receiver systems are powered by a high capacity 48VDC battery system that is continuously fed from the site AC power. This is currently planned to be a packaged system from a commercial vendor. These are common in the telecommunications industry and are readily available as turn-key systems from a number of sources.

3.7.4 Computing and Network Hardware
All computing and networking hardware is operated from the site AC power and utilizes battery backed Uninterruptible Power Supplies (UPS).

3.8 RFI
One of the primary EVLA design criteria is to be able to observe in a hostile environment of radio frequency interference (RFI). The wide bandwidths and frequency tuning range of the EVLA greatly increase our exposure to radio frequency interference (RFI). The centimeter wavelength bands are being increasingly filled by wireless communication: cell phones, pagers, aeronautical navigation and traffic control, satellite broadcast, and many other

services. Terrain shielding, which for decades helped isolate radio observatories from RFI, is becoming less relevant as interference from broadcast and communication satellites, balloons, and airplanes increases. A modern broad-band radio astronomy system needs to have greater sensitivity and bandwidth to do the new science, but also has to work amidst a growing forest of strong and potentially debilitating artificial signals. The new receivers and transmission system are designed with particular attention to the extra demands imposed by these signals.

3.8.1 Design Goals

Our goal is to design a system that can function with strong man-made signals in the receiver passband and not corrupt visibility measurements due to spurious intermodulation products. To provide the necessary dynamic range to enable handling of strong signals (both man-made and natural, in both the spatial and frequency domains), the entire signal transmission system must be designed with extremely linear response. This goal is accomplished by a layered approach, each layer avoiding or removing RFI which cause non-linearities in the subsequent electronics. This is essential for utilization of the full bandwidth brought from the antennas, and for avoidance of signal compression due to finite dynamic range, which give rise to non-linearities and spurious signals. At the top layer, this is accomplished by using the minimal amount of amplifier gain and careful design for linear response. Signals are then digitized in the antenna with either 3 or 8-bit digitizers, the latter providing a narrower bandwidth, higher dynamic range signal path for improved RFI immunity.

The next layer of RFI mitigation consists of a digital Finite Impulse Response (FIR) filter. This filter is reconfigurable in software by loading tap weights into the filter memory. The FIR filter can be used to place rejection notches or bandpass edges where needed and can be dynamically reconfigured to adjust to a changing RFI environment.

The final layer of RFI excision is in the digital correlator itself. The up to 8-bit sampling of the DRAO WIDAR correlator design provides outstanding immunity to strong RFI -- spectral dynamic ranges in excess of 55 dB are anticipated. The new correlator is designed with high tolerance to strong interfering signals, and has a sufficiently large number of high-resolution frequency channels to permit detailed removal of data contaminated by narrow-band interfering signals.

In addition, total power measurements are available at several places in the system in order to monitor RFI.

3.8.2 Environmental Monitoring System

The purpose of the RFI EMS is to measure the characteristics of externally generated RF signals which are incident on the VLA, and which the EVLA electronics has to tolerate. These characteristics include frequency, power, modulation, time on and off, and direction of incidence. The EMS is to provide calibrated power levels in terms of Power Flux Density (PFD) per various resolution bandwidths, and ultimately operate over 300 MHz-50 GHz.

The current system includes:
Antennae: 1-8 GHz omnidirectional
1-18 GHz directional horn on rotator

Front End: 3 MHz-10 GHz

Signal Path: Operational up to 18 GHz

Receiver: Surplus HP70001A spectrum analyzer operational up to 22 GHz, with narrowest RBW = 10 Hz.

Tower: Antennae and Front End mounted on 54 foot tower at the VLA

3.8.3 System Hardware Emission Testing Facilities

The purpose of the RFI EMC facility is to measure the characteristics of radiated RF signals from electronics equipment designed for the EVLA. The chamber and associated test equipment is to ultimately operate over the 300 MHz- 50 GHz range and measure total power of emissions.

The current system includes:

Facility:	Surplus RF Shielded Chamber stored at Green Bank specified at 100 dB shielding up to 10 GHz.
Front End:	300 MHz-12 GHz amplifiers stored in IPG.
Signal Path:	To be designed.
Receiver:	Surplus HP70001A spectrum analyzer operational up to 22 GHz with narrowest RBW = 10 Hz.

3.9 References

1. Cornwell, T. J., “Computing for EVLA Calibration and Imaging,” VLA Memo 24, 2001
2. Sahr, W. J., Hunt, G. C., & Cornwell, T. J., “The Expanded VLA Project”, ADASS XI, to appear in ASP Conference Series, 2002