

EVLA Correlator Laboratory Requirements in Penticton

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ABSTRACT

The EVLA correlator development is now moving into the phase where it will require extensive use of the main digital laboratory at the DRAO Penticton site. A synopsis of the development timeline, preliminary lab floor layout requirements, and power and cooling requirements is developed. **The requirements defined in this memo are not “etched in stone”, and may evolve with time and to accommodate other uses of the lab.**

Introduction

The EVLA correlator is constructed of the following components (quantities for a full 32-station correlator are given):

1. **24” racks:** 36”W x 43”D x 83” H. Qty=24
2. **12U sub-racks/crates.** Qty=48
3. **6U sub-racks/crates.** Qty=16
4. Printed circuit boards:
 - a. **Station Board** (15.7”W x 19”H). 300-350 W. Qty=128.
 - b. **Baseline Board** (15.7”W x 19”H). 400-600 W. Qty=160.
 - c. **Delay Module** (mezzanine card). Qty=256.
 - d. **Timecode Board** (160mm W x 230mm H). Qty=2.
 - e. **Common Backplane** (3U x 1.2”). Qty~1250.
 - f. **PCMC** mezzanine card. Qty~290.
 - g. **Fanout Board** (130mm W x 230 mm H). 10-15 W. Qty~265.
 - h. Fiber-optic Receiver Module (**FORM**—NRAO). Mezzanine card on the Station Board. Qty~128.



- i. **PC/104+** embedded CPU mezzanine card (purchase) Qty~290.
- j. **Phasing Board** (est. 230 mm x 400 mm). Qty=4-8.
5. Rack-mount, compact-PCI **control computers**. 300-500 W. Qty=2.
6. **100 Mbps Ethernet switches** + connect cables. Qty~24.
7. **1 Gbps Ethernet switches**. Qty~10.
8. “**Backend**” data processing computers. Qty~50.
9. High speed interconnect **cables**. ~10m Qty~500; ~1 m Qty~2500.
10. 48 VDC **power plant**, 150-220 kW capacity.

The e-MERLIN correlator will be considerably smaller and will consist of the above components, but all fitting into 2 racks. There will be 8 Station Boards, 16 Baseline Boards, and support modules in this correlator.

Needless to say, it will be impossible to construct the entire EVLA correlator in the laboratory in Penticton because of size, power, and cooling limitations in the space available. Nevertheless, it is desired to construct not only prototypes, but a representative “slice” of the system in the laboratory so that it can be adequately tested before full construction of the correlator begins at the VLA site.

This document outlines development testing activities and laboratory requirements to support them. To ensure that minimum time is spent debugging and testing items at the VLA site that could be done here, it will be important to ensure that sufficient laboratory resources are available to do so.

Development activities and timeline

A detailed description of the correlator development and test plan can be found in [1]. For the purposes of the laboratory setup in Penticton, the following synopsis is useful.

1. **Thermal test rack development and testing**. This phase is currently underway and consists of the construction and population of a 24” rack with heat-generating boards, and the development of cooling topologies to deal with the load. This phase is currently expected to end in Q2-2005.
2. **Preliminary prototype testing and debugging**. This phase is the bench test of a small number of boards to test the end-to-end high-speed transmission system that is the backbone of correlator data transmission. This phase will likely begin in Q1/Q2 of 2005 and take a few months to complete.
3. **Initial prototype testing and debugging**. This phase is the initial prototype test of all of the main modules in the system. One module of each type is tested to



ensure it is operational and debugged before more prototypes are built. This phase will likely commence in Q2/Q3 2005, and complete in Q1/Q2 2006.

4. **Prototype correlator(s) construction and testing**. Two prototype correlators, consisting of bench-mount systems will be constructed, one for the EVLA, and one for e-MERLIN. Each correlator consists of 4 Station Boards, 1 Baseline Board, and necessary support modules. Construction of these self-contained correlators—likely bench-top units—is likely to commence at the end of 2005, with shipment to the VLA site and the UK for testing in early 2006.
5. **Limited production construction and testing**. In this phase, a complete slice of the system is constructed and tested. This will consist of 1 fully-populated Station Rack, 1 fully-populated Baseline Rack, and a rack of support equipment (computers, switches, fiber signal generators, backend computers). Construction is likely to commence in mid-2006 and testing should be complete by the end of 2006.
6. **Full production construction and testing**. In this phase, boards are fabricated by an external contractor, and come to the DRAO lab site for testing and burn-in. In this phase it is possible that the full set of racks may be at the DRAO site for outfitting and initial testing, although shipping complexities may require direct shipment to the VLA site. It is likely that in this phase, the full e-MERLIN correlator will be constructed and tested in the DRAO lab. This phase is likely to begin in early 2007, and be complete by mid 2007.

Items 5. and 6. above place the most severe power and cooling requirements on the DRAO lab, as described in the following section.

Laboratory space and power requirements

Figure 1 is a diagram of the screened room showing bench, equipment, and power requirements to support EVLA correlator development. The following points are worth noting.

1. The existing large lab workbench is referred to as “Main WB #1” in the drawing.
2. Another large lab workbench, the same size as the existing one, and in the location shown is required. This is referred to as “Main WB #2”. It is possible that the EVLA will not require 100% capacity of both main workbenches, but it is unknown at this time how much space could be free for other projects.
3. Power for Main WB #1 and Main WB #2 requirements are as shown in the Figure. The existing method for power delivery (i.e. the power pole) on Main WB #1 seems sufficient.



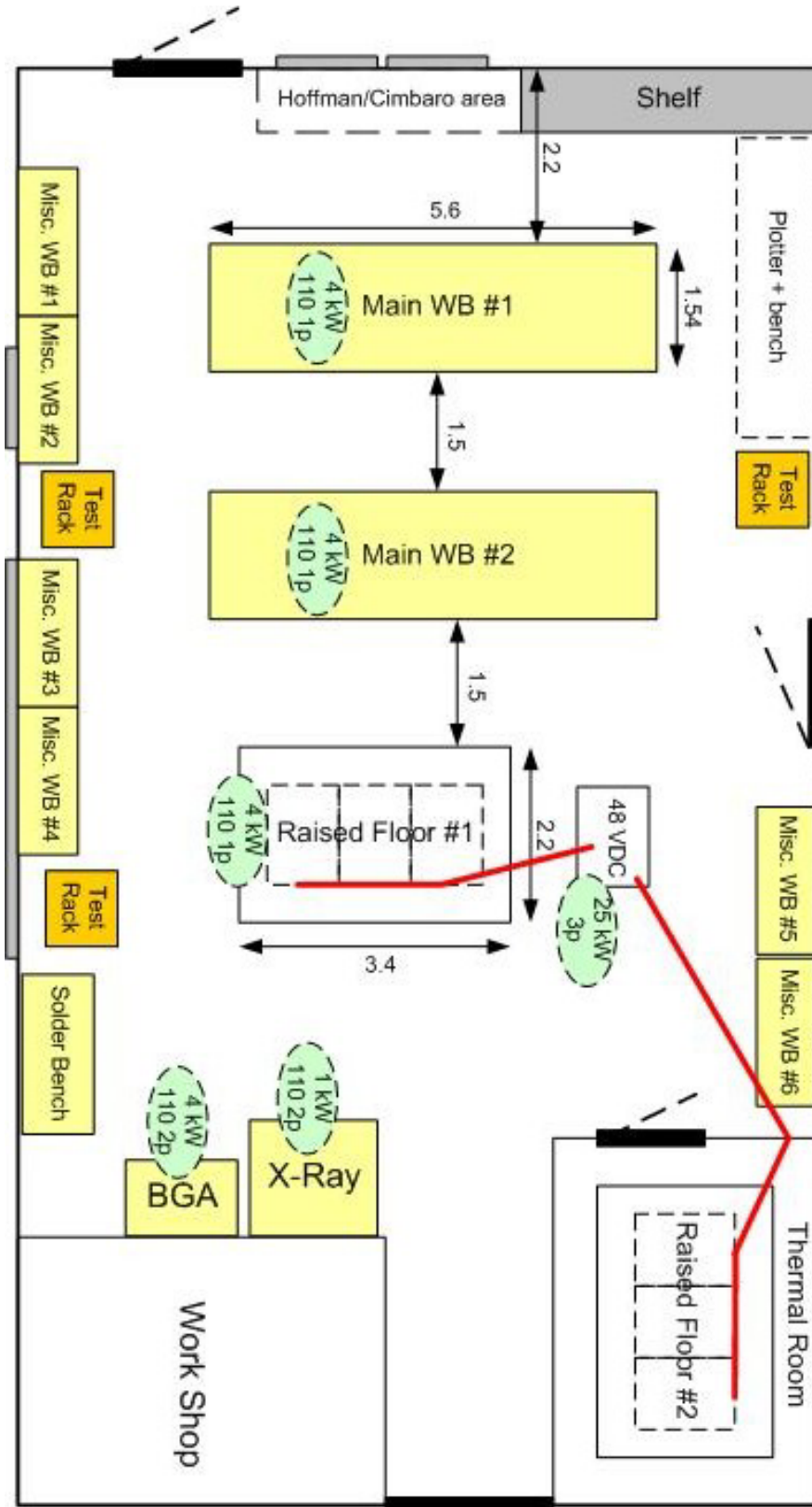


Figure 1 Laboratory room layout requirements.

4. The immediate requirements for the thermal test rack can be met with a 10 kW service to supply two rack-mount 48 VDC power supplies we currently have, in the approximate location of the “48 VDC” block shown in the figure. Enough cooling capacity will have to be available to handle a 10 kW maximum load in this test rack. It is possible, although currently unlikely, that we may move to a closed-cycle liquid cooling system in the rack, and in this case, a 10 kW capacity external heat exchanger will be required. If we move to this method, then it is likely worth the investment of installing plumbing so that the heat exchanger can be mounted outside the screened room for eventually handling the heat load from 3 racks (~25 kW).
5. “Raised Floor #1” and “Raised Floor #2” are 1.5 ft raised floors that simulate the installation environment of the correlator (i.e. raised computer floor). It is envisioned that blower fans at the base of these floors will be required to supply air at the volume required by each of the 3 racks mounted on the floors as shown. This is to simulate the “pressurized floor” environment of the final installation. Air volume flow requirements are estimated at ~1200 cfm per rack, at ~20 °C. These floors will only be needed for limited production and full production construction and testing as noted above. Raised Floor #1, will likely be used for e-MERLIN correlator construction and testing, as this will happen after limited production and testing.
6. Power requirements are as shown in the figure. The “48 VDC” block—assuming it can fit in one rack as shown—will contain a ~25 kW 48 VDC power supply that will supply power to the racks on the raised floors. Note that it is not envisioned that it will be necessary to operate both raised floors at full capacity at the same time. The solid red lines indicate the 48 VDC cable runs that will be needed to supply 48 VDC to the equipment mounted on the raised floors.
7. For burn-in, “Raised Floor #2” is installed in the existing Thermal Room. Bearing in mind that we will have to burn-in each of $128+160+8+16=312$ large boards for 200 hours each, it is desirable to have 3 fully populated racks in the Thermal Room for burn-in. This could consume upwards of 20 kW, and this heat load will have to be removed. It is desirable to temperature-cycle the boards, under burn-in from 0 to 40 °C. With 3 fully-populated racks, it is likely that burn-in will take about 50 days. If these power requirements are beyond the capability of what the room can reasonably provide, then we will live with what the room is capable of providing.
8. It is possible that the number of boards that has to be burned-in increases to 424 if NRAO secures funding for EVLA Phase-II, requiring construction of a 40-station correlator.
9. The BGA re-work and X-ray machines could be located as shown in the drawing. Power requirements are as shown. Refer to equipment system input power requirements for specific receptacle requirements. There are no additional



operational requirements for the units (i.e. they are self-contained), except that they will need network connections, and the fume hood over the BGA machine might be desirable. Thus, the BGA machine and the existing solder bench are located in the same area.

10. The “Test Racks” shown are not all specific to the EVLA, and are places where test racks for other purposes could go (e.g. ACSIS, CLAR). The same goes for the miscellaneous work benches shown (Misc. WB#1-6). At least one ad-hoc test rack will likely be required for EVLA development to house initial host control computers.
11. The exiting plotter + bench, shelf, and Hoffmann/Cimbaro areas could stay as they are since they don’t interfere with EVLA requirements.
12. Specialized test equipment required by correlator development, to be used on one of the main work benches is as follows:
 - a. Agilent 16900A logic analyzer. Network connection needed. This unit uses a separate monitor. Special probe lands are on printed circuit boards to facilitate use of this logic analyzer.
 - b. Existing Tektronics DSA 602 digital storage oscilloscope. No network connection needed.
 - c. Test beds. These will consist of modified sub-racks/crates, complete with 48 VDC power supplies and fans, and will be used for initial prototype testing and debugging as well as production test and debug.
13. As there will be a considerable number of boards go through the lab for production testing and burn-in, procedures, equipment, and storage must be in-place to handle them. ESD protection is of paramount importance as we are dealing with boards containing tens of thousands of devices, many of them with features sizes of 90 nm, and operating voltages of 1.0-1.2 V. The total expenditure on production boards is in excess of \$6 million USD. The baseline requirements are as follows:
 - a. ESD “totes” (blue boxes) to facilitate transfer of boards through the process. Estimate 10 blue boxes.
 - b. ESD bags to house each circuit board containing active electronics. These bags are more than likely provided by the production facility.
 - c. Wrist-strap and grounding post at each workstation on *every* workbench, including the X-ray machine, BGA rework station, and the solder bench. Wrist straps may be augmented by heel straps.
 - d. ESD lab coats. Estimated quantity 10.



- e. ESD monitoring unit at each ESD station. This monitoring unit must ensure that the wrist strap is functioning properly, and that the electro-static environment at the station is safe.
- f. Elimination of all chairs, benches, and any other work surfaces that are not ESD safe. Only ESD safe surfaces should be in the room.
- g. Training of all personnel in safe ESD practices. Restriction of the lab, or portions of the lab with “rope barriers”, to prevent unsafe ESD handling procedures.
- h. ESD shipping boxes complete with ESD foam of sufficient quantity to ship all boards to the VLA site.

Summary

1. The immediate needs are for 10 kW power and cooling capacity for the thermal test rack, in the approximate location of the “48 VDC” block as shown in the figure.
2. Main WB #2 should be in place by May-June of 2005.
3. The X-ray and BGA re-work machines should be in place by May-June of 2005. Acceptance testing of these machines upon receipt is required and so the power receptacles for them should be in place by the end of February 2005.
4. ESD procedures and equipment in place for prototype testing by May-June of 2005. (13. b-g above). Each large circuit board is worth about \$20,000 USD, and improper handling could introduce faults that render the board useless, and could delay and confuse testing.
5. All ESD equipment in place by the end of 2005.
6. Raised Floor #1, and the power and cooling capacity to support it should be in place by May-June 2006.
7. Raised Floor #2, and the power and cooling capacity to support it should be in place by the end of 2006.

References

[1] Carlson, Brent, TEST AND VERIFICATION PLAN: EVLA Correlator Project Development and Test Plan, Revision DRAFT, October 1, 2004.

