Proprietary and Confidential

AEi Systems Sample

RELIABILITY ANALYSIS

Single Board Computer Module Subassembly

Final Report

PREPARED FOR

PREPARED BY

AEi Systems, LLC

5933 W. Century Blvd. Suite 1100

Los Angeles CA 90045

DATE

This document is proprietary and confidential
to AEi Systems, LLC

1. Scope

This document contains the results of a Bellcore/Telcordia parts count MTBF analysis of the a Single Board Computer module subassembly.

Analysis:	MTBF Analysis
Last Rev Date:	6/17/05
Assembly:	xxxx
Subassemblies	
Excel File:	Failure Rankings 30C.xls, BoM.xls
Relex File	Project.RPJ

Failure Rate Summary – Parts Quality I/Quality II

Analysis	Failure Rate (FPMH)	MTBF (Hrs)
Telcordia Ground Benign +30C, MTBF		
	0.725193	**1,378,942.67**

CONTENTS

1. Scope ____ 2

2. Functional Description ____ 4

3. Assumptions ____ 4

4. Quality and Reliability in the Design Process ____ 5

5. Component Approval and Qualification ____ 6

6. Methods of Analysis ____ 6

Table 1 - Default Reliability Parameters ____ 10

7. Analysis Results ____ 13

Table 2 – Percentage Summary @ 30 degrees C. Quality II. ____ 13

Figure 1 – Failure Rate ranges by category. ____ 14

Table 3 – Top (75%) contributors to system failure rate @ 30 degrees C. ____ 15

Figure 2 –System failure rate over temperature. ____ 16

Figure 3 – % Failure rate over temperature by part category. ____ 16

8. Conclusions and Recommendations ____ 18

2. Functional Description

The system contains passive and active devices (approximately 258 parts). The majority of the devices are resistors and capacitors. The active devices consist of various integrated circuits, diodes, memory, and a microcontroller.

3. Assumptions

The following assumptions were made in order to complete this analysis.

- The analysis was performed in accordance with Telcordia Issue 1 Method 1 Case 3.
- The environment used was GB, GC - Ground Benign, Controlled at +30C.
- The quality levels of the components in this analysis are assumed to be Level 1 or Level 2 using the Bellcore definition, which is provided below. The quality level of the passive components in this analysis is assumed to be Level 1 while the quality level of the active components, filters, crystals, connectors, etc. is assumed to be Level 2.
- No temperature rise above ambient is assumed for any part.
- Operational Duty Cycle: 100% Continuous, Burn-in time: 0 hours.
- For most of the critical ICs reliability data was obtained from the device manufacturer. However, different manufacturers specific reliability data differently. Most test their parts for a short period of time and then apply mathematical formulas to discern FITs (failures per billion hours) or MTBF numbers. The mathematical assumptions (Confidence level, temperature, EA energy, etc.) differ across manufacturers. In cases where data was available, the data, usually a FITs number was used. In other cases, the lowest failure rate data provided by the reliability software estimation or Ahrennius equations (which derive failure rate data at one temperature from data at another temperature) were used. In some cases the confidence level and EA energy were assumed to be 60% and 0.7V, respectively.
- In some cases the fabrication technology, (CMOS selected in all cases) was also unavailable and therefore, estimated.

- Resistors were assumed to be film based chips.
- Capacitors were assumed to be ceramic chips.
- In some cases the part classification did not match those available in the reliability software. The closet match was chosen.
- The reliability model described is directed toward unit level failures caused by device hardware failures; failures due to programming errors on firmware are not considered. However, the hardware failure rates of firmware devices are considered.
- The model is based upon the concept of a serial reliability model. This refers to any unit for which the failure of any single part will cause a failure of the unit. Troubles caused by transient faults, software problems, procedural errors, or unexpected operating environments can have a significant impact on system level reliability. Therefore, system hardware failures represent only a portion of the total system trouble rate. Most of the mechanical/structures components (screws, trays, etc.) were not included in the analysis.
- **The file Failure Rankings 30C.xls file (Unsorted_QI_II tab) contains the information on the category, subcategory, and key prediction factors selected for each part. In some cases, two or more possible categorical selections may have been appropriate. This file should be reviewed by those familiar with the specific parts and the design to verify selection accuracy.**

4. Quality and Reliability in the Design Process

During the design process the system quality and reliability were a constant focus. This focus was carried out through the use of design specifications, design reviews, component/board/system testing, thermal analysis and measurements and other steps consistent with best commercial design practices. These steps coupled with the review of manufacturer's quality and reliability data help to insure only components and suppliers who meet rigid reliability stipulations are designed into the product.

5. Component Approval and Qualification

The company is partnering with its suppliers and sub-contractors to provide highly reliable systems to its customers. These relationships are based on implementing a Parts Management Plan. This plan is structured around the requirements of pertinent Telcordia Specifications.

The Plan addresses the following areas:

I. Parts/Supplier Identification and Approval (Including an Approved Vendors List)
II. Supplier Management Criteria, (Including Lot to Lot Controls & Acceptable Quality Level, etc)
III. Parts Qualification Requirements
IV. Part Processing (Manufacturing) Requirements
V. Documentation
VI. Materials and Processes

These procedures and processes will assure that only components that meet their detailed quality and reliability provisions are used in the company's products.

6. Methods of Analysis

Failure Rates for individual parts in the product have been established based upon historical data. Generally, failure rates are expressed in terms of the number of failures in 100,000,000 (1×10^9) hours of operation. The primary source of this failure rate data is Telcordia Technologies, "Reliability Prediction Procedure for Electronic Equipment. SR-332, Issue 1, May 2001."

Various factors, such as part application, environment, temperature, humidity, vibration, shock, power levels, voltage stress, cycle rates, construction characteristics, etc., all affect the predicted failure rate for a part. Within this reference, all of these various factors are

considered within the reliability model for each part type. Consequently, some parts have very simple models; other parts have very complex models,

Reliability Prediction Procedure

The procedure defined in SR-332 allows several different techniques to be used for calculating MTBF. Method I is based solely on the "Parts Count" procedure and has three different cases (Case 1, 2 & 3). The baseline failure rates for Method I calculations are derived from telecommunications and other industry field data.

Method II procedure uses unit or device statistical predictions based on combining Method I with predictions from data gathered during laboratory testing. Method III uses statistical predictions of in service reliability from field tracking data.

Method 1 Case 3 was utilized for the majority of this report. Method 1 dictates an ambient temperature of 30C. In several instances of newer technologies where no up-to-date field data existed, manufacturer's life test data augmented the Method 1 data. This prediction methodology is tailored to the design & application environment of the product thus providing a more accurate reliability figure.

The parts database provided by the company was prepared and then loaded into the reliability software. The library, which uses data gathered from past analyses, was applied and the MTBF calculated, using the defaults in Table 1 and specific values.

The results of the MTBF analysis were then sorted in descending order, to determine which components account for the majority of the failures. The detailed results (@ 30°C) are shown in Table 2 below for the top failure rate contributors in entire system.

SR-332 defines four distinct Quality Levels (0, I, II, & III) to be used in reliability predictions. Each level describes the necessary quality/ reliability factors to be satisfied. The descriptions of the available Bellcore model quality levels are as follows:

Quality Level I: (lowest quality)

This level shall be assigned to commercial-grade devices that are procured and used without thorough device qualification or lot-to-lot controls by the equipment manufacturer. However,

- (a) Steps must have been taken to ensure that the components are compatible with the design application and the manufacturing process; and
- (b) An effective feedback and corrective action program must be in place to identify and resolve problems quickly in manufacture in the field.

Quality Level II:

This level shall be assigned to devices that meet requirements (a) and (b) of Quality Level I, plus the following:

- (c) Purchase specifications must explicitly identify important characteristics (electrical, mechanical, thermal) and acceptable quality levels (i.e., AQLs, DPMs) for lot control;
- (d) Devices and vendors must be qualified and identified on approved parts/vendor lists (device qualification must include appropriate life and endurance tests);
- (e) Lot-to-lot controls, either by the equipment manufacturer or the device manufacturer, must be in place at adequate AQLs/DPMs to ensure consistent quality.

Quality Level III: (highest quality)

This level shall be assigned to devices that meet requirements (a) through (e) of Quality Levels I and II, plus the following:

- (f) Devices must be re-qualified periodically;
- (g) Lot-to-lot controls must include 100% screening (temperature cycling and burn-in) which, if the results warrant it, may be reduced to a "reliability audit" (i.e., on a sample basis) or to an acceptable "reliability monitor" with demonstrated and acceptable cumulative early failure values out to 10,000;
- (h) Where burn-in screening is used, the percent defective allowed (PDA) should be specified; and
- (i) An ongoing, continuous reliability improvement program must be implemented by both the device and equipment manufacturer.

Table 1 - Default Reliability Parameters

Category	Subcategory	Voltage Stress	Current Stress	Power Stress	Tech	Quality	Package	Application
Integrated Circuit	Logic, CGA or ASIC				CMOS	LEVEL II	Non-Hermetic	
Integrated Circuit	PAL, PLA				CMOS	LEVEL II	Non-Hermetic	
Integrated Circuit	Linear					LEVEL II	Non-Hermetic	
Integrated Circuit	Microprocessor				CMOS	LEVEL II	Non-Hermetic	
Integrated Circuit	Memory				CMOS	LEVEL II	Non-Hermetic	
Integrated Circuit	EEPROM				CMOS	LEVEL II	Non-Hermetic	
Integrated Circuit	VHSIC/VLSI CMOS				CMOS	LEVEL II	Non-Hermetic	
Semiconductor	Diode		50%			LEVEL II	Non-Hermetic	Signal, Regulator, Varistor
Semiconductor	Si NPN/Si PNP			50%		LEVEL II	Non-Hermetic	
Semiconductor	Si FET			50%		LEVEL II	Non-Hermetic	Switching
Semiconductor	Detector, Isolator, Emitter					LEVEL II	Non-Hermetic	
Resistor	Film (Chip (RM))			50%		LEVEL I	Chip	
Resistor	Network, Thick Film					LEVEL I	Thick Film	
Resistor	Thermistor					LEVEL II		PPTC
Resistor	Carbon			50%		LEVEL I		
Capacitor	Ceramic, Chip					LEVEL I	Chip	
Capacitor	Solid Tantalum, Chip	60%				LEVEL I	Non-Hermetic	
Inductor	Transformer					LEVEL I		High Power/Low Power Pulse
Inductor	Coil					LEVEL I		TF, Fixed or Molded
Inductor	Coil/RF Bead					LEVEL II		Power Filter
Connector	General					LEVEL II		
Connector	PCB Edge					LEVEL II		
Switch	Toggle or Pushbutton		50%			LEVEL II		SPDT
Miscellaneous	Quartz Crystal					LEVEL II		
Miscellaneous	Oscillator					LEVEL II		

MTBF Definitions

- Steady State- is that phase of the product's operating life during which the failure rate is constant. The steady state phase is assumed preceded by an infant mortality phase characterized by a decreasing failure rate,
- Device or Part- the basic component.
- Unit - any replaceable assembly or device. This may include PCB's, modules, plug-In units, power supplies, etc. The unit is the lowest level of replaceable assemblies/devices.
- Unit operating temperature- The unit operating temperature is determined by placing a probe above the unit while it is operating under normal conditions.
- Device operating temperature- The device operating temperature is the unit operating temperature plus the component temperature under normal conditions. For the Parts Count Method Analysis, the component junction temperature and the ambient are assumed to be 40C.

Devices Excluded

In this reliability model per SR-332, wire cable, solder connections, wire wrap connections and printed circuit boards are excluded.

MTBF Defined

The Mean Time Between Failure (MTBF) is a measure of the average time interval between successive random failures of a product (or device). This assumes that the product (or part) is operating in the “Mature Reliability” period of its’ operating life. High failure rates normally associated with the “Infant Mortality” period are assumed to have been eliminated by testing and burn-in procedures. High failure rates associated with the “Wear Out” period are yet to be encountered and will be reduced by preventative maintenance and replacement of Wear Out components before they cause a catastrophic failure.

During the mature reliability period, failures are generally of a random nature and, on the average, relatively constant in rate. Such failures are the result of inherent limitations in the design as well as accidents caused by usage or poor maintenance.

With the product (or device) operating in the steady state failure rate, random failure period of the product lifetime, the distribution of time between failures is approximately exponential, Because this distribution of time between failures statistically defines the probability of failure free operation over a specified period of time, the reliability (probability of survival) can be expressed by the mathematical equation,

$$R = P_s = e^{-t/MTBF} = e^{-t\,(FR)}$$

where R = P_s = Probability of failure free operation for a time period equal to or greater than "t" and e = 2.718.

t = defined time period for failure free operation

MTBF = Mean Time Between Failure

FR = Failure Rate (the reciprocal of MTBF)

For example, a FR of 0.843437 FPMH translates to 1/0.843437 * 1E6 = 1,185,624.36 hours

7. Analysis Results

At 30C, the major contributors in the assembly are shown in tables 2-3.

The overall system failure rate is **Failure Rate (FPMH) = 0.725193**

and the **MTBF (Hrs) = 1,378,942.67**

Table 2 – Percentage Summary @ 30 degrees C. Quality II.

Percentage Summary

Part Type	Quantity	% Quantity	Failure Rate	% Failure Rate
IC, Microproc	1.00	0.39	0.013656	1.88
Opto-elec	2.00	0.78	0.002548	0.35
Res, Fixed	109.00	42.41	0.136092	18.77
Res, Network	19.00	7.39	0.074297	10.25
Cap, Fixed	89.00	34.63	0.251159	34.63
Ind, Coil	1.00	0.39	0.001249	0.17
Connector	2.00	0.78	0.039236	5.41
Crystal	4.00	1.56	0.100000	13.79
User	30.00	11.67	0.106956	14.75

Figure 1 – Failure Rate ranges by category.

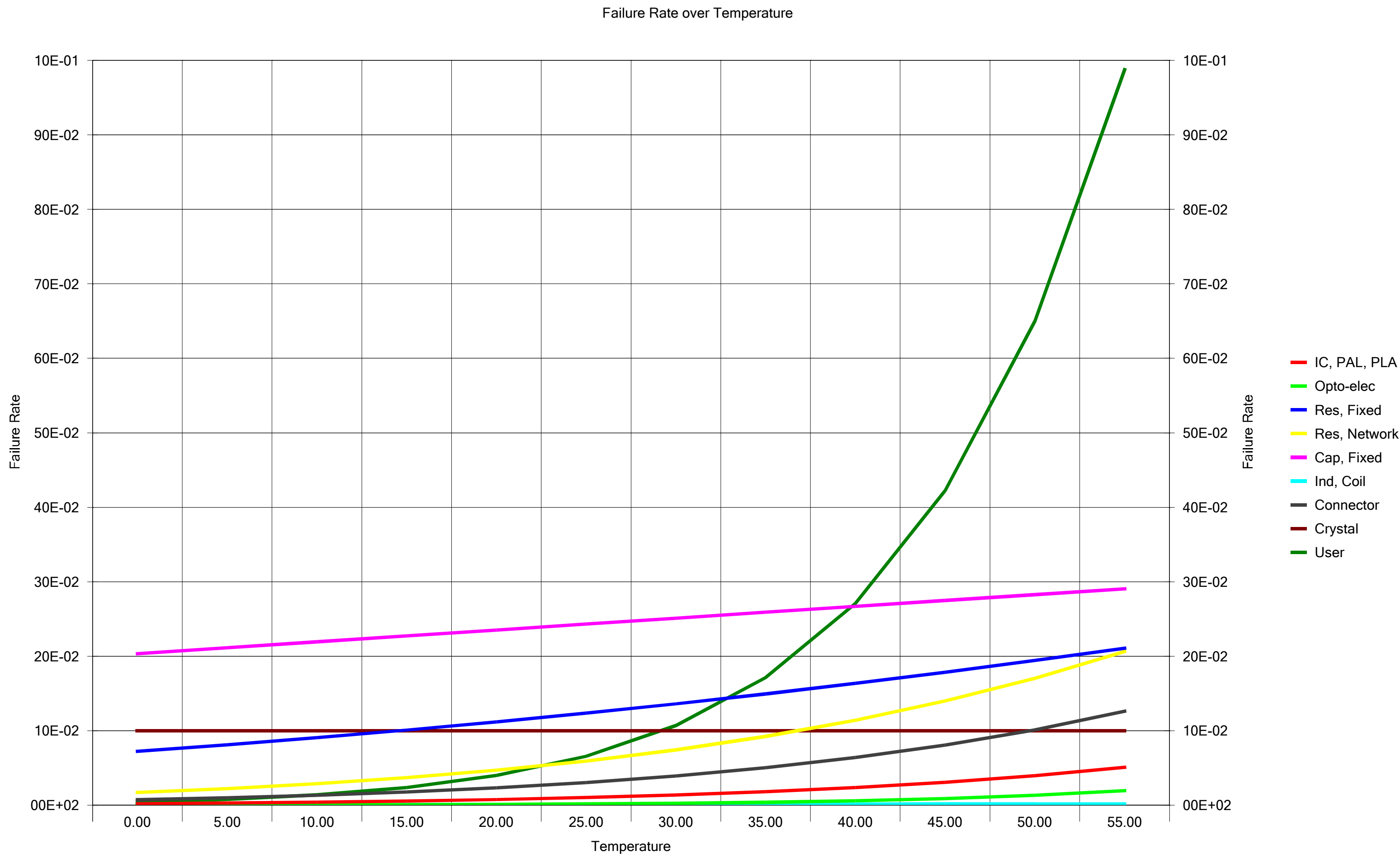


Table 3 – Top (75%) contributors to system failure rate @ 30 degrees C.

Part Number	Description	QTY	FR	FR%	CUM	CUM%	Category	Subcategory	Mfr.	M Part #
CV052	47nF/16V 0402 -20/+80% Y5V -25/+85 R	32	0.090304	12.45%	0.090304	12.45%	Capacitor	Chip, Ceramic (CDR)		
CV050	1nF/50V 0402 10% X7R -55/+125 R	28	0.079016	10.90%	0.16932	23.35%	Capacitor	Chip, Ceramic (CDR)		
IS129	AGL 40QFN -40/+85	1	0.040808	5.63%	0.210128	28.98%	Other	User Defined	Maxim	MAX7301
VM042	2*80-pin SlimStack™ Receptacle, Surface M	2	0.039236	5.41%	0.249364	34.39%	Connection	General	Molex	52760-1609
RN080	0R*4 1206 5% Konvex TK250 -55/+125 R	8	0.031283	4.31%	0.280647	38.70%	Resistor	Network Film (RZ)		
QQ066	QQ 32.76800KHz SMQ-32S 9*3.4mm R	1	0.025	3.45%	0.305647	42.15%	Miscellaneous	Quartz Crystal	Jauch	32.76800KHZ
QQ090	JXE75/1 12.00000MHz SMQ R	1	0.025	3.45%	0.330647	45.59%	Miscellaneous	Quartz Crystal	Jauch	12MHz
QQ099	JXE75/1 25.00000MHz SMQ R	1	0.025	3.45%	0.355647	49.04%	Miscellaneous	Quartz Crystal	Jauch	25MHZ
QQ108	3.68640MHz SMQ JXE115 -40/85 R	1	0.025	3.45%	0.380647	52.49%	Miscellaneous	Quartz Crystal	Jauch	3.68640MHZ
RN081	22R*4 1206 5% Konvex TK250 -55/+125 R	6	0.023462	3.24%	0.404109	55.72%	Resistor	Network Film (RZ)		
IT074	EAI SSOP-28/200 3.3-5V -40/+85	1	0.023108	3.19%	0.427217	58.91%	Other	User Defined	Maxim	MAX3245
RM486	0R 0402 0.06W 5% TK200 R	11	0.013734	1.89%	0.440951	60.80%	Resistor	Film (RL, RLR, RN, RNR, RM)		
IC252	32-bIT BGA-256 -40/85	1	0.013656	1.88%	0.454607	62.69%	Integrated Circui	Microprocessor	Intel	GDPXA255A0E400
CV057	100nF/10V-16V 0402 10% X5R -55/+85 R	4	0.011288	1.56%	0.465895	64.24%	Capacitor	Chip, Ceramic (CDR)		
IM385	128MB Intel StrataFlash Synchronous Memo	2	0.010302	1.42%	0.476197	65.66%	Other	User Defined	Intel	RC28F128K3C115
CV052	47nF/16V 0402 -20/+80% Y5V -25/+85 R	3	0.008466	1.17%	0.484663	66.83%	Capacitor	Chip, Ceramic (CDR)		
RN053	10K*4+0 1206 5% Konvex TK250 -55/+125 I	2	0.007821	1.08%	0.492484	67.91%	Resistor	Network Film (RZ)		
RM487	100K 0402 0.06W 5% TK200 R	6	0.007491	1.03%	0.499975	68.94%	Resistor	Film (RL, RLR, RN, RNR, RM)		
IM046	SO-08/150 5V	1	0.005716	0.79%	0.505691	69.73%	Other	User Defined	Catalyst	CAT93C46S
CC067	10µF/10V-16V 1206 10% X5R -55/+85 R	2	0.005644	0.78%	0.511335	70.51%	Capacitor	Chip, Ceramic (CDR)		
CC067	10µF/10V-16V 1206 10% X5R -55/+85 R	2	0.005644	0.78%	0.516979	71.29%	Capacitor	Chip, Ceramic (CDR)		
CC068	220nF/50V 0805 10% X7R -55/+125 R	2	0.005644	0.78%	0.522623	72.07%	Capacitor	Chip, Ceramic (CDR)		
CT044	4.7µF/10V 3216 10% -55/+125 R	2	0.005644	0.78%	0.528267	72.84%	Capacitor	Chip, Ceramic (CDR)		
CV049	22pF/50V 0402 5% C0G -55/+125 R	2	0.005644	0.78%	0.533911	73.62%	Capacitor	Chip, Ceramic (CDR)		
CV049	22pF/50V 0402 5% C0G -55/+125 R	2	0.005644	0.78%	0.539555	74.40%	Capacitor	Chip, Ceramic (CDR)		

Failure rankings for all of the components can be found in the Failure Rankings 30C.XLS document.

Figure 2 –System failure rate over temperature.

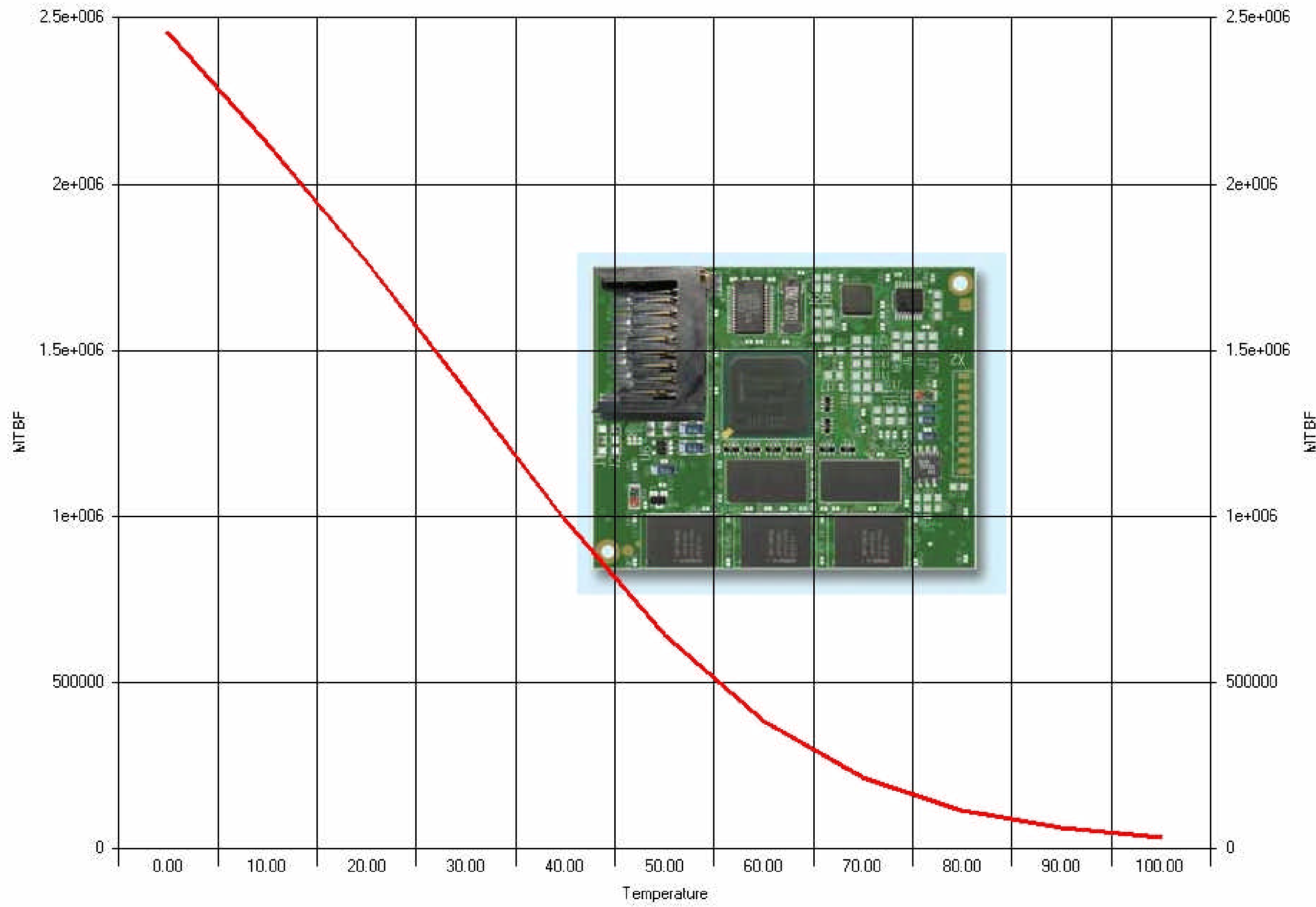
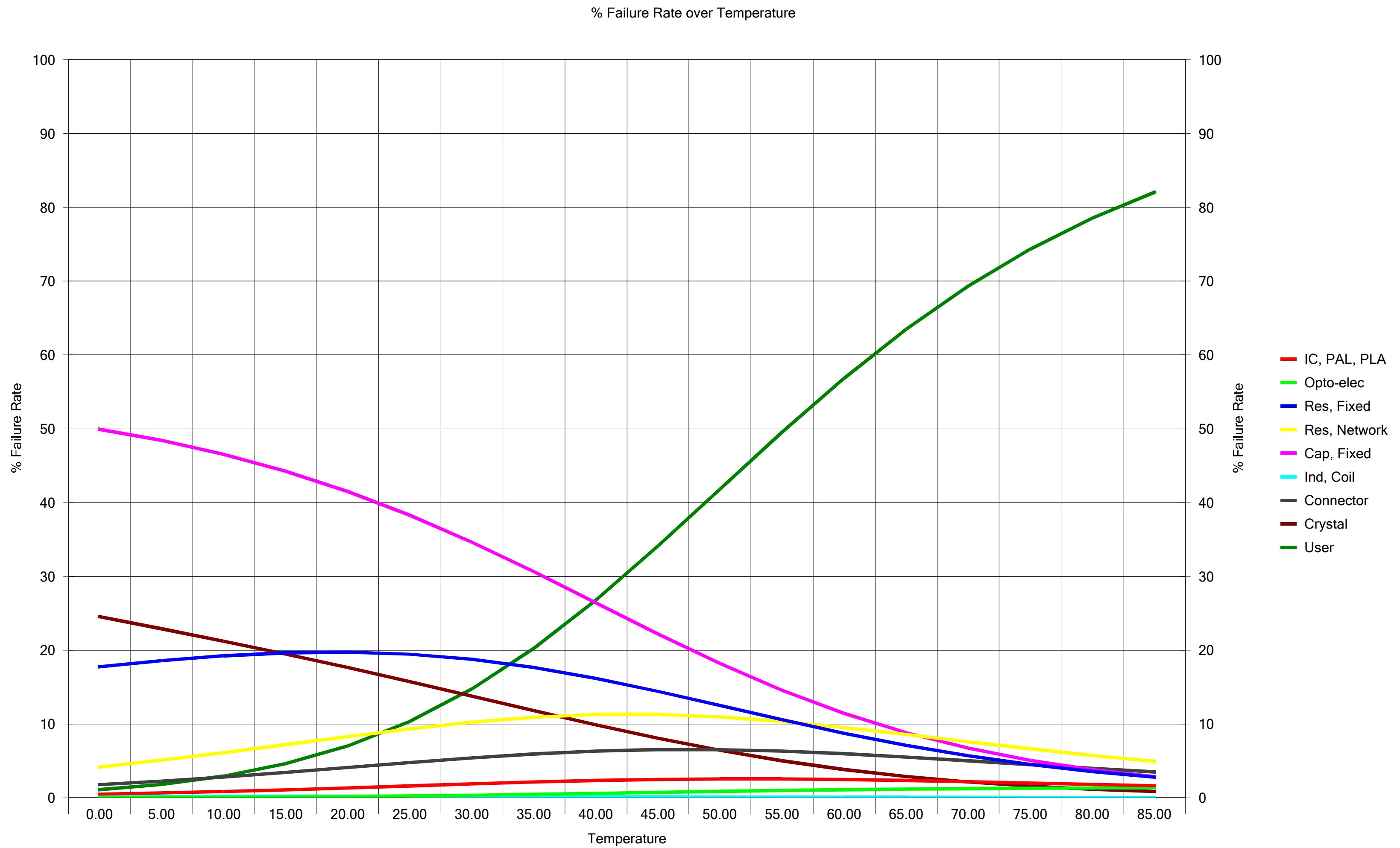


Figure 3 – % Failure rate over temperature by part category.


% Failure Rate over Temperature
% Failure Rate
100
90
80
70
60
50
40
30
20
10
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
70.00
75.00
80.00
85.00
Temperature
IC, PAL, PLA
Opto-elec
Res, Fixed
Res, Network
Cap, Fixed
Ind, Coil
Connector
Crystal
User

8. Conclusions and Recommendations

The failure rate of the product at 30 degrees C is primarily dependent on the integrated circuits, in particular the memory, and the capacitors and crystals.

The category/subcategory selection information (Failure Rankings 30C.xls) should be reviewed by those familiar with the specific parts and the design to verify selection accuracy.

Reliability data for some of the integrated circuits has been obtained from previous analyses. While a handful of parts required estimated data because the manufacturers could not, would not or did not provide such data (Intel/Microchip), it is doubtful that further data on the integrated circuits would markedly impact the MTBF performance.

The accuracy of the calculation could be improved by requesting more failure rate data from manufacturers at different temperatures, if such data exists, especially for the integrated circuits and Jauch components.