

## **TEST AND VERIFICATION PLAN**

### **EVLA Correlator Prototype On-the-Sky Test Plan**

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## 1 Revision History

<b>Revision</b>	<b>Date</b>	<b>Changes/Notes</b>	<b>Author</b>
DRAFT	March 10, 2006	DRAFT release for review and comment. Tests can be refined or more tests can be added.	B. Carlson
DRAFT2	May 8, 2006	Add 2 <sup>nd</sup> Ethernet port to Station Board for the DTS receiver. Add software and manpower requirements sections.	B. Carlson
DRAFT3	May 29, 2006	Add purpose of test statement in Introduction, and table of testing priorities in section 7.	B. Carlson

## 2 Introduction

This document defines a test plan and test matrix for EVLA on-the-sky (OTS) prototype correlator testing. The purpose of OTS prototype testing is to establish confidence, before committing to full production, that the correlator functions properly. Extensive and detailed testing will have already taken place with computer-generated test vectors, but there is still some probability, likely small but of unknown magnitude, that OTS testing will reveal some hidden low-level systematic effect that could be devastating were it to find its way into the final system. OTS testing aims to mitigate this possibility as much as possible.

A list of 44 tests, beginning with simple tests and finishing with a series of 10 scientist-driven tests, are defined. Tests are defined in a high-level fashion, with the goals of each test indicated but without a complete definition of the correlator setup for the particular test. These setups must be developed as XML scripts, most easily facilitated with correlator GUIs. Thus, this document will likely spawn a series of configuration files or even other documents describing more specifics of each test. Further science input and activities (such as source selection, image processing, phase closure analysis) are required for many tests.

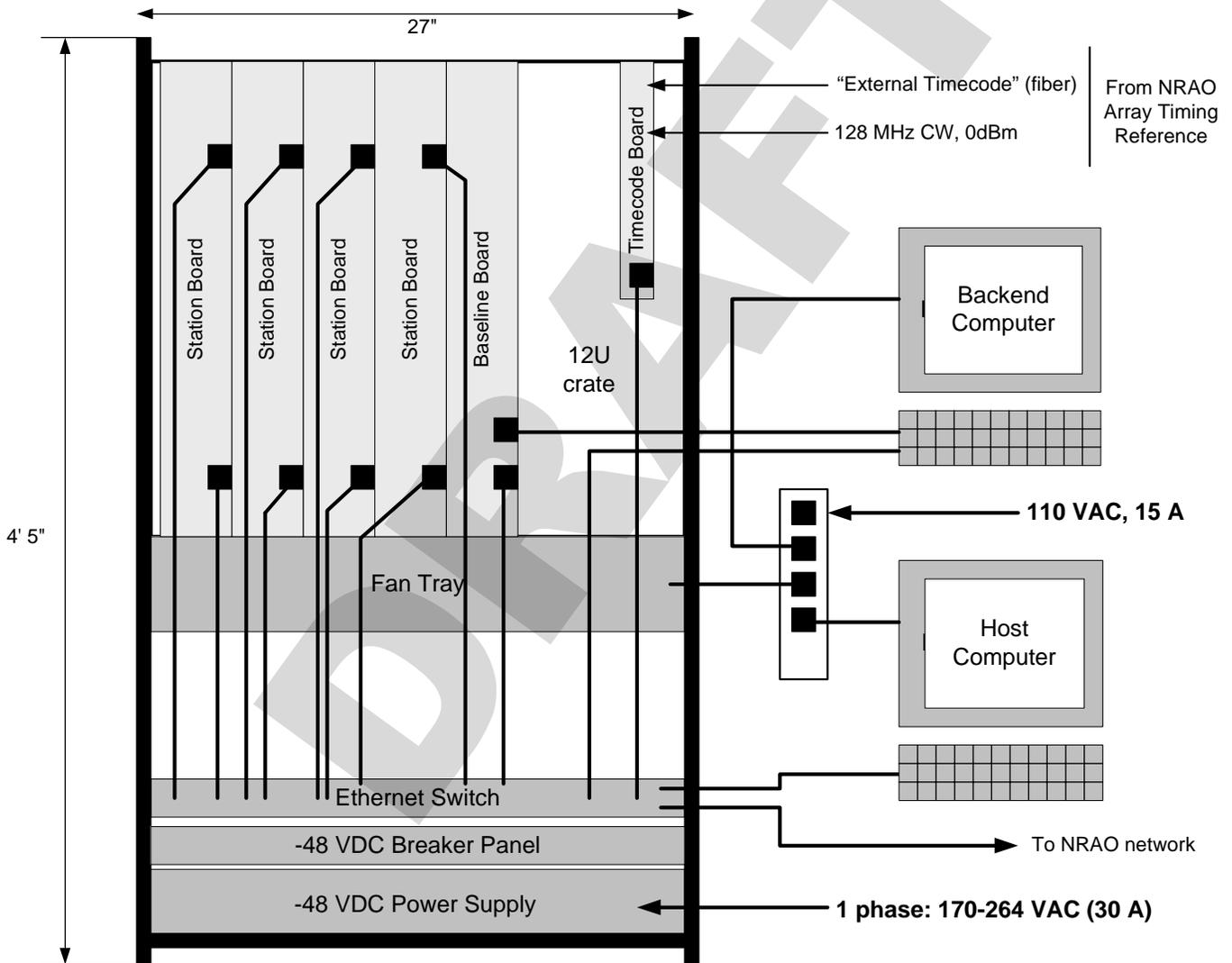
Sufficient real-time software for the correlator must be available to support these tests. This mostly impacts the Station Board CMIB software since delay tracking, phase model generation, and dump control signaling are important components required for successful testing. Refer to the “Programmer’s Guide” A25290N0000 for specifics on how all of these functions are implemented in the correlator.

Some of the tests define the need for a “**digital tone comb generator**” in the DTS transmitter. This generator sets every  $N^{\text{th}}$  sample after initial quantization to its maximum value or, for a lower amplitude, adds +1 to every  $N^{\text{th}}$  sample. The simplest implementation is to set  $N$  to 64 (for 32 tones across the band), wherein every 4<sup>th</sup> sample in one de-multiplexed stream is affected. A slightly more complex implementation is to set some odd value such as 65 so that the affected samples “roll” across the de-multiplexed data paths.

Tones generated in this way show up in filtered sub-bands and can be extracted with the sub-band phase-cal tone extractors in the Filter Chip, providing a valuable diagnostic tool to ensure data path integrity and delay tracking integrity in the system from source to extraction point. Any changes in the phase or amplitude of the tone extractor output can indicate some sort of hiccup in timing or delay tracking that could indicate a problem. It is believed that this generator could be easily integrated into the FPGA in the DTS transmitter. If it is not possible to do this, then it could be implemented in the DTS receiver or in the Input Chip of the Station Board. These tones appear in the wideband and sub-band auto-correlation spectra. However, because of the frequency shift (fshift), they do not show up in the cross-correlation spectra—a well-known effect in VLBI systems—although normally tone comb generation is turned off in spectral-line observations.

### 3 Test Setup

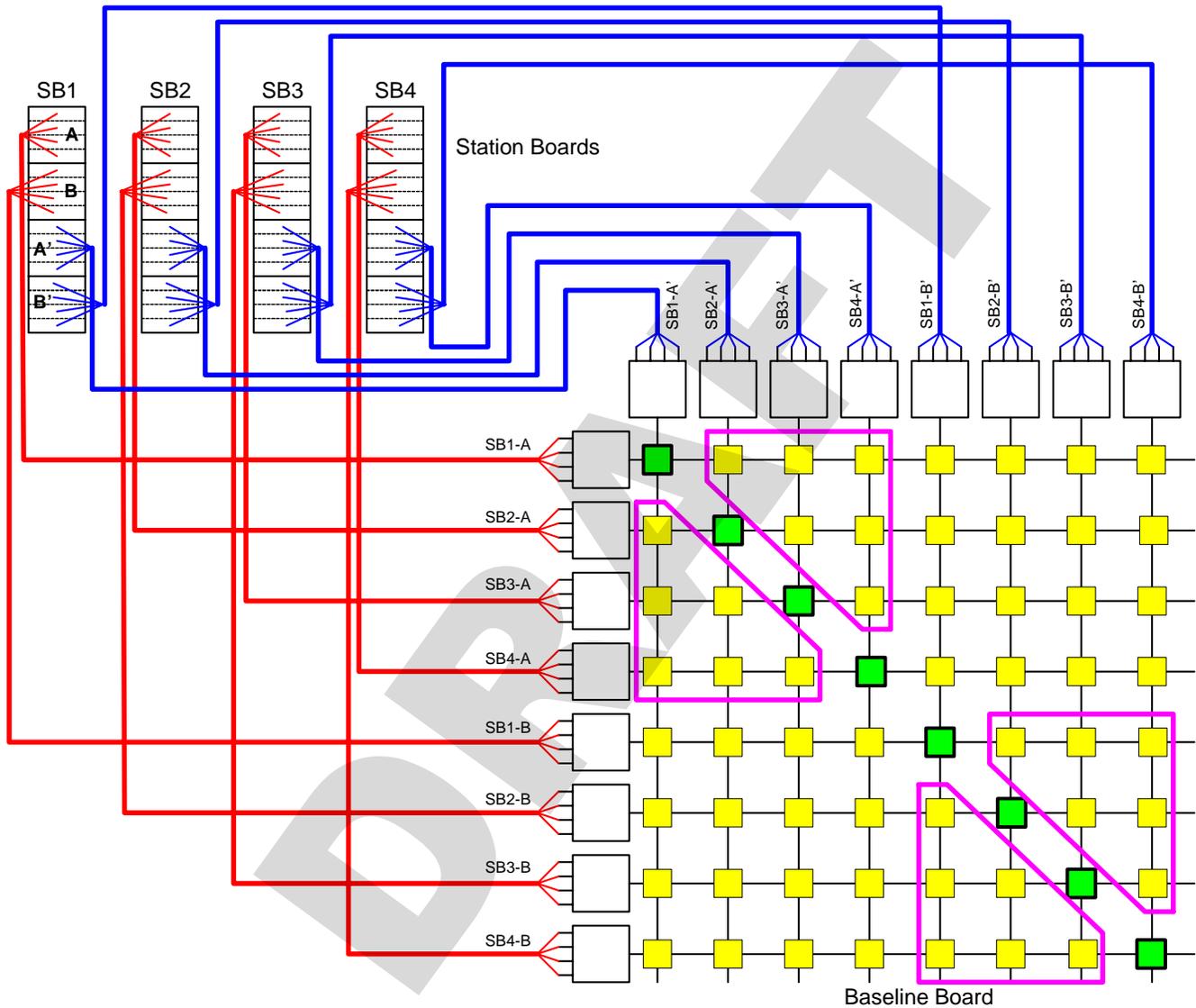
The prototype correlator system for on-the-sky testing is contained within a standalone short 24" rack, which includes the boards, cables, cooling fans, M&C Ethernet switch, and -48 VDC power supply. A simplified diagram of this rack is shown in Figure 3-1. Power requirements are shown in the figure. There is one Host Computer, which provides the primary user interface for testing and Real-Time Data Display (RTDD) and includes all necessary boot files for the boards. There is one Backend Computer, which has a connection to the M&C Ethernet switch, and one direct Gbit Ethernet connection to the Baseline Board. A port on the Ethernet switch connects to the NRAO network. Not shown are antenna fiber connections to Station Boards.



**Figure 3-1 Prototype correlator test setup. The rack is 36" deep. The Host Computer may be a laptop as may be the Backend Computer.**

One Timecode Generator Board is shown—two could be used if it is desired to test redundancy of these boards in this test, although the test plan does not explicitly state the need for this kind of test.

The Station Boards are wired to the Baseline Boards, without any Fanout Boards as shown in Figure 4-1 of A25010N0001. This figure is repeated here for completeness and is shown in Figure 3-2.



**Figure 3-2 Prototype correlator Station Board-to-Baseline Board connections.**

This arrangement allows all of the bandwidth (2 GHz) to be correlated with 1 polarization product, and 1/2 of the bandwidth (1 GHz—8 sub-bands) to be correlated with 2 or 4 products. Cabling is different than the normal EVLA cabling, and so configurations will have to be specially built (with the use of GUIs and save/recall scripts) to support this setup.

Although all of the boards are designed with the ability for remote power monitor and control, there is currently no plan to implement or test this capability in the prototype correlator. Thus, any power cycles (or resets) that may be required to recover from CPU hang-ups etc. must be manual. The system can be left running when not in use if desired, since each board contains dead-man thermal overload protection.

As mentioned in the introduction, a digital tone comb generator in the DTS transmitter or receiver module FPGA is required for diagnostic testing.

The prototype correlator is mostly a standalone system except for the following noteworthy exceptions:

- The “**External Timecode**” signal and **128 MHz CW** 0 dBm reference clock from the Array Timing Reference are required. Refer to A25022N0090 for a definition of these interfaces. Refer to section 4. of the Programmer’s Guide A25290N0000 for an indication of how these signals are used in the correlator.
- Fibers from antennas are connected to DTS receiver mezzanine cards installed in Station Boards. Analog baseband outputs from the DTS receivers, via coaxial cable, travel to the existing VLA correlator (the “old correlator”). These connections are important for comparison tests of the new correlator to the old correlator, although there is no capability or need to operate both correlators concurrently.
- An NRAO network connection to the M&C Ethernet switch is required. This is used for correlator TIMECODE setting and for connection to the NRAO Model Server. If software to support automatic TIMECODE setting is not available, then it can be done manually so long as there is a visual way of checking that the setting is correct (e.g. TIMECODE time and UTC time display side-by-side for visual check).
- The NRAO “**Model Server**” is a task, somewhere on the NRAO network, that generates polynomial delay models for antennas involved in the tests. Baseline requirements for these models are defined in section 4.4.8 of the Programmer’s Guide A25290N0000, although the order of the polynomial is not yet defined and is likely a free parameter defined by NRAO. The protocol for the transfer of these models from the Model Server to the correlator embedded processors is not yet defined, although generally it is likely to be XML format. These models must be provided to the correlator a few seconds in advance to ensure their timely application. 10 seconds advance receipt of models is recommended.
- The Backend computer must be able to save data sets to the NRAO network for further analysis and image processing. This is provided via the network connection to the M&C Ethernet switch shown in Figure 3-1.

## 4 Software Requirements

This section defines software that must be in place to support prototype correlator OTS testing. These minimum requirements are established assuming that there is no EVLA M&C software in place to support testing. Even if there is, it is important that the prescribed software elements are in place to ensure that the test team has unambiguous low-level access to all correlator functions that are to be tested.

1. Board-level and chip-level GUIs to support easy configuration and status monitoring of configurations, built within the limitations of prototype correlator data routing shown in Figure 3-2. It must be possible to build configurations, save configurations, recall configurations, and execute configurations. This functionality is currently built into all of the GUIs that are under construction, or have completed construction, for correlator prototype testing.
2. Top-level and rack-level GUIs to support the ability, in a hierarchical fashion, to set configurations and determine the status of testing in an intuitive way. Diagrams of GUIs for this purpose are shown in Figure 4-1 and Figure 4-2. Access to board-level and chip-level GUIs is provided by “drilling down” (double-clicking) on board icons in Figure 4-2.
3. Real-time “wide band” delay tracking. This requires real-time software, operating at interrupt-level on the Station Board CMIB, with task-level software accepting/getting models from the Model Server. Refer to A25290N0000 section 4 “Programmer’s Guide to EVLA Correlator System Timing, Synchronization, Data Products, and Operation” for detailed information on delay tracking.
4. Real-time phase model generation. This requires real-time software operating at interrupt-level on the Station Board CMIB. Refer to A25290N0000 section 5.
5. Real-time dump control generation. This requires real-time software operating at interrupt-level on the Station Board CMIB. Refer to A25290N0000 section 6. Dump control must be provided for normal dumping, recirculation, and phase binning.
6. The Backend computer must be able to save data sets to the NRAO network for further analysis and image processing. This is provided via the network connection to the M&C Ethernet switch shown in Figure 3-1.
7. Graphical real-time data display capability. Refer to A25280N0000
8. Image processing and analysis software must be in place to allow:
  - a. Phase and amplitude closure tests.
  - b. Continuum and spectral-line image formation for image quality and dynamic range analysis.
  - c. Pulsar phase binning analysis; integrated pulse profiles, bin imaging, pulsar ephemeris determination.

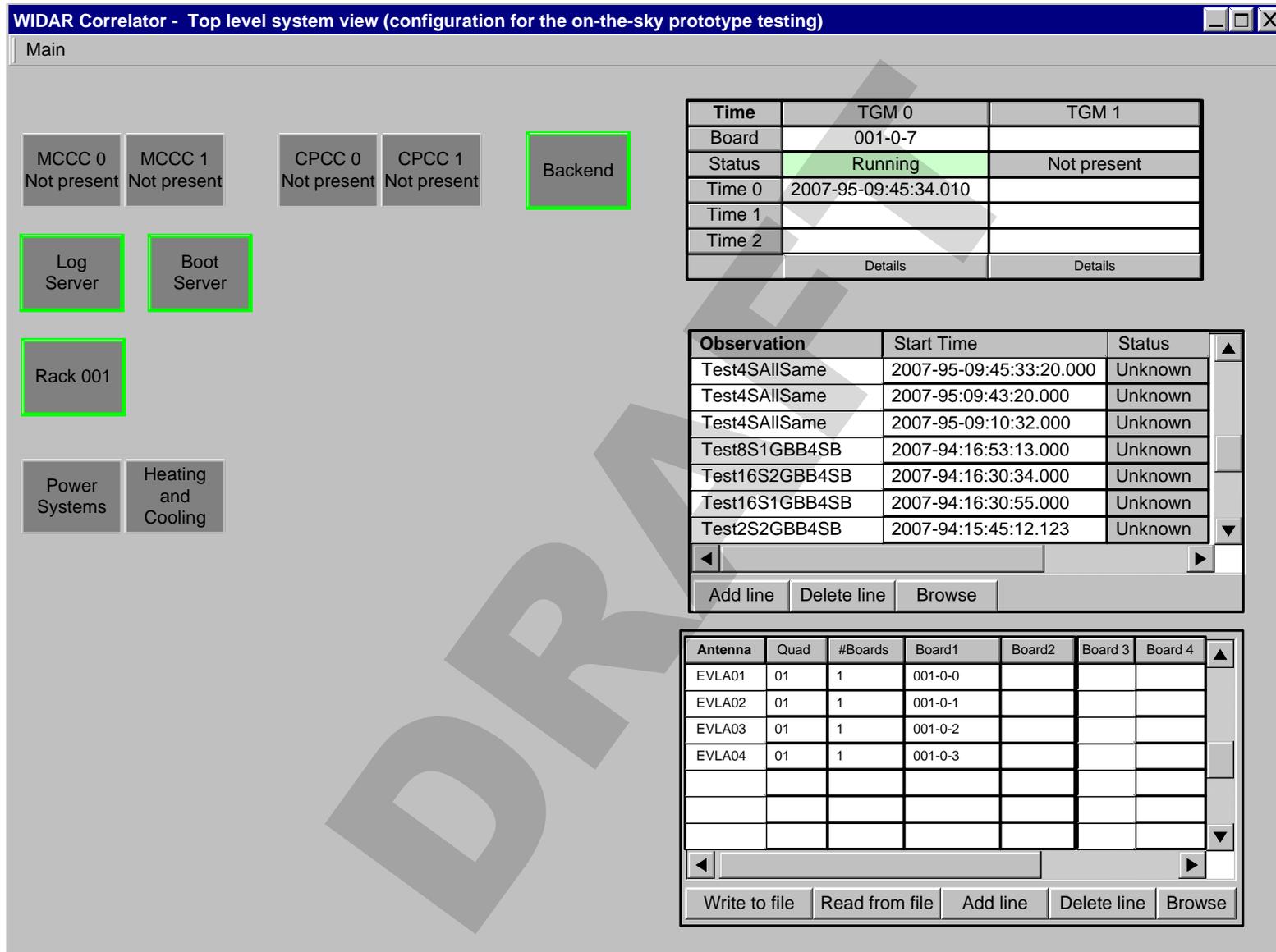
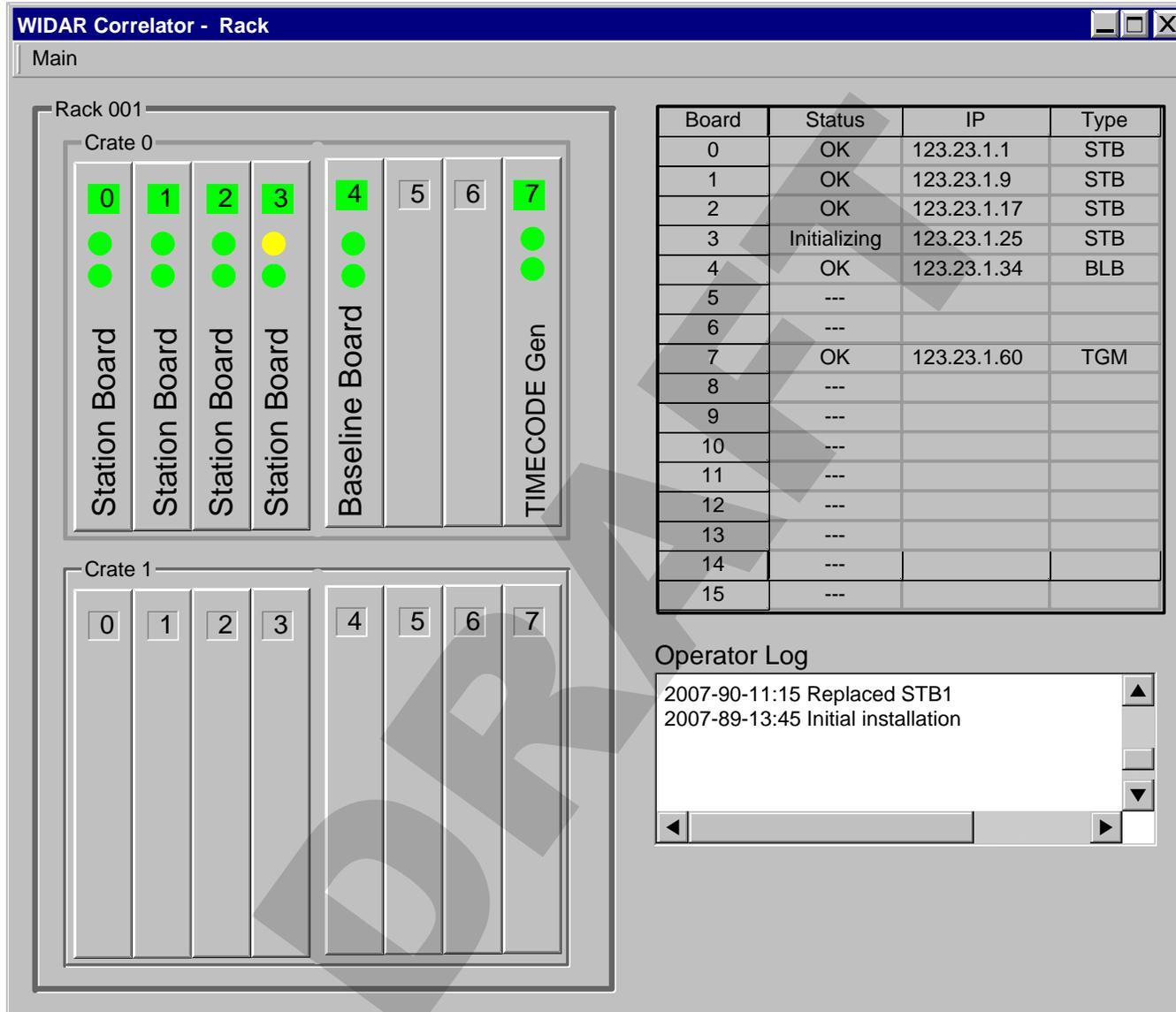


Figure 4-1 Top-level GUI.



**Figure 4-2 Rack-level GUI. This GUI shows the content and status of the OTS prototype test correlator.**

## 5 Manpower Requirements

The prototype correlator system will have already undergone extensive testing before it is delivered to the site (VLA site) for OTS testing. There will therefore be a high degree of confidence that the correlator will perform as intended. Test setup/configuration files for each test case will have been built, tested, and saved prior to delivery as well.

Nevertheless, the system will not be a turn-key system and it is important to have key people on-site for testing. In addition, scientist support is required for source selection, correlator parameter determination, and data analysis.

Key people that are required on-site to support OTS testing are as follows:

1. Bruce Rowen. Bruce has written most, if not all, of the low-level device drivers and real-time software in the correlator. He is the important bridge between high-level configuration files generated by GUIs, and low-level hardware register configurations.
2. Kevin Ryan. Kevin has written much of the GUI software to support testing. He is an important bridge between GUI-level button-pushing, and the GUI-generated configuration files. Kevin will be able to make any necessary design modifications to GUIs, built by him or others (Sonja in particular).
3. Martin Pokorny. Martin is responsible for the Backend software, and the writing of correlator data products for image processing/analysis.
4. Dave Fort. Dave is responsible for the hardware design of the Station Board and most of the FPGAs on it, including the digital filter FPGA. Dave provides the important bridge between hardware register settings and hardware operation on the Station Board. Dave must be equipped with portable software tools to allow design modification of FPGAs and generation of modified bitstream files to fix possible problems and bugs.
5. Brent Carlson. Brent is responsible for the hardware design of the Baseline Board and the FPGAs and correlator chip on it, as well as overall system design. Brent provides the same function as Dave, except for the Baseline Board. Brent must also be suitably equipped with software tools to allow FPGA problem and bug fixes.
6. EVLA system hardware support. Mike Revnell is likely the primary NRAO person for this task since he designed the DTS receiver module, the primary hardware interface to the correlator.
7. EVLA project scientist/scientists. It must be possible to provide dynamic and ad-hoc support for source selection, correlator parameter selection, and image processing/data analysis. Likely it is acceptable for this person (or these persons) to be located in Socorro, with telephone access to people at the site, provided output data can be transferred to the AOC in a reasonable period of time.

Duration of testing, and the requirement for people to be on-site is impossible to predict, but is likely to be for several weeks at a time, possibly for several months duration.

## 6 Test Plan Matrix

The following matrix is a list of tests that should be performed for on-the-sky testing. The main purpose, a simplified description of the test setup, and expected outcome is defined for each test. Many tests require science input to choose sources that meet testing goals, as well as specific configurations to meet the goals of the tests. The last 10 tests are defined for astronomer-driven key science experiments of various kinds. It is hoped that a quasi-random mixture of science experiments will provide additional test coverage over and above that achieved with the tests defined in the matrix. More tests could be added if desired.

TEST	Purpose of Test	Description/Test Setup	Expected Outcome	Notes
0	Shipping damage check, prototype correlator installation and setup.	Unpack system, check for damage, install boards. Install system in test location.	All components available and undamaged. System installation successful.	Some assembly required.
1	System power-up and self-check with local 128 MHz oscillator on the Timecode Board.	Connect AC power to -48 VDC power supply. Connect AC power to to AC-powered components. Power-up system, use the Timecode local crystal oscillator. Perform Station Board checks. Perform Baseline Board checks. Check connectivity of Station-to-Baseline Boards. Check connectivity to Backend. Check RTDD and data capture capability. Check for test vector fringes.	All self-checks and functions ok. Backend receives frames. RTDD can display data products.	No antennas are required.

2	Computer network setup and check.	The Host Computer must be connected to the embedded processors via the switch. The switch is connected to the NRAO network to allow for time setting (or this setting may be manual via a control computer GUI), and for connection to Model Server.	Connected to network. Communications established with NRAO Model Server.	The control computer sets correlator configurations. The only connection to EVLA M&C is the Model Server and, optionally, the time setting.
3	Run self-checks with connection to NRAO "External Timecode", and 128 MHz 0 dBm CW.	Same as TEST 1, except use NRAO time reference. Check for timing synchronization of TIMECODE to array UTC.	TIMECODE synchronized to NRAO UTC. Phase-lock achieved on all chips on all boards. All intra-system checks ok.	No antennas required.
4	Establish connectivity of Station Boards to antennas via installed DTS receiver mezzanine cards.	Install DTS receivers into Station Boards. Connect antenna fibers to DTS receiver mezzanine cards installed in Station Boards.	Station Boards should be detecting antenna time ticks and no errors should be detected on the fiber links. The connection of the DTS receiver to the Station Board, with the use of CRC checking, should indicate all connections good.	These checks can be performed with 1 antenna, 1 Station Board at a time, or with DTS transmitter emulator.
5	Check multiple RF bands, 8-bits, for statistics and spectral content.	Run 8-bit data from antenna into correlator. Acquire wideband state counts. Acquire wideband autocorrelation spectra (1024 channels). Check statistics and spectral shape for expected values.	Statistics should indicate Gaussian noise. Persistence display with RTDD should indicate stability. Auto-spectrum should be as expected by receiver group.	These checks can be performed with 1 antenna, 1 Station Board at a time.

<p>6</p>	<p>Check multiple RF bands, 3-bits for wideband statistics and spectral content.</p>	<p>Run 3-bit data from antenna into correlator. Acquire wideband state counts. Acquire wideband autocorrelation spectra (1024 channels). Check statistics and spectral shape for expected values.</p>	<p>Statistics should indicate Gaussian noise. Persistence display with RTDD should indicate stability. Auto-spectrum should be as expected by receiver group.</p>	<p>If 3-bit sampler not available then this test can be skipped, or 3-bit data can be emulated by truncation and sample-repeat interpolation.</p>
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<p>7</p>	<p>8-bit sub-band filtering, 4-bit requantization, phase cal, statistics, sub-band auto-corr checks.</p>	<p>Run 8-bit sampler data from antenna into Station Boards; inject digital tone comb (preferably at DTS transmitter) so that there is at least 1 tone in each of the 8, 128 MHz sub-bands. Set RF to L-band so there is lots of unique spectral content for analysis. Set Delay Module to Quiescent State (A25290N0000 section 4.4.1). Set sub-band filters for 128 MHz. Set 4-bit re-quantization. Acquire wideband states, auto-corr, sub-band state counts, power, phase-cal extraction. Adjust scaling factor, clip counter. Note settings for each sub-band. Acquire Baseline-Board sub-band auto-spectra, maximum channels, no recirculation.</p>	<p>Re-verify wideband states, auto-spectra. Check sub-band state count histogram, power, phase-cal (stable amplitude and phase vs frequency). Check sub-band auto-spectra for content compared to wideband spectra.</p>	<p>These checks can be performed with 1 antenna, 1 Station Board active at a time.</p>
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<p><b>8</b></p>	<p>3-bit sub-band filtering, 4-bit re-quantization, phase cal, statistics, sub-band auto-corr checks.</p>	<p>Run 3-bit sampler data from antenna into Station Boards; inject digital tone comb (preferably at DTS transmitter) so that there is at least 1 tone in each of the 8, 128 MHz sub-bands. Set RF to X-band, to utilize full bandwidth. Set Delay Module to Quiescent State (A25290N0000 section 4.4.1). Set sub-band filters for 128 MHz. Set 4-bit re-quantization. Acquire wideband states, auto-corr, sub-band state counts, power, phase-cal extraction. Adjust scaling factor, monitor clip counter. Note settings for each sub-band. Acquire Baseline-Board sub-band auto-spectra, maximum channels, no recirculation.</p>	<p>Re-verify wideband states, auto-spectra. Check sub-band state count histogram, power, phase-cal (stable amplitude and phase vs frequency). Check sub-band auto-spectra for content compared to wideband spectra.</p>	<p>These checks can be performed with 1 antenna, 1 Station Board active at a time.</p>
<p><b>9</b></p>	<p>Establish real-time delay tracking, connection to Model Server. 8-bit test vector data, 4-bit re-quantization.</p>	<p>Use, as input, random noise/vector generator from DTS receiver. Turn on digital tone comb generator. Turn on wideband delay tracking in Station Boards. Turn on sub-band filters, state counts, phase-cal extractors.</p>	<p>Phase-cal ampl and phase vs time should be stable. State counts, power, spectra should be as expected. Delay tracking active and verified with phase cal.</p>	<p>These checks can be performed without any antenna if need be.</p>
<p><b>10</b></p>	<p>Establish real-time delay tracking, connection to Model Server. 3-bit test vector data, 4-bit re-quantization.</p>	<p>Use, as input, random noise/vector generator from DTS receiver. Turn on digital tone comb generator. Turn on wideband delay tracking in Station Boards. Turn on sub-band filters, state counts, phase-cal extractors.</p>	<p>Phase-cal ampl and phase vs time should be stable. State counts, power, spectra should be as expected. Delay tracking active and verified with phase cal.</p>	<p>These checks can be performed without any antenna if need be.</p>

<p><b>10a</b></p>	<p>Noise diode switching test, delay tracking active, 3 or 8-bit quantization, 1 antenna.</p>	<p>RF set for C or X-band. Turn on noise diode switching in antenna. Turn on digital tone comb generator. Turn on noise diode power detection on Station Board. Adjust phase of noise diode switching signal to determine max differential between ON and OFF.</p>	<p>Power difference between noise diode ON and OFF should be as expected. Phase-cal ampl and phase vs time should be stable.</p>	<p>This check requires 1 antenna, with noise diode switching turned on.</p>
<p><b>11</b></p>	<p><b>First fringe test</b>, single, short baseline, 8-bit, 4-bit re-quantization. One sub-band. One antenna should be "Reference Antenna", with well known LO fiber delay.</p>	<p>Set RF to C-band for minimal interference. Set antenna differential frequency shift to 1 kHz. Observe and track strong continuum source. Turn on digital tone comb generator in DTS transmitter. Turn on one sub-band filter at the center of the wideband. Turn on wideband and sub-band data quality indicators, sub-band auto-correlation and cross-correlation. Set maximum lag search window as supported by software w/o recirculation.</p>	<p>Stable phase-cal ampl and phase vs time, with delay tracking active. State counts, auto-spectra, power measurements within normal regions. Cross-correlation fringes detected, displayed with RTDD. Ampl and phase vs frequency as expected. SNR as expected. Refine fiber delay model for reference antenna. Try to save data from Backend to Archive, and load into image processing s/w (AIPS).</p>	<p>This test requires 2 antennas, possibly for an extended period of time.</p>
<p><b>12</b></p>	<p>First fringe check compared with old correlator, short baseline.</p>	<p>Single baseline fringes with old correlator for comparison with new correlator, TEST 11. Minimal setup change...route analog out of DTS receiver to old correlator. Fshifts turned off.</p>	<p>Check SNR and normalized amplitudes. Check spectrum. Check and compare with AIPS.</p>	<p>This test requires 2 antennas for a short period for the observation. Comparison of old and new correlator can be performed off-line.</p>

<p><b>13</b></p>	<p>Fringe test, single, short baseline, 3-bit, 4-bit re-quantization. One sub-band.</p>	<p>Set RF to X-band for full 2 GHz bandwidth. Set differential frequency shift to 1 kHz. Observe and track strong continuum source. Turn on digital tone comb generator in DTS transmitter. Turn on one sub-band filter at the center of the wideband. Turn on wideband and sub-band data quality indicators, sub-band auto-correlation, cross-correlation. Set maximum lag search window.</p>	<p>Stable phase-cal ampl and phase vs time, with delay tracking active. State counts, auto-spectra, power measurements within normal regions. Cross-correlation fringes detected, displayed with RTDD. Ampl and phase vs frequency as expected. SNR as expected. Try to save data from Backend to Archive, and load into image processing s/w (AIPS).</p>	<p>This test requires 2 antennas, possibly for an extended period of time.</p>
<p><b>14</b></p>	<p>Finge check compared with old correlator, short baseline, X-band.</p>	<p>Same as TEST 13, but use old correlator, Fshifts turned off.</p>	<p>Check SNR and normalized amplitudes. Check spectrum. Check and compare with AIPS.</p>	<p>This test requires 2 antennas for a short period for the observation. Comparison of old and new correlator can be performed off-line.</p>
<p><b>15</b></p>	<p>Fringe test, single, short baseline, 8-bit, 4-bit re-quantization. All sub-bands active, max bandwidth.</p>	<p>Same as TEST 11, except all sub-bands active.</p>	<p>Same as TEST 11, except all sub-bands active. Analyze all sub-bands. Stitch sub-bands if possible.</p>	<p>This test requires 2 antennas, probably for a short period of time.</p>
<p><b>16</b></p>	<p>Same as TEST 15, except 3-bit quantization.</p>	<p>Same as TEST 15, except 3-bit quantization.</p>	<p>Same as Test 15.</p>	<p>Same as Test 15.</p>

<p><b>17</b></p>	<p>Fringe test, single, max EVLA baseline, 8-bit, 4-bit re-quantization. All sub-bands active, max bandwidth (1 GHz/pol'n)</p>	<p>Set RF to C-band. Set differential frequency shift to 1 kHz. Observe and track strong continuum source. Turn on digital tone comb generator in DTS transmitter. Turn on wideband and sub-band data quality indicators, sub-band auto-correlation, cross-correlation. Set max spectral channels for each product.</p>	<p>Stable phase-cal ampl and phase vs time, with delay tracking active. State counts, auto-spectra, power measurements within normal regions. Cross-correlation fringes detected, displayed with RTDD. Ampl and phase vs frequency as expected. Watch for delay-tracking-error induced coherence losses. SNR as expected. Try to save data from Backend to Archive, and load into image processing s/w (AIPS). Stitch sub-bands if possible.</p>	<p>This test requires 2 antennas, possibly for an extended period of time.</p>
<p><b>18</b></p>	<p>Fringe check compared with old correlator, max EVLA baseline.</p>	<p>Comparison test with TEST 17 and TEST 19, settings for old correlator.</p>	<p>SNR for old correlator bandwidth should be consistent with SNR for new correlator.</p>	<p>This test requires 2 antennas for a short period of time.</p>
<p><b>19</b></p>	<p>Fringe test, single, max EVLA baseline, 3-bit, 4-bit re-quantization. All sub-bands active, max bandwidth (2 GHz/pol'n)</p>	<p>Same as TEST 17, except 3-bit quantization.</p>	<p>Same as TEST 17</p>	<p>This test requires 2 antennas, possibly for an extended period of time.</p>

<p><b>20</b></p>	<p>Amplitude and phase closure test, deep integration, max EVLA baselines, 8-bit, 4-bit re-quantization. All sub-bands active, max bandwidth (1 GHz/pol'n)</p>	<p>Set RF to S-band. Set differential frequency shift to 1 kHz. Observe and track strong continuum source for deep integration. Turn on digital tone comb generator in DTS transmitter. Turn on noise diode switching in antenna and correlator. Generate all data products, data quality indicators. Set max spectral channels for each product.</p>	<p>Stable phase-cal ampl and phase vs time. SNRs as expected. Amplitude and phase closure determined to limits of EVLA specifications. Stitch sub-bands if possible. First image.</p>	<p>This test requires 4 antennas, for the duration of the requested deep integration.</p>
<p><b>21</b></p>	<p>Continuum amplitude and phase closure test, max EVLA baselines, 3-bit, 4-bit re-quantization. All sub-bands active, max bandwidth (2 GHz/pol'n)</p>	<p>Set RF to X-band for full 2 GHz bandwidth. Set differential frequency shift to 1 kHz. Observe and track strong continuum source for deep integration. Turn on digital tone comb generator in DTS transmitter. Turn on noise diode switching in antenna and correlator. Generate all data products, data quality indicators. Set max spectral channels for each product.</p>	<p>Stable phase-cal ampl and phase vs time. SNRs as expected. Amplitude and phase closure determined to limits of EVLA specifications. Stitch sub-bands if possible. First image.</p>	<p>This test requires 4 antennas, for the duration of the required deep integration.</p>
<p><b>21a</b></p>	<p>Same as 21, except use Q-band, for max fringe-phase acceleration, to find delay and phase tracking errors.</p>	<p>Same as TEST 21, except use Q-band. Ensure that delay center on the sky is well-defined and previously well characterized by VLA. This test aims to ensure that delay and phase tracking is precise and accurate, and to find "time application" errors in correlator.</p>	<p>Expected image and amplitude and phase closure solutions.</p>	<p>This test requires 4 antennas, for the duration of the required deep integration.</p>

<p><b>22</b></p>	<p>Spectral-line amplitude and phase closure test, max EVLA baselines, 8-bit, 4-bit re-quantization. All sub-bands active, using multiple stages in digital filter.</p>	<p>Set RF to band with max spectral-line "variety". Suggest Q-band to maximize impact of "time of application" of models errors in correlator. Observe spectral-line source with max dynamic range, many spectral-line sources in the field. Set differential frequency shift to 1 kHz. Observe and track spectral-line sources for deep integration. Turn off digital tone comb generator in DTS transmitter. Generate all data products, data quality indicators. Set several different sub-band bandwidths, using a variety of filter stages. Set max spectral channels for each product.</p>	<p>SNRs as expected. Amplitude and phase closure to limits of EVLA specifications. Spectral dynamic range should meet EVLA specifications. Build images of spectral-line sources, compare with existing archive images.</p>	<p>This test requires 4 antennas, for the duration of the required deep integration.</p>
<p><b>23</b></p>	<p>Recirculation, spectral-line test, single baseline.</p>	<p>Observe same field as TEST 22. Turn on recirculation with various factors and sub-band bandwidths. Turn off digital tone comb generator in DTS transmitter.</p>	<p>Compare recirculation spectra with non-recirculation (Test 22 results) or with simultaneous non-recirculation results.</p>	<p>This test requires 2 antennas, possibly for an extended period of time.</p>
<p><b>24</b></p>	<p>Same as TEST22, except using recirculation.</p>	<p>Same as TEST 22, except with recirculation.</p>	<p>Compare results with TEST 22, if possible the same spectral resolution as TEST 22, except using recirculation.</p>	<p>This test requires 4 antennas, for the duration of the required deep integration.</p>

<p><b>25</b></p>	<p>Pulsar phase binning test, single, short baseline, (250 usec <math>\leq</math> bin width <math>\leq</math> 500 usec). 8-bit quantization.</p>	<p>Observe strong L-band pulsar with desired bin-width <math>\leq</math> 500 usec. Set number of bins to max, set bin integration for high SNR pulse profile acquisition. Tone comb generator off. Max sub-bands and bandwidth.</p>	<p>Integrated pulse profile and derived dispersion measure should compare favourably with established profiles for this pulsar. Should be able to derive refined pulsar ephemeris from this data set. Compare with ephemeris from other sources.</p>	<p>This test requires 2 antennas, possibly for an extended period of time.</p>
<p><b>26</b></p>	<p>Pulsar phase binning test, single, short baseline, bin width <math>\geq</math> 1 msec. 8-bit quantization.</p>	<p>Observe strong L-band pulsar with desired bin-width <math>\geq</math> 1 msec. Set bin integration for high SNR pulse profile acquisition. Tone comb generator off. Max sub-bands and bandwidth.</p>	<p>Integrated pulse profile and derived dispersion measure should compare favourably with established profiles for this pulsar. Should be able to derive refined pulsar ephemeris from this data set. Compare with ephemeris from other sources.</p>	<p>This test requires 2 antennas, possibly for an extended period of time.</p>
<p><b>27</b></p>	<p>High performance, pulsar phase binning test, single short baseline, bin width <math>\sim</math> 20 usec, 8-bit quantization.</p>	<p>Observe millisecond pulsar. One CCC per Correlator Chip active. Set bin integration for high SNR pulse profile acquisition. Tone comb generator off. Max sub-bands. Highest binning performance.</p>	<p>Integrated pulse profile and derived dispersion measure should compare favourably with established profiles for this pulsar. Should be able to derive refined pulsar ephemeris from this data set. Compare with ephemeris from other sources.</p>	<p>This test requires 2 antennas, likely for not very long.</p>

<p><b>28</b></p>	<p>Pulsar phase binning test, 4 antennas, max bandwidth, max spectral resolution, deep integration.</p>	<p>Observe relatively weak L-band pulsar with any desired bin width, within dump performance restrictions of correlator. Max sub-bands and bandwidth.</p>	<p>Integrated pulse profile and derived dispersion measure should compare favourably with established profiles for this pulsar. Should be able to derive refined pulsar ephemeris from this data set. Compare with ephemeris from other sources. Build image and compare with existing archive images.</p>	<p>This test requires 4 antennas, for the duration of the deep integration.</p>
<p><b>29</b></p>	<p>Real-time interference robustness and blanking test, single, short baseline.</p>	<p>L-band, short baseline, max bandwidth, 8-bit quantization, 7-bit (and/or 4-bit) re-quantization. All sub-bands active/max bandwidth. Experiment with settings of RFI blanker in Filter Chip. Compare wideband auto-spectra with cross-spectra. Determine settings and effectiveness of RFI blanker, in combination with interference excision capability of Backend.</p>	<p>Try to obtain "RFI-clean" coherently integrated spectrum. Determine SNR of each spectral channel, which will be different only if Backend excision turned on. If source spectral lines available, try to quantify effectiveness of interference suppression measures on the quality of these lines.</p>	<p>This test requires 2 antennas, for the duration of experimentation of RFI blanking parameters.</p>
<p><b>30</b></p>	<p>Real-time interference robustness and blanking test, 4 antennas, short medium, and long baselines.</p>	<p>Same as TEST 29, except 4 antennas active. Mixed spectral-line and continuum source (s). Deep integration. May require very fast dump times.</p>	<p>Same as TEST 29, except build image and try to quantify the effectiveness of RFI rejection, including RFI excision in image processing software.</p>	<p>This test requires 4 antennas, for the duration of the deep integration, allowing for time to experiment with RFI blanking parameters.</p>
<p><b>31</b></p>	<p>High SNR solar observation.</p>	<p>Correlator settings as required by astronomy teams, possibly incorporating "wideband recirculation". Possibly requiring 64 lags per CCC</p>	<p>Results as required by astronomy teams.</p>	<p>This test requires 4 antennas for the duration of the experiment.</p>

		output mode from correlator.		
<b>32</b>	Narrowband, high-spectral resolution.	Maximum spectral resolution on desired sub-band bandwidth. Possibly 1 Hz resolution. Correlator settings, number of antennas, set by astronomy team. Try to exercise all stages in the Filter Chip.	Results as required by astronomy teams.	This test requires 4 antennas for the duration of the experiment.
<b>33</b>	Radar-mode data capture.	Set sub-band for capture to 31.25 kHz. Capture data into NFS files. Use Filter Chip Stage 2 mixer to stop fringes and very-fine delay tracking. Observe spectral-line source with continuum.	Correlate captured data in software. Ensure results are as expected.	This test requires 4 antennas for the duration of the data capture portion of the experiment.
<b>34-44</b>	Astronomer-driven key science experiments of various kinds: continuum, high dynamic range spectral-line, mixed continuum and spectral-line, pulsar, recirculation, fast dumping, long integrations, radar mode.			

## 7 Test Priorities

This section establishes the priority for each of the tests defined in section 6. Priority definitions are as follows:

- **Critical** – This is a critical test that must be performed to verify hardware. If this test is not performed, there is a reasonable probability that an unrecoverable hardware error could find its way into the final system.
- **High** – This is a high priority test that should be performed to verify hardware, but if not performed and a bug is found after production, has a high probability that it can be fixed with an FPGA code change.
- **Medium** – This is a medium priority test that should be performed to verify that hardware/software timing and interactions are correct. If a bug is not found until after production there is a high probability that it can be fixed with a software code change, or possibly an FPGA code change.
- **Low** – This is a low priority test that should be performed since the EVLA will operate in this parameter space, but there is a zero probability that it will find an unrecoverable hardware bug.

The following table lists the priority for each test of section 6, and comments as to why that priority code is assigned.

Test	Priority	Comments
0	Critical	Needed before any tests can be performed.
1	Critical	Needed before any tests can be performed.
2	Critical	Needed before any tests can be performed.
3	Critical	Needed before any tests can be performed.
4	Critical	Needed before any tests can be performed.
5	Medium	Establishes basic signal quality measures. More of a DTS link test measure, but not critical for correlator hardware. Multiple RF bands specified, but only 1 RF band required if performed.
6	Medium	Establishes basic signal quality measures. More of a DTS link test measure, but not critical for correlator hardware. Multiple RF bands specified, but only 1 RF band required if performed.
7	High	Establishes functionality of digital filter banks, and sub-band autocorrelations.
8	High	Establishes functionality of digital filter banks, and sub-band autocorrelations.
9	Critical	Needed before any further critical tests can be performed.
10	Critical	Needed before any further critical tests can be performed.
11	Medium	Establishes functionality of noise diode switching and single-station delay tracking. While not critical, this test is a step

		before the next critical test, and uses only 1 antenna.
12	Critical	Establishes that delay tracking is working, to 1 <sup>st</sup> order, with 8-bit input.
13	Critical	Establishes that delay tracking is working, to 1 <sup>st</sup> order, with 3-bit input.
14	High	Comparison with old correlator to establish baseline confidence in sensitivity and performance of new correlator.
15	Medium	All sub-bands active, 8-bit input. Low probability that problem is found here that is not found with test vectors.
16	Medium	All sub-bands active, 3-bit input. Low probability that problem is found here that is not found with test vectors.
17	High	8-bit input max EVLA baseline used to determine if delay/phase models applied at the correct time. Important step before test 20.
18	High	Comparison with old correlator to establish baseline confidence in sensitivity and performance of new correlator on longest baseline.
19	Medium	3-bit input max EVLA baseline. Lower than critical priority since 8-bit test already performed.
20	Critical	8-bit input phase/amplitude closure test, longest baselines, deep integration. Most important critical test for finding low-level systematic bugs.
21	Medium	8-bit input phase/amplitude closure test, longest baselines, deep integration. Not so important if 8-bit test performed.
21a	Medium	Finds “time of application” errors for phase and delay models. Any bugs found are most likely due to software.
22	Critical	8-bit input, spectral line phase/amplitude closure test. Critical since it is used to help to quantify spectral dynamic range.
23	Low	Recirculation.
24	Low	Recirculation.
25	Low	Pulsar phase binning.
26	Low	Pulsar phase binning.
27	Low	Pulsar phase binning.
28	Low	Pulsar phase binning.
29	Medium	Exercises interference mitigation on real data. Likely no bug found that can’t be fixed with FPGA or software code changes. Some chance that it could reveal that 8-bit initial sampling is not sufficient, but that is a major change involving more than the correlator.
30	Low	
31	Low	
32	Medium	First exercise of all stages of digital filter on real data.
33	Low	
34-44	Low	Useful for beginning of system integration and testing.

**Table 7-1 Table of test priorities.**