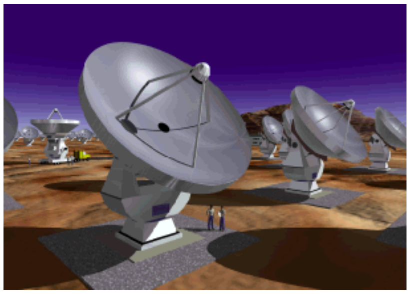

ALMA Correlator

Reliability, Maintenance and Testing

CORL-60.00.00.00-014-A-PLA

Version: A

Status: Draft
2003-09-16

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Xxx	Xxx	yyyy-mm-dd
xxx	Xxx	yyyy-mm-dd
Released By:		
Name and Signature	**Organization**	**Date**
xxx	Xxx	yyyy-mm-dd

Change Record

Version	**Date**	**Affected Section(s)**	**Change Request #**	**Reason/Initiation/Remarks**
A	2003-09-16	All	None	First Draft

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1 Introduction

This document presents the plan for reliability, maintenance, and testing of the baseline ALMA correlator.

2 Reliability

Estimates of the failure rate of the baseline ALMA correlator are based on the past performance of similar systems in the experience of the NRAO. The vast majority of failure-prone components in the system, as presently designed, are expected to be integrated circuits and power supplies.

Passive components, such as resistors and capacitors, have been shown to have very low failure rates in large digital systems operated by the NRAO. Thus, it is to be expected that the reliability of the system will largely be a function of the active devices.

For power supplies, the manufacturers' reliability figures are about the only source of reliability information short of performing accelerated lifetime tests.

2.1 Integrated Circuit Reliability

The table below summarizes the failures tabulated for three NRAO systems. Custom integrated circuits have been excluded from both the VLA and VLBA in these tabulations. The failure rates of the VLA custom ICs have accelerated in recent years (the well-known end-of-life phenomenon), and present failure rates are not representative of the first 20 years of system operation. The first-run VLBA custom ICs had a known bad process, resulting in an abnormally high failure rate. A second run of VLBA custom ICs produced chips with a normal failure rate.

The implied failure rate column in the table below reflects the fact that there are 55,000 integrated circuits in the baseline ALMA correlator design.

Table 1. Implied IC Failure Rate

SYSTEM	# ICs	IC FAILURES	MONTHS	IMPLIED ALMA FAILURE RATE
VLA CORRELATOR	67,000	105	48	1.8 ICs PER MONTH
VLBA CORRELATOR	18,000	8	48	0.6 ICs PER MONTH
GBT SPECTROMETER	3,500	5	24	3.3 ICs PER MONTH

We therefore expect a circuit board failure due to an integrated circuit failure about every two weeks. Failure of a single chip typically will shut down one to a few circuit boards, and this means that typically one IF baseband from one antenna will be down until the chip can be replaced. This will occur fairly often, but will have only minor impact on observing.

2.2 Power Supply Reliability

There are two main types of power supplies in the baseline ALMA correlator. The AC to 48 VDC conversion is done using large telecom industry racks. DC to DC converters on printed circuit cards take the 48 VDC output of these racks and supply appropriate voltages to the logic cards.

Manufacturer's reliability information on the AC to DC conversion indicates an MTBF of 250,000 hours per 200 amp rectifier unit. Each quadrant of the correlator uses 6 rectifier units, which provides N+1 redundancy. With 24 active rectifier units, and assuming a uniformly distributed random failure profile, we may expect an overall MTBF of about 10,000 hours for the AC to DC system. The failure of one rectifier unit in a rack does not shut down the system, and the units are hot-swappable. Array downtime is therefore expected to be negligible due to this source.

The DC to DC converters used in the correlator are Synqor PQ4800 series units with a 20,000,000 hour demonstrated MTBF. Each quadrant of the correlator uses about 600 DC to DC supplies. We may therefore expect an overall MTBF of about 33,000 hours for the DC to DC system. Failure of a single DC to DC converter typically will shut down one to a few circuit boards, and this means that typically one IF baseband from one antenna will be down until the converter can be replaced. This will be a rare event with minimal impact on observing.

3 Maintenance

There are no moving parts in the baseline ALMA correlator, so routine maintenance requirements exist only for things like cooling air conditioning and air filtration which are building, not correlator, functions.

When failures in the system occur, maintenance will be principally at the circuit card change level. System tests will be available sufficient to limit the location of a problem to one or at most two circuit cards. Repair of the system will then be a matter of replacing the defective card. Repair of the defective card will occur at the Operation Support Facility (OSF), using card test fixtures provided with the system.

Adequate spare cards and power supplies will be kept at the Array Operation Site (AOS) technical building for maintenance.

4 System Testing

4.1 Test Plans and Procedures

The correlator IPT will hire and train an engineer who will move with the baseline correlator to Chile. This engineer will be given duties while the system is being constructed in the United States that will allow him or her to become thoroughly familiar with the system and to be completely competent in its repair.

There will be a comprehensive suite of software tests that will allow this engineer and associated technician to trace any problem in the system to one or two circuit cards.

Test software, already in place and planned, will allow an engineer or technician to stimulate the part of the system being tested in many incremental places with test signals. Looking for appropriate responses at points downstream of suspected failure points will help in pinpointing the problem. Repair of the system will be at the card replacement level.

Card repair will take place at the OSF where a complete set of test fixtures will be available.

4.2 Test Equipment

Given the software support envisioned for troubleshooting the system, most maintenance should require no test equipment at all. Difficult problems, however, will undoubtedly require an oscilloscope and voltmeter, plus a tool kit.

Similar equipment, together with custom card test fixtures, will be required at the actual OSF repair site.

5 Training Plan for Correlator Maintenance

As mentioned above, it is planned to hire an engineer early in the construction phase of the first quadrant of the baseline correlator who will move with the system to Chile. This engineer will participate in the initial testing of logic cards for the system, as well as in the construction and testing of the system.

This experience, combined with extensive documentation, will allow this person to be fully capable of training maintenance personnel at the site, as well as handle any technical problem encountered in the operation of the system.

In addition to the permanent site engineer, engineers from Charlottesville will participate in the initial installation of the system at the ALMA site.

6 Life Cycle Costs

The main life costs associated with the baseline correlator will be the salaries and benefits of maintenance personnel, plus infrastructure costs such as electricity and cooling.

Lifetime purchases of spare logic cards and spare loose parts will have been done with the purchase of material for the initial build of the system. These spare cards and parts, along with a complete suite of test fixtures, will be shipped to the OSF at a time appropriate to their potential need at the site.

Experience, however, has shown the eventual need to replace aging system power supplies. A generous supply of spare power supplies, both AC to DC rectifier units and DC to DC converters, will be purchased for shipment to the site as spares. However, it will probably be necessary eventually to purchase new units for extended system upkeep.