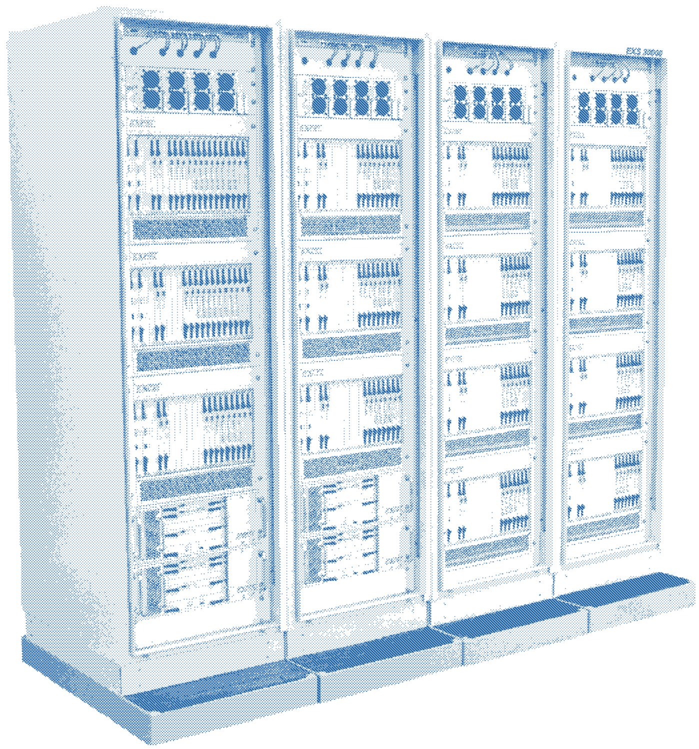

Reliability Statement:
EXS Switching

A White Paper Produced by

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The actual performance of any particular system is affected by its installation, application, sparing strategy and environment of use and may therefore differ from these estimates. No warranty or liability is assumed or implied on the basis of these calculations.

Switching Reliability Statement

Abstract

Excel Switching Corporation provides the following information as a general guide to the reliability of its switching systems. This document covers the results of the Product Reliability Analysis conducted by Excel and Bellcore, as well as Reliability Estimates calculated by Excel. In summary, fully redundant EXS systems conform to, and often exceed, all requirements in Bellcore GR-512-CORE, with availability for such systems estimated at 99.999%

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1.0 Bellcore Reliability Assessment

1.1 Executive Summary

In conjunction with Bellcore, a Product Reliability Analysis was performed on Excel's EXS 2000 and EXS 6000 systems. Excel commissioned this review in order to verify the reliability of our switching systems, compare our reliability with the Bellcore telecommunications standards, identify potential areas for improvement, and develop an in-house capability to model the reliability of our designs.

Excel is very pleased to announce the following results of the Bellcore analysis:

> ***"...the EXS 2000 node and EXS system with two (redundant) rings conform to all hard - ware reliability requirements in GR-512-CORE for individual termination downtime, total capability downtime, and cutoff call rate."***
>
> ***Bellcore Technical Report***
> ***AU-774, Volume 1, May, 1998***

The results of the Bellcore calculations are shown below.

1.2 Analysis Scope

The scope of the reliability analysis consisted of a detailed review of the EXS system from a reliability perspective. This review was based on system documentation and technical meetings with Excel's hardware and software design engineers. Next, reliability block diagrams and Markov models were developed by Bellcore to describe the various system failure modes. The reliability models were solved using circuit pack failure rates provided by Excel that were derived from Bellcore's *Automated Reliability Prediction Procedure* (ARPP) Version 8 software package. The results were then tabulated in failure mode tables for calculating various reliability parameters such as:

- Individual Termination Downtime
- Total Capability Downtime
- Cutofff Call Rate

Results for both the EXS 2000 node and EXS system were compared to the hardware reliability requirements in Section 5 of GR-512-CORE, *LSSGR Reliability Section 12*, Issue January 1998.

This analysis examined the EXS architecture for redundancy, fault detection, impact of software updates, and other operation and maintenance (OA&M) activities that could impact reliability. The analysis also looks for potential design deficiencies such as "single points of failure" in the power distribution, internal bus, backplane wiring and fan units.

1.3 Analysis Results

1.3.1 Total Capability Downtime

Total Capability Downtime is the expected average annual time spent in failure modes that affect all digital trunk capability (ie. all 2000 or all 6000 calls).

	Downtime per Port (minutes per year)		
Port Type	**EXS 2000**	**EXS 6000**	**GR-512**
T1 Digital Trunk	0.20		0.4
E1 Digital Truck	0.20		0.4
ISDN PRI Packet	0.26		0.4
SS7 Link	0.22		0.4
Two-Ring EXS System		1.00E-09	0.4

1.3.2 Individual Termination Downtime

Individual Termination Downtime is defined as the expected average annual time spent in failure modes that affect one or more digital trunks, SS7 links or ISDN PRI packet interfaces.

	Downtime per Port (minutes per year)		
Port Type	**EXS 2000**	**EXS 6000***	**GR-512**
T1 Digital Trunk	0.55	0.55	12
E1 Digital Truck	0.51	0.51	12
ISDN PRI Packet	0.60	0.60	12
SS7 Link	0.56	0.56	35

1.3.3 Hardware Cutoff Call Rate

Hardware Cutoff Call Rate, expressed in cutoffs per 10^9 hours of call duration, is the expected average cut-off call rate of all failures greater than 60 msec that affect one or more interfaces.

	Cutoffs/Hour of Call Duration		
Port Type	**EXS 2000**	**EXS 6000***	**GR-512**
T1 Digital Trunk	8.89E-06	8.89E-06	1.00E-05
E1 Digital Trunk	7.84E-06	7.84E-06	1.00E-05
ISDN PRI Packet	9.24E-06	9.24E-06	1.50E-05
SS7 Link	8.89E-06	8.89E-06	n/a

* Data shown is for Two-ring EXS6000.

2.0 Excel Reliability Estimates

2.1 Executive Summary

Excel-derived estimates of board and system reliability, using the Bellcore tools and techniques, result in high reliability in all fully redundant EXS configurations. We recommend fully redundant configurations for any real time call processing service where continuous system availability is critical.

2.2 Analysis Scope

Using the Bellcore Reliability Assessment approach and methodology, Excel Switching Corporation has incorporated Markov modeling into its existing suite of reliability tools. Mean Time Between Failure (MTBF) calculations are developed for all boards and field-replaceable subassemblies. Design Verification Testing (DVT) and Design Maturity Testing (DMT) are used to validate design functionality and MTBF calculations. This information forms the inputs to the Markov models to derive system-level reliability predictions for a variety of unique configurations.

2.3 Analysis Results

Calculated System Availability, using 2-level Bellcore Markov Model for some typical configurations is as follows:

	Non-Redundant T1 96 DS0 EXS	**Non-Redundant N+1 T1 96 DS0 EXS**	**Redundant No N+1 T1 384 DS0 EXS**	**Redundant N+1 T1 384 DS0 EXS**
Availability percentage	99.996%	99.997%	99.996%	**99.999%**
Downtime min/yr	22.82	14.23	18.71	0.93
MTBF hours	43,453	110,796	84,258	98,513

3.0 Assumptions and Methodology for System Reliability

3.1 Calculated MTBF

In calculating the Mean Time Between Failure (MTBF) of each unique Excel part number, Excel Switching Corporation has used the following assumptions and methodology:

- Variable parameters used in these calculations include:
  - 25 degree C operating temperature
  - 50 degree C burn in for 48 hours
  - ground fixed environment
- Calculations are based on the product bill of material at the time of product release to general availability, and may change over time with the addition of engineering change orders.
- The reliability estimates are derived with conservative assumptions as to environment of use. DMT results indicate a useful life in excess of these calculations.
- These calculations are estimated mean times between failure. Actual performance of any particular piece of equipment is affected by its installation, application and environment and may differ from these estimates.

3.1.1 MTBF by Excel Part Number

Excel designs its products to meet a minimum requirement of 100,000 hours MTBF. The calculations indicate that the subassemblies easily exceed this requirement. A representative sampling of Excel MTBF calculations are shown below:

Description	Part Number	MTBF (hours)	Fit Rate
EX-Chassis	n/a	946,969	1,056
E-ONE 8 span line card 120 ohm	63-3100-04	402,161	2,487
ST1LC I/O	63-1027-00	795,207	1,258
EXNET Controller card	63-2081-00	218,034	4,586
EXNET I/O	63-2105-00	1,142,231	437
EX/CPU - EXTENDED API	63-2126-00	242,650	4,121
ST1LC	63-2366-00	283,530	3,527
SE1LC I/O	63-2370-00	388,225	2,576
SE1LC	63-2371-00	334,140	2,993
E-ONE 16 span line card	63-3100-05	327,034	3,058
Standby E-ONE I/O-16 120 ohm	63-3200-05	495,552	2,018
EX/CPU - I/O	67-2115-00	148,291	6,743
PSC150	68-2060-00	418,713	2,388
MFDSP w/4 SIMMs	68-2328-00	326,857	3,059

3.2 System Availability Calculations

The Bellcore analysis, as well as all internal Excel reliability assessments, are performed based on the following set of assumptions. Actual performance of any particular piece of equipment is affected by its installation, application, sparing strategy and environment of use and may differ from these estimates.

- The estimates have been calculated using Bellcore ARPP Software, Revision 8.0, TR-332, Issue 5, December 1995, using their parts count methodology and component failure rates.
- Component reliability estimates for parts not included in the Bellcore database have been derived from vendor-supplied information, data books, or field data obtained from a variety of sources.
- MTBF calculations as described in Section 3.1 form the basis of these calculations.
- Active boards and subassemblies and SS7 cards have 95% error detection assumption.
- Standby boards and subassemblies have a lower error detection assumption, depending on board type.
- One software update per year is included in the calculations.
- Mean time to repair of 3 hours (site arrival) and 15 minutes (actual repair time) is used per outage, per Bellcore service model assumptions.
- Software download times are excluded from the calculations, per Bellcore LSSGR Section 12.

3.3 Bellcore Reference Calculations

System Reliability calculation estimates are constructed using the following guidelines, tools and model assumptions listed below, along with estimated mean times between failure at the component level.

- Bellcore ARPP (*Automated Reliability Prediction Procedure)* V8.0 failure rate predictions for individual components, based on TR-332.
- Interactive Markov Analysis Program (IMPA) software, LP-Y83, Bellcore (July 1994).
- Reliability and Quality Switching Systems Generic Requirements (RQSSGR), TR-NWT-000284, Bellcore (October, 1990).
- Reliability and Quality Measurements for Telecommunications Systems (RQMS); GR-929-CORE, Bellcore (December, 1995).
- Reliability, Section 12, LSSGR; GR-512-CORE, Bellcore (December, 1997).

Excel Switching Corporation designs, manufactures, markets and supports a family of open architecture, programmable switches used in 60 countries worldwide, in a variety of telecommunications applications including wireless and wireline service provisioning, enhanced service platforms, Intelligent Networks and Personal Communications Services.

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