VLA-VLBA Interference Protection Memo #35

VLA Site-Generated RFI Control Plan

Dan Mertely and Rick Perley

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Abstract

EVLA RF emissions limits and site building architectural shielding are summarized. Tables of existing or potential site-based RF emitters, and EVLA module and rack shielding are presented. The emissions limits are created from EVLA Memo #106 and Interference Protection Memos 34, the architectural shielding values are estimated from VLA-VLBA Interference Protection Memos 29 and 32, and the emissions and shielding data from documented IPG test data.

1 INTRODUCTION

Radio frequency interference (RFI) generated by electronic devices located at the VLA site has the potential to significantly disrupt current VLA, and future EVLA and LWDA observations. Measures have been in place for over a decade to reduce the effects of emissions from site-based 2-way radios and personal computers via notifications and voluntary, equipment time-of-use limitations by site personnel. However, as digital electronic equipment at the VLA site has proliferated, and new EVLA higher-sensitivity and wider bandwidth observing programs prepare to go on-line, additional RFI control and mitigation measures are now necessary.

2 PURPOSE

The purpose of this VLA Site Generated RFI Control Plan is to:

1) Re-document the detrimental thresholds, and establish RF emission zone limits around the VLA site.
2) Inventory suspected RFI generating equipment currently installed at the VLA site,
3) Describe emissions tests performed or planned for existing equipment,
4) Describe mitigation measures taken or planned for existing equipment,
5) Establish new equipment screening procedures, as well as new equipment limitation guidelines.

3 STATUS

As of the time of the writing of this report (December, 2006), a relatively small number of commercial electronic equipment items, and a large number of EVLA RF and digital modules have been RF emissions tested. In addition, most of the proposed rack and module hardware has been tested in order to quantify shielding effectiveness. Most of these emissions and shielding tests were performed in the EVLA/ALMA shielded chamber, which is located in the north-east corner of the VLA site warehouse. The tests have been performed over the 4 years since the chamber was assembled, by seven different Cooperative Exchange students, as supervised by three different electrical engineers. As a result of this diversity of testers, test procedures were not uniformly executed, and test results are not uniformly documented. Where possible, the original shielding and emissions data has been re-analyzed according to the current conventions before inclusion in this report.

4 REQUIREMENTS

The received power flux density (PFD) limitations for RF emissions have been detailed in-general for radio astronomy observing by A.R. Thompson of NRAO[1], and lately for the EVLA by Rick Perley[2]. The detrimental limits for each observing band follow the 10% of Tsys variation criterion established by Thompson, and incorporated into the ITU R-RA.769 recommendation, and Perley's EVLA series memos 46, 104, and 106. The limits proposed in EVLA Memo #106 attempt to take into account the attenuation provided by fringe rotation when the observing instrument is an interferometer array, observing a source greater than 5 degrees away from the celestial North Pole[3]. Perley's VLA-VLBA Interference memo #34 ("Notes on RFI Management") expands on the detrimental limits of EVLA Memo #106 by defining the detrimental limits in terms of power units (Watts) as captured by an EVLA antenna, per an astronomically significant bandwidth, from an RFI source at a reference distance of 1 m. Table 1, below, which was constructed from equation (9) of EVLA memo #106, and equation (7) of Interference memo #34, details the detrimental power limits for the center of each of the proposed EVLA receiving bands, in a bandwidth (BW) determined by the spectral line width of an astronomical source corresponding to a velocity width of 3 Km/sec. The detrimental power, maximum emission levels for an RFI source at any other distance may be easily calculated by adding the appropriate 20 log10(separation distance) flux spreading factor to the detrimental power limit. From the same interference memo, equation (8) may be used to determine the additional shielding required to reduce emissions from an excessively-strong source to below the detrimental limits at the nearest EVLA antenna.

The Tsys values used for the two, sub-GHz bands are taken from the VLA Observational Status Summary, Table 4[4]. For the bands above 1 GHz, the Tsys is taken from the EVLA Project Book[5], chapter 5, Table 5-1.

Table 1: EVLA Detrimental levels Used
(Within the BW width listed in column 2)

Freq (GHz)	BW (KHz)	Tsys (K)	PFD-detrimental (W/m^2) @ EVLA antenna	dBPFD-detrimental (dBW/m^2) @ EVLA antenna	P-detrimental (EIRP max) (dBW) @ RFI source @ 1 m†
0.0738	0.738	1000	2.81363E-20	-196	-184
0.328	3.28	150	3.70519E-19	-184	-173
1.5	15	26	6.1425E-18	-172	-161
3	30	26	4.914E-17	-163	-152
6	60	26	3.9312E-16	-154	-143
10	100	30	2.1E-15	-147	-136
15	150	37	8.74125E-15	-141	-130
23	230	59	5.02497E-14	-133	-122
34	340	53	1.45818E-13	-128	-117
45	450	74	4.72028E-13	-123	-112

† Assuming isotropic emission ($G_{e,dBi}$, $G_{r,dBi} = 0$) and no shielding ($S_{dB} = 0$). From eq (9) of VLA/VLBA Interference Memo #34, "Notes on RFI Management":

$P_e < -180.6 + 20\,\mathrm{Log10}(r_m) + 30\mathrm{Log10}(\nu_G) + 10\,\mathrm{Log10}(T_{sys}) - G_{e,dBi} - G_{r,dBi} + S_{dB}$ (dBW),

With r_m being the distance between the emitter and antenna in meters,

ν_G being the frequency in GHz,

and T_{sys} the temperature in K.

[1] IEEE Trans. Ant. Prop., AP-30, 450-456, 1982.

[2] EVLA series memos 46, 104, and 106.

[3] EVLA series memo #106, section 5.

[4] http://www.vla.nrao.edu/astro/guides/vlas/current.

[5] http://www.aoc.nrao.edu/evla/pbook.shtml.

5 EMITTER LOCATIONS/ SITE LAYOUT

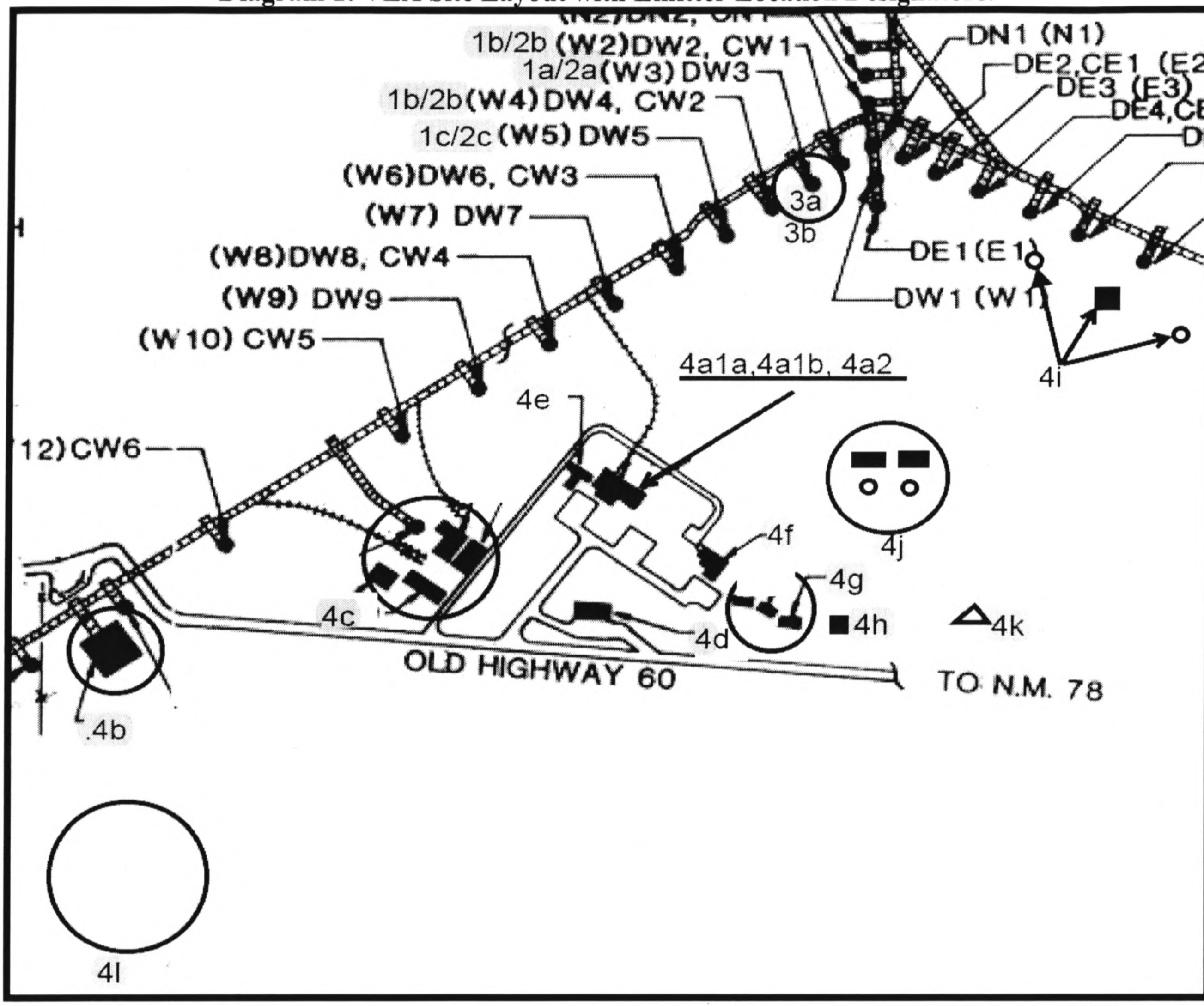
The RFI-generating equipment source locations can be broken down into the following broad categories, as itemized in List 1, and shown on the site layout (Diagram 1) below.

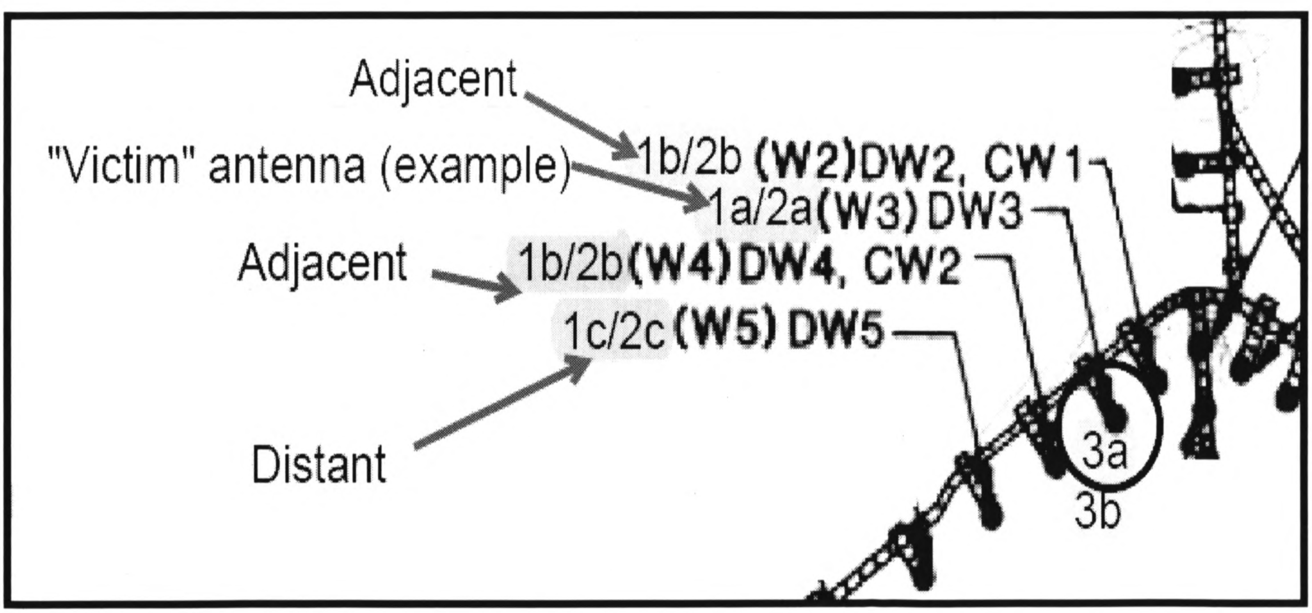
List 1: RF Emitter Location Designators.

1) Antenna vertex room
 1a) Same antenna vertex room
 1b) Adjacent antenna vertex rooms (adjacent pads, D configuration)
 1c) Distant antenna vertex rooms (> 1 pad, or 40m away[6])
2) Antenna Pedestal room
 2a) Same antenna pedestal room
 2b) Adjacent antenna pedestal rooms
 2c) Distant antenna pedestal rooms (> 1 pad, or 40m away[6])
3) Site grounds
 3a) Immediate proximity to antennas (distance ≤ 40m away[6])
 3b) Distant outdoor areas (distance > 40m away[6])
4) Site buildings
 4a) Control Building (CB)
  4a1) Shielded CB areas
   4a1a Operations control room
   4a1b VLA Correlator room
   4a1c EVLA Correlator room
  4a2) Unshielded areas (all other CB areas)
 4b) AAB (including attached buildings, paint shop, and trailers.
 4c) Tech Services building cluster (including MOS, Auto, Electrical, Carpentry, Warehouses)
 4d) Visitor's Center
 4e) SLOB building/FO Lab
 4f) Cafeteria
 4g) VSQ buildings
 4h) RF-EMS shelter
 4i) API shelter and antennas
 4j) ATF site trailers and antennas
 4k) ATF source tower
 4l) LWDA site shelter and antennas

[6] Minimum VLA pad-to-pad distance, from "VLA Site – WYE Layout" drawing, B219001.

Diagram 1: VLA Site Layout with Emitter Location Designators.





6 PROPAGATION LOSSES AND SHIELDING FACTORS

Each location can have a propagation factor assigned to it according to the following key parameters:

6-1 FLUX SPREADING LOSSES

The strength of the electro-magnetic field flux dissipates proportionally to the expanding surface area of a sphere centered on the source, by a factor proportional to 1/(distance^2). Thus the PFD from a source with an effective Isotropic Radiated Power (EIRP) in the direction of the receiving antenna is equal to the pfd @ r = 1m, divided by the distance^2 factor listed above. The table 2, following, summarizes the distances used for calculating the flux spreading "loss" assumptions used in subsequent analysis.

6-2 ARCHITECTURAL SHIELDING LOSSES

The VLA Operations room in the Control Building was originally constructed with wire-mesh shielding installed in the walls, windows, ceiling, and floor. An attempt at characterizing the effective shielding of the room was made by Clint Janes in the mid 1990s, and yielded a figure of around 30 dB[7]—15 dB will be used for Interference Protection Group (IPG) analysis, as a conservative figure based on the results of C. S. Patcheck/IPG tests of 2002[8]. The VLA correlator room in the CB was originally designed to show greater than 90 dB of shielding to 1 GHz[9]. Age, use, and penetrations have deteriorated the shielding effectiveness of this room—50 dB will be used for IPG analysis, as estimated from the results of C. S. Patcheck/IPG tests of 2002[10]. The EVLA correlator room in the CB was originally designed to show greater than 100 dB of shielding to 10 GHz[11]. Post installation penetrations have deteriorated the shielding effectiveness of this room to less than 80 dB, as estimated from tests of April, 2006[12]. Subsequent improvements to the connector bulkhead should have improved this weak-point—90 dB will be used for IPG analysis. Other VLA site buildings (including the non-shielded areas of the CB) are constructed of various materials, such as corrugated steel, brick, press-board and glass, each yielding different, but not substantial shielding values—5 dB will be used for IPG analysis, by conservative estimate from the results of C. S. Patcheck/IPG tests of 2002[13]. The ALMA site trailers are of corrugated steel, and have wire-mesh shielding added to the windows. The minimal shielding value of the original construction (~ 10 dB, at best[14]), was improved later to a value of 30 dB in L-band[15]—20 dB will be used for IPG analysis based on these results. Tests by Philstrom and Mertely in August 2006 showed the shielding of the LWA shelter to be in the 30 dB range from VHF to C-band[16]--the RF-EMS and API shelters are assumed to have similar shielding. The table 2, following, summarizes the architectural shielding assumptions used in subsequent analysis.

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[7] Draft "EVLA Overall RFI Hardware Plan", Appendix D, Table 2. Email dated 20020520. Clint Janes.
[8] VLA-VLBA Interference Protection Memo #32, pg 27
[9] By analogy with the EVLA correlator room, OEM default specification—See ***
[10] VLA-VLBA Interference Protection Memo #32, pg 23
[11] USC Test Plan, "3.0 Test Specification Limits".
[12] "EVLA Shielded Room re-test report", Email dated 20060406. D. Mertely
[13] VLA-VLBA Interference Protection Memo #32, pg 24, 25
[14] VLA-VLBA Interference Protection Memo #32, pg 27
[15] VLA-VLBA Interference Protection Memo #29, pg 1
[16] "LWDA Equipment shelter shielding", Attached spreadsheet, Position 1 results. Email dated 20060817. Dan Mertely

Table 2: VLA Site Flux Spreading Losses and Architectural Shielding Assumptions used.

BUILDING/AREA	LOCATION DESIGNATOR (LD) (FROM LIST 1)	DISTANCE USED (m)	ARC'TL SHIELDING USED (dB)	TOTAL "LOSSES" USED (dB)
ANT V-ROOM TO SAME ANT	1a	N/A	UNKNOWN	(VARIES)[17]
ANT V-ROOM TO ADJ ANT	1b	40	30[18]	62
ANT V-ROOM TO DIST ANT	1c	80	30[18]	68
ANT P-ROOM TO SAME ANT	2a	N/A	UNKNOWN	TBD
ANT P-ROOM TO ADJ ANT	2b	N/A	UNKNOWN	TBD
ANT P-ROOM TO DIST ANT	2c	N/A	UNKNOWN	TBD
SITE GROUNDS, < 40m (PROX)	3a	20	0	26
SITE GROUNDS, > 40m (DIST)	3b	(VARIES)	0	(VARIES)
CB, OPS ROOM	4a1a	200	15	61
CB, VLA CORR ROOM	4a1b	200	50	96
CB, EVLA CORR ROOM	4a1c	200	90	136
OTHER VLA SITE BLDGS	4a2, 4b-4g	160-300	5	49
RF-EMS SHELTER	4h	450	30	83
API SHELTER	4i	100	30	70
ALMA TRAILERS	4j	300	20	70
ALMA TOWER	4k	450	0	53
LWDA SHELTER	4l	400	30	82

Table 3: EIRPmax, unshielded (dBW) allowed for each location by EVLA frequency band.
1a: using Ridgeway measured losses from vertex room to FE input.
All others: using total losses from Table 2, and det EIRP limits from Table 1, Column 6.

	Freq (GHz)	0.0738	0.328	1.5	3	6	10	15	23	34	45
Loc Desig											
1a		-114	-103	-78	-69	-57	-61	-53	-17	-12	-2
1b		-122	-111	-99	-90	-81	-74	-68	-60	-55	-50
1c		-116	-105	-93	-84	-75	-68	-62	-54	-49	-44
2a		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
2b		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
2c		TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3a		-152	-141	-129	-120	-111	-104	-98	-90	-85	-80
3b		VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR	VAR
4a1a		-123	-112	-100	-91	-82	-75	-69	-61	-56	-51
4a1b		-88	-77	-65	-56	-47	-40	-34	-26	-21	-16
4a1c		-48	-37	-25	--16	-07	0	+06	+14	+19	+24
4a2, 4b-4g		-135	-124	-112	-103	-94	-87	-81	-73	-68	-63
4h		-116	-105	-93	-84	-75	-68	-62	-54	-49	-44
4i		-114	-103	-91	-82	-73	-66	-60	-52	-47	-42
4j		-115	-104	-92	-83	-74	-66	-60	-52	-48	-43
4k		-131	-120	-108	-99	-90	-83	-77	-69	-64	-59
4l		-102	-91	-79	-70	-61	-54	-48	-40	-35	-30

7 INSTALLED SOURCES

List 2, following, is a sample of a working document which shall list existing and potential VLA site based RF emitters, and assign a type designator to each. Table 3, following, is a sample of a working document which shall document for each emitter type, the equipment model number, locations(s), emissions tests performed, measured EIRP, required shielding, and mitigation measures taken for each

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[17] Table 1, "Suppression of Self-Generated RFI Emissions for the EVLA", R. Ridgeway, RFI2004, Penticton, Canada.

[18] EVLA Memo #78, R. Ridgeway, Pg 2.

installation. The working document which includes List 2 and Table 3 shall be maintained by the Interference Protection Office in a group-accessible location on a NRAO server[19].

List 2: RF Emitter designators (sample).

a) COMMERCIALLY PURCHASED EQUIPMENT
a1) PC EQUIPMENT
a1a) DESK TOP PCs
a1b) LAP TOP PCs
a1c) PDAS
a2) MONITORS/"DUMB" TERMINALS
a2a) CRT
a2b) LCD
a2c) PLASMA
a3) PRINTERS
a4) LAN EQUIPMENT
a4a) MEDIA CONVERTERS
a4b) HUBS
a4c) ROUTERS
a4d) SWITCHES
a4e) WIRELESS NETWORKS
a5) TEST EQUIPMENT
a5a) SIGNAL GENERATORS
a5b) SPECTRUM ANALYZERS
a5c) OSCILLOSCOPES
a5d) VOLT-OHM METERS
a6) SITE RADIOS
a6a) VHF
a6b) UHF
a6c) FRS
a6d) CB
a7) CELL PHONES
a7a) NRAO
a7b) PRIVATE
a8) CORDLESS PHONES
a8a) NRAO
a8b) PRIVATE
a9) POWER SUPPLIES
a9a) ON-ANTENNA
a9a1 LINEAR
a9a2 SWITCHING
a9b) BUILDING
a9b1) LINEAR
a9b2) SWITCHING
a10) WELDERS
a11) VEHICLES
a11a) GASOLINE
a11a) DIESEL
a12) AM/FM RADIOS
a13) TELEVISION MONITORS
a14) GPS RECEIVERS
a15) FLORESCENT LIGHTING
a16) APPLIANCES
a16a) OPERATOR'S KITCHEN
a16a1) OVENS
a16a2) TOASTERS
a16a3) COFFEE POTS
a16a4) REFRIGERATOR/FREEZERS
a16b) GENERAL KITCHEN

[19] http://www.aoc.nrao.edu/evla//techdocs/RFI/chamber-tests/EVLA-testing-status[yyyymmdd].doc.

a16b1) OVENS
a16b2) TOASTERS
a16b3) COFFEE POTS
a16b4) REFRIGERATOR/FREEZERS
a16c) PERSONAL
a16c1) OVENS
a16c2) TOASTERS
a16c3) COFFEE POTS
a16c4) REFRIGERATOR/FREEZERS
a16d5) SPACE HEATERS
a17) DIGITAL CAMERAS
a17a) NRAO
a17b) VISITORS
a18) AUTOMOBILE REMOTE CONTROLS
a19) TELEPHONES (WIRED)
a19a) ANALOG
a19b) DIGITAL
b) NRAO DESIGNED EQUIPMENT
b1) ANTENNA
b1a) VLA
b1a1) FRONT END RECEIVERS
b1a1a) F201 4m
b1a1b) F202 90cm
b1a1c) F103 20cm
b1a1d) A-rack 6cm/2cm
b1a1e) F106 4cm
b1a1f) F109 1cm
b1a1g) F110 6mm
b1a2) LO MODULES
b1a2a) L1 VCXO
b1a2b) L2 HARMONIC GENERATOR
b1a2c) L3 LO TRANSMITTER
b1a2d) L4 ANTENNA LO RECEIVER
b1a2e) L6 SYNTHESIZER
b1a2f) L7 FRINGE GENERATOR
b1a2g) L8 TIMING GENERATOR
b1a2h) F3 MICROWAVE LO
b1a3) CONVERTER MODULES
b1a3a) F11 4P UPCONVERTER
b1a3b) F2 L BAND UPCONVERTER
b1a3c) F12 XQ DOWNCONVERTER
b1a3d) F4 DOWNCONVERTER
b1a3e) F8 IF OFFSET
b1a3f) T2 IF COMBINER
b1a3g) T1 MODEM
b1a4) MONITOR AND CONTROL MODULES
b1a4a) F14 FRONT END CONTROL
b1a4b) L5 LO CONTROL
b1a4c) F5 A-RACK MONITOR AND CONTROL
b1a4d) M1 DATA SET
b1a4e) M2 DATA TAP
b1a4f) M3 CENTRAL BUFFER
b1a4g) M4 ANTENNA BUFFER
b1a4h) M5 COMMAND SIMULATOR
b1a5) POWER SUPPLIES
b1a5a) LINEAR
b1a5b) SWITCHING
b1b) EVLA
b1b1) FRONT END RECEIVERS
b1b1a) F201 4m
b1b1b) F202 90cm
b1b1c) F303 20cm

b1b1d) F304 13cm
b1b1e) F305 6cm
b1b1f) F106 4cm
b1b1g) F109 1cm
b1b1h) F110 6mm
b1b2) LO MODULES
b1b2a) L304 LO/REF RECEIVER
b1b2b) L305 REFERENCE GENERATOR AND DISTRIBUTION
b1b2c) L300 REFERENCE GENERATOR
b1b2d) L301 SYNTHESIZER
b1b2e) L302 SYNTHESIZER
b1b3) CONVERTER MODULES
b1b3a) T301 4P CONVERTER
b1b3b) T302 LSC CONVERTER
b1b3c) T303 UX CONVERTER
b1b3d) T304 DOWN CONVERTER
b1b3e) D30X DTS
b1b4) MONITOR AND CONTROL MODULES
b1b4a) F14 TRANSITION FRONT END CONTROL
b1b4b) F320 TRANSITION FRONT END CONTROL
b1b4c) F317 FRONT END CONTROL
b1b4d) T305 DOWNCONVERTER CONTROL
b1b5) POWER SUPPLIES
b1b5a) LINEAR
b1b5b) SWITCHING
b2) SITE BUILDINGS
b2a) VLA
b2a1) LO MODULES
b2a1a) T2 IF COMBINER
b2a1b) T1 MODEM
b2a2) MONITOR AND CONTROL MODULES
b2a2a) M1 DATA SET
b2a2b) M2 DATA TAP
b2a2c) M3 CENTRAL BUFFER
b2a2d) M4 ANTENNA BUFFER
b2a2e) M5 COMMAND SIMULATOR
b2a3) MARK 5 RECORDERS
b2a4) POWER SUPPLIES
b2a4a) LINEAR
b2a4a) SWITCHING
b2a5) CUSTOM TEST EQUIPMENT
b2b) EVLA
b2b1) LO MODULES
b2b1a) L350 REFERENCE GENERATOR AND DISTRIBUTION
b2b1b) L351 MASTER OFFSET GENERATOR
b2b1c) L354 LO DRIVER
b2b1d) L355 DIGITAL TIMING DISTRIBUTOR
b2b1e) L353 LO TRANSMITTER SYSTEM
b2b2) CONVERTER MODULES
b2b2a) T301 4P CONVERTER
b2b2b) T302 LSC CONVERTER
b2b2c) T303 UX CONVERTER
b2b2d) T304 DOWN CONVERTER
b2b2e) D30X DTS
b2b3) MONITOR AND CONTROL MODULES
b2b3a) M350 UTILITY MODULE
b2b4) POWER SUPPLIES
b2b4a) LINEAR
b2b4b) SWITCHING
b2B5) CUSTOM TEST EQUIPMENT

Table 3: RF Emitter Inventory (sample).

EMITTER DESIGNATOR	MODEL#	LOC(S)	TEST(S) PERFORMED	MAX EIRP 0-1/1-20 GHz	PROP LOSS TOTAL	RQD AD'NL SHIELDING 0-1/1-20 GHz	MITIGATION REQUIREMENTS
(List 3, above)		(List 1, above)		(dBW/RBW)	(dB)	(dB)	
a1a	Dell Optiplex	4a1a	emissions	-80/-90	72	32/10	
	PC model #	4a1b	PC, mouse		107	none/none	
	GX280	4a1c			147	none/none	
		4a2			60-65	44/22	
		4b			60-65	44/22	
		4c			60-65	44/22	
		4d			60-65	44/22	
		4e			60-65	44/22	
		4f			60-65	44/22	
		4h			60-65	44/22	
		4i			81	23/1	
		4j			80	24/2	
		4l			93	11/none	
a2a	Gateway 17"	4a1a	emissions	-65/-77	72	47/23	
	CRT monitor	4a1b	PC, mouse, CRT		107	12/none	
	model #	4a1c			147	none/none	
	VX900	4a2			60-65	59/35	
		4b			60-65	59/35	
		4c			60-65	59/35	
		4d			60-65	59/35	
		4e			60-65	59/35	
		4f			60-65	59/35	
		4h			60-65	59/35	
		4i			81	38/14	
		4j			80	39/15	
		4l			93	26/2	
a2b	Dell flatscrn	4a1a	emissions	-54/-83	72	58	
	monitor	4a1b	PC, mouse, LCD		107	23/none	
	model #	4a1c			147	none/none	
	E156FP	4a2			60-65	70/29	
		4b			60-65	70/29	
		4c			60-65	70/29	
		4d			60-65	70/29	
		4e			60-65	70/29	
		4f			60-65	70/29	
		4h			60-65	70/29	

		4i 4j 4l			81 80 93	49/8 50/9 37/none	
a2b	LI LCD flat screen TV Model # 42LC2D	4d	emissions PC, mouse, LCD	-73/-83	60-65	51/29	

3 Equipment Screening Guidelines

With the proliferation of new RF and digital equipment being purchased and designed for use at the VLA site, it is critical that RF emissions screening guidelines be established for both commercially-purchased equipment, as well as NRAO designed modules or devices. These screening guidelines will be based on the likelihood that a device will exceed the EVLA detrimental thresholds at the nearest antenna, when installed at the anticipated VLA site "emitter location(s)" of List1/Diagram 1, above. The likelihood of a class of device exceeding the EVLA detrimental thresholds will be determined by the results of prior "emitter class" testing, and/or the engineering judgment of the Interference Protection Office engineering staff.

Equipment believed to have the greatest risk to EVLA scientific observing will be 100% screened—all such devices will be required to undergo RF emissions screening before they will be allowed to be installed at the VLA site. If emissions testing of such equipment indicates that the device will radiate above the EVLA detrimental thresholds from its anticipated installation point, the equipment will be shielded to below the threshold, or be tagged for turn-off during scientific observations.

Equipment already on-site and falling within the category of devices targeted for 100% screening will be emissions tested and tagged as such over the next year. Equipment found to exceed the EVLA detrimental levels detailed in EVLA memo #106 will be shielded to an emissions level below the detrimental levels, or will be tagged for turn-off during scientific observations.

Equipment of lower risk will be screened by "class". If the class designation of a new equipment item indicates the likelihood of radiated emissions above the EVLA detrimental levels, the equipment will be shielded to an emissions level below the detrimental levels, or will be tagged for turn-off during scientific observations. If design or performance changes suggest a significant change in radiated power from that recorded during previous emissions tests of devices in a class, a new emissions test will be performed on a representative new equipment model in that class. Future equipment in that class will be required to be shielded to the level determined by the most recent RF emissions test.

The following is the equipment "class" list, listed in order of the likelihood of generating harmful RFI, and identified by the equipment class designator given in List 2, above:

List 3: Equipment Screening Priority.

1. Intentional radiators to be 100% screened:
   - a) COMMERCIALLY PURCHASED EQUIPMENT
     - a6) SITE RADIOS
       - a6a) VHF
       - a6b) UHF
       - a6c) FRS
       - a6d) CB
     - a7) CELL PHONES
       - a7a) NRAO
       - a7b) PRIVATE
     - a8) CORDLESS PHONES
       - a8a) NRAO
       - a8b) PRIVATE

2. Un-intentional radiators to be 100% screened:
   - b) NRAO DESIGNED EQUIPMENT
     - b1) ANTENNA
       - [illegible]
       - [illegible]
       - [illegible]

b1a2b) F3 MICROWAVE LO
b1a3) CONVERTER MODULES
b1a3b) F2 L BAND UPCONVERTER
b1a3c) F12 XQ DOWNCONVERTER
b1b) EVLA
b1b2) LO MODULES
b1b2c) L300 REFERENCE GENERATOR
b1b2d) L301 SYNTHESIZER
b1b2e) L302 SYNTHESIZER
b1b3) CONVERTER MODULES
b1b3a) T301 4P CONVERTER
b1b3b) T302 LSC CONVERTER
b1b3c) T303 UX CONVERTER
b1b3d) T304 DOWN CONVERTER
b1b3e) D30X DTS

3. Un-intentional radiators to be sampled by class:
   All equipment in List 2 <u>not</u> listed in "1. Intentional radiators" or "2. Un-intentional radiators", above.

The emissions testing system currently used in the EVLA/ALMA reverberation chamber is unable to test to the EVLA Detrimental levels of EVLA memo #106 across all proposed EVLA receiving bands[20]. As a result, all unintentional radiators identified for emissions testing will be tested with shielding covers removed or open. The shielding effectiveness of the total, in situ equipment shielding (module, bin, rack, and architectural) shall be tested separately. Shielding values so measured shall be deducted from the EIRP values calculated from the equipment emissions testing, before calculation of the PFD of the equipment emissions at the nearest antenna and comparison with the detrimental PFD levels. Emissions testing will be performed in accordance with the document, **"EVLA/ALMA Reverberation Chamber Emissions Testing Procedure"[21]**. Shielding effectiveness testing will be performed in accordance with the document, **"Reverberation Chambers"[22]**.

[20] As seen in Figure 10, "verizon-VX7000-emissions-test-results1.doc", Email dated 20060406, D. Mertely, for example.
[21] http://www.aoc.nrao.edu/evla//techdocs/RFI/chamber-tests/test-procedures/emissions-test-proc1.doc
[22] http://www.aoc.nrao.edu/evla//techdocs/RFI/chamber-tests/test-procedures/reverb.pdf, Section 4.3, pg 6.