TEST AND VERIFICATION REPORT

EVLA Correlator Reliability Report #1

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Revision: Report #1

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List of Abbreviations and Acronyms

RBD – Reliability Block Diagram.

COTS – Commercial Off-The-Shelf.

BGA – Ball Grid Array.

MTBF – Mean Time Between Failures. Always specified in hours.

FITS – “Failures in time”. 1 FITS is 1 failure in 10^9 hrs.

Definitions

Telcordia SR-332 – Telecom reliability standard.

MIL-HDBK-217F N2 – Military reliability standard.

1 Revision History

Revision	Date	Changes/Notes	Author
Report #1	June 6, 2005	Report #1 Release	B. Carlson

2 Introduction

This is the first in a series of reliability reports that will be produced as the EVLA correlator system design is refined, better reliability models become available, and as field data starts to be incorporated into reliability analysis. The purpose of this and subsequent reports is to predict the reliability of the system to, in the short term, recommend design changes to maximize reliability and, in the long term, to provide data so that adequate spares and maintenance can be planned to ensure that the correlator is able to be fully operational for its expected 20 year lifetime.

The size of the system and the number of components utilizing leading-edge technology make accurate reliability prediction difficult and tenuous at best. Nevertheless, reliability standards exist that facilitate reliability prediction, and these standards are conservative. Two of these standards are MIL-HDBK-217F and Telcordia SR 332. The military 217F standard has been used for decades for reliability prediction of electronic equipment and incorporates field data into reliability models. It is thought to be too conservative for the purpose of the EVLA correlator and so the Telcordia model is used in the reliability analysis. The Telcordia standard evolved out of the 217F standard and was developed to more accurately reflect telecom field reliability data. Since the EVLA correlator is in a central-office-like environment and since it has a 20 year lifetime, it is felt that the Telcordia model is a more accurate representation of correlator reliability. In bare numbers, the 217F standard is roughly 2-3 times more conservative than the Telcordia standard.

Reliability prediction of a large system is no easy task. However, it is more quickly, confidently, and accurately predicted with the use of software that incorporates the Telcordia model (and, where necessary, the 217F model). The **Relex** reliability prediction software was chosen to use for this analysis[1]. The appendices of this report include reports generated directly by the software. The Relex software contains 3 components that are important for the correlator. The first and foundational component is reliability prediction. MTBF (Mean Time Between Failure) numbers are developed for all components of the system in a hierarchical fashion. At the component level, where possible, manufacturer's reliability data is used. Where reliability data is not available, the Telecordia model that best describes the component is used. The second component is the Reliability Block Diagram or **RBD** capability of Relex. With this graphical-entry capability, it is possible to build a model of the system that reflects either inherent or explicit redundancy, and real-life parameters for things like MTTR (Mean Time To Repair), replacement time, servicing intervals, spares available, discard percentage, spares replenishment etc. The third component is **OpSim**, whereby Relex can automatically determine the number of spares required for the lifetime of the system, given the parameters that are entered. When the analysis of the RBD is performed with

[1] After evaluation of other reliability prediction and analysis software, the Relex software including RBD and OpSim was found to most closely meet the needs of the project.

OpSim, it is possible to obtain quantitative measures of system availability throughout the lifetime of the system given some reasonable assumptions as to the failure-rate distribution. The result of this analysis is a measure of spares requirements and system availability over the next 20 years. Provided entered parameters reflect reality, actual system maintenance costs are predicted.

Another component of Relex that is available is PRISM. PRISM aims to incorporate into reliability prediction human and real-life factors that may not directly be incorporated into the Telcordia model. PRISM thus incorporates the distinct possibility that lurking hardware and software bugs have a very real effect on system availability. In this report, PRISM is not incorporated into the reliability prediction models as it is the intention that it will take considerable effort over a year or more to "shake down" the system until it becomes fully operational. Thus, reliability prediction and system availability analysis in this report takes a distinct long-term view of the system and factors out the inevitable unreliability of the system in the short term.

According to the Telcordia SR-332 standard (section 2.8), PCB and solder joints of devices attached to the PCB do not factor into reliability prediction:

> *When unit failure rates are being predicted, wire, cable, solder connections, wire wrap connections, and printed wiring boards (but not attached devices* [author's note: assume this means mezzanine cards] *and connector fingers) may be excluded.*

The statistical considerations for the standard also indicate that the Telcordia predictions are conservative, and that **the actual failure rate is liable to be lower than the estimate of the failure rate, with greater than a 90% chance**. Section 2.10 of the Telcordia standard states:

> *As a protection for reliable service, predictions provided by RPP (Reliability Prediction Procedures) methods are conservative. That is, the actual failure rate is liable to be lower than the RPP estimate of the failure rate. The main reason for this rests with the generic failure rates for devices provided in Table 7-1. The values provided in this table are 90% Upper Confidence Level point estimates. This means that there is a 90% chance that the actual device generic failure rate is lower than the table value.*
>
> *When these values are combined (as in calculating a unit failure rate from the failure rates of the various devices in its assembly), the predicted value is even more conservative. Thus, there is at least a 90% chance (e.g. perhaps a 95% chance) that the actual failure rate for a unit is lower than the value predicted by the RPP.* ***In general, the greater the number of different device types used in a unit, the more conservative the unit RPP prediction is.***

Burn-in time and temperature also affect the reliability prediction. According to section 2.5 of the Telcordia standard:

> *… The longer the burn-in and the higher the burn-in temperature, the more the First-Year Multiplier is reduced*. [author's note: example given in the standard, indicates

that for extensive high-temperature burn-in (168 hrs of device burn-in at 150 C, 70 hrs of unit burn-in at 70 C), the First Year Multiplier is reduced by a factor of about 3.5—i.e. the first year failure rate is 3.5X less than without burn-in].

However, the standard (section 2.5) goes on to say:

> *Some suppliers have questioned the value of burn-in for mature product designs. Telcordia investigated the relevance of burn-in for mature product designs through a study that included three types of burn-in, as well as no burn-in. This study examined the trade-off of time saved in the manufacturing cycle vs. the cost of any additional failure if burn-in is eliminated. This study concluded that for mature product designs it is not necessary to do a burn-in, and the savings of time and material without burn-in would reduce the cost of the mature product.*

Thus, it would seem that burn-in costs more than it is worth, although for a high-reliability system at a remote site and with limited number of spares, the burn-in cost would likely be worth it. The Relex reliability model of the correlator includes a unit (i.e. board) burn-in temperature of 70 C for 100 hours.

Note that throughout this report, failure rate is in FITS (number of failures in 10^9 hours), and MTBF is in hours.

3 Overview

The EVLA correlator is a large complex system with several hundred printed circuit boards deployed in a couple of dozen racks. Great care is being taken to design the hardware and software in such a way as to minimize reliability problems, but nevertheless there are reliability problems that can creep into the design that engineers not directly concerned with reliability may be unaware of. A detailed component analysis looking at things like operating voltage, power, and temperature dependent reliability effects provided feedback to engineers that is relatively easy and inexpensive to incorporate in the design stage, but that can be extremely costly and time consuming once the system is operational.

In the long term it is essential to have some idea of what the maintenance and spares requirements of the system are to ensure that it remains operational for its entire 20 year lifetime. In some cases, knowledge of spares is relatively unimportant such as in COTS computers, which are expected to be replaced every so often. In other cases, knowledge of spares requirements are critical since after a few years it is unlikely that modules can be replenished due to obsolete components and technology. In this case, if adequate spares are not available it could mean the eventual loss of system components to the point where it is essentially not operational.

As it turns out, a critical parameter (affecting spares requirements) in the technology used in the EVLA correlator is the number of times that a circuit board can be re-worked to replace a BGA (Ball Grid Array) device. BGA devices, with their high pin-counts, are essential for delivering the functionality and performance that the correlator promises. However, to replace a BGA device, specialized equipment is needed to heat the entire circuit board to remove and replace the device without causing heat gradients that can warp the circuit board. Since a circuit board can only withstand a finite number of heating/cooling cycles, at some point it is necessary to discard the circuit board. If a new assembly cannot be ordered to replace the discarded assembly, then adequate spares are required to replace discarded boards. Thus, the probability that the failure on a board is a BGA device, the failure rate of the board, and the number of re-works allowed per board, determine the discard percentage of the board and the spares requirements.

The Relex software is very powerful and is built for reliability analysis and system availability and spare prediction but it does have some limitations[2]. The main limitations that affect the ability to produce results are as follows:

- <u>It is not possible to produce a reliability report on a total-system component count basis</u>. Thus it is not possible to discern directly from the report what the MTTF (Mean Time To Failure) for the total quantity of a particular component is so that a simple calculation can yield what the component spares requirements are for the lifetime of the system. For example, the report does not add up all of the correlator chips in the system given the number of Baseline Board assemblies. It

[2] Referring to Relex Version 7.7 that is used for this report.

can only report the MTBF of the collection of Baseline Boards—not a total of chips on all boards. A workaround to this problem is to develop a separate spreadsheet to manually add up all of the components of a particular type and calculate the aggregate reliability.

- The first choice in assigning a reliability value to a particular component or COTS sub-assembly is to use manufacturer's data since some components or sub-assemblies are not slotted well into one of Telcordia's sub-categories. In this case, the software is told that the reliability of the component is assigned, rather than calculated from the model. <u>Unfortunately, when specified reliability data is used, it is no longer possible to assign a temperature-dependence on the reliability</u> and thus it is only possible to assign a reliability number at the operating temperature the component is expected to be at, using the approximate rule of thumb that every 10 ^{o}C change in temperature changes the MTBF of the component by about a factor of 2. The result of this is that it is not possible to use the software's built-in ability to determine the reliability vs time function of an assembly or of the system. It is hoped that the ability to assign a temperature dependence on assigned reliability numbers will be possible in future releases of the software, and thus in future system reliability reports.
- The Reliability Block Diagram (RBD) cannot be built on a hierarchical basis, and thus it is unwieldy to build a diagram that exactly reflects redundancy in the system. Therefore some approximations are used.

Figure 1 graphically shows the failure rates for the aggregate of various components in the system. The histogram bars going from left to right correspond to the legend going from top to bottom. The Station Boards, Baseline Boards, and air conditioners dominate the failure rates in the system.

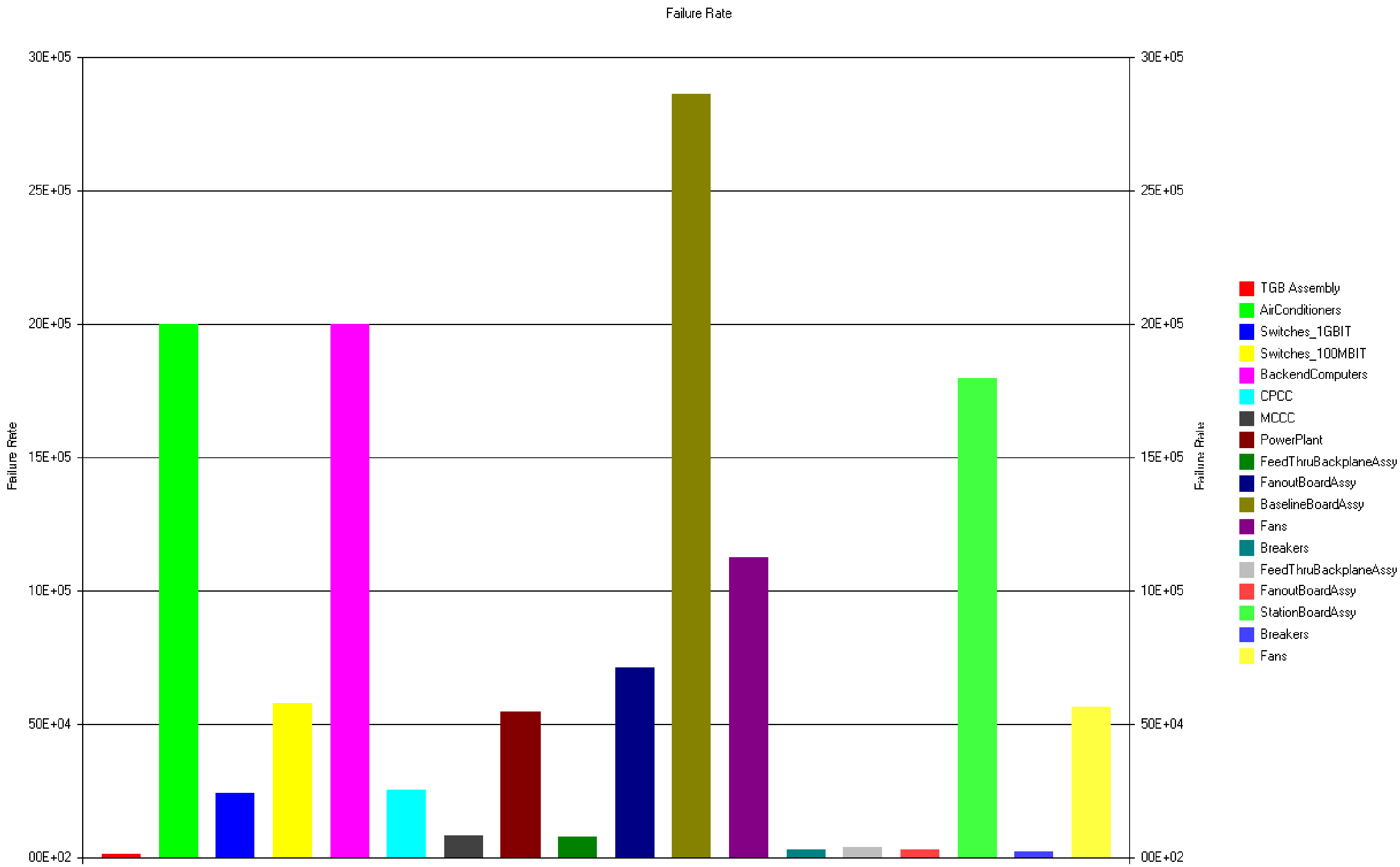


Figure 1 Graph of aggregate failure rates (FITS) for various components in the system.

4 Reliability Prediction Results

Table 1 is a synopsis of individual MTBF values for assemblies and sub-assemblies in the correlator system. The results incorporate design recommendations where noted in **bold** in the description. In the cases where the discard percentage is 100%, it is assumed that it is not possible to repair the module, but that it is always possible to replenish the module from the same or different manufacturer. For in-house designed modules the discard percentage is based on the probability of failure of a BGA device on a board, and a maximum of 3 re-work cycles allowed per board. Discard percentage is calculated as follows:

$$\text{Discard \%} = \text{Probability of BGA failure on board} / 2^{(\text{\# reworks allowed})}$$

That is, each possibility of a rework cycle reduces the number of boards that have to be discarded by a factor of 2.

In addition, the following points and assumptions are of note:

- Where devices can be replaced on a board without a full-board heating cycle, it is assumed that an infinite number of reworks are possible. The discard percentage applies to the board assembly itself not including any installed mezzanine cards.
- In the case where the temperature at which the MTBF calculation is performed, it is the average temperature of the PCB—individual chip temperatures are higher where noted. Refer to the Relex reliability report for actual chip temperature estimates.
- There is a mixture of 60% and 90% confidence levels in the data. Where manufacturer's data use the Arrhenius relation to extrapolate from accelerated life tests on a sample size to MTBF, it is a 60% confidence level. When the Telcordia model is used, it is a 90% confidence level.
- In the cases where 90 nm FGPAs are used there is no manufacturer's reliability data available yet, and so reliability data for similar 130 nm devices is used.
- On all boards, the reliability of the DC-DC power supply modules mostly dominates the failure rate. The failure rate data for the Artesyn modules (i.e. footprint, function, and performance equivalent to the Vicor modules) at 45 ^{o}C case temperature is used since the manufacturer's calculation is according to the Telcordia model at 50% load and is 3.8 million hours. The MTBF of the Vicor modules is calculated at 25 ^{o}C according to MIL-HDBK-217F and is 1.5 million hours. There is no data available to extrapolate to 45 ^{o}C for the Vicor modules, although some temperature dependent information on mil-spec modules exist in the data sheets for previous generation supplies.
- The mean time to *replace* a module in the correlator is 60 minutes. This doesn't include air conditioner, battery, or power plant rack replacement or repair.
- MTBF = 10^9 / failure rate (FIT).

Refer to the appendices for the complete Relex-generated reliability report.

Assembly	Description	MTBF (hrs)	MTBF (years)	Discard %
PC/104+ (Kontron MOPSLCD6)	COTS embedded processor. MTBF based on mfg data for similar CPU, since MTBF for this CPU not yet available.	390,000	44	100
PCMC	PC/104+ Mezzanine Card. Calculated MTBF @ 35 ^oC	3.7 million	423	1.4
Timecode Generator Board	Complete with PCMC, PC/104+ mezzanine cards. Calculated MTBF @ 45 ^oC	164,758	18	0.086
Fanout Board	1 Gbps fanout board. No BGA devices. Calculated MTBF @ 35 ^oC. **Motorola 1:10 LVPECL fanout chips @ T_j=50 ^oC—require heatsink.** MTBF of SynQor power supply from mfg at 40 ^oC, 80% load.	361,000	41	0
Feedthru Backplane	Feedthru backplane/midplane. Calculated MTBF @ 35 ^oC. Assume failure is damaged pin and therefore not repairable.	10,632,400	1217	100
Baseline Board	Complete with PCMC, PC/104+ mezzanine cards; w/o SFP fiber or copper module. Calculated MTBF @ 35 ^oC, T_{jmax}=50-55 ^oC for all chips. **DDR SDRAM not BGA**. **The LP2995 linear regulator must use a PSOP-8 package rather than SO-8**.	56,000	6.4	3.75
Station Board	Complete with PCMC, PC/104+, Delay modules, NRAO FORM. Calculated MTBF @ 35 ^oC, T_{jmax}=50-55 ^oC for all chips.	71,168	8.1	1.177
Delay Module	Calculated MTBF @ 35 ^oC; T_{jmax}=50-55 ^oC for all chips. All chips are BGAs.	574,390	65.7	10.77
NRAO FORM	Complete with power supply sub-assemblies. Calculated MTBF @ 35 ^oC, T_{jmax}=50-55 ^oC for all chips.	337,532	38.6	0.36

Table 1 Individual assembly reliability prediction results. There is a 60-90% chance that the MTBFs are greater than these numbers indicate.

Table 2 is a synopsis of the system MTBF values and takes into account total quantities of each assembly. Spares requirements for a 20 year lifetime are included in this table.

System Component	Qty	Description	Aggregate MTBF (hrs)	Spares
TGB	2	Timecode Generator Board complete assembly. Spares pre-assigned.	82,379	2
Air Conditioners	4	Liebert Air Conditioners (Telcordia model). MTBF of 2000 hrs each is a guess at this point.	500	N/A (repair on-site)
1 Gbps Ethernet Sw	10	24-port switch (Telcordia model for an "Ethernet device") Spares pre-assigned.	4,167	2 (infinite replenish)
100 Mbps Ethernet Sw	24	24-port switch, assume 1 per rack (Telcordia model for an "Ethernet device") Spares pre-assigned.	1,736	2 (infinite replenish)
Backend Computers	50	COTS PC, individual MTBF of 25,000 hrs (2.8 yrs), technology advancements likely will cause replacement on this timescale as well. (Telcordia model says 2200 hours, and this is thought to be too pessimistic). Spares pre-assigned.	500	5 (infinite replenish)
CPCC	2	Correlator Power Control Computer c/w digital I/O coards, Compact PCI form. MTBF based on web surveys and "guesstimates". Assume redundant operation possible. Spares pre-assigned.	3,982	1 (infinite replenish)
MCCC	2	Master Correlator Control Computer, assume same computer as backend, assume redundant operation possible. Spares pre-assigned.	12,500	1 (infinite replenish)
48 VDC power plant rectifier modules	1	Emmerson power plant with mfg data for rectifiers, 1 year MTBF batteries. Spares pre-assigned.	1,829	2 (infinite replenish)
Feedthru backplane	1228	Feedthru backplane. Spares requirements assigned apriori, not calculated by OpSim and may not be optimum.	8,568	50

Fanout Board	266	Fanout board. Spares requirements assigned apriori, not caculated by OpSim, and may not be optimum. Boards are infinitely repairable and parts obsolescence is not likely.	1,357	11
Baseline Board	160	Baseline Board complete assembly, c/w PC/104+, PCMC, w/o SFP module. **Spares calculated by OpSim**.	**350** (2 wks)	**26**
Station Board	128	Station Board complete assembly, c/w PC/104+, PCMC, Delay Module, FORM. **Spares calculated by OpSim**. [Discard % of the Delay Module not taken into account in the simulation (RBD limitations)—calculate need Delay Module 8.4 spares.]	**556** (3 wks)	**9**
Rack Fans	96	R1G225-AC73-52 EBM PABST. Telcordia model. Spares assigned apriori.	592	8 (infinite replenish)
Rack Breakers	288	No specific mfg identified. MTBF is Telcordia model. Spares assigned apriori.	20,424	20 (infinite replenish)

Table 2 Aggregate reliability and spares prediction for the system. Numbers are for a 32-station correlator.

With the MTBF numbers, assumptions, spares indicated in Table 2, and Reliability Block Diagram (RBD) of Figure 2, the OpSim simulation indicates that system availability is normally greater than 95% for the first 18 years, and then drops to 93.8% for the last 2 years of a 20 year lifetime, due in large part to the increasing unavailability of spare Baseline Boards. Not shown in the table or in the Relex-generated report, is repair time information for various modules, servicing time of the air conditioner, replacement time of the modules etc that is entered for each element of the RBD. This information is used by the Relex software to calculate/simulate system availability. Generally, the repair time is 72 hours with a normal distribution and a sigma of 10 hours. Failure followed an exponential distribution—i.e. constant failure rate vs time. The *replacement* time (time to replace a failed module) was set for 60 minutes. In the RBD, fans, breakers, Station Boards, and Baseline Boards were set for N+1 redundant. For example, the failure of 1 module did not render the system inoperable—the simulation still considered the system 100% available with a failed module.

As more information becomes available on servicing and repair time, the model can be refined to include all repair costs, downtime costs, shipping costs, and servicing costs so that a complete maintenance schedule and cost forecast can be generated for the system. <u>However, the critical information obtained thus far—i.e. spares requirements for the expensive Station Boards (spares=9) and Baseline Boards (spares=26) is important to</u>

know. While it is difficult to know for sure if these spares quantities are really required, given that there is a 60-90% chance that the MTBF is better, it is likely safe to say that these are conservative estimates. The Baseline Board spares requirements are as high as indicated because of the 3.75% discard percentage due to a high number of BGA devices on the boards.

5 Design Recommendations

The following design recommendations came out of this reliability analysis.

1. The DC-DC converter modules on the boards must be kept cool. It is recommended that their case temperatures be less than 45 ^{o}C. Although the manufacturer's data indicates that they can run hot, there is a reliability penalty for doing so[3].
2. The Motorola 1:0 LVPECL fanout buffers on the Fanout Board must be cooled so that $T_{jmax} \leq 50\ ^{o}C$ for acceptable reliability. This is based on manufacturer's data that shows strong reliability dependence on temperature. It is likely that monolithic or individual heatsinks will be required for these chips. Careful prototype testing must be performed in their intended environment (i.e. in the rack) to ensure T_{jmax} requirements are achieved. If necessary, a board re-spin may be required to facilitate mounting holes for a heatsink.
3. The DDR SDRAMs on the Baseline Board should not be BGA devices so that failed devices can be replaced without a board re-heat cycle. This reduces the discard percentage of the board, and thus the lifetime spares requirements. The DPSRAMs on the Baseline Board could be non-BGA devices, but the numbers are not as great, and a DPSRAM bit failure does not have as great a consequence as in the DDR SDRAMs used for the LTA.
4. All chips on the boards, if possible, must be such that $T_{jmax} \leq 50\ ^{o}C$, cooler if possible. This is especially important for high device-count chips like the digital filters on the Station Board, and the correlator chips and LTA chips on the Baseline Board.
5. The LP2995 linear regulator on the Baseline Board must use a PSOP-8 package rather than an SO-8 package since the SO-8 package has an unacceptably high thermal resistance and, under the conditions it is used, would run very hot and be unreliable.
6. Although not addressed by this study, systems must be in place to minimize the number of power/heat cycles in the operational correlator as heating and cooling can induce thermal stresses to worsen the reliability of the system. More research is required to try to quantify what this effect might be, since it is not mentioned in the Telcordia model.

[3] This assertion is supported by what little data there is on reliability vs temperature for these modules. The Vicor mil-spec DC-DC modules' specifications provide some indication of temperature dependence, although not for the new generation of power supplies being used in the correlator.

6 Reliability Block Diagram

The Reliability Block Diagram (RDB) developed for the correlator system is shown in Figure 2. The RBD graphically represents how failures of one or modules affect the availability of the system. Elements in series indicate that if any one of the elements fails the whole system is unavailable. Elements in parallel indicate that there exists redundancy, and the degree of redundancy can be defined and is shown in the diagram.

The diagram was built to show MTBF, expected number of failures, and total downtime for each element, although not all of these quantities show up for every element due to figure copy and paste problems. The following table lists, for each element in the RBD, the MTBF of the element (this MTBF is for individual components of each element[4]), the expected number of failures of the element (including the effects of redundancy—i.e. failure of the redundant whole), and the total downtime for the element, for the entire 20 year (175,000 hour) lifetime of the system. Some of the numbers in the table admittedly don't make sense if one considers a uniform distribution of an average (mean) failure rate. However, it must be remembered that failures don't occur with a uniform distribution—there will be long stretches of time where there are no failures and then times where there are clumps of failures. The system availability analysis performed by Relex OpSim uses a Monte Carlo simulation for the reasonably complex RBD being analyzed here (the details of which are admittedly not fully understood by the author), and takes into account repair time, spares availability, discard percentage etc.

Element	**MTBF (hrs ea)**	**Expected # failures**	**Total downtime (hrs)**	**Comments**
TGB	164,758	0	0	1:2 redundancy, parallel operating. This capability is built into the design.
Fanout Board (station racks)	361,423	5.05	5.3	No redundancy since these modules are used for Timecode distribution.
Feedthru Backplane (station racks)	10^7	0	0	Defined as N+1 redundant
Station Boards	71,205	0.8	16.2	Defined as N+1 redundant
Breakers (station racks)	5.9×10^6	0	0	Defined as N+1 redundant
Fans (station racks)	56,837	0.05	0.6	Defined as N+1 redundant
Fanout Board (baseline racks)	361,423	0.066	0.036	Defined as N+1 redundant
Baseline Boards	55,954	2.25	451	Defined as N+1 redundant

[4] I'm not sure why Relex decided to define MTBF here in this way, rather than the MTBF of the collection of elements. Refer to Table 2 for the MTBF of the total number of elements of a particular type.

Element	MTBF (hrs ea)	Expected # failures	Total downtime (hrs)	Comments
Feedthru Backplane (baseline racks)	10^7	0	0	Defined as N+1 redundant
Fans (baseline racks)	56,837	0.6	54.5	Defined as N+1 redundant
Breakers (baseline racks)	$5.9x10^6$	0	0	Defined as N+1 redundant
1 Gbit/sec Ethernet switches	41,666	42	42	No redundancy. Losing an entire switch brings down many baselines and effectively renders the system unavailable. This model could be improved to show multiple Ethernet ports, in an N+1 redundant, hot-swappable configuration.
100 Mbit/s Ethernet switches	41,666	100	103.3	No redundancy. Losing an entire switch brings down many baselines and effectively renders the system unavailable. This model could be improved to show multiple Ethernet ports, in an N+1 redundant, hot-swappable configuration.

Element	MTBF (hrs ea)	Expected # failures	Total downtime (hrs)	Comments
Backend Computers	25,000	0	0	40:50 redundancy, N+1 redundancy on each set of 16 boards that correlate a chunk of baselines for all bands.
CPCC	7,964	0	0	1:2 redundant. Not sure if this can be run in full redundant mode for power control…may require power control “redundancy combiner board” (diode OR).
MCCC	25,000	0	0	1:2 redundant. MCCC software design to support redundancy is required.
Power Plant Racks	100,000	3.4	104.4	MTBF is a guess. Rack may not fail. No spares or standby.
Power Plant Rectifiers	39,700	0.194	20.2	Mfg MTBF data. N+1 redundant, hot-swappable.
Power Plant Batteries	87,600	72	536	1 year MTBF. 1:2 redundant. Will only cause failure if power is lost when batteries are changed. Need to modify RBD to factor this in.
Air Conditioners	2,000	406	6335	MTBF is a guess. Model factors in servicing time every 100 days. Needs refinement from Mfg data and experience. No redundancy.

Table 3 Table of RBD elements and OpSim results.

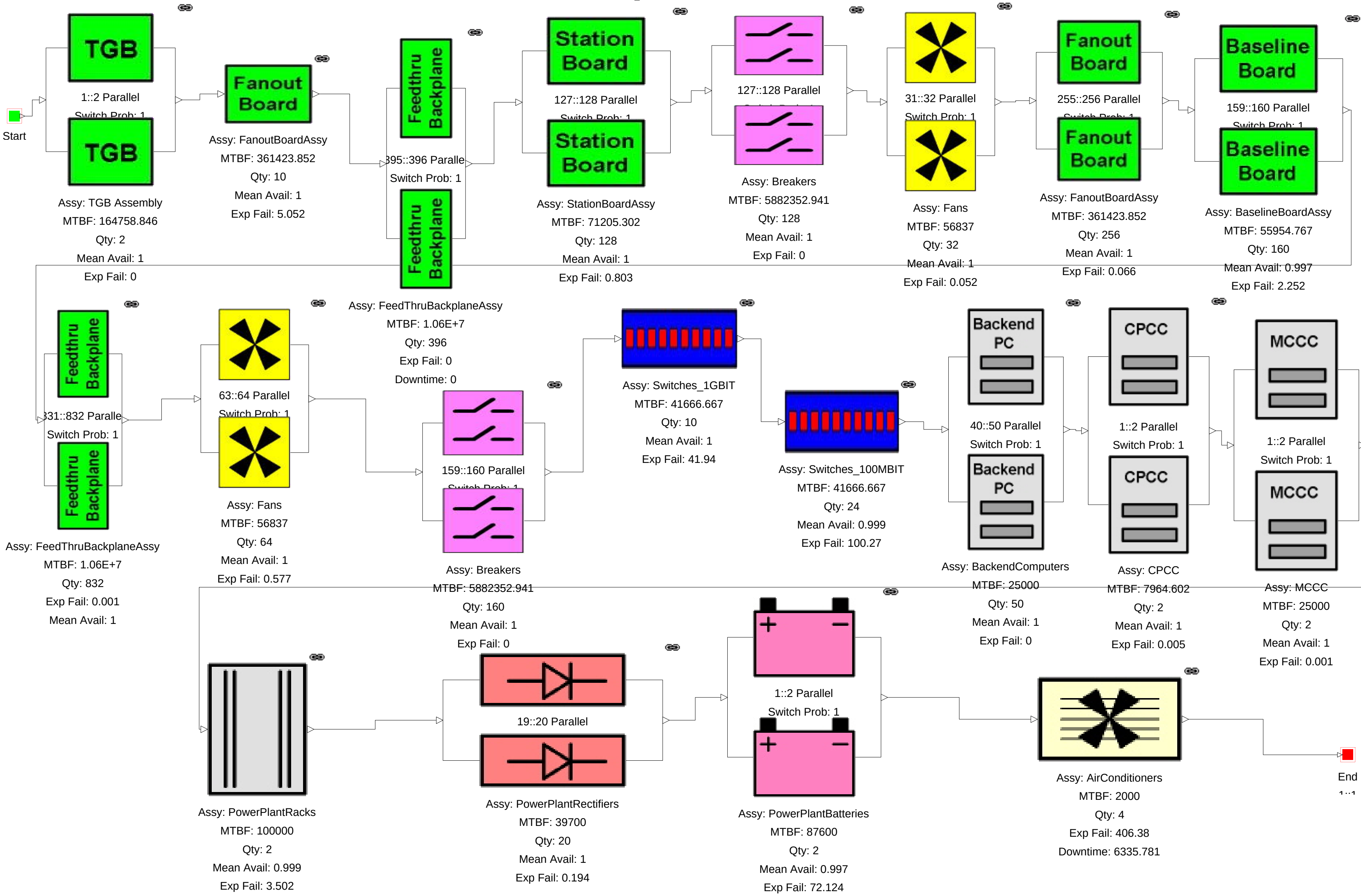


Figure 2 EVLA Correlator system Reliability Block Diagram

EVLA Correlator Availability Timeline

File Name: EVLACorrelator_Report1_June03-05.RPJ
Configuration: RBD
Cost of Configuration: 7,391,432.00
Cost of Spares: NA
Steady State Availability:
Desired Availability:
Achieved Availability:
Operational Availability:

MTTF: 224.71
MTBF: 364.41
Results At: 175000.0
Reliability:
Availability:
Unreliability:
Unavailability:
Failure Rate:

Time (hrs)	Availability	
1000.00	0.95600	
18400.00	0.97600	
35800.00	0.97500	
53200.00	0.96700	
70600.00	0.96700	
88000.00	0.97200	
105400.00	0.96500	
122800.00	0.95600	
140200.00	0.96600	
157600.00	0.95200	
175000.00	0.93800	

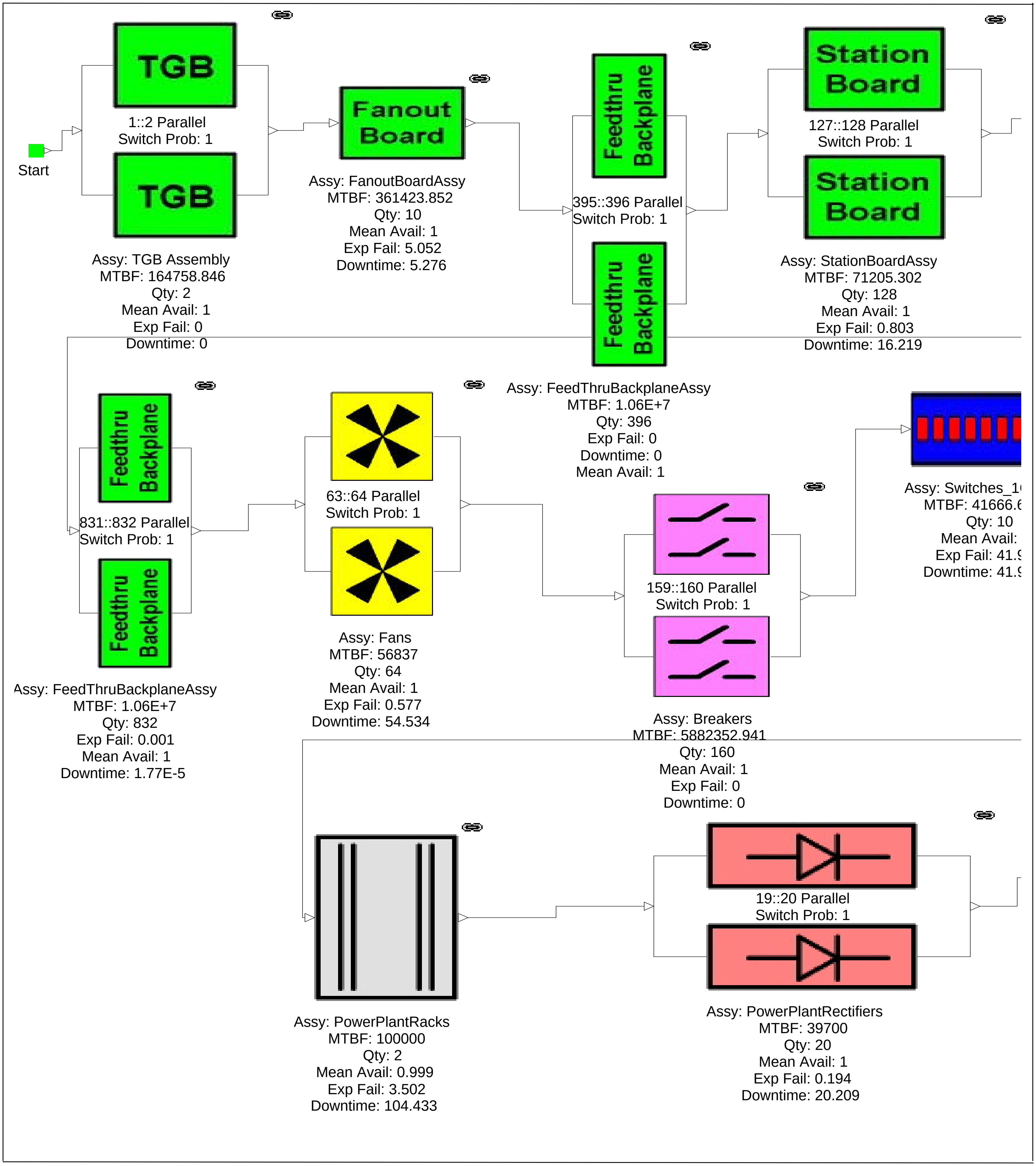
EVLA Correlator Optimization Report

Calculation Start Time: 1000.00
Calculation End Time: 175000.00
Simulation Iterations: 1000

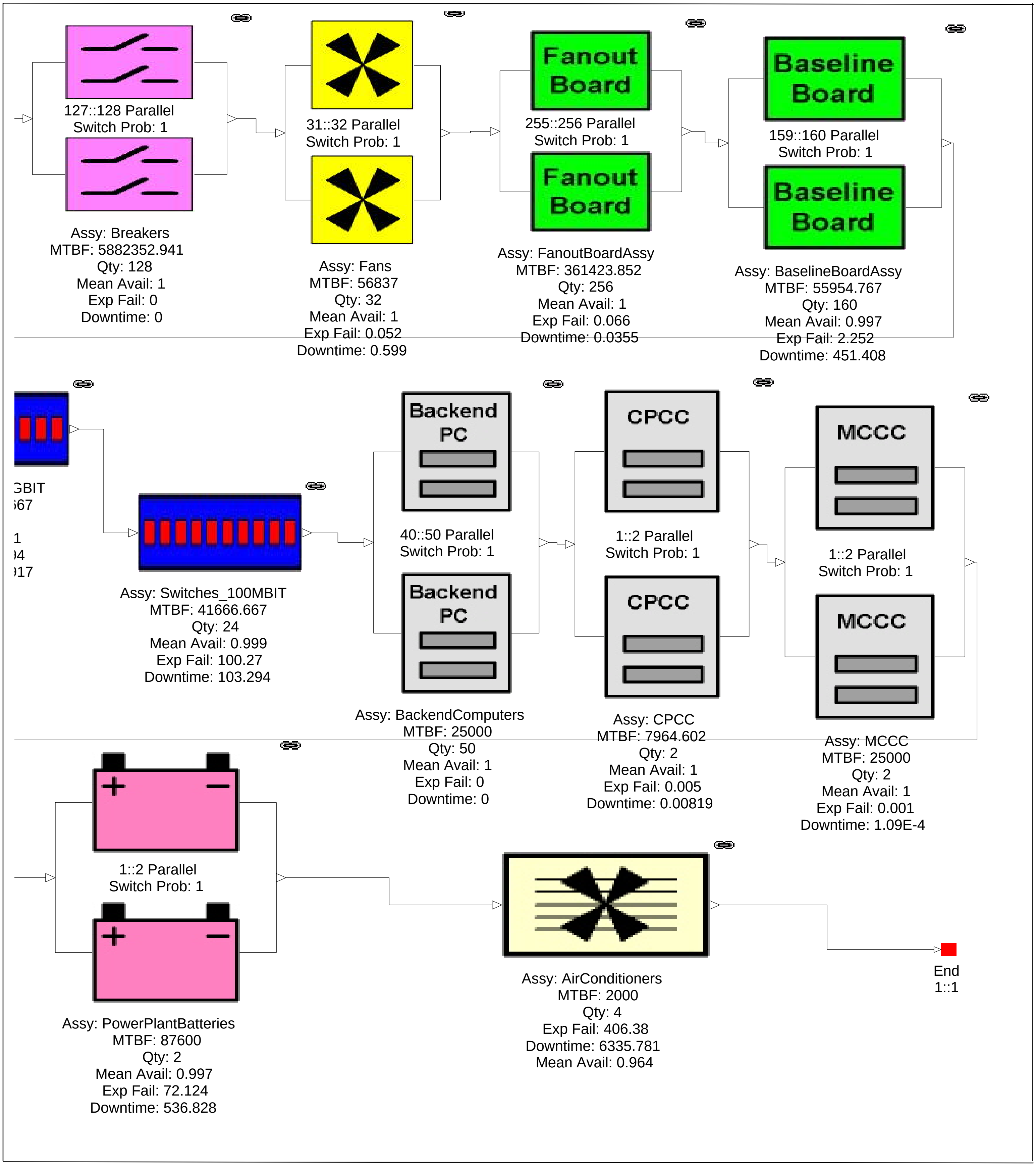
File Name: EVLACorrelator_Report1_June03-05-
Configuration: RBD
MTBF: 364.4

Part Number	Description	Quantity of On-Site Spares	Quantity of Off-Site Spares	Preventive Interval	Inspection Interval
	Correlator system backend computers	5	0	NA	NA
	Correlator Power Control Computer (CPCC)	1	0	NA	NA
	Master Correlator Control Computer (MCCC)	1	0	NA	NA
	Power Plant Racks	NA	NA	NA	NA
	Power Plant Rectifier Modules	2	0	NA	NA
	Power Plant Battery Strings	1	0	365.00	100.00
	Correlator system 1 Gbit Ethernet switches	2	0	NA	NA
	Correlator system 100 Mbps Ethernet Switches	2	0	NA	NA
25500-Y-000004	Timecode Generator Board Assembly	2	0	NA	NA
25500-Y-000003	Fanout Board Complete Assembly	1	0	NA	NA
25500-Y-000005	Station Board Complete Assembly	9	0	NA	NA
	Rack breakers	10	0	NA	NA
	Rack fans	4	0	NA	NA
25500-Y-000003	Fanout Board Complete Assembly	10	0	NA	NA
25500-Y-000006	Baseline Board Complete Assembly	26	0	NA	NA
	Rack fans	4	0	NA	NA
	Rack breakers	10	0	NA	NA
25500-Y-000002	FeedThru Backplane Complete Assembly	30	0	NA	NA
25500-Y-000002	FeedThru Backplane Complete Assembly	20	0	NA	NA
	Air conditioning/cooling systems	NA	NA	100.00	NA

EVLA Correlator Reliability Block Diagram



EVLA Correlator Reliability Block Diagram



EVLA Correlator Reliability Report

Part Number	System	**Description**	Complete EVLA Correlator System
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	12,952,405.5
Temperature	15.00	**MTBF (hrs)**	77

Assembly Name	Part Number	Qty	Failure Rate (FIT)	MTBF (hrs)	Availability
EVLACorrSystem	System	1.00	12,952,405.5	77	.7510
TGB Assembly	25500-Y-000004	2.00	12,139.0	82,379	.9999
TGB	25151	1.00	3,237.9	308,837	1.0000
PCMC_25142	25500-Y-000000	1.00	267.4	3,739,375	1.0000
PC104+	25500-Y-000008	1.00	2,564.1	390,000	1.0000
FiberRack		1.00	0.0	0	1.0000
AirConditioners		4.00	2,000,000.0	500	.9843
Switches_1GBIT		10.00	240,000.0	4,167	.9259
Switches_100MBIT		24.00	576,000.0	1,736	.8389
BackendComputers		50.00	2,000,000.0	500	.9980
ControlCPURack		1.00	331,111.1	3,020	.9997
CPCC		2.00	251,111.1	3,982	.9997
MCCC		2.00	80,000.0	12,500	.9999
PowerPlant		1.00	546,609.4	1,829	.9995
PowerPlantRectifiers		20.00	503,778.3	1,985	.7486
PowerPlantBatteries		2.00	22,831.1	43,800	.9995
PowerPlantRacks		2.00	20,000.0	50,000	.9995
BaselineRacks		1.00	4,799,240.6	208	.9751
FeedThruBackplaneAssy	25500-Y-000002	832.00	78,251.4	12,779	.9999
FeedThruBkpl_25171	25171	1.00	94.1	10,632,400	1.0000
FanoutBoardAssy	25500-Y-000003	256.00	708,309.6	1,412	.9986
FanoutBoard_25071	25071	1.00	2,766.8	361,424	.9991
BaselineBoardAssy	25500-Y-000006	160.00	2,859,452.5	350	.9776
PC104+	25500-Y-000008	1.00	2,564.1	390,000	1.0000
BaselineBoard_BareA-ssy_25081	25081	1.00	15,143.1	66,037	1.0000
PCMC_25142	25500-Y-000000	1.00	164.4	6,083,137	1.0000
Fans		64.00	1,126,027.1	888	.9989
Breakers		160.00	27,200.0	36,765	1.0000
StationRacks		1.00	2,447,305.5	409	.9852
FeedThruBackplaneAssy	25500-Y-000002	396.00	37,244.6	26,849	1.0000

EVLA Correlator Reliability Report

Part Number	System	**Description**	Complete EVLA Correlator System
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	12,952,405.5
Temperature	15.00	**MTBF (hrs)**	77

Assembly Name	Part Number	Qty	Failure Rate (FIT)	MTBF (hrs)	Availability
FeedThruBkpl_25171	25171	1.00	94.1	10,632,400	1.0000
FanoutBoardAssy	25500-Y-000003	10.00	27,668.3	36,142	.9999
FanoutBoard_25071	25500-Y-000003	1.00	2,766.8	361,424	1.0000
StationBoardAssy	25500-Y-000005	128.00	1,797,618.9	556	.9858
FORM_NRAO	25500-Y-000009	1.00	2,962.7	337,532	1.0000
FORM_bare_assy		1.00	2,397.7	417,060	.9992
FORM_power_sup-ply		3.00	564.9	1,770,086	.9998
DelayModule_25043	25500-Y-000001	2.00	1,741.0	574,390	1.0000
StationBoard_BareAss-y_25041	25041	1.00	6,611.7	151,246	1.0000
PCMC_25142	25500-Y-000000	1.00	164.4	6,083,137	1.0000
PC104+	25500-Y-000008	1.00	2,564.1	390,000	1.0000
Breakers		128.00	21,760.0	45,956	1.0000
Fans		32.00	563,013.5	1,776	.9994

EVLA Correlator Reliability Report

Part Number	25151	**Description**	Timecode Generator Board PCB Assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	3,237.9
Temperature	45.00	**MTBF (hrs)**	308,837

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
LM35DZ	National Semi precision centigrade temperature sensor TO-92		6.5	4.0	45	26.2	.81
LM35DM	National Semi precision centigrade temperature sensor SO-8		6.5	3.0	45	19.6	.61
DS90LV001TM	National Semi single LVDS buffer SOIC8	National Semi Reliability Data Sheet	15.0	1.0	45	15.0	.46
BCW60D	ZETEX TRANSISTOR GENERAL PURPOSE NPN SOT23		0.5	4.0	45	2.2	.07
1N4148W-7	Diodes surface mount switching diode SOD-123		0.8	3.0	45	2.4	.07
LT6700CS6-1	Linear dual comparator with 400mV reference SOT-23		0.1	3.0	45	.3	9.27e-0-
HFBR-5903	Agilent Optic transceiver HFBR-5903	No data available anywhere (mfg or prediction)	751.9	1.0	45	751.9	23.22
MC100ES6220TB-R2	Motorola low voltage dual 1:10 differential ECL/PECL clock fanout buffer	MTBF @ Tj=50 C; For every 10C drop in temp, reliability increases by 2X	125.0	1.0	50	125.0	3.86
H11A617ASD	Fairchild Semi 4-pin phototransistor optocoupler SMD		165.4	1.0	45	165.4	5.11
591-3001-007	Dialight 3mm Prism CBI surface mount Bi-Color LED, Super Red/Green		4.5	6.0	45	27.1	.84
PQ60033QML15N-NS	SynQor 48V-to-3.3V isolated DC/DC converter 15A	MTBF @ 80% load, 300LFM, 40C Tamb	476.2	1.0	45	476.2	14.71
DDZ5V1B-7	Diodes surface mount precision zener diode 5.1V SOD-123		1.3	1.0	45	1.3	.04
DDZ4V3B-7	Diodes surface mount precision zener diode 4.3V SOD-123		1.3	1.0	45	1.3	.04

EVLA Correlator Reliability Report

Part Number 25151

Reference Des

Date June 6, 2005

Environment GB, GC - Ground Benign, Controlled

Temperature 45.00

Description Timecode Generator Board PCB Assembly

File Name EVLACorrelator_Report1_Ju-

Time 12:24 PM

Failure Rate (FIT) 3,237.9

MTBF (hrs) 308,837

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
HCPL-7510-300	Agilent HCPL-7510 isolated linear sensing IC, surface mount		165.4	1.0	45	165.4	5.11
PQ60015QML15N-NS	SynQor 48V-to-1.5V isolated DC/DC converter 15A	Mfg datasheet MTBF	476.2	1.0	45	476.2	14.71
PQ60050QML15N-NS	SynQor 48V-to-5V isolated DC/DC converter 15A	Mfg datasheet MTBF	476.2	1.0	45	476.2	14.71
EP1SGX10C-F672--C5	Altera Stratix Gx EP1SGX10C F672 device, Timing chip	Altera reliability data @ 55C; CL=60%	22.3	1.0	45	22.3	.69
LM26CIM5-RPA	National Semi factory preset thermostat, 65°C, SOT-23	National average failure rate	10.0	1.0	45	10.0	.31
CSX750ABB125.0-00MTR	Citizen oscilator CSX750ABB125.000-MTR		60.0	1.0	45	60.0	1.85
QPI-1L	Vicor Active Filter, 12A	PD~=2W; ThetaJA=15C/W no airflow; no reliability data found	111.7	1.0	75	111.7	3.45
87333-1420	MOLEX 2mm 14-pin 2 row right angle through hole connetor		12.6	2.0	45	25.3	.78
YTQ-132-01-L-Q-0-01	Samtec 2mm Hi-Density socket 4Rowx32		1.0	1.0	45	1.0	.03
AMP-146129-4	AMP SMD SINGLE ROW PLUG HEADER		1.5	1.0	45	1.5	.05
85505-0001	Molex right angle through hole RJ45 jack		1.0	1.0	45	1.0	.03
87331-0820	Molex 4x2 2mm vertical through hole connector		1.0	1.0	45	1.0	.03
933070	ERNI type F right angle female connector with shield, without peg		22.2	2.0	45	44.4	1.37
104416	ERNI type E right angle female connector with upper shield, without peg		50.5	2.0	45	101.0	3.12
114403	ERNI right angle male power module with three contact levels		18.9	2.0	45	37.9	1.17

EVLA Correlator Reliability Report

Part Number	25151	**Description**	Timecode Generator Board PCB Assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	3,237.9
Temperature	45.00	**MTBF (hrs)**	308,837

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
39-27-4022	Molex .100" micro shunt header, dual row low profile, 2 circuits		0.0	1.0	45	.0	.00
142-0701-501	Johnson Components RF connector SMA, right angle bulkhead through hole		0.6	1.0	45	.6	.02
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	320.0	45	9.6e-002	2.96e-0-
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	150.0	45	.1	4.63e-0-
CAP-TANT-6032-1-00UF-6.3V-10%	CAP-TANT-6032-100-uF-6.3V-10%		1.1	2.0	45	2.2	.07
CAP-TANT-3216-1-0UF-16V-10%	CAPACITOR TANT SMD 3216 10uF-16V-10%		1.1	9.0	45	9.8	.30
IND-1008-1UH-5%	INDUCTOR SMD 1008 1uH-5%		0.5	3.0	45	1.6	.05
EP12SD1ABE	C&K EP Series right angle push button switch SPDT		12.6	1.0	45	12.6	.39
7101MD9ABE	C&K 7000 Series right angle toggle switch SPDT		18.9	1.0	45	18.9	.58
0453-003	LITTELFUSE 3A SMD VFAST ACTING FUSE		12.6	1.0	45	12.6	.39
EEVFK1K470P	PANASONIC SMD ELECTROLYTIC CAPACITOR FK SERIES 47uF-80V-20%		7.6	4.0	45	30.6	.94
BLM18PG121SN1	Murata BLM18P Series Ferrite Bead, 120 ohm, 2000 MA, SMD 0603		1.0e-002	3.0	45	3.0e-002	9.27e-0-

EVLA Correlator Reliability Report

Part Number	25500-Y-000000	**Description**	PCMC Assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment		**Failure Rate (FIT)**	267.4
Temperature		**MTBF (hrs)**	3,739,375

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
XC2V250-5FG256C	Xilinx EPLD Virtex-II 250-5FG256C, PCMC FPGA		30.0	1.0	45	30.0	11.22
XC18V02VQ44	Xilinx In-System-Programma-ble PROM, XC18V02VQ44		35.0	1.0	45	35.0	13.08
MAX1039AEEE	Maxim-IC 12-Channel 2-Wire Serial 8-Bit ADC		28.4	1.0	45	28.4	10.61
IDTQS3861Q	IDT 10-Bit bus switch with enable QSOP24		9.5	6.0	45	57.0	21.31
S1A-13	DIODES 1A surface mount rectifier SMA		5.3	1.0	45	5.3	1.97
1375800-1	AMP PC104-Plus Press-Fit connector, 120-pin Non-Stackthrough No Standoff		0.1	1.0	45	.1	.04
146305-6	AMP .100inch 6-pin single row right angle through hole connector		0.1	1.0	45	.1	.04
YTW-32-10-G-Q-3-50-110-001	Samtec 2mm Hi-Density stacker 4Rowx32 .350inch height		0.1	1.0	45	.1	.04
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	200.0	45	6.0e-002	.02
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	200.0	45	.2	.07
CAP-TANT-6032-1-00UF-6.3V-10%	CAP-TANT-6032-100-uF-6.3V-10%		0.9	9.0	45	8.2	3.08

EVLA Correlator Reliability Report

Part Number 25500-Y-000008
Reference Des
Date June 6, 2005
Environment
Temperature

Description PC/104+ complete assembly
File Name EVLACorrelator_Report1_Ju-
Time 12:24 PM
Failure Rate (FIT) 2,564.1
MTBF (hrs) 390,000

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
MOPSLCD6		MTBF not yet available; use data from MOPS/386A	2,564.1	1.0	45	2564.1	100.00

EVLA Correlator Reliability Report

Part Number		**Description**	Air conditioning/cooling systems
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	2,000,000.0
Temperature	15.00	**MTBF (hrs)**	500

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
LIEBERT_AIR_CO-NDITIONER			500,000.0	1.0	15	500000.0	100.00

EVLA Correlator Reliability Report

Part Number		**Description**	Correlator system 1 Gbit Ethernet switches
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	240,000.0
Temperature	45.00	**MTBF (hrs)**	4,167

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
GIGABIT_ETHER-NET_24PORT_CO-PPER		Telcordia calculated FIT for "Ethernet device"	24,000.0	1.0	45	24000.0	100.00

EVLA Correlator Reliability Report

Part Number		**Description**	Correlator system 100 Mbps Ethernet Switches
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	576,000.0
Temperature	45.00	**MTBF (hrs)**	1,736

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
100MBIT_ETHER-NET_24PORT		Telcordia calculated FIT for "Ethernet device"	24,000.0	1.0	45	24000.0	100.00

EVLA Correlator Reliability Report

Part Number		**Description**	Correlator system backend computers
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	2,000,000.0
Temperature	45.00	**MTBF (hrs)**	500

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
DESKTOP_PC		Telcordia 2200 hrs seems pessimistic; Probably ~4X better; It is possible to get desktop PCs with reported MTBFs of 25,000 hrs	40,000.0	1.0	45	40000.0	100.00

EVLA Correlator Reliability Report

Part Number		**Description**	Correlator Power Control Computer (CPCC)
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	251,111.1
Temperature	45.00	**MTBF (hrs)**	3,982

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
COMPACT_PCI_C-RATE		No mfg data; 3 years on crate is likely conservative	3,333.3	1.0	45	3333.3	2.65
COMPACT_PCI_C-PU		No specific mfg data; based on web survey of Compact PCI CPU MTBFs	22,222.2	1.0	45	22222.2	17.70
COMPACT_PCI_I-O_BRD		No mfg data available; guessimate	10,000.0	10.0	45	100000.0	79.65

EVLA Correlator Reliability Report

Part Number		**Description**	Master Correlator Control Computer (MCCC)
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	80,000.0
Temperature	45.00	**MTBF (hrs)**	12,500

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
DESKTOP_PC		Telcordia 2200 hrs seems pessimistic; Probably ~4X better; It is possible to get desktop PCs with reported MTBFs of 25,000 hrs	40,000.0	1.0	45	40000.0	100.00

EVLA Correlator Reliability Report

Part Number 25171

Reference Des

Date June 6, 2005

Environment

Temperature

Description FeedThru Backplane (aka Common

File Name EVLACorrelator_Report1_Ju-

Time 12:24 PM

Failure Rate (FIT) 94.1

MTBF (hrs) 10,632,400

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
933142	ERNI type F vertical male connector with peg and extended terminal		13.8	1.0	35	13.8	14.71
933141	ERNI type E vertical male connector without peg, with extended terminal		31.4	1.0	35	31.4	33.43
114404	ERNI vertical female power module 3 positions		11.8	1.0	35	11.8	12.54
70543-0001	Molex single row .100in 2-pin connector		0.5	1.0	35	.5	.50
55558-4	AMP tap power distribution 25A with screw		7.9	2.0	35	15.7	16.72
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	1.0	35	3.0e-004	3.19e-0-
SP08	C&K dip switch SP08 SIP		20.8	1.0	35	20.8	22.10

EVLA Correlator Reliability Report

Part Number 25071

Reference Des

Date June 6, 2005

Environment GB, GC - Ground Benign, Controlled

Temperature 35.00

Description Fanout Board (aka Station Data Fanout Board--SDFB)

File Name EVLACorrelator_Report1_Ju-

Time 12:24 PM

Failure Rate (FIT) 2,766.8

MTBF (hrs) 361,424

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
1N4148W-7	Diodes surface mount switching diode SOD-123		0.6	1.0	35	.6	.02
LT6700CS6-1	Linear dual comparator with 400mV reference SOT-23		0.1	1.0	35	.1	3.61e-0-
MC100ES6220TB-R2	Motorola low voltage dual 1:10 differential ECL/PECL clock fanout buffer	MTBF @ Tj=50 C; For every 10C drop in temp, reliability increases by 2X	125.0	16.0	50	2000.0	72.28
H11A617ASD	Fairchild Semi 4-pin phototransistor optocoupler SMD		72.2	1.0	35	72.2	2.61
591-3001-007	Dialight 3mm Prism CBI surface mount Bi-Color LED, Super Red/Green		2.0	1.0	35	2.0	.07
PQ60033QML15N-NS	SynQor 48V-to-3.3V isolated DC/DC converter 15A	MTBF @ 80% load, 300LFM, 40C Tamb	476.2	1.0	35	476.2	17.21
QPI-1L	Vicor Active Filter, 12A	PD~=2W; ThetaJA=15C/W no airflow; no reliability data found	64.3	1.0	65	64.3	2.32
933070	ERNI type F right angle female connector with shield, without peg		13.8	2.0	35	27.7	1.00
104416	ERNI type E right angle female connector with upper shield, without peg		31.4	2.0	35	62.9	2.27
114403	ERNI right angle male power module with three contact levels		11.8	2.0	35	23.6	.85
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	800.0	35	.2	8.67e-0-
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	250.0	35	.3	9.04e-0-
CAP-TANT-3216	CAPACITOR TANT SMD 3216 10uF-16V-10%		0.9	17.0	35	15.5	.56

EVLA Correlator Reliability Report

Part Number	25071	**Description**	Fanout Board (aka Station Data Fanout Board--SDFB)
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	2,766.8
Temperature	35.00	**MTBF (hrs)**	361,424

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
0453-003	LITTELFUSE 3A SMD VFAST ACTING FUSE		7.9	1.0	35	7.9	.28
EEVFK1K470P	PANASONIC SMD ELECTROLYTIC CAPACITOR FK SERIES 47uF-80V-20%		6.4	2.0	35	12.8	.46
RES-0201	RESISTOR SMD 0201-100R-1%		1.0e-002	64.0	35	.6	.02

EVLA Correlator Reliability Report

Part Number	25500-Y-000008	**Description**	PC/104+ complete assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	2,564.1
Temperature	35.00	**MTBF (hrs)**	390,000

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
MOPSLCD6		MTBF not yet available; use data from MOPS/386A	2,564.1	1.0	35	2564.1	100.00

EVLA Correlator Reliability Report

Part Number	25081	**Description**	Baseline Board bare assembly w/o mezzanine
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	15,143.1
Temperature	35.00	**MTBF (hrs)**	66,037

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
BCW60D	ZETEX TRANSISTOR GENERAL PURPOSE NPN SOT23		0.4	5.0	35	2.1	.01
1N4148W-7	Diodes surface mount switching diode SOD-123		0.6	14.0	35	8.6	.06
LT6700CS6-1	Linear dual comparator with 400mV reference SOT-23		0.1	13.0	35	1.3	8.58e-0-
CDCVF2310	TI 1 to 10 CLK BUFFER, CDCVF2310	JTAG only, normally idle; FIT from TI web; 55C 60% confidence; 0.7 eV	5.3	38.0	35	201.4	1.33
H11A617ASD	Fairchild Semi 4-pin phototransistor optocoupler SMD		72.2	2.0	35	144.4	.95
591-3001-007	Dialight 3mm Prism CBI surface mount Bi-Color LED, Super Red/Green		2.0	16.0	35	31.5	.21
DDZ5V1B-7	Diodes surface mount precision zener diode 5.1V SOD-123		1.0	1.0	35	1.0	6.93e-0-
DDZ4V3B-7	Diodes surface mount precision zener diode 4.3V SOD-123		1.0	1.0	35	1.0	6.93e-0-
HCPL-7510-300	Agilent HCPL-7510 isolated linear sensing IC, surface mount		72.2	1.0	35	72.2	.48
CSX750ABB125.0-00MTR	Citizen oscilator CSX750ABB125.000-MTR		60.0	1.0	35	60.0	.40
QPI-1L	Vicor Active Filter, 12A	PD~=2W; ThetaJA=15C/W no airflow; no reliability data found	64.3	2.0	65	128.6	.85
EP2S30-F672-C3	Altera Stratix II EP2S30 F672 device, Speed 3, Recirculation Controller	No reliability data on 90 nm available; use 130 nm reliability data; 55C	23.0	16.0	35	368.0	2.43
EP1SGX10C-F672--C5	Altera Stratix Gx EP1SGX10C F672 device, Timing chip	Altera reliability data @ 55C; CL=60%	22.3	1.0	35	22.3	.15

EVLA Correlator Reliability Report

Part Number 25081

Reference Des

Date June 6, 2005

Environment GB, GC - Ground Benign, Controlled

Temperature 35.00

Description Baseline Board bare assembly w/o mezzanine

File Name EVLACorrelator_Report1_Ju-

Time 12:24 PM

Failure Rate (FIT) 15,143.1

MTBF (hrs) 66,037

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
EP1C6F256C6	Altera Cyclone EP1C6-F256-C6, MCB Interface Chip	130 nm, 55C reliability data from Altera	23.0	1.0	50	23.0	.15
IDT70V3319S133-BC	IDT DPSRAM 256kx18, 133 MHz, 256-pin BGA	IDT Q&R Report Oct 2004; 3.3V SRAM; 125C, Ea=0.7eV; CL=60%	4.0	64.0	35	256.0	1.69
EP1C6F256C6	Altera Cyclone EP1C6-F256-C6, MCB Interface Chip	130 nm, 55C reliability data from Altera	23.0	64.0	50	1472.0	9.72
MT46V16M16FG-7-5E-HALFSTRENG-TH	Micron DDR SDRAM, 16Mx16, -75E speed, 60-ball FBGA, Half Strength	Reliability from Micron data @ 50C, SDR SDRAM	40.0	64.0	35	2560.0	16.91
INNOTECH-ASIC--BGA672	Innotech ASIC BGA672, 2048 complex-lag Correlator	Telcordia model; approx consistent with MIL 217FN2 from Innotech	49.4	64.0	50	3159.6	20.86
EP1C6F256C6	Altera Cyclone EP1C6-F256-C6, MCB Interface Chip	130 nm, 55C reliability data from Altera	23.0	1.0	50	23.0	.15
EP1C6F256C6	Altera Cyclone EP1C6-F256-C6, MCB Interface Chip	130 nm, 55C reliability data from Altera	23.0	1.0	50	23.0	.15
EP1C6F256C6	Altera Cyclone EP1C6-F256-C6, MCB Interface Chip	130 nm, 55C reliability data from Altera	23.0	1.0	50	23.0	.15
ACCEL-REGULAT-OR-3A	Innotech Accel regulator, QFN24-5mmx5mm	About 3X better reliability than the correlator chip; according to Innotech email	10.0	64.0	50	640.0	4.23
MAX1953EUB	MAXIM-IC Current-Mode PWM Buck Controller, MAX1953EUB, 10-Pin uMAX package	From Maxim data @25C, 60% confidence	24.7	1.0	50	24.7	.16
FDS6898A	FAIRCHILD dual N-channel logic level PWM optimized PowerTrench MOSFET, FDS6898A, SO-8 package	Not used except for 10Gbit/s Ethernet; Theta JC=40C/W	0.0	1.0	85	.0	.00

EVLA Correlator Reliability Report

Part Number	25081	**Description**	Baseline Board bare assembly w/o mezzanine
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	15,143.1
Temperature	35.00	**MTBF (hrs)**	66,037

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
CMPSH1-4	Central Semiconductor 1A Schottky Barrier Rectifier, CMPSH1-4, SOT-23 package	This is a Schotky diode; 10 mA forward current estimate; only used for 10 Gbit/s Ethernet	0.0	1.0	35	.0	.00
D048C012T012M2N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 1.2V 80A output	Artesyn equivalent @ Tcase=45C; Telcordia model	259.1	2.0	65	518.1	3.42
D048C015T012M2N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 1.5V 80A output	Artesyn equivalent @ Tcase=45C; Telcordia model	259.1	2.0	65	518.1	3.42
D048C025T015M2N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 2.5V 60A output	Artesyn equivalent @ Tcase=45C; Telcordia model	259.1	4.0	65	1036.3	6.84
D048C033T015M1N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 3.3V 45A output	Artesyn equivalent @ Tcase=45C; Telcordia model	259.1	1.0	65	259.1	1.71
D048C050T015M1N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 5.0V 30A output	Artesyn equivalent at Tcase=45C; Telcordia model	259.1	4.0	65	1036.3	6.84
LP2995MR	National Semiconductor DDR Termination Regulator LP2995M, SO-8	MUST KEEP COOL; Linear Regulator; PD=1W; Use PSOP-8; ThetaJA=43C/W	786.3	1.0	78	786.3	5.19
PCA9306DCTT	Texas Instruments dual bidirectional I2C bus and SMBus voltage-level translator PCA9306DCTT, SSOP8	High thermal resistance 220C/W ; From TI Data,FR=6.57FI-T; 55C, 0.7eV, 60% confidence; Must adjust FR if T>55C	6.6	2.0	35	13.1	.09
TMP37FT9	Analog Dev.precision centigrade temperature sensor TO-92		5.5	2.0	35	11.0	.07
TMP37FS	Analog Dev.precision centigrade temperature sensor SO-8		5.5	4.0	35	22.0	.15
87333-1420	MOLEX 2mm 14-pin 2 row right angle through hole connetor		7.9	2.0	35	15.7	.10

EVLA Correlator Reliability Report

Part Number	25081	**Description**	Baseline Board bare assembly w/o mezzanine
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	15,143.1
Temperature	35.00	**MTBF (hrs)**	66,037

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
YTQ-132-01-L-Q-0-01	Samtec 2mm Hi-Density socket 4Rowx32		1.0	1.0	35	1.0	6.60e-0-
85505-0001	Molex right angle through hole RJ45 jack		1.0	2.0	35	2.0	.01
87331-0820	Molex 4x2 2mm vertical through hole connector		1.0	2.0	35	2.0	.01
933070	ERNI type F right angle female connector with shield, without peg		13.8	2.0	35	27.7	.18
104416	ERNI type E right angle female connector with upper shield, without peg		31.4	2.0	35	62.9	.42
114403	ERNI right angle male power module with three contact levels		11.8	2.0	35	23.6	.16
39-27-4022	Molex .100" micro shunt header, dual row low profile, 2 circuits		0.0	4.0	35	.0	.00
V23838-S5-N1	Infineon press-fit cage for SFP transceiver		0.0	2.0	35	.0	.00
1367073-1	AMP 20-Position, 0.8mm pitch, right angle		3.1	4.0	35	12.6	.08
74732-0220	Molex XPAK 10Gbps Guide Rail		0.0	1.0	35	.0	.00
1367337-1	AMP 70-Position, 0.8mm pitch, right angle		11.0	1.0	35	11.0	.07
V23838-S5-N1-BB	Infineon press-fit cage for SFP transceiver, belly to belly		0.0	2.0	35	.0	.00
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	3,000.0	35	.9	5.94e-0-
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	8,300.0	35	8.3	.05
CAP-TANT-3528-1-00UF-4V-10%	CAPACITOR TANT SMD 3528 100uF-4V-10%		0.9	364.0	35	332.6	2.20
CAP-TANT-3216-1-0UF-16V-10%	CAPACITOR TANT SMD 3216 10uF-16V-10%		0.9	176.0	35	160.8	1.06

EVLA Correlator Reliability Report

Part Number 25081

Description Baseline Board bare assembly w/o mezzanine

Reference Des

File Name EVLACorrelator_Report1_Ju-

Date June 6, 2005

Time 12:24 PM

Environment GB, GC - Ground Benign, Controlled

Failure Rate (FIT) 15,143.1

Temperature 35.00

MTBF (hrs) 66,037

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
IND-1008-1UH-5%	INDUCTOR SMD 1008 1uH-5%		0.5	73.0	35	33.4	.22
EP12SD1ABE	C&K EP Series right angle push button switch SPDT		7.9	1.0	35	7.9	.05
7101MD9ABE	C&K 7000 Series right angle toggle switch SPDT		11.8	1.0	35	11.8	.08
AGILENT PROBE FOOTPRINT	Agilant probe footprint		0.0	16.0	35	.0	.00
EEVFK1K470P	PANASONIC SMD ELECTROLYTIC CAPACITOR FK SERIES 47uF-80V-20%		6.4	15.0	35	95.9	.63
BLM18PG121SN1	Murata BLM18P Series Ferrite Bead, 120 ohm, 2000 MA, SMD 0603		1.0e-002	154.0	35	1.5	.01
A700X107M008AT-E010	Kemet Aluminum Capacitor, A700 series, 100uF/8V, case size 7343		4.6	128.0	35	584.8	3.86
PRC212500K/181M	California Micro Devices, AC termination network PRC212, 50ohm/180pF, 18 lines QSOP20 package		7.3	29.0	35	211.4	1.40
JMK212BJ475MG-T	Taiyo Yuden Ceramic Capacitor, 4.7uF/6.3V X5R 20% tolerance, 0805		1.0	1.0	35	1.0	6.41e-0-
JMK212BJ106MG-T	Taiyo Yuden Ceramic Capacitor, 10uF/6.3V X5R 20% tolerance, 0805		1.0	1.0	35	1.0	6.41e-0-
0453-010	LITTELFUSE 10A SMD VFAST ACTING FUSE		0.5	2.0	35	1.0	6.60e-0-
EXBA10P470J	Panasonic chip resistor network EXBA10P470J, 47ohm, 8 resistors, 2512 package		3.2	11.0	35	35.6	.24
67F075	Airpex thermostat		10.0	2.0	35	20.0	.13

EVLA Correlator Reliability Report

Part Number	25081	**Description**	Baseline Board bare assembly w/o mezzanine
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	15,143.1
Temperature	35.00	**MTBF (hrs)**	66,037

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
IHLP-2525CZ-ER--1R5-M-01	Vishay low profile, high current inductor, 1.5uH 9A SMT		0.5	65.0	35	29.7	.20

EVLA Correlator Reliability Report

Part Number	25500-Y-000000	**Description**	PCMC Assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	164.4
Temperature	35.00	**MTBF (hrs)**	6,083,137

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
XC2V250-5FG256C	Xilinx EPLD Virtex-II 250-5FG256C, PCMC FPGA		30.0	1.0	35	30.0	18.25
XC18V02VQ44	Xilinx In-System-Programma-ble PROM, XC18V02VQ44		35.0	1.0	35	35.0	21.28
MAX1039AEEE	Maxim-IC 12-Channel 2-Wire Serial 8-Bit ADC		28.4	1.0	35	28.4	17.26
IDTQS3861Q	IDT 10-Bit bus switch with enable QSOP24		9.5	6.0	35	57.0	34.67
S1A-13	DIODES 1A surface mount rectifier SMA		5.3	1.0	35	5.3	3.20
1375800-1	AMP PC104-Plus Press-Fit connector, 120-pin Non-Stackthrough No Standoff		0.1	1.0	35	.1	.06
146305-6	AMP .100inch 6-pin single row right angle through hole connector		0.1	1.0	35	.1	.06
YTW-32-10-G-Q-3-50-110-001	Samtec 2mm Hi-Density stacker 4Rowx32 .350inch height		0.1	1.0	35	.1	.06
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	200.0	35	6.0e-002	.04
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	200.0	35	.2	.12
CAP-TANT-6032-1-00UF-6.3V-10%	CAP-TANT-6032-100-uF-6.3V-10%		0.9	9.0	35	8.2	5.00

EVLA Correlator Reliability Report

Part Number
Reference Des
Date June 6, 2005
Environment GB, GC - Ground Benign, Controlled
Temperature 25.00

Description Rack fans
File Name EVLACorrelator_Report1_Ju-
Time 12:24 PM
Failure Rate (FIT) 1,126,027.1
MTBF (hrs) 888

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
R1G225-AC73-52			17,594.2	1.0	25	17594.2	100.00

EVLA Correlator Reliability Report

Part Number
Reference Des
Date June 6, 2005
Environment GB, GC - Ground Benign, Controlled
Temperature 25.00

Description Rack breakers
File Name EVLACorrelator_Report1_Ju-
Time 12:24 PM
Failure Rate (FIT) 27,200.0
MTBF (hrs) 36,765

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
48VDC BREAKER			170.0	1.0	25	170.0	100.00

EVLA Correlator Reliability Report

Part Number	25171	**Description**	FeedThru Backplane (aka Common Backplane or
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	94.1
Temperature	35.00	**MTBF (hrs)**	10,632,400

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
933142	ERNI type F vertical male connector with peg and extended terminal		13.8	1.0	35	13.8	14.71
933141	ERNI type E vertical male connector without peg, with extended terminal		31.4	1.0	35	31.4	33.43
114404	ERNI vertical female power module 3 positions		11.8	1.0	35	11.8	12.54
70543-0001	Molex single row .100in 2-pin connector		0.5	1.0	35	.5	.50
55558-4	AMP tap power distribution 25A with screw		7.9	2.0	35	15.7	16.72
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	1.0	35	3.0e-004	3.19e-0-
SP08	C&K dip switch SP08 SIP		20.8	1.0	35	20.8	22.10

EVLA Correlator Reliability Report

Part Number 25500-Y-000003

Reference Des

Date June 6, 2005

Environment GB, GC - Ground Benign, Controlled

Temperature 35.00

Description Fanout Board (aka Station Data Fanout Board--SDFB)

File Name EVLACorrelator_Report1_Ju-

Time 12:24 PM

Failure Rate (FIT) 2,766.8

MTBF (hrs) 361,424

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
1N4148W-7	Diodes surface mount switching diode SOD-123		0.6	1.0	35	.6	.02
LT6700CS6-1	Linear dual comparator with 400mV reference SOT-23		0.1	1.0	35	.1	3.61e-0-
MC100ES6220TB-R2	Motorola low voltage dual 1:10 differential ECL/PECL clock fanout buffer	MTBF @ Tj=50 C; For every 10C drop in temp, reliability increases by 2X	125.0	16.0	50	2000.0	72.28
H11A617ASD	Fairchild Semi 4-pin phototransistor optocoupler SMD		72.2	1.0	35	72.2	2.61
591-3001-007	Dialight 3mm Prism CBI surface mount Bi-Color LED, Super Red/Green		2.0	1.0	35	2.0	.07
PQ60033QML15N-NS	SynQor 48V-to-3.3V isolated DC/DC converter 15A	MTBF @ 80% load, 300LFM, 40C Tamb	476.2	1.0	35	476.2	17.21
QPI-1L	Vicor Active Filter, 12A	PD~=2W; ThetaJA=15C/W no airflow; no reliability data found	64.3	1.0	65	64.3	2.32
933070	ERNI type F right angle female connector with shield, without peg		13.8	2.0	35	27.7	1.00
104416	ERNI type E right angle female connector with upper shield, without peg		31.4	2.0	35	62.9	2.27
114403	ERNI right angle male power module with three contact levels		11.8	2.0	35	23.6	.85
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	800.0	35	.2	8.67e-0-
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	250.0	35	.3	9.04e-0-
CAP-TANT-3216	CAPACITOR TANT SMD 3216 10uF-16V-10%		0.9	17.0	35	15.5	.56

EVLA Correlator Reliability Report

Part Number 25500-Y-000003

Reference Des

Date June 6, 2005

Environment GB, GC - Ground Benign, Controlled

Temperature 35.00

Description Fanout Board (aka Station Data Fanout Board--SDFB)

File Name EVLACorrelator_Report1_Ju-

Time 12:24 PM

Failure Rate (FIT) 2,766.8

MTBF (hrs) 361,424

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
0453-003	LITTELFUSE 3A SMD VFAST ACTING FUSE		7.9	1.0	35	7.9	.28
EEVFK1K470P	PANASONIC SMD ELECTROLYTIC CAPACITOR FK SERIES 47uF-80V-20%		6.4	2.0	35	12.8	.46
RES-0201	RESISTOR SMD 0201-100R-1%		1.0e-002	64.0	35	.6	.02

EVLA Correlator Reliability Report

Part Number
Reference Des
Date June 6, 2005
Environment GB, GC - Ground Benign, Controlled
Temperature 35.00

NRC · CNRC

Description NRAO FORM bare assembly
File Name EVLACorrelator_Report1_Ju-
Time 12:24 PM
Failure Rate (FIT) 2,397.7
MTBF (hrs) 417,060

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
100SP1T2B4M6RE	SW_SPDT		11.8	1.0	35	11.8	.49
0326-2-19-01-0627-100	1SOCKET		0.2	57.0	35	9.0	.37
901-143	SMA		0.4	1.0	35	.4	.02
1241-PF-120G_A-ND_1184-CPF-10-4G2	PC104PLUS		18.9	1.0	35	18.9	.79
2222-118-19101	2222-118-19101		11.8	1.0	35	11.8	.49
6255T1LC	6255T1LC		2.0	3.0	35	5.9	.25
6255T5LC	6255T5LC		2.0	3.0	35	5.9	.25
87331-0820	Molex 4x2 2mm vertical through hole connector		1.0	1.0	35	1.0	.04
154002	SMF-FUSE		0.5	1.0	35	.5	.02
AD8304ARU	AD8304ARU	Mfg data @ 50C; CL=60%; 0.7ev AE;; FIT=6 @70C	1.0	3.0	35	3.0	.13
AD9751AST	AD9751AST	Mfg data @50C; CL=60%; FIT=5 @70C	1.0	1.0	35	1.0	.04
ADS7841EB	ADS7841EB	Mfg data @150C; CL=90%; 0.7eV AE	4.0	1.0	35	4.0	.17
ADT1.5-1	ADT1.5-1		27.4	1.0	35	27.4	1.14
AT25128N-10SI-2.7	AT25128		21.4	1.0	35	21.4	.89
BCW61DTA	BCW61D		3.5	3.0	35	10.5	.44
DF7-2P-3.96DS	DF7-2P-3.96DS		0.3	1.0	35	.3	.01
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	300.0	35	.3	.01
CAP-TANT	100UF		0.9	8.0	35	7.3	.30
ECQ-U2A473MN	ECQ-U2A473MN		0.9	2.0	35	1.8	.08
EP1S20F780C5	EP1S20F780A	Mfg data 55C; 60% CL	23.0	3.0	35	69.0	2.88
RES-0805	39K		3.0e-004	6.0	35	1.8e-003	7.51e-0-

EVLA Correlator Reliability Report

Part Number
Reference Des
Date June 6, 2005
Environment GB, GC - Ground Benign, Controlled
Temperature 35.00

Description NRAO FORM bare assembly
File Name EVLACorrelator_Report1_Ju-
Time 12:24 PM
Failure Rate (FIT) 2,397.7
MTBF (hrs) 417,060

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	170.0	35	5.1e-002	2.13e-0-
EXC-3BP102H	EXC-3BB102H		0.5	3.0	35	1.4	.06
EXC-3BP121H	EXC-3BP121H		0.5	9.0	35	4.1	.17
LM61BIM3	LM61BIM3		2.7	1.0	35	2.7	.11
LMC6482IMM	LMC6482IMM(8)		27.2	9.0	35	245.2	10.23
LT1460DCS8-2.5	LT1460DCS8-2.5		5.5	1.0	35	5.5	.23
MA8024	2.4V		2.7	3.0	35	8.2	.34
MAX525BCAP	MAX525BCAP		27.2	1.0	35	27.2	1.14
PCN21B-110SB-2-PF_AND_PCN21B--55SC-2PF	IOCONN		17.3	1.0	35	17.3	.72
PM3604-68-B	PM3604-68-B		11.8	1.0	35	11.8	.49
PT4561N	PT4561	Mfg data per Bellcore TR-332; Ta=40C; 50% stress	204.1	1.0	35	204.1	8.51
PT4562N	PT4562	Mfg data per Bellcore TR-332; 40C; 50% stress	204.1	1.0	35	204.1	8.51
PVDZ172NS	PVDZ172NS		72.2	3.0	35	216.6	9.03
RX192DLXAFC10	RX192DL		328.1	3.0	35	984.4	41.06
S3098CB12	S3098CB12	No reliability data found; not found on AMCC's website; 10 Gbps receiver with CDR	46.3	3.0	35	138.9	5.79
SG-8002JF-PWI64-.00	SG-8002JF-PCB		60.0	1.0	35	60.0	2.50
SML-LXT0805GW--TR	SML-LXT0805GW-TR		2.0	3.0	35	5.9	.25
CAP-TANT	100UF		0.9	2.0	35	1.8	.08
TM5RC-88	RJ45		1.3	1.0	35	1.3	.05
XC95144XL-TQ144	XC95144XL-TQ144	Mfg data; 55C; 60% CL	25.0	1.0	35	25.0	1.04
XN0121500	XN01215		3.5	6.0	35	21.0	.88

EVLA Correlator Reliability Report

Part Number		**Description**	NRAO FORM power supply
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	564.9
Temperature	35.00	**MTBF (hrs)**	1,770,086

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
800-10-064-61-001-0000	1PLUG		0.0	19.0	35	.0	.00
CDH53-100LC	CDH53		0.0	1.0	35	.0	.00
CDRH127-7R6NC	CDRH127		0.0	1.0	35	.0	.00
CAP-0603	0.22		1.0e-003	6.0	35	6.0e-003	3.19e-0-
CAP-0805	1UF		1.0e-003	2.0	35	2.0e-003	1.06e-0-
CAP-TANT	100UF		0.9	10.0	35	9.1	4.85
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	28.0	35	8.4e-003	4.46e-0-
LT1964ES5-BYP	LT1964ES5-BYP	LT mfg reliability data; 55C; 60% CL	1.4	1.0	35	1.4	.72
SMB5817	SMB5817		5.3	1.0	35	5.3	2.79
SML-LXT0805GW--TR	SML-LXT0805GW-TR		2.0	6.0	35	11.8	6.27
T510X337M010AS	330UF		4.6	1.0	35	4.6	2.43
T510X687M004AS	680UF		4.6	1.0	35	4.6	2.43
TLP137	TLP137		72.2	2.0	35	144.4	76.67
TPS54613PWP	TPS54613PWP	Mfg data; 55C; 60% CL, 0.7eV	1.1	1.0	35	1.1	.58
TPS6755ID	TPS6755ID	Mfg reliability data; 55C; CL=60%	2.3	1.0	35	2.3	1.22
TPS70102PWP	TPS70102PWP	Mfg data; 55C; CL=60%	0.6	1.0	35	.6	.32
TPS75425QPWP	TPS75425QPWP	Mfg data; 55C; 60% CL	0.6	1.0	35	.6	.32
TPS75433QPWP	TPS75433QPWP	Mfg data; 55C; 60% CL	0.6	1.0	35	.6	.32
XN0150100L	2SD601AX2	Don't know exactly what part this is, just a guess	2.0	1.0	35	2.0	1.08

EVLA Correlator Reliability Report

Part Number	25500-Y-000001	**Description**	Delay Module
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	1,741.0
Temperature	35.00	**MTBF (hrs)**	574,390

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
XC2V3000-6FF1152	Xilinx Virtex-II 3000-6FF1152, Delay Module FPGA		30.0	1.0	35	30.0	3.45
MT48LC16M16A2-FG-75	SDRAM (4MEG X 16 X 4 banks) Micron	Reliability from Micron Data; @50C	40.0	18.0	35	720.0	82.71
CIT-CSX750ACB1-33.330MTR	133.330 MHz Oscillator, SMD, CITIZEN		60.0	1.0	35	60.0	6.89
AMP-146129-4	AMP SMD SINGLE ROW PLUG HEADER		0.9	1.0	35	.9	.11
FCN-264P120-G/J	Fujitsu straight plug 120 positions, FCN-264P120-G/J		18.9	2.0	35	37.7	4.33
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	400.0	35	.1	.01
CAP-TANT-6032-1-00UF-6.3V-10%	CAP-TANT-6032-100-uF-6.3V-10%		0.9	4.0	35	3.7	.42
IND-1008-1UH-5%	INDUCTOR SMD 1008 1uH-5%		0.5	19.0	35	8.7	1.00
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	220.0	35	.2	.03
CAP-TANT-3216-4-.7UF-10V-	CAP-TANT-SMD-3216--4.7uF-10V-10%;		0.9	10.0	35	9.1	1.05

EVLA Correlator Reliability Report

Part Number	25041	**Description**	Station Board Bare Assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	6,611.7
Temperature	35.00	**MTBF (hrs)**	151,246

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
AGILENT PRO SOFT TOUCH FOOTPRINT	Agilant pro soft touch footprint		0.0	4.0	35	.0	.00
TESTPOINT-THRU	TESTPOINT THRU HOLE 40 THOU HOLE		0.0	144.0	35	.0	.00
SY02-HPLL-IPNL6-4-OUNA128-4-TC--CM	Raltron Electronics frequency synchronizer SY02-HPLL	No reliability data found; transistor count is guess; PD=66 mW	27.2	1.0	35	27.2	.41
SK2111AXFT	Semtech 1 to 10 LVDS driver LQFP32	128 MHz, 112mW est JA=30C/W @ 400 LFM; No reliability data found; transistor count is a guess	38.2	13.0	40	496.0	7.50
BCW60D	ZETEX TRANSISTOR GENERAL PURPOSE NPN SOT23		0.4	12.0	35	5.1	.08
1N4148W-7	Diodes surface mount switching diode SOD-123		0.6	17.0	35	10.5	.16
LT6700CS6-1	Linear dual comparator with 400mV reference SOT-23		0.1	8.0	35	.8	.01
CDCVF2310	TI 1 to 10 CLK BUFFER, CDCVF2310	JTAG only, normally idle; FIT from TI web; 55C 60% confidence; 0.7 eV	5.3	13.0	35	68.9	1.04
H11A617ASD	Fairchild Semi 4-pin phototransistor optocoupler SMD		72.2	2.0	35	144.4	2.18
591-3001-007	Dialight 3mm Prism CBI surface mount Bi-Color LED, Super Red/Green		2.0	19.0	35	37.4	.57
EP1SGX10C-F672--C5	Altera Stratix Gx EP1SGX10C F672 device, Timing chip	Altera reliability data @ 55C; CL=60%	22.3	3.0	35	66.9	1.01
XC4VSX35-10FF6-68	XILINX VIRTEX 4 SERIES FPGA	No reliability data; use Xilinx 0.13 um @ 55C	30.0	36.0	35	1080.0	16.33
XC4VLX40-10FF1-148	XILINX VIRTEX 4 SERIES FPGA	No reliability data; use Xilinx 0.13 um data @55C	30.0	1.0	35	30.0	.45

EVLA Correlator Reliability Report

Part Number	25041	**Description**	Station Board Bare Assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	6,611.7
Temperature	35.00	**MTBF (hrs)**	151,246

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
XC4VSX35-10FF6-68	XILINX VIRTEX 4 SERIES FPGA	No reliability data; use Xilinx 0.13 um @ 55C	30.0	2.0	35	60.0	.91
XC4VSX35-10FF6-68	XILINX VIRTEX 4 SERIES FPGA	No reliability data; use Xilinx 0.13 um @ 55C	30.0	1.0	35	30.0	.45
XC4VSX35-10FF6-68	XILINX VIRTEX 4 SERIES FPGA	No reliability data; use Xilinx 0.13 um @ 55C	30.0	1.0	35	30.0	.45
XC4VSX35-10FF6-68	XILINX VIRTEX 4 SERIES FPGA	No reliability data; use Xilinx 0.13 um @ 55C	30.0	1.0	35	30.0	.45
QPI-1L	Vicor Active Filter, 12A	PD~=2W; ThetaJA=15C/W no airflow; no reliability data found	64.3	2.0	65	128.6	1.95
D048C012T012M2N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 1.2V 80A output	Artesyn equivalent @ Tcase=45C; Telcordia model	259.1	4.0	65	1036.3	15.67
D048C015T012M2N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 1.5V 80A output	Artesyn equivalent @ Tcase=45C; Telcordia model	259.1	1.0	65	259.1	3.92
D048C025T015M2N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 2.5V 60A output	Artesyn equivalent @ Tcase=45C; Telcordia model	259.1	1.0	65	259.1	3.92
D048C033T015M1N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 3.3V 45A output	Artesyn equivalent @ Tcase=45C; Telcordia model	259.1	1.0	65	259.1	3.92
D048C050T015M1N	Vicor VICBrick DC-DC Converter, Quarter Brick, 48V in, 5.0V 30A output	Artesyn equivalent at Tcase=45C; Telcordia model	259.1	1.0	65	259.1	3.92
TMP37FT9	Analog Dev.precision centigrade temperature sensor TO-92		5.5	6.0	35	33.0	.50
TMP37FS	Analog Dev.precision centigrade temperature sensor SO-8		5.5	6.0	35	33.0	.50
CB2V53C064M0000	CTS 64MHz SMT Crystal Oscillator 2V5		60.0	1.0	35	60.0	.91
87333-1420	MOLEX 2mm 14-pin 2 row right angle through hole connetor		7.9	2.0	35	15.7	.24

EVLA Correlator Reliability Report

Part Number	25041	**Description**	Station Board Bare Assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	6,611.7
Temperature	35.00	**MTBF (hrs)**	151,246

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
YTQ-132-01-L-Q-0-01	Samtec 2mm Hi-Density socket 4Rowx32		1.0	1.0	35	1.0	.02
85505-0001	Molex right angle through hole RJ45 jack		1.0	2.0	35	2.0	.03
87331-0820	Molex 4x2 2mm vertical through hole connector		1.0	2.0	35	2.0	.03
FUJITSU FCN-264J120-G/A	Fujitsu FCN-264J120-G/A straight socket		1.0	4.0	35	4.0	.06
933070	ERNI type F right angle female connector with shield, without peg		13.8	3.0	35	41.5	.63
104416	ERNI type E right angle female connector with upper shield, without peg		31.4	3.0	35	94.3	1.43
114403	ERNI right angle male power module with three contact levels		11.8	3.0	35	35.4	.54
ERNI - 104114 FEMALE C	ERNI - 11 X 7, FEMALE HM 2mm CONN		12.1	1.0	35	12.1	.18
ERNI - 114114 FEMALE B	ERNI - 22 X 7, FEMALE HM 2mm VER CONN		24.2	3.0	35	72.6	1.10
39-27-4022	Molex .100" micro shunt header, dual row low profile, 2 circuits		0.0	7.0	35	.0	.00
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	3,000.0	35	.9	.01
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	2,500.0	35	2.5	.04
CAP-TANT-6032-1-00UF-6.3V-10%	CAP-TANT-6032-100-uF-6.3V-10%		0.9	40.0	35	36.5	.55
CAP-TANT-3216-1-0UF-16V-10%	CAPACITOR TANT SMD 3216 10uF-16V-10%		0.9	8.0	35	7.3	.11
IND-1008-1UH-5%	INDUCTOR SMD 1008 1uH-5%		0.5	18.0	35	8.2	.12
CAP-TANT-3216-4-.7UF-10V-	CAP-TANT-SMD-3216--4.7uF-10V-10%;		0.9	41.0	35	37.5	.57

EVLA Correlator Reliability Report

Part Number 25041
Reference Des
Date June 6, 2005
Environment GB, GC - Ground Benign, Controlled
Temperature 35.00

Description Station Board Bare Assembly
File Name EVLACorrelator_Report1_Ju-
Time 12:24 PM
Failure Rate (FIT) 6,611.7
MTBF (hrs) 151,246

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
EP12SD1ABE	C&K EP Series right angle push button switch SPDT		11.8	1.0	35	11.8	.18
7101MD9ABE	C&K 7000 Series right angle toggle switch SPDT		11.8	1.0	35	11.8	.18
0453-003	LITTELFUSE 3A SMD VFAST ACTING FUSE		7.9	2.0	35	15.7	.24
67F075	Airpex thermostat		10.0	1.0	35	10.0	.15
753-10-5-600B-G	CTS corp. Resistor Network; 8 term.		27.8	8.0	95	222.4	3.36
753-08-5-600B-G	CTS corp. Resistor Network; 6 term.		20.9	73.0	95	1522.1	23.02

EVLA Correlator Reliability Report

Part Number	25500-Y-000000	**Description**	PCMC board
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	164.4
Temperature	35.00	**MTBF (hrs)**	6,083,137

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
XC2V250-5FG256C	Xilinx EPLD Virtex-II 250-5FG256C, PCMC FPGA		30.0	1.0	35	30.0	18.25
XC18V02VQ44	Xilinx In-System-Programma-ble PROM, XC18V02VQ44		35.0	1.0	35	35.0	21.28
MAX1039AEEE	Maxim-IC 12-Channel 2-Wire Serial 8-Bit ADC		28.4	1.0	35	28.4	17.26
IDTQS3861Q	IDT 10-Bit bus switch with enable QSOP24		9.5	6.0	35	57.0	34.67
S1A-13	DIODES 1A surface mount rectifier SMA		5.3	1.0	35	5.3	3.20
1375800-1	AMP PC104-Plus Press-Fit connector, 120-pin Non-Stackthrough No Standoff		0.1	1.0	35	.1	.06
146305-6	AMP .100inch 6-pin single row right angle through hole connector		0.1	1.0	35	.1	.06
YTW-32-10-G-Q-3-50-110-001	Samtec 2mm Hi-Density stacker 4Rowx32 .350inch height		0.1	1.0	35	.1	.06
RES-0402	RESISTOR SMD 0402 100k-1%	Panasonc failure rate data; thick-fim chip resistors	3.0e-004	200.0	35	6.0e-002	.04
CAP-0402		Panasonic failure rate data, multilayer ceramic capacitor	1.0e-003	200.0	35	.2	.12
CAP-TANT-6032-1-00UF-6.3V-10%	CAP-TANT-6032-100-uF-6.3V-10%		0.9	9.0	35	8.2	5.00

EVLA Correlator Reliability Report

Part Number	25500-Y-000008	**Description**	PC/104+ complete assembly
Reference Des		**File Name**	EVLACorrelator_Report1_Ju-
Date	June 6, 2005	**Time**	12:24 PM
Environment	GB, GC - Ground Benign, Controlled	**Failure Rate (FIT)**	2,564.1
Temperature	35.00	**MTBF (hrs)**	390,000

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
MOPSLCD6		MTBF not yet available; use data from MOPS/386A	2,564.1	1.0	35	2564.1	100.00

EVLA Correlator Reliability Report

Part Number
Reference Des
Date June 6, 2005
Environment GB, GC - Ground Benign, Controlled
Temperature 25.00

Description Rack breakers
File Name EVLACorrelator_Report1_Ju-
Time 12:24 PM
Failure Rate (FIT) 21,760.0
MTBF (hrs) 45,956

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
48VDC BREAKER			170.0	1.0	25	170.0	100.00

EVLA Correlator Reliability Report

Part Number
Reference Des
Date June 6, 2005
Environment GB, GC - Ground Benign, Controlled
Temperature 25.00

Description Rack fans
File Name EVLACorrelator_Report1_Ju-
Time 12:24 PM
Failure Rate (FIT) 563,013.5
MTBF (hrs) 1,776

Part Number	Description	Comments	Failure Rate, Unit	Quantity	Temp (C)	FR (FIT)	FR %
R1G225-AC73-52			17,594.2	1.0	25	17594.2	100.00

Percentage Summary

Part Type	Quantity	% Quantity	Failure Rate	% Failure Rate
IC, Logic	42930.00	1.21	1143784.687662	9.22
IC, Memory	25506.00	0.72	647850.592220	5.22
IC, Microproc	290.00	0.01	743589.743590	5.99
IC, Linear	26256.00	0.74	1798954.328069	14.50
IC, GaAs	384.00	0.01	17782.174604	0.14
Trans, Bipolar	3496.00	0.10	5029.111686	0.04
Trans, FET	160.00	0.00	0.000000	0.00
Diode	8996.00	0.25	22683.220003	0.18
Opto-elec	8726.00	0.25	17210.428620	0.14
Res, Variable	1289372.00	36.30	551.944400	0.00
Res, Network	17152.00	0.48	263611.854295	2.12
Cap, Fixed	2009134.00	56.56	223658.939140	1.80
Ind, Transformer	128.00	0.00	3508.609932	0.03
Ind, Coil	55436.00	1.56	14313.412192	0.12
Rotating Device	96.00	0.00	1689040.589757	13.61
Switch	2674.00	0.08	86722.445859	0.70
Connector	25700.00	0.72	201643.873425	1.63
Boards with PTH	3114.00	0.09	793.000000	0.01
Connection	1380.00	0.04	1380.000000	0.01
Fuse	448.00	0.01	224.000000	0.00
Fiber Optic	2544.00	0.07	283667.183821	2.29
Misc	1040.00	0.03	3239796.009070	26.12
User	27012.00	0.76	2000000.000000	16.12

First Year Dropout

Month	Failure Rate	Expected # of Failures	Avg. Cumulative Failure Rate
1	87240887.203194	183.736488	251693819.451343
2	52162065.643623	215.345730	147497075.425429
3	38566512.162602	236.081938	107799971.679990
4	31116844.011451	251.870519	86257027.134392
5	26340012.471413	264.760960	72537249.200861
6	22984554.978231	275.725778	62951090.790741
7	20482136.506832	285.308812	55833427.058901
8	18535076.611281	293.847180	50316297.938235
9	16971438.147708	301.565289	45900348.406699
10	15684543.811106	308.620564	42276789.643490
11	14604478.765741	315.127982	39243833.425864
12	13683391.366641	321.174245	36663726.613276