

3300 ICP System Reliability and Availability Summary

Mitel System Engineering Group, May 2008

Table of Contents

1	INTRODUCTION	3
2	FAILURE ANALYSIS OF CARDS AND SYSTEMS	3
2.1	SYSTEM FAILURE ANALYSIS	4
2.2	SUB-ASSEMBLY FAILURE ANALYSIS	5
3	CRITICAL HARDWARE MTTF VALUES FOR MITEL PRODUCTS	6
4	SYSTEM AVAILABILITY VALUES FOR MITEL PRODUCTS	7

1 Introduction

Business Continuity Model

People
Process
Geography
Power Distribution
Data Network
PBX Software
PBX Hardware

This white paper is part of a suite of documents published by Mitel that discuss IP based telephone system availability. A tree diagram depicting the relationship between all of the documents in the suite is provided in the document called *List of Telephone System Availability Documents, DK117891*.

The top level paper in this series is the Mitel White Paper entitled *Telephone System Availability, DK117892*. This white paper introduces the 7 layer Business Continuity Model and discusses each of the 7 layers of the model and how they affect overall system availability.

All of the documents in the availability suite can be found at Mitel On Line. This document describes in general principles how Mitel derives the values for reliability for the subassemblies and systems in the 3300 product family, and lists the AFR and MTTF figures for all of the major assemblies, including controllers, service units, peripheral cabinets, their field-replaceable sub-assemblies (FRUs) and IP telephone sets.

The usual criteria as to what constitutes a failure in a telephone system is that the system has failed if more than 10% of the users cannot make a call (i.e. less than 90% can make a call). Mitel uses this definition in the analysis of systems to create a list of predicted failure rates for sub-assemblies and systems. These predicted rates are always compared to real field return rates as products move from the design phase into full production, and discrepancies are used to improve both the assembly process and the prediction process.

2 Failure analysis of cards and systems

There are five basic values that are used to describe the reliability of components and systems. These values are:

- AFR or Annualized Failure Rate: This is the number of units that are expected to fail in any given year within the normal life span of the component or product.
- FITs or Failures in Time: This is the number of units that are expected to fail in 10^9 device-hours within the normal life span of the component or product. This value is the most commonly used measure of the reliability of components, and

forms the basis for the component assembly analysis. The rate can be converted by simple arithmetic means into AFR.

- **MTTF or Mean Time to Failure:** This is the statistical length of time that a component will operate (uptime) before a failure occurs. Measured in years, it is the inverse of the AFR.
- **MTTR:** The meaning of MTTR is dependent on the context:

Mean Time to Repair refers to hardware failures and the length of time that will elapse from the time a component failure was detected to the component being restored to service (repair time).

Mean Time to Recovery refers to software failures and the length of time that will elapse from the time that a system software failure is detected to the time that the system's operational integrity has been restored or recovered.

- **MTBF or Mean Time Between Failures:** This is the statistical length of time elapsed between sequential component failures. This metric also includes the time it takes for the component to be restored to service. In other words, MTBF is equal to the MTTF plus the MTTR (or uptime + repair time). If the MTTR is very short compared to the MTTF, then the MTBF and MTTF values will be virtually the same, which is why the terms are often used interchangeably.

For determining the availability of a system, the MTTF and MTTR are the values that would be used. The MTTF is derived from the reliability data, but the MTTR is determined by the logistics of the repair activity. To keep the repair time short, it may be necessary to stock spare parts either at the customer site, or locally at a distributor. To calculate how many spares might be required for the various sub-assemblies in a system, the AFR is the number that is most important. Use of these values is described in the document Mitel White Paper entitled *Telephone System Availability, DK117892*.

2.1 System Failure Analysis

For the purposes of determining the reliability and availability of systems, Mitel has chosen a number of "typical" installations, with combinations of IP and TDM connectivity. Depending on the capacity of the system, different numbers of IP users, TDM users, and TDM trunks will be considered. There are different internal services (both hardware and software) that are necessary for the calls between these various interfaces to work, and loss of a service may have a different effect on each type of call.

IP Phones and Controllers

For any 3300 controller, the capability for the user to pick up the handset of an IP telephone and dial a call defines a working system. If the controller and the set are both functional the call can be made. Almost all of the components in the controller are necessary to make this call, no matter which of the IP phones is in use, so in this case the difference between 10% of the users having service and 90%, or even 100%, is almost negligible. It therefore follows that virtually any component that fails on the main system cards will result in a system failure. There are some exceptions to this, and components which can fail without taking the system down have been considered in the analysis of the sub-assembly.

TDM Lines and Trunks

For TDM calls things work a bit differently depending on the way resources are provided or shared among end devices. Digital trunks are almost the same as IP access, since the framers will typically service either all channels or no channels, not some of them. There will be either 100% service on each T1/E1 framer, or no service, which means any failure on a single framer (Combo) module will be considered a system failure. The dual framer modules, although they could be working 50%, would be considered dead by the 90% rule. Since the maximum that can be supported on any controller is three dual trunk modules, a single framer becomes a system outage at the 90% level. Although the system behavior looks better with a larger number of framers when multiple NSU's are installed, this is not a configuration that is included in the "typical system" list that is used for reliability calculations. This configuration is more of a pure TDM (tandem) switching function than an IP switch, and should be analyzed as a special case. Therefore, a single framer failure is considered a system failure for purposes of MTTF in all of the typical configurations.

The only area where the 90% limit is truly meaningful is in counting analog lines. For the internal modules (AMB and AOB) on the CX or MXe controllers, the numbers are small enough that one line or trunk down is the maximum allowed in any of the MTTF calculations. For a 16-port line card, two faulty circuits constitutes a card failure, and for the 24-port card three circuits will do so. For the 12 line circuits on a combo card, a card failure is also 2 faulty circuits. For the four trunk circuits on a combo, one bad circuit makes the card faulty. So for the purposes of calculating our MTBF figures, we use two line circuits or one trunk circuit as the criteria for failure. At a system level, we count the number of cards and allow for a 10% failure rate in determining what is an actual system failure.

Internal Resources

DSP and echo canceller usage is more flexible than the hard rules on the lines and trunks, since these are more likely to be over-provisioned for normal traffic. If one DSP device out of eight fails, leaving less than 90% working, there are diagnostics that will determine that it is bad when the device stops communicating with call control, and the system will stop using that device. Without knowing exactly which system resources are affected by the loss of any given device, it must be assumed that loss of one device on a quad DSP module could effectively take the system down. However, in all controller models except the smallest (CX) there are enough resources that at normal traffic, loss of 25% resource will not prevent more than 10% of users from getting service, so that this would not be considered a system failure. Loss of one DSP out of four will be identified as a fault condition which should initiate a service procedure (i.e. it has affected the MTTF and AFR), but it will not result in immediate service failure (it has not affected the availability of the system).

2.2 Sub-Assembly Failure Analysis

At the card level, each component is reviewed according to its circuit functions, to determine its probability of failure, and is then identified as being critical or not depending on whether its failure would result in the failure of the card as a whole. The entire assembly is then evaluated based on the component count procedures in Telcordia SR-332 to determine its overall Annualized Failure Rate (AFR) and Mean Time To Failure (MTTF).

This section contains an example calculation for the steady state failure rate of a simple assembly made up of only a few components. The calculation technique is the same as is used for all assemblies in the Mitel products, no matter the complexity. The assembly consists of the following components, with steady state failure rates (λ_{SS}) as shown:

Device Type	Quantity	λ_{SSi} (FITs)
IC, Digital, Bipolar	17	6.4
Transistor, Silicon, PNP	5	1.7
Capacitor, Ceramic	5	0.6
LED	10	2.67

From these values, the predicted steady-state failure rate of the total assembly (λ_{PC}) can be calculated using the following equation:

$$\lambda_{PC} = \sum_{i=1}^n L_i$$

$$= (17 \times 6.4) + (5 \times 1.7) + (5 \times 0.6) + (10 \times 2.67)$$

$$= 147 \text{ FITs}$$

$$\text{AFR} = 147 \times 8760 / 10^9$$

$$= 0.13\%$$

$$\text{MTTF} = 1 / \text{AFR}$$

$$= 776.6 \text{ years}$$

3 Critical Hardware MTTF Values for Mitel Products

Both the card level analysis and the system level analysis for AFR and MTTF figures are reevaluated periodically as required. A weighted average of the AFR figures for all the sub-assemblies is used to predict the overall AFR, and hence the MTTF, of all of the system controllers and other top-level assemblies. The following tables show the critical hardware MTTF values for standard product configurations.

Device	MTTF (years)
Mitel 3300 CX Controller	6.3
Mitel 3300 CXi Controller	5.7
Mitel 3300 MX Controller	6.3
Mitel 3300 LX Controller	11.0
Mitel 3300 MXe Controller (base unit with non-redundant drives and PSU)	11.5
Mitel 3300 MXe Controller (expanded, with redundant drives and PSU)	19.7
Mitel 3300 MXe Server	13.2
Mitel 3300 AX Controller (chassis with controller card and dual PSU)	11.5
Mitel Universal Analog Services Unit (4x16)	35.0
Mitel Analog Services Unit (0x24)	67.2
Mitel Analog Services Unit II (chassis only, without line and trunk cards)	102.2
ASU II: 16 Port ONS (card)	49.0
ASU II: 24 Port ONSP (card)	31.6
ASU II: 12 Port ONS + 4 Port LS (card)	31.0
ASU II: AC POWER SUPPLY	30.4
Mitel Universal Network Services Unit (NSU)	63.7
Mitel R2 Network Services Unit (NSU)	63.7
Mitel BRI Network Services Unit (NSU)	38.2

Table 1: Mitel 3300 Products, Critical Hardware MTTF

Device	MTTF
Mitel 5201 IP Phone	86.1
Mitel 5205 IP Phone	74.9
Mitel 5207 IP Phone	65.1
Mitel 5212 IP Phone	49.0
Mitel 5215 IP Phone	40.2
Mitel 5215 IP Phone (Dual Mode)	60.3
Mitel 5220 IP Phone	38.1
Mitel 5220 IP Phone (Dual Mode)	37.8
Mitel 5224 IP Phone	44.4
Mitel 5230 IP Phone	46.6
Mitel 5235 IP Phone	54.8
Mitel Navigator®	36.0
Mitel 5330 IP Phone	57.2
Mitel 5340 IP Phone	56.2
Mitel 5560 IPT	50.7
Mitel IP Paging Unit	51.8

Table 2: Mitel IP Phones, Critical Hardware MTTF

4 System Availability Values for Mitel Products

From the reliability figures in Table 1, the expected availability of different system configurations can be calculated, again using a weighed sum of the AFR figures for each of the sub-assemblies.

Assuming that when an assembly fails the actual down time (MTTR) is 4 hours, then for the MXe Controller with MTTF = 11.5 years, the system availability will be:

$$\begin{aligned}
 \text{Availability} &= \text{MTTF} / (\text{MTTF} + \text{MTTR}) \\
 &= (11.5 \times 8760) / (11.5 \times 8760 + 4) \\
 &= 99.996\%
 \end{aligned}$$

Sample configurations for each of the available controllers are shown in the following table. The controllers are shown across the top of the various columns, and the number of interfaces that it is supporting is shown under each controller type. The AFR of the controller itself is shown in the next block; this is the Critical System AFR (and MTTF), essentially for just the IP telephony portion of the system. The quantity and the predicted AFR for each subassembly are used to calculate the expected of the combination; this is the Total System AFR and MTTF, including the TDM interfaces. Below this, the MTTR is combined with the assumed MTTR to derive the availability of both the controller and the entire system.

If the controllers are connected in a resilient configuration, the overall availability will increase dramatically, as shown in the document *Telephone System Availability*. Both the Critical and the Total System Availability numbers for resilient pairs of systems are shown in the final section of the table.

Components	System Size (Controller Type)							
	CX	CXi	MX	LX	MXe base	MXe exp	MXe Server	AX
Peripheral Cabinet				2		2		
Universal ASU			1	2				
24 Port ASU			1	1				
ASU II Chassis	1	1			1	2		
16 Port ONS	2	2			1	2		6
12 Port ONS + 4 Port LS					1	2		2
Dual T1/E1 Trunk					1	3		1
T1/E1 Trunk Combo	1	1						
Universal NSU			0.5	3				
ONS Sets	40	40	44	120	32	124	0	120
DNIC Sets	0	0	0	256	0	256	0	0
IP Sets	60	60	100	500	200	700	2500	60
Total Lines (sets)	100	100	144	876	232	1080	2500	180
LS Trunks	12	12	16	8	10	14	0	8
Digital Trunks	24	24	24	144	48	144	0	48
Total Trunks	36	36	40	152	58	158	0	56
Trunking Ratio	36%	36%	28%	17%	25%	15%	0%	31%
Controller AFR	15.8%	17.5%	15.9%	9.1%	8.7%	5.1%	7.6%	8.7%
Controller MTTF (years)	6.3	5.7	6.3	11.0	11.5	19.7	13.2	11.5
(hours)	55,417	50,000	55,236	96,034	100,986	172,765	115,919	100,625
Total System AFR	22.1%	23.8%	21.0%	21.0%	15.9%	20.1%	7.6%	29.9%
Total System MTTF (years)	4.5	4.2	4.8	4.8	6.3	5.0	13.2	3.3
(hours)	39,610	36,763	41,728	41,634	55,243	43,657	115,919	29,309
Site Visits per 100 Lines per year	0.221	0.238	0.146	0.024	0.068	0.019	0.003	0.166
MTTR (hours to repair/replace resource)	4	4	4	4	4	4	4	4
Critical System Availability	99.993%	99.992%	99.993%	99.996%	99.996%	99.998%	99.997%	99.996%
Total System Availability	99.990%	99.989%	99.990%	99.990%	99.993%	99.991%	99.997%	99.986%
Resilient System Configuration - Quantity	2	2	2	2	2	2	2	2
Critical Assemblies System Availability	99.9999948%	99.9999936%	99.9999948%	99.9999983%	99.9999984%	99.9999995%	99.9999988%	99.9999984%
Total Assemblies System Availability	99.9999898%	99.9999882%	99.9999908%	99.9999908%	99.9999948%	99.9999916%	99.9999988%	99.9999814%