AusNet Transmission Group Pty Ltd

Transmission Revenue Review 2017-2022

Appendix 7A: Fitting probability distributions to Service Component data

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ISSUE/AMENDMENT STATUS

Issue Number	Date	Description	Author	Approved by
1	14/08/2015	Initial issue	Rob Ball	Tom Hallam
2	14/09/2015	Addendum 1	Rob Ball	Tom Hallam
3	28/10/2015	Addendum 2	Rob Ball	Tom Hallam

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Table of Contents

1 Service Component Parameters

This Appendix sets out the information used to calculate AusNet Services' proposed Service Component caps and collars, as presented in section 7.3.2 of the Revenue Proposal. This information was obtained using the @RISK product, a risk analysis and simulation add-in tool for Microsoft Excel.

For each parameter, proposed caps and collars have been set equal to the 5th and 95th percentiles, respectively, of the probability distribution that provides the best fit to the relevant historical data. This approach aligns with that adopted by the AER in AusNet Services' current determination and in recent determinations for TransGrid and TasNetworks.

For two sub-parameters (loss of supply event frequency (>0.30 system minutes) and incorrect operational isolation of primary or secondary equipment), the IntUniform distribution was found to be the best fit. However, to align with the AER's approach for the current determination , the Poisson distribution has instead been used to set caps and collars for these sub-parameters.

The following table summarises the probability distributions and percentiles underpinning the proposed caps and collars.

Table 1.1: Summary of probability distributions and percentiles

Parameter	Preferred Distribution	5th percentile	95th percentile
Line outage rate (fault)	Erlang	0.1592	0.3571
Line outage rate (forced)	Lognorm	0.1232	0.1730
Reactive plant outage rate (fault)	LogLogistic	0.2173	0.5570
Reactive plant outage rate (forced)	Erlang	0.1336	0.4414
Transformer outage rate (fault)	Rayleigh	0.0469	0.3585
Transformer outage rate (forced)	Weibull	0.0620	0.1537
Number of events >0.05 system minutes	Hypergeometric	0.0000	5.0000
Number of events >0.30 system minutes	Poisson	0.0000	2.0000
Average outage duration	Weibull	1.7200	253.8200
Failure of protection equipment	Poisson	20.0000	38.0000
Material failure of SCADA system	Geometric	0.0000	6.0000
Incorrect operational isolation of primary or secondary equipment	Poisson	2.0000	10.0000

The remainder of this document sets out the rationale for selecting each distribution and the underlying percentile data as calculated by @RISK.

1.1 Service parameter 1 – average circuit outage rate

1.1.1 Lines outage rate – fault (continuous)

Findings:

- A-D fit statistic: Erlang distribution best fit, standard deviation 0.0606
- K-S fit statistic: Weibull distribution best fit, standard deviation 0.0583
- **A-D preferred (Erlang) due to data falling in both middle and tails of distribution**

Figure 1.1: Lines outage rate (fault) – distribution fit using A-D

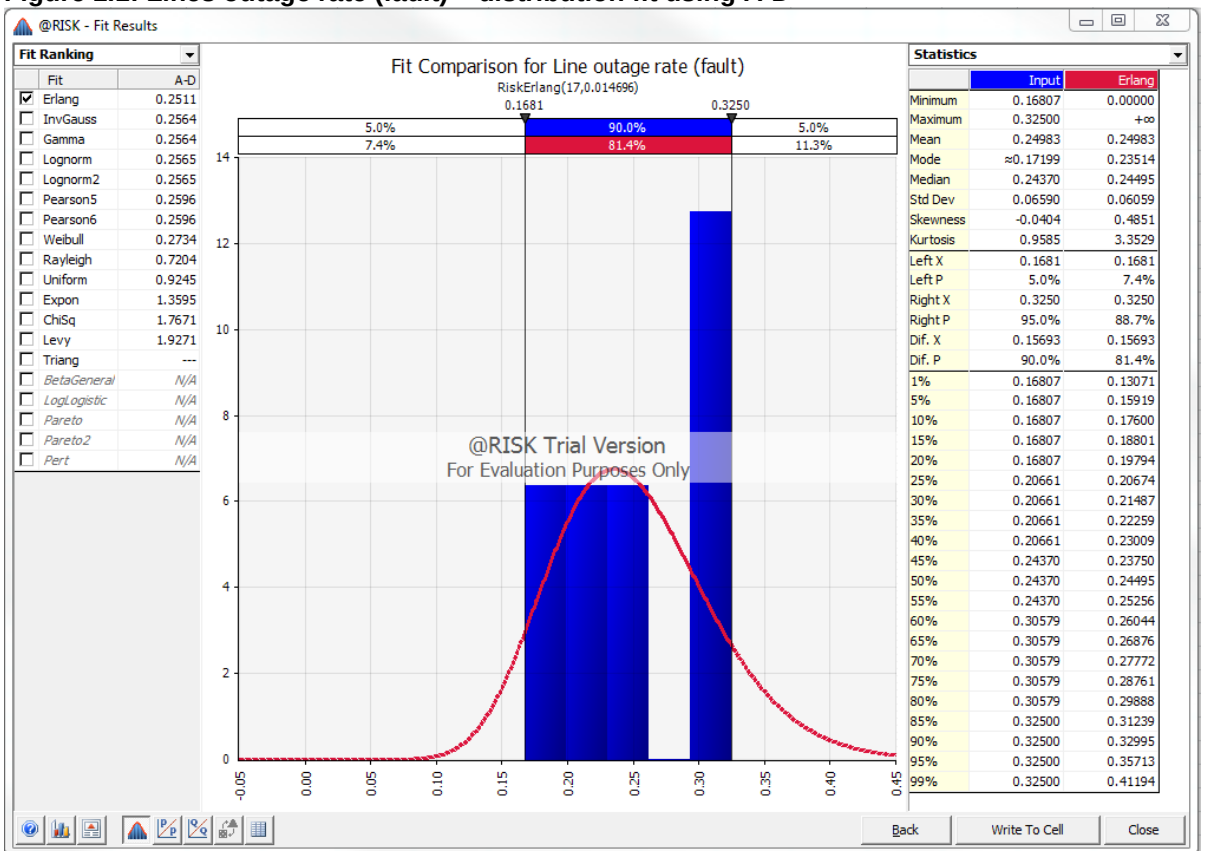


Figure 1.2: Lines outage rate (fault) – statistics table using A-D

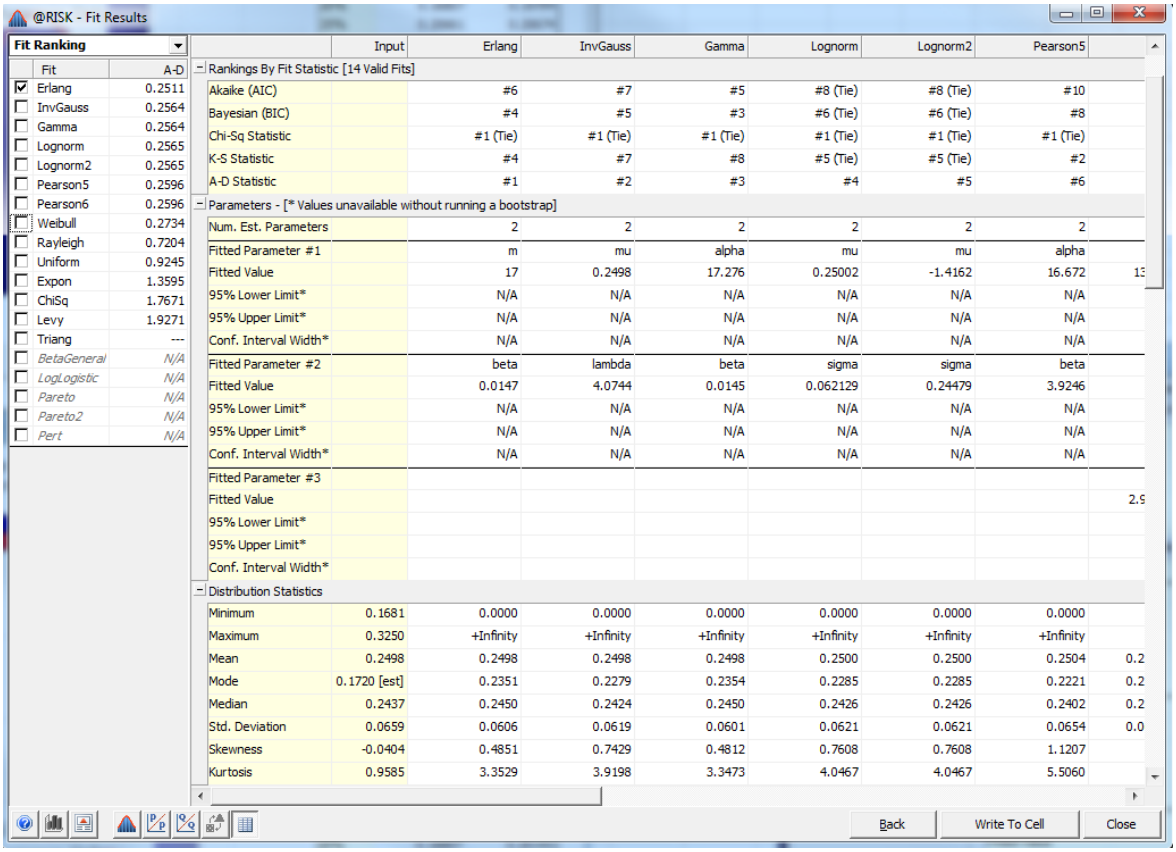


Figure 1.3: Lines outage rate (fault) – distribution fit using K-S

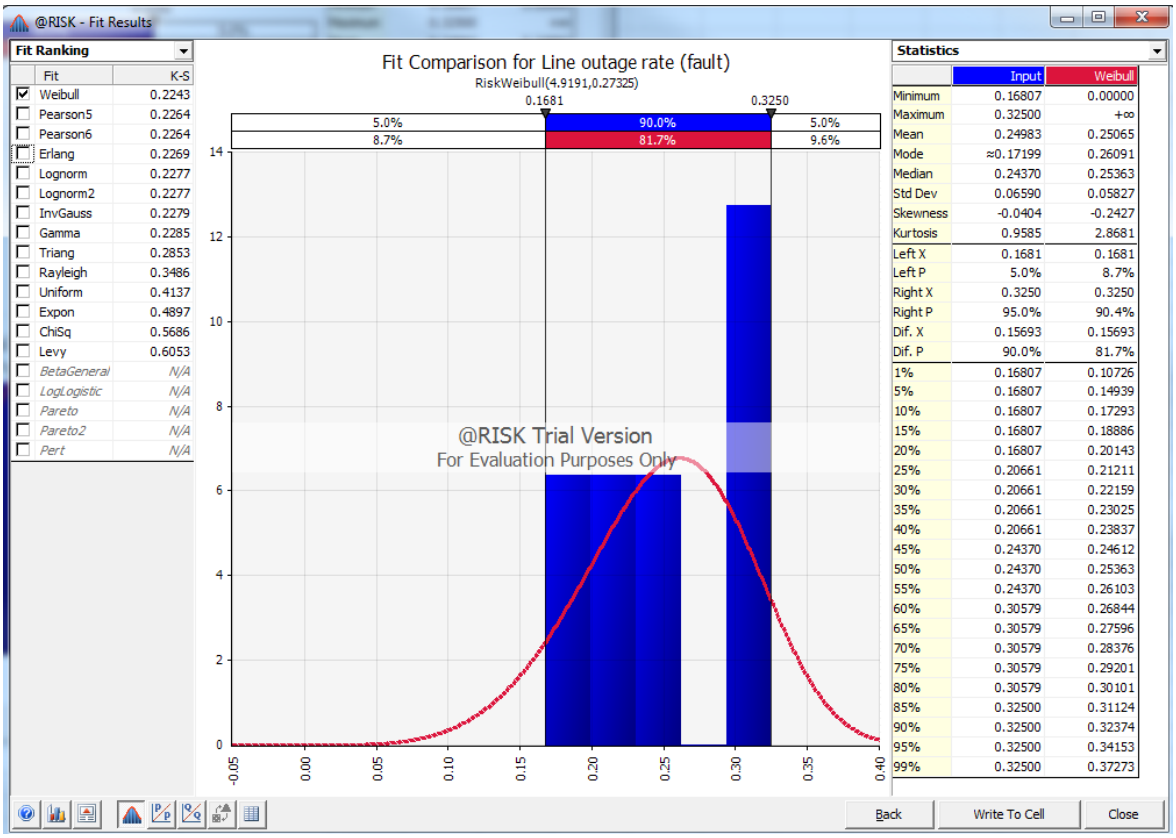
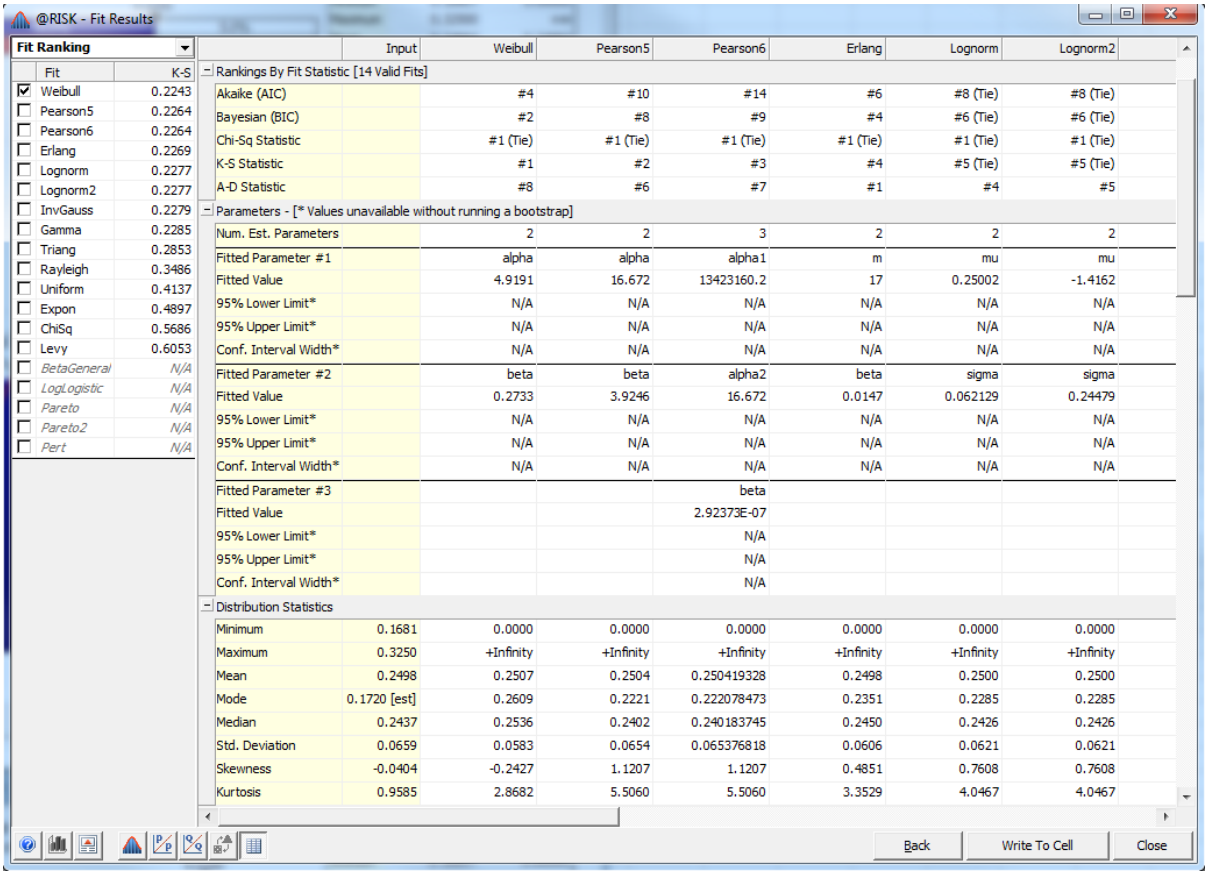


Figure 1.4: Lines outage rate (fault) – statistics table using K-S



1.1.2 Lines outage rate – forced (continuous)

Findings:

- A-D fit statistic: Gamma distribution best fit, standard deviation 0.01507
  - Erlang very close. Slightly worse fit, slightly better std dev (0.01505)
- K-S fit statistic: Lognorm distribution best fit, standard deviation 0.01518
- **K-S preferred (Lognorm) due to data concentrated in middle of distribution**

Figure 2.1: Lines outage rate (forced) – distribution fit using A-D

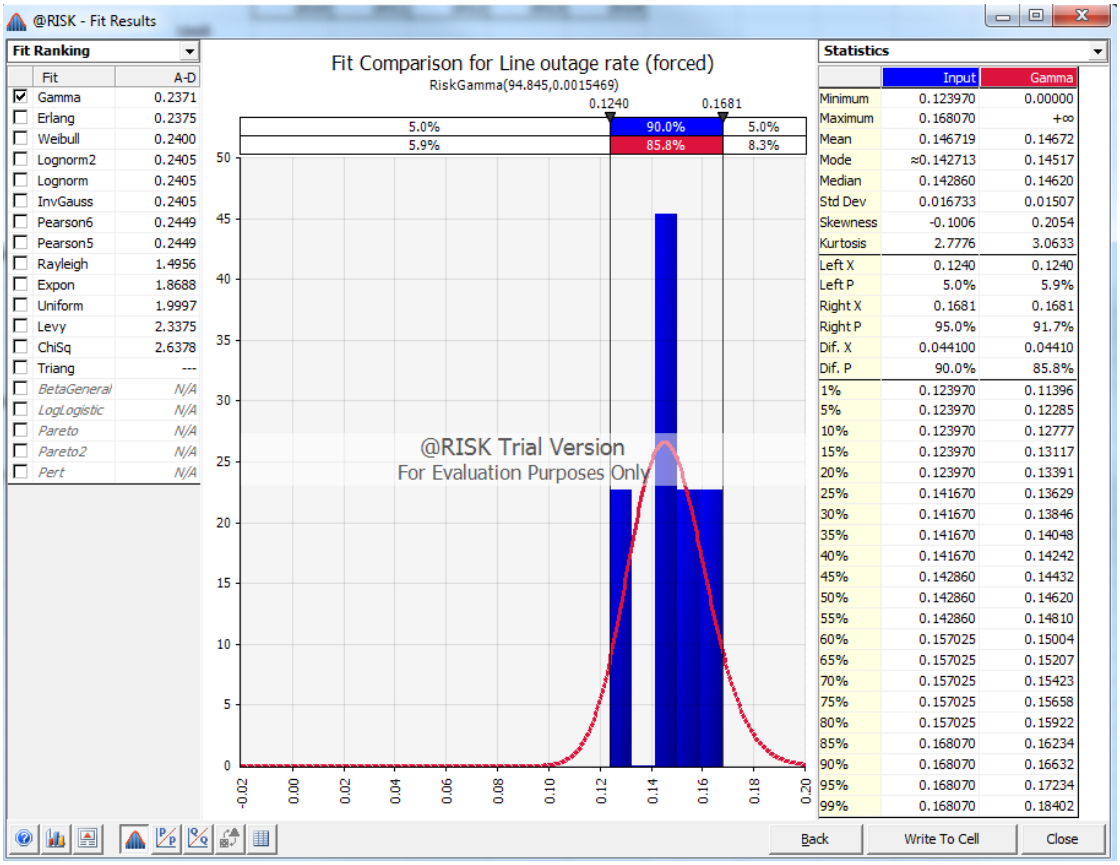


Figure 2.2: Lines outage rate (forced) – statistics table using A-D

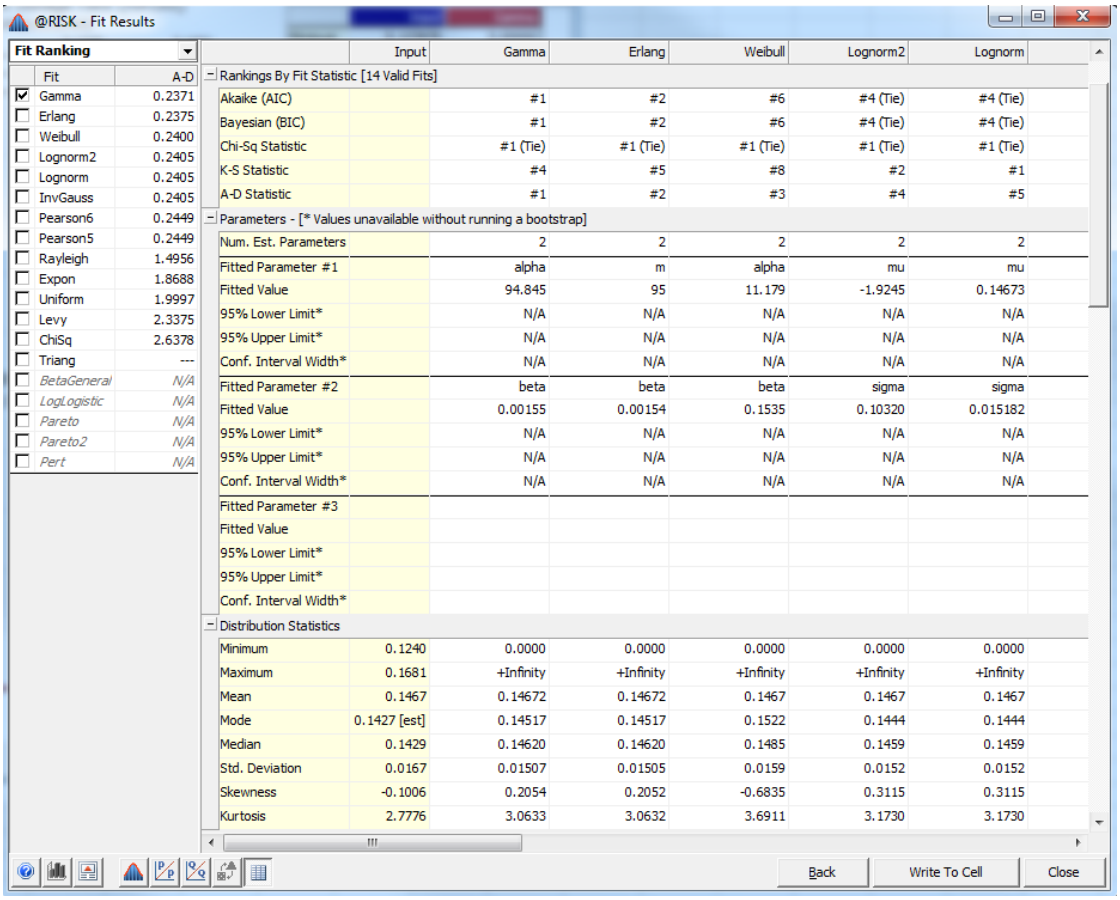
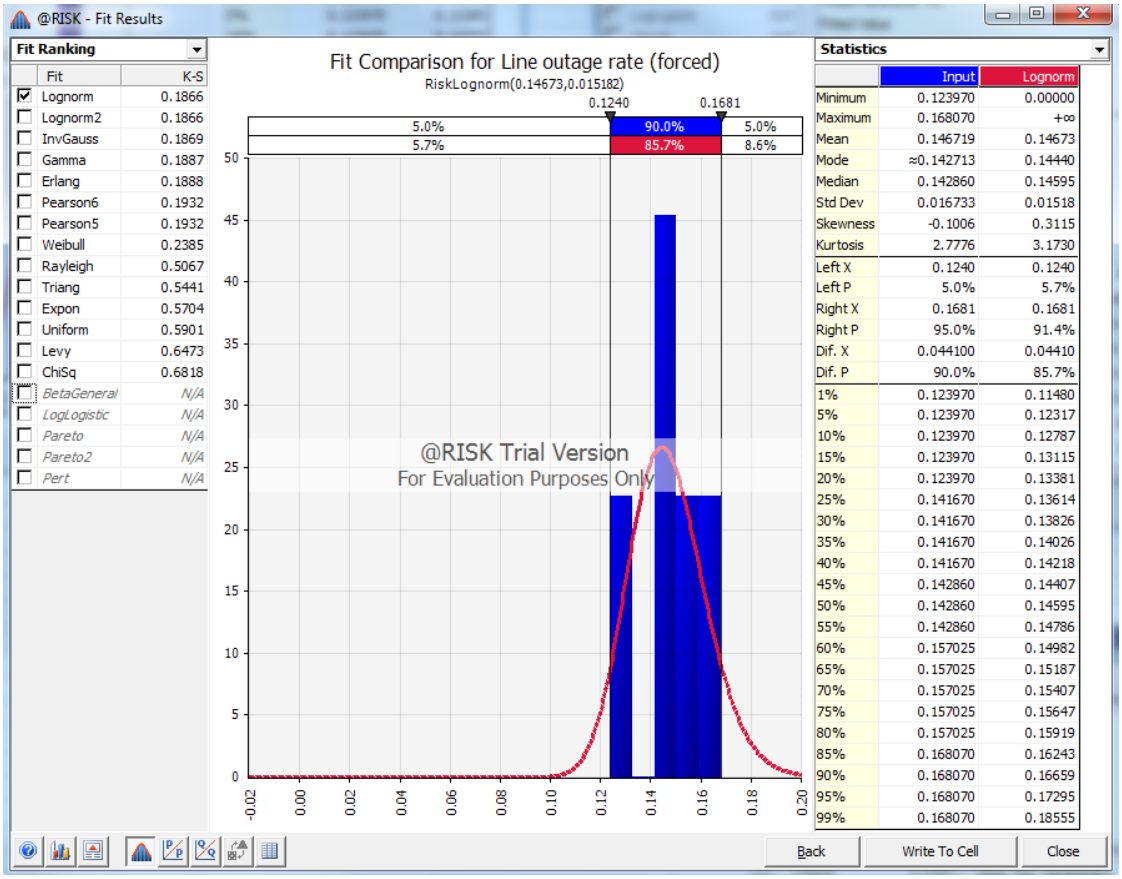


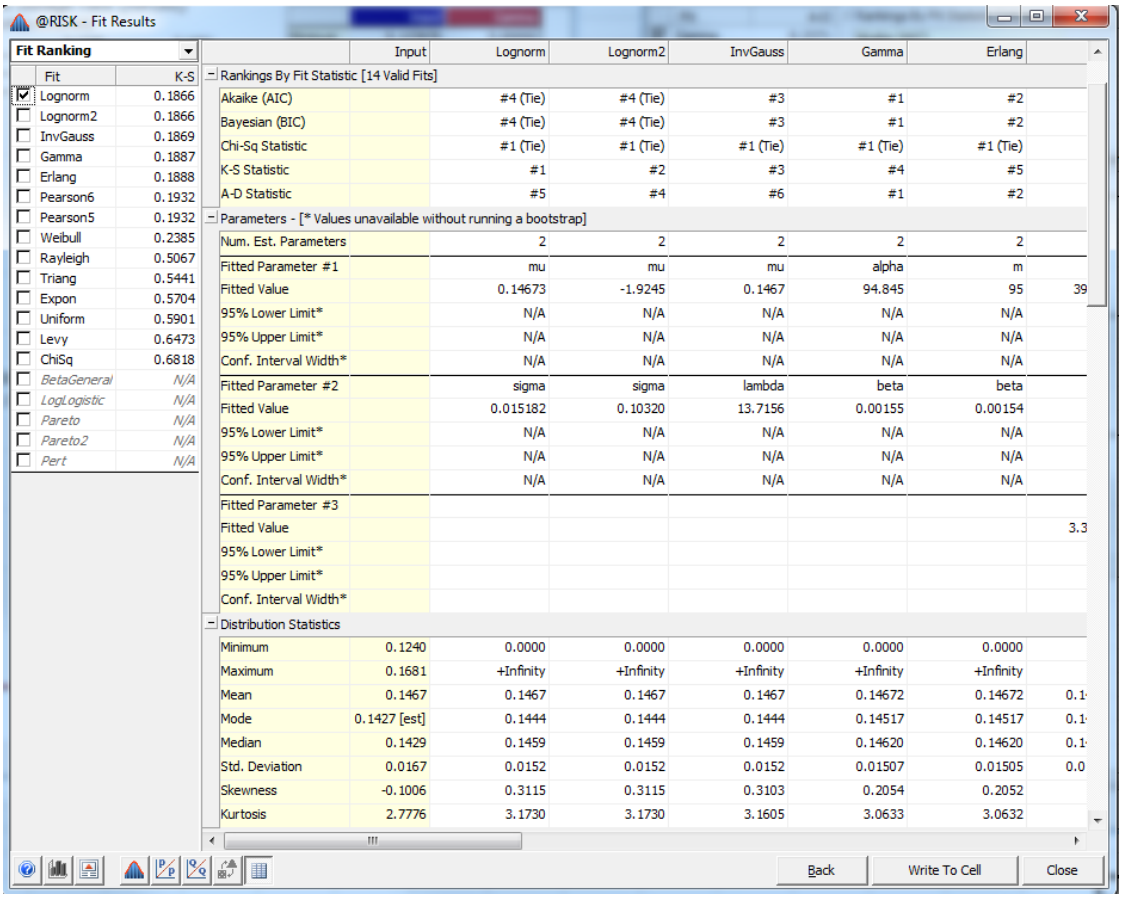
Figure 2.3 Lines outage rate (forced) – distribution fit using K-S



Fit	K-S
Lognorm	0.1866
Lognorm2	0.1866
InvGauss	0.1869
Gamma	0.1887
Erlang	0.1888
Pearson6	0.1932
Pearson5	0.1932
Weibull	0.2385
Rayleigh	0.5067
Triang	0.5441
Expon	0.5704
Uniform	0.5901
Levy	0.6473
ChiSq	0.6818
BetaGeneral	*N/A*
LogLogistic	*N/A*
Pareto	*N/A*
Pareto2	*N/A*
Pert	*N/A*

	Input	Lognorm
Minimum	0.123970	0.00000
Maximum	0.168070	+∞
Mean	0.146719	0.14673
Mode	≈0.142713	0.14440
Median	0.142860	0.14595
Std Dev	0.016733	0.01518
Skewness	-0.1006	0.3115
Kurtosis	2.7776	3.1730
Left X	0.1240	0.1240
Left P	5.0%	5.7%
Right X	0.1681	0.1681
Right P	95.0%	91.4%
Dif. X	0.044100	0.04410
Dif. P	90.0%	85.7%
1%	0.123970	0.11480
5%	0.123970	0.12317
10%	0.123970	0.12787
15%	0.123970	0.13115
20%	0.123970	0.13381
25%	0.141670	0.13614
30%	0.141670	0.13826
35%	0.141670	0.14026
40%	0.141670	0.14218
45%	0.142860	0.14407
50%	0.142860	0.14595
55%	0.142860	0.14786
60%	0.157025	0.14982
65%	0.157025	0.15187
70%	0.157025	0.15407
75%	0.157025	0.15647
80%	0.157025	0.15919
85%	0.168070	0.16243
90%	0.168070	0.16659
95%	0.168070	0.17295
99%	0.168070	0.18555

Figure 2.4: Lines outage rate (forced) – statistics table using K-S



Fit	K-S
Lognorm	0.1866
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Pearson6	0.1932
Pearson5	0.1932
Weibull	0.2385
Rayleigh	0.5067
Triang	0.5441
Expon	0.5704
Uniform	0.5901
Levy	0.6473
ChiSq	0.6818
BetaGeneral	*N/A*
LogLogistic	*N/A*
Pareto	*N/A*
Pareto2	*N/A*
Pert	*N/A*

	Input	Lognorm	Lognorm2	InvGauss	Gamma	Erlang	
Rankings By Fit Statistic [14 Valid Fits]							
Akaike (AIC)		#4 (Tie)	#4 (Tie)	#3	#1	#2	
Bayesian (BIC)		#4 (Tie)	#4 (Tie)	#3	#1	#2	
Chi-Sq Statistic		#1 (Tie)	#1 (Tie)	#1 (Tie)	#1 (Tie)	#1 (Tie)	
K-S Statistic		#1	#2	#3	#4	#5	
A-D Statistic		#5	#4	#6	#1	#2	
Parameters - [* Values unavailable without running a bootstrap]							
Num. Est. Parameters		2	2	2	2	2	
Fitted Parameter #1		mu	mu	mu	alpha	m	
Fitted Value		0.14673	-1.9245	0.1467	94.845	95	39
95% Lower Limit*		N/A	N/A	N/A	N/A	N/A	
95% Upper Limit*		N/A	N/A	N/A	N/A	N/A	
Conf. Interval Width*		N/A	N/A	N/A	N/A	N/A	
Fitted Parameter #2		sigma	sigma	lambda	beta	beta	
Fitted Value		0.015182	0.10320	13.7156	0.00155	0.00154	
95% Lower Limit*		N/A	N/A	N/A	N/A	N/A	
95% Upper Limit*		N/A	N/A	N/A	N/A	N/A	
Conf. Interval Width*		N/A	N/A	N/A	N/A	N/A	
Fitted Parameter #3							
Fitted Value							3.3
95% Lower Limit*							
95% Upper Limit*							
Conf. Interval Width*							
Distribution Statistics							
Minimum	0.1240	0.0000	0.0000	0.0000	0.0000	0.0000	
Maximum	0.1681	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	
Mean	0.1467	0.1467	0.1467	0.1467	0.14672	0.14672	0.1
Mode	0.1427 [est]	0.1444	0.1444	0.1444	0.14517	0.14517	0.1
Median	0.1429	0.1459	0.1459	0.1459	0.14620	0.14620	0.1
Std. Deviation	0.0167	0.0152	0.0152	0.0152	0.01507	0.01505	0.0
Skewness	-0.1006	0.3115	0.3115	0.3103	0.2054	0.2052	
Kurtosis	2.7776	3.1730	3.1730	3.1605	3.0633	3.0632	

1. Reactive plant outage – fault (continuous)

Findings:

- A-D fit statistic: LogLogistic distribution best fit, standard deviation 0.1110
- K-S fit statistic: LogLogistic distribution best fit, standard deviation 0.11099
- **A-D preferred (LogLogistic) due to data concentrated near tails of distribution**

Figure 3.1: Reactive plant outage (fault) – distribution fit using A-D

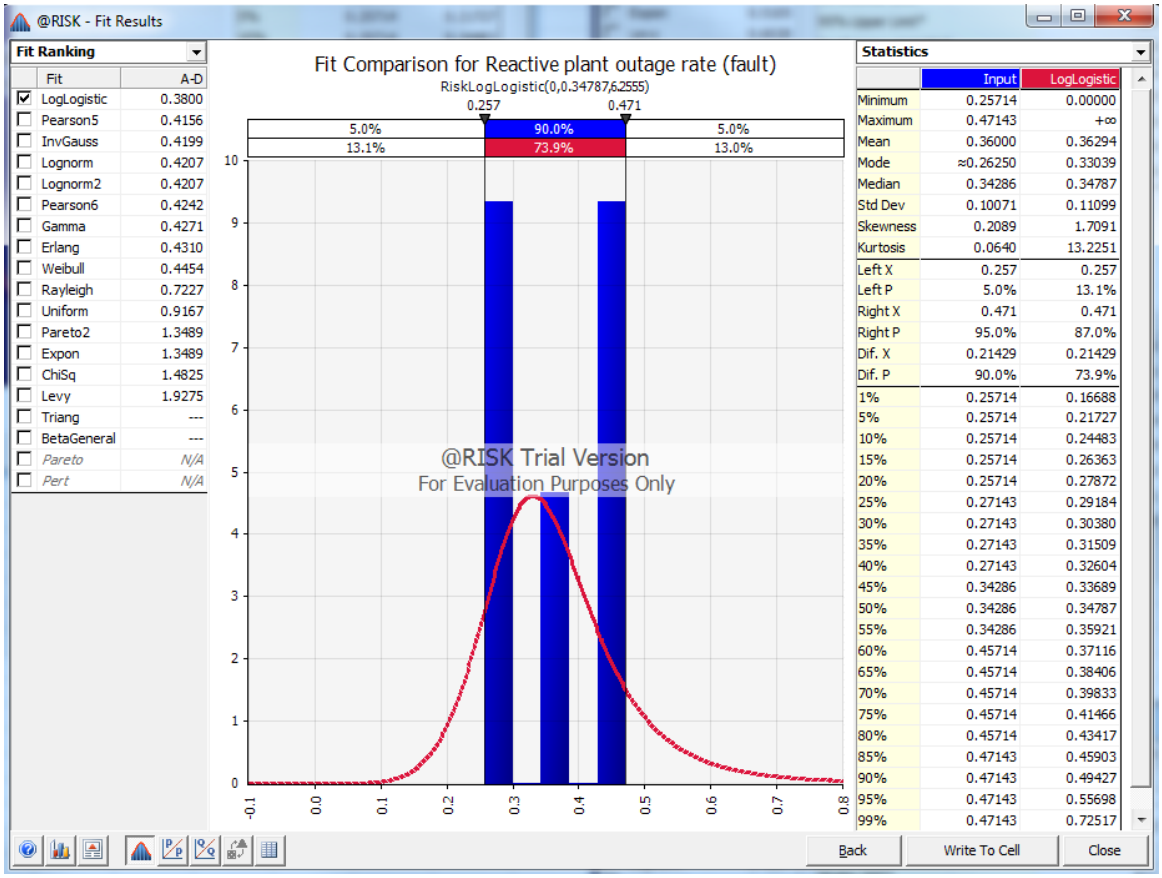


Figure 3.2: Reactive plant outage (fault) – statistics table using A-D

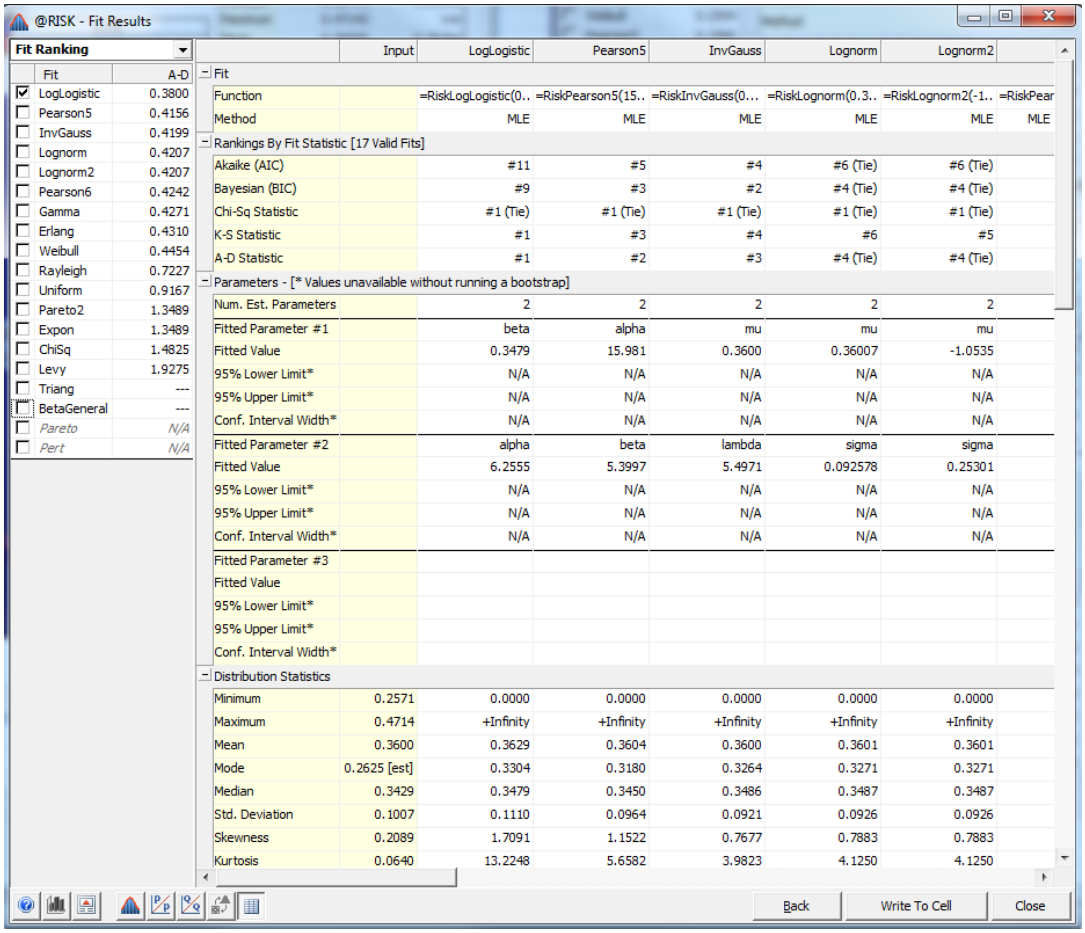


Figure 3.3: Reactive plant outage (fault) – distribution fit using K-S

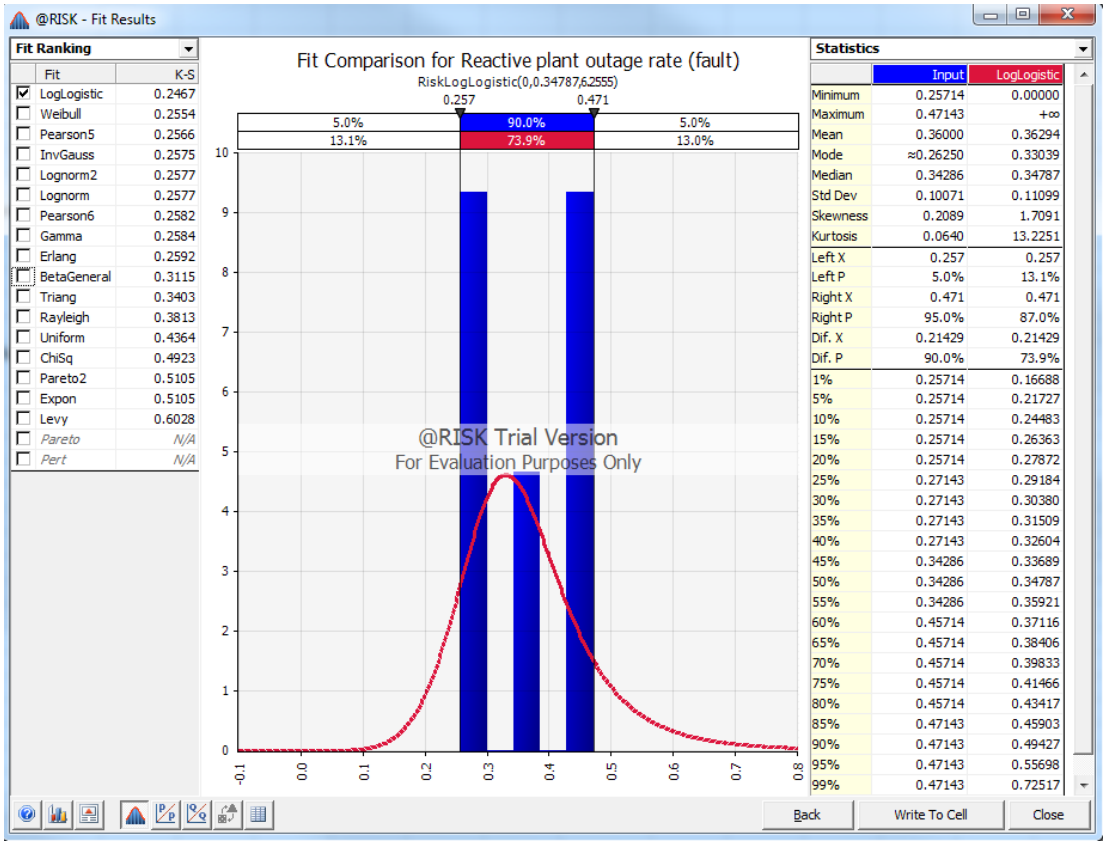
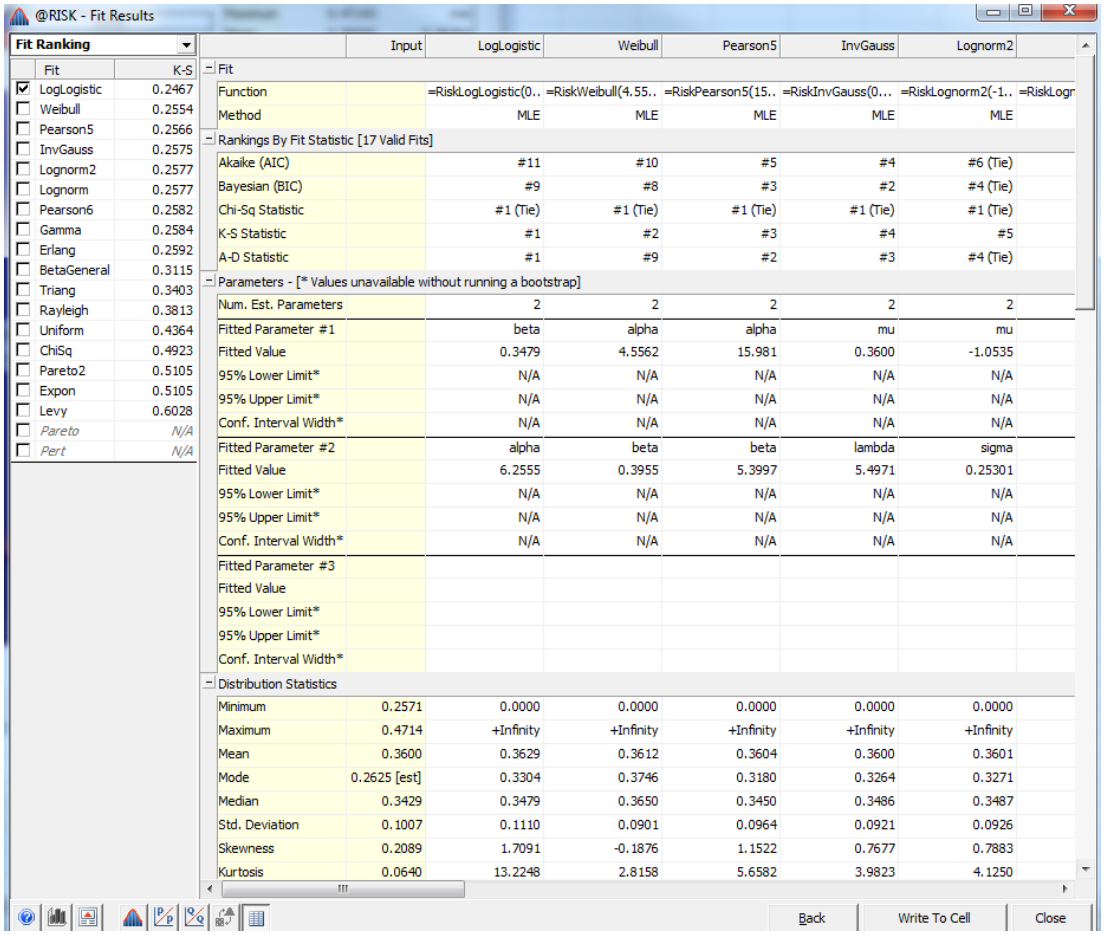


Figure 3.4: Reactive plant outage (fault) – statistics table using K-S



@RISK - Fit Results

Fit Ranking

Fit	K-S
LogLogistic	0.2467
Weibull	0.2554
Pearson5	0.2566
InvGauss	0.2575
Lognorm2	0.2577
Lognorm	0.2577
Pearson6	0.2582
Gamma	0.2584
Erlang	0.2592
BetaGeneral	0.3115
Triang	0.3403
Rayleigh	0.3813
Uniform	0.4364
ChiSq	0.4923
Pareto2	0.5105
Expon	0.5105
Levy	0.6028
Pareto	*N/A*
Pert	*N/A*

	Input	LogLogistic	Weibull	Pearson5	InvGauss	Lognorm2
Fit						
Function		=RiskLogLogistic(0..	=RiskWeibull(4.55..	=RiskPearson5(15..	=RiskInvGauss(0...	=RiskLognorm2(-1.. =RiskLogr
Method		MLE	MLE	MLE	MLE	MLE
Rankings By Fit Statistic [17 Valid Fits]						
Akaike (AIC)		#11	#10	#5	#4	#6 (Tie)
Bayesian (BIC)		#9	#8	#3	#2	#4 (Tie)
Chi-Sq Statistic		#1 (Tie)	#1 (Tie)	#1 (Tie)	#1 (Tie)	#1 (Tie)
K-S Statistic		#1	#2	#3	#4	#5
A-D Statistic		#1	#9	#2	#3	#4 (Tie)
Parameters - [* Values unavailable without running a bootstrap]						
Num. Est. Parameters		2	2	2	2	2
Fitted Parameter #1		beta	alpha	alpha	mu	mu
Fitted Value		0.3479	4.5562	15.981	0.3600	-1.0535
95% Lower Limit*		N/A	N/A	N/A	N/A	N/A
95% Upper Limit*		N/A	N/A	N/A	N/A	N/A
Conf. Interval Width*		N/A	N/A	N/A	N/A	N/A
Fitted Parameter #2		alpha	beta	beta	lambda	sigma
Fitted Value		6.2555	0.3955	5.3997	5.4971	0.25301
95% Lower Limit*		N/A	N/A	N/A	N/A	N/A
95% Upper Limit*		N/A	N/A	N/A	N/A	N/A
Conf. Interval Width*		N/A	N/A	N/A	N/A	N/A
Fitted Parameter #3						
Fitted Value						
95% Lower Limit*						
95% Upper Limit*						
Conf. Interval Width*						
Distribution Statistics						
Minimum	0.2571	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	0.4714	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity
Mean	0.3600	0.3629	0.3612	0.3604	0.3600	0.3601
Mode	0.2625 [est]	0.3304	0.3746	0.3180	0.3264	0.3271
Median	0.3429	0.3479	0.3650	0.3450	0.3486	0.3487
Std. Deviation	0.1007	0.1110	0.0901	0.0964	0.0921	0.0926
Skewness	0.2089	1.7091	-0.1876	1.1522	0.7677	0.7883
Kurtosis	0.0640	13.2248	2.8158	5.6582	3.9823	4.1250

Back | Write To Cell | Close

2. Reactive plant outage – forced (continuous)

Findings:

- A-D fit statistic: LogLogistic distribution best fit, standard deviation 0.12073
    - Erlang distribution very close. Slightly worse fit, better std dev (0.09495)
- K-S fit statistic: LogLogistic distribution best fit, standard deviation 0.12073
- **A-D preferred due to data concentrated near tails of distribution, however prefer the second best fit (Erlang) which has a superior standard deviation**

Figure 4.1: Reactive plant outage (forced) – distribution fit using A-D (two best fits)

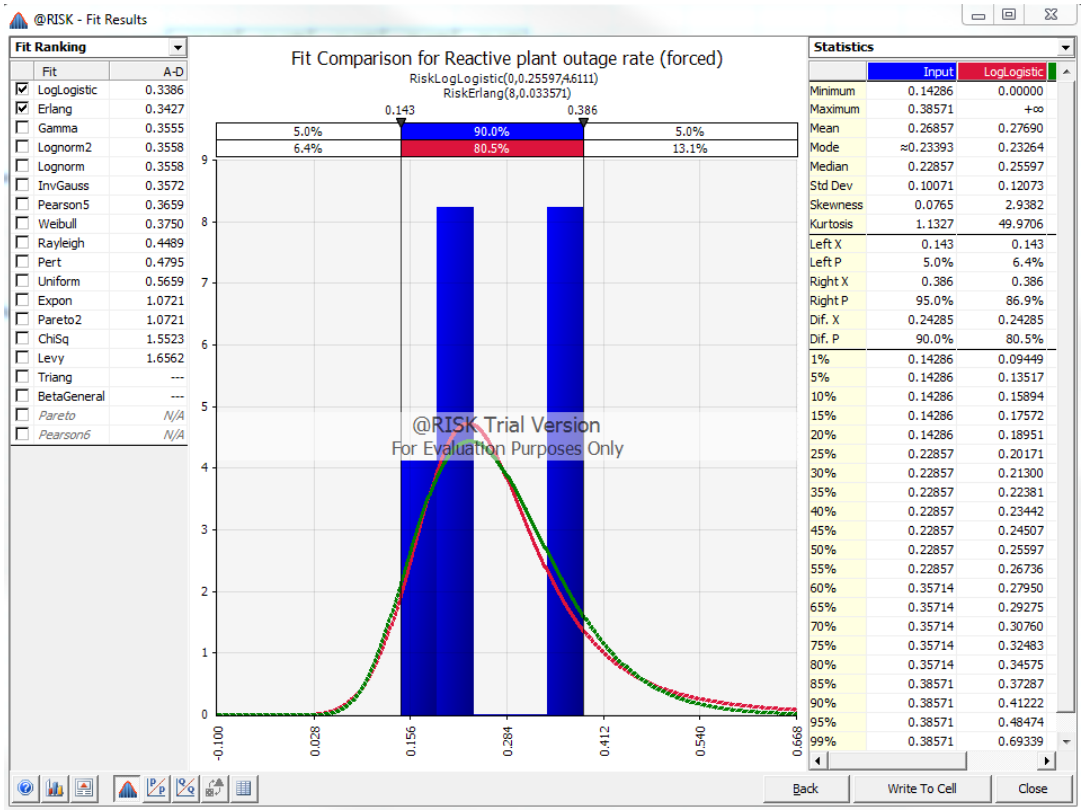


Figure 4.2: Reactive plant outage (forced) – statistics table using A-D

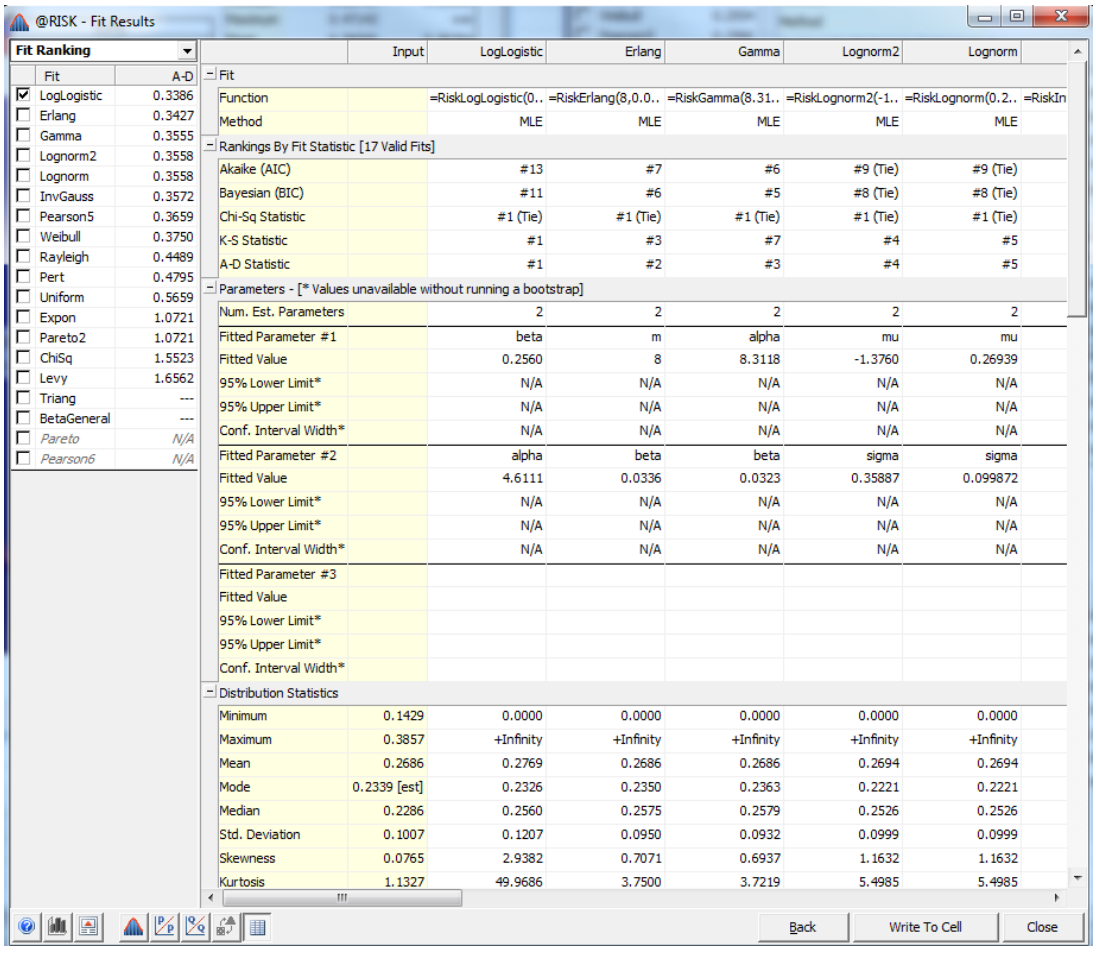


Figure 4.3: Reactive plant outage (forced) – distribution fit using K-S

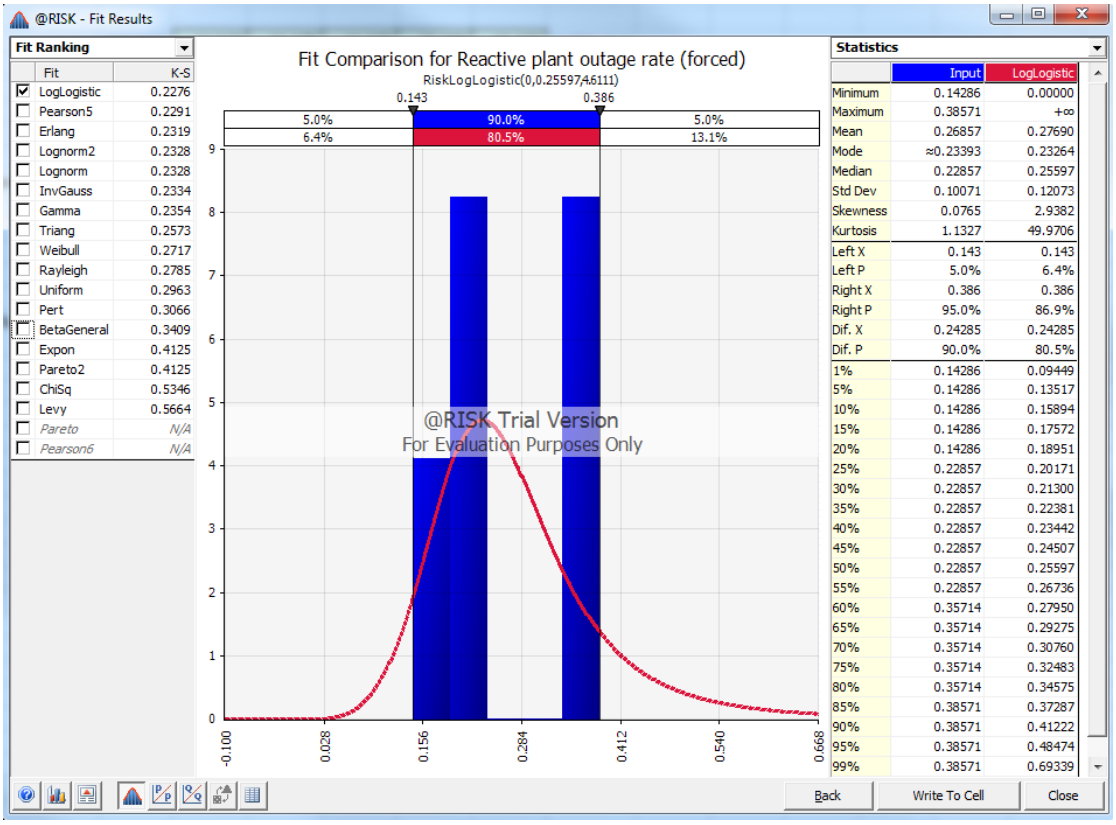
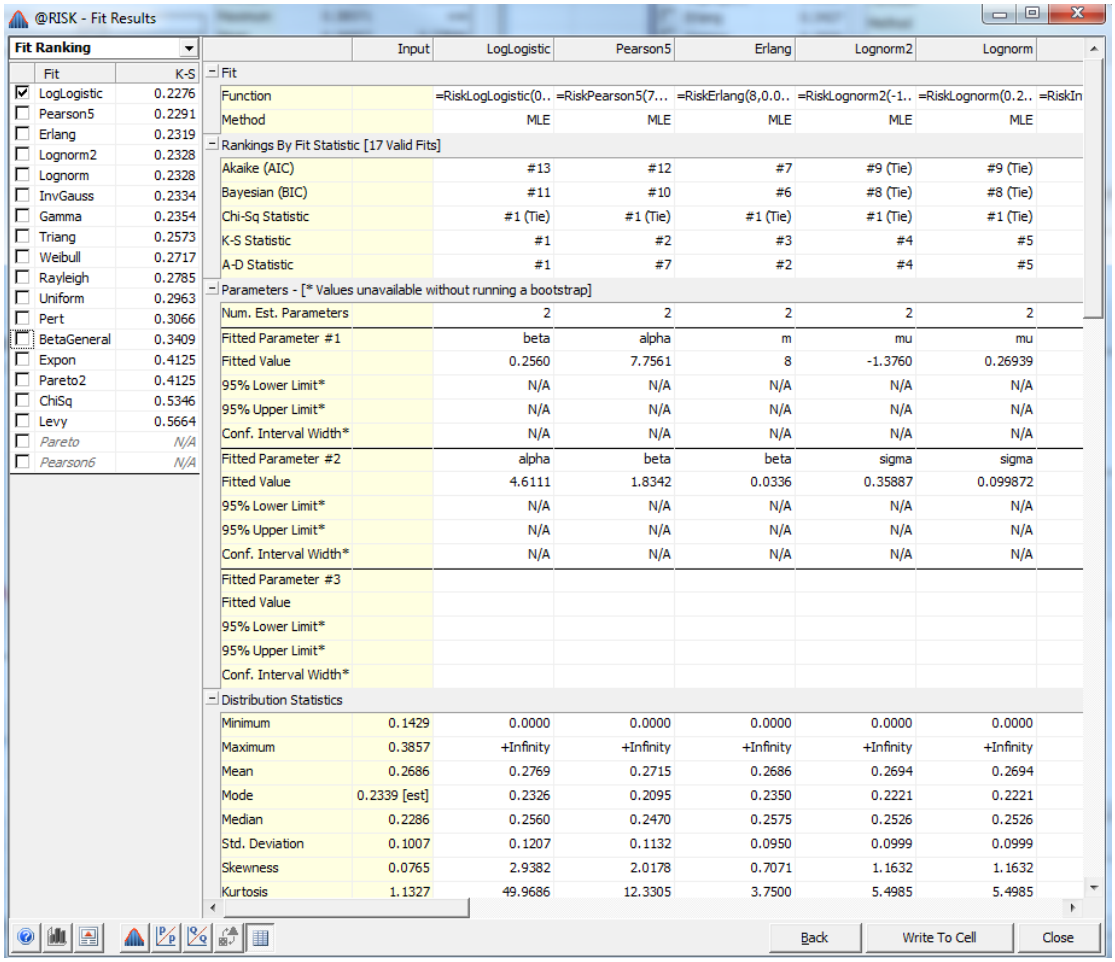


Figure 4.4: Reactive plant outage (forced) – statistics table using K-S



3. Transformers outage – fault (continuous)

Findings:

- A-D fit statistic: Rayleigh distribution best fit, standard deviation 0.0959
- K-S fit statistic: Uniform distribution best fit, standard deviation 0.11277
- **A-D preferred (Rayleigh) due to data concentrated near tails of distribution**

Figure 5.1: Transformers outage (fault) – distribution fit using A-D

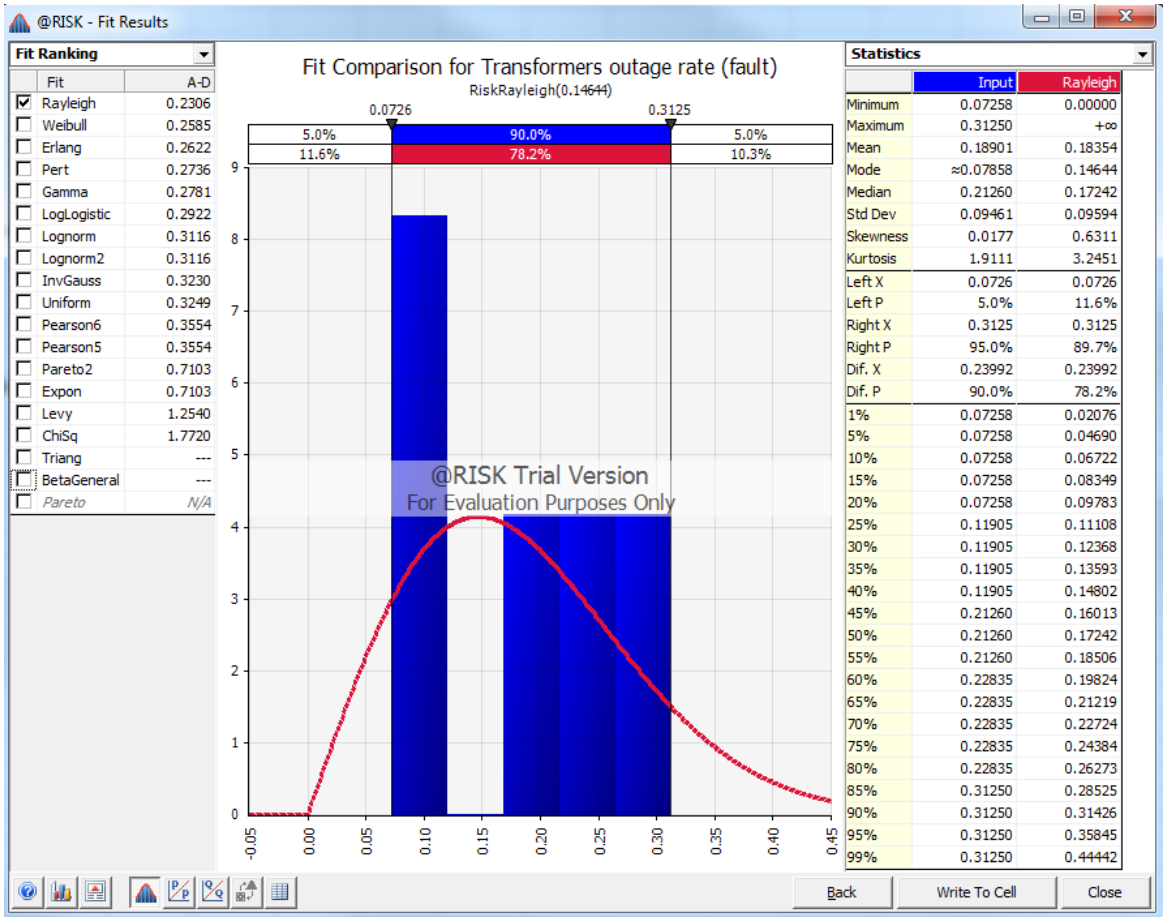


Figure 5.2: Transformers outage (fault) – statistics table using A-D

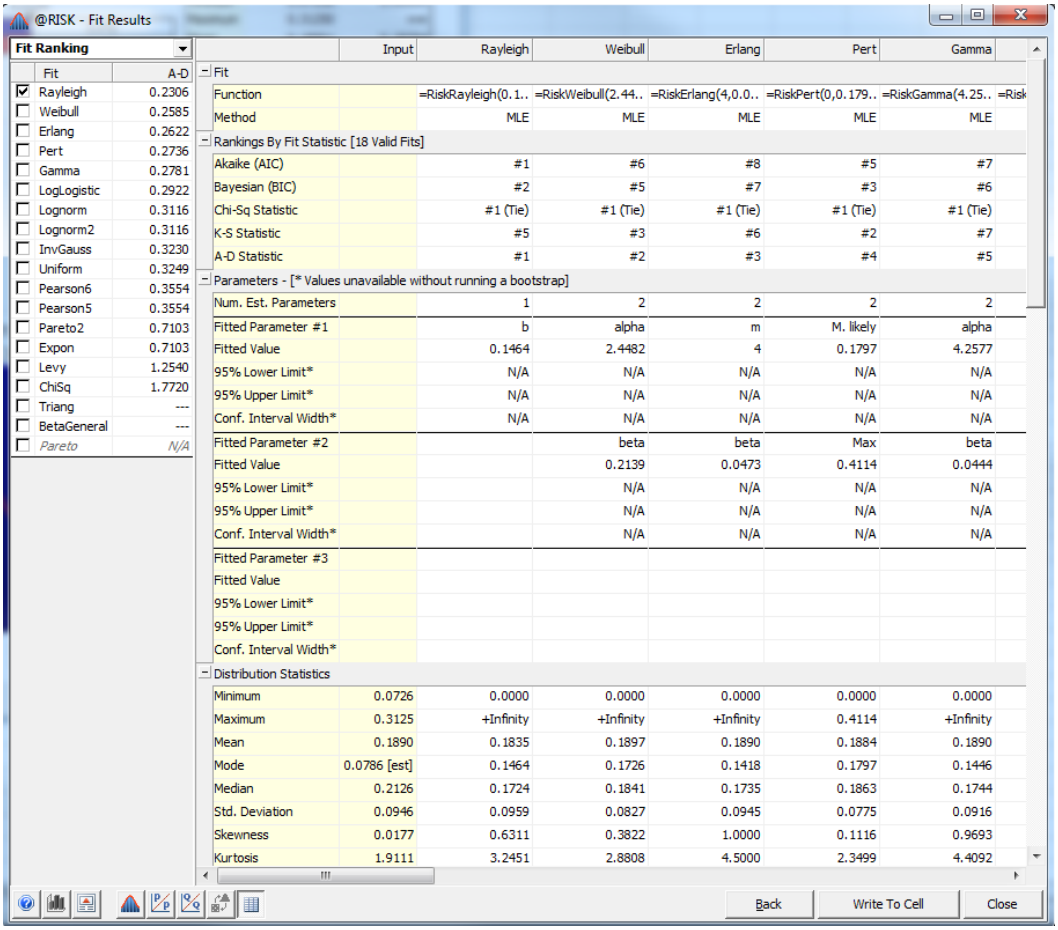


Figure 5.3: Transformers outage (fault) – distribution fit using K-S

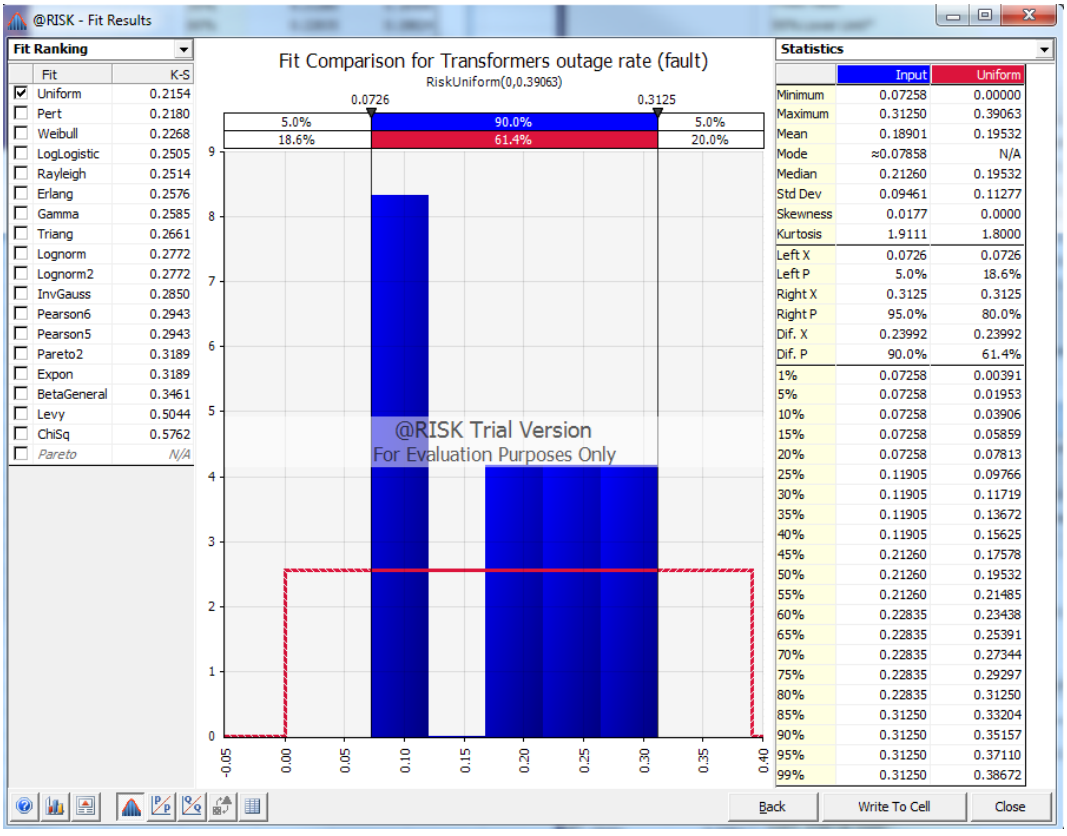
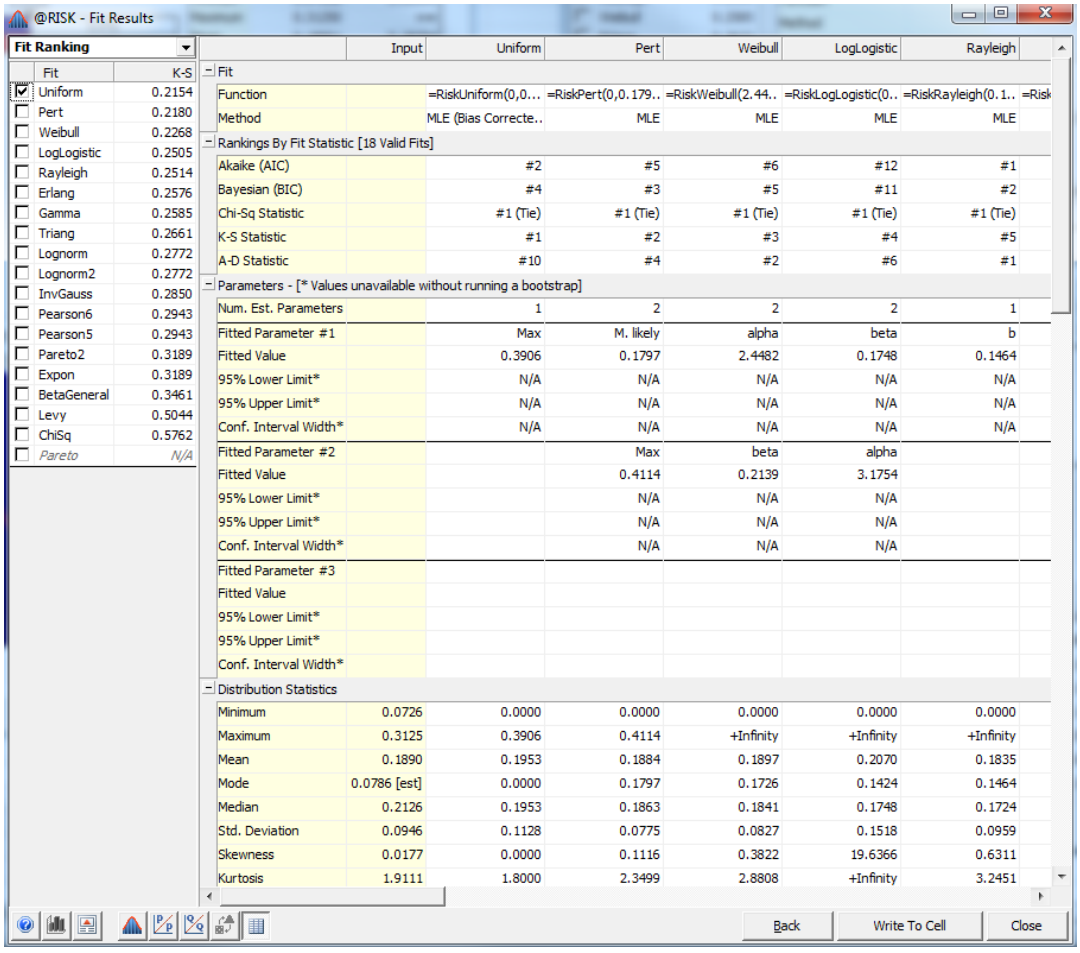


Figure 5.4: Transformers outage (fault) – statistics table using K-S



4. Transformers outage – forced (continuous)

Findings:

- A-D fit statistic: Weibull distribution best fit, standard deviation 0.02779
- K-S fit statistic: Weibull distribution best fit, standard deviation 0.02779
- **A-D preferred (Weibull) due to data concentrated near tails of distribution**

Figure 6.1: Transformers outage (forced) – distribution fit using A-D

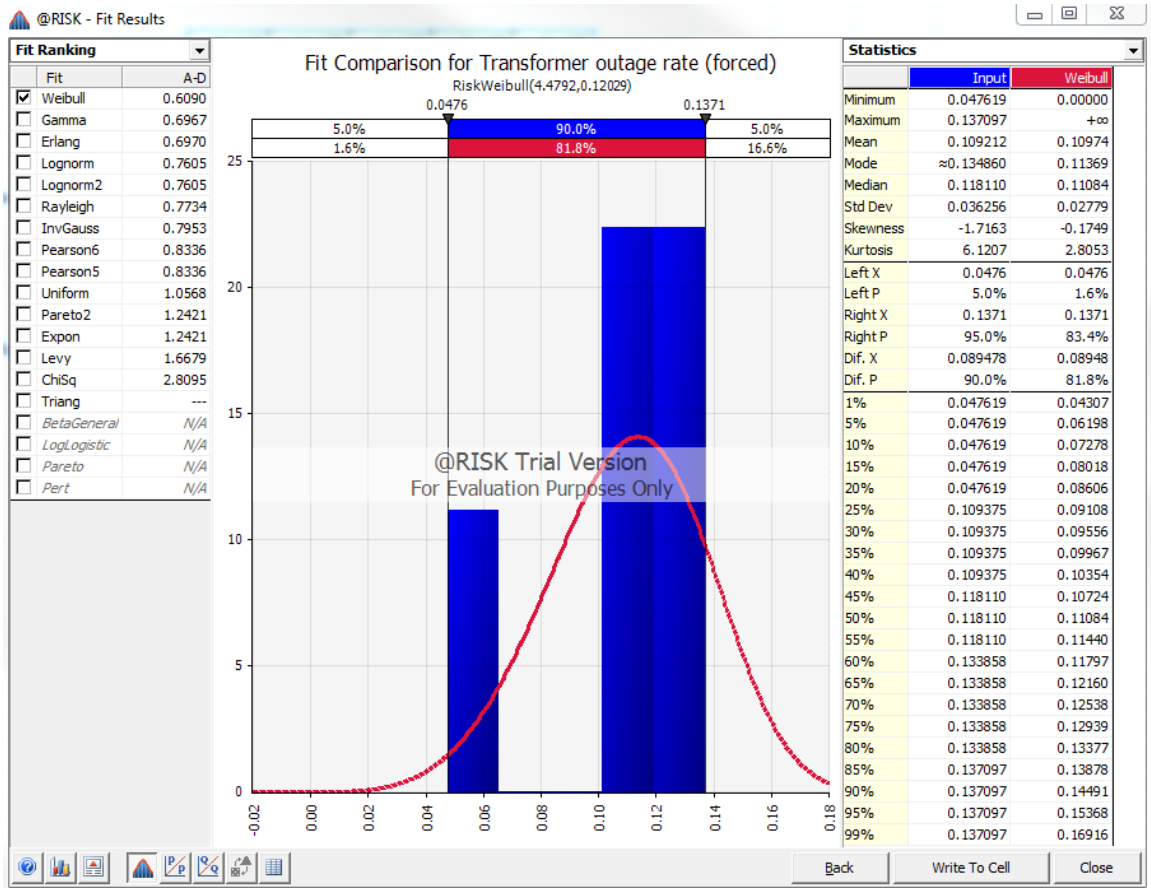


Figure 6.2: Transformers outage (forced) – statistics table using A-D

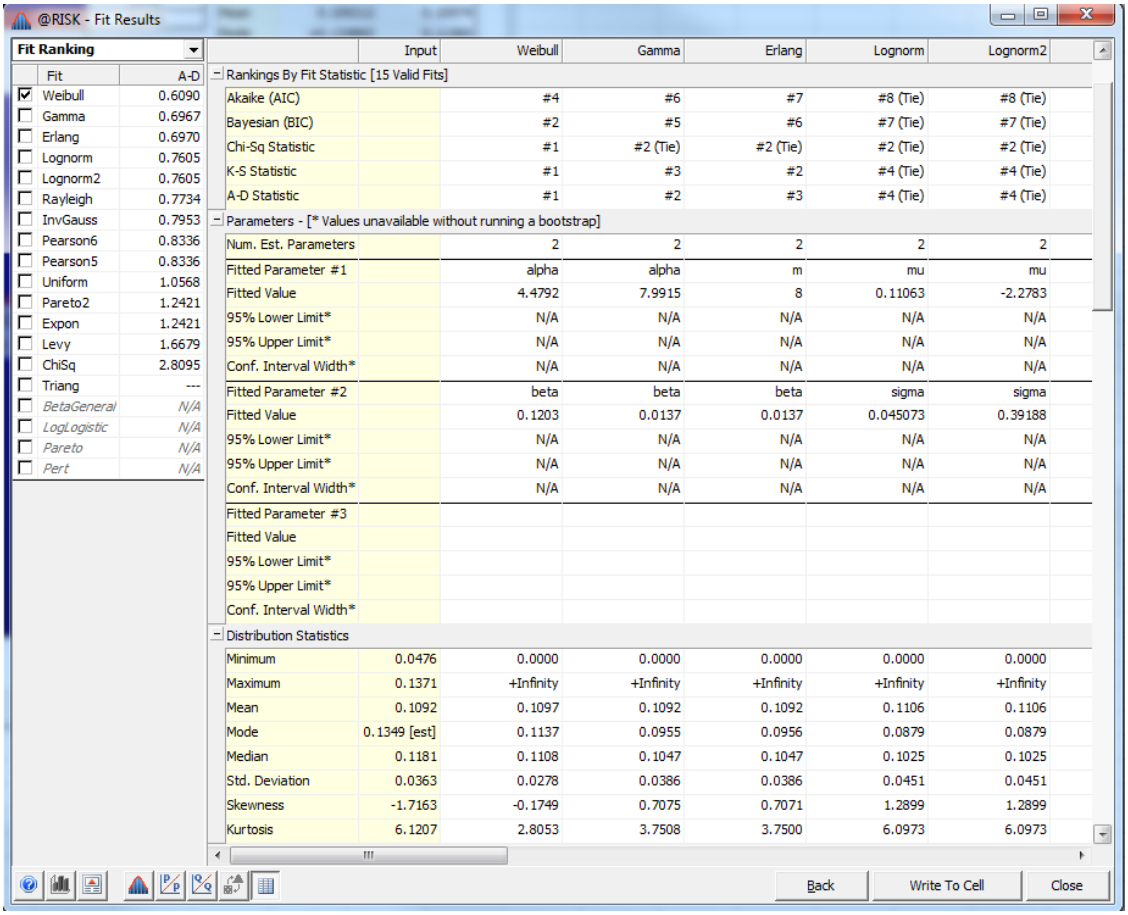


Figure 6.3: Transformers outage (forced) – distribution fit using K-S

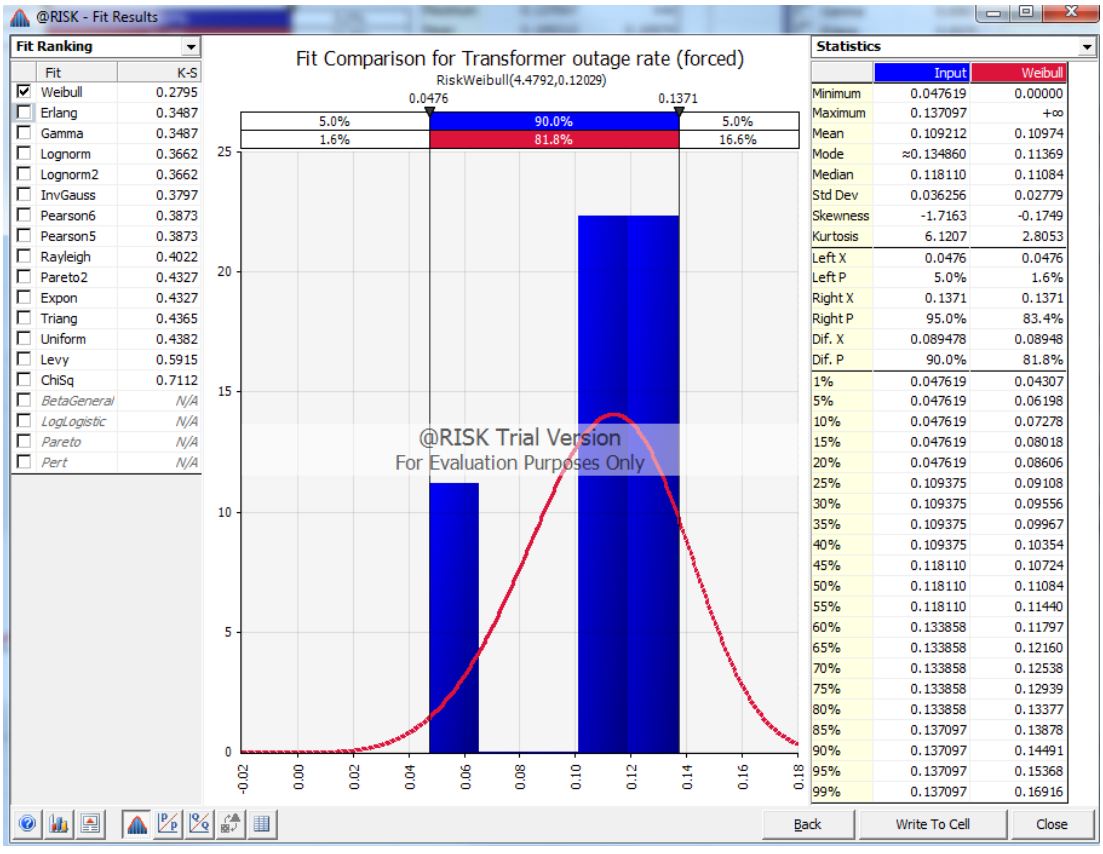
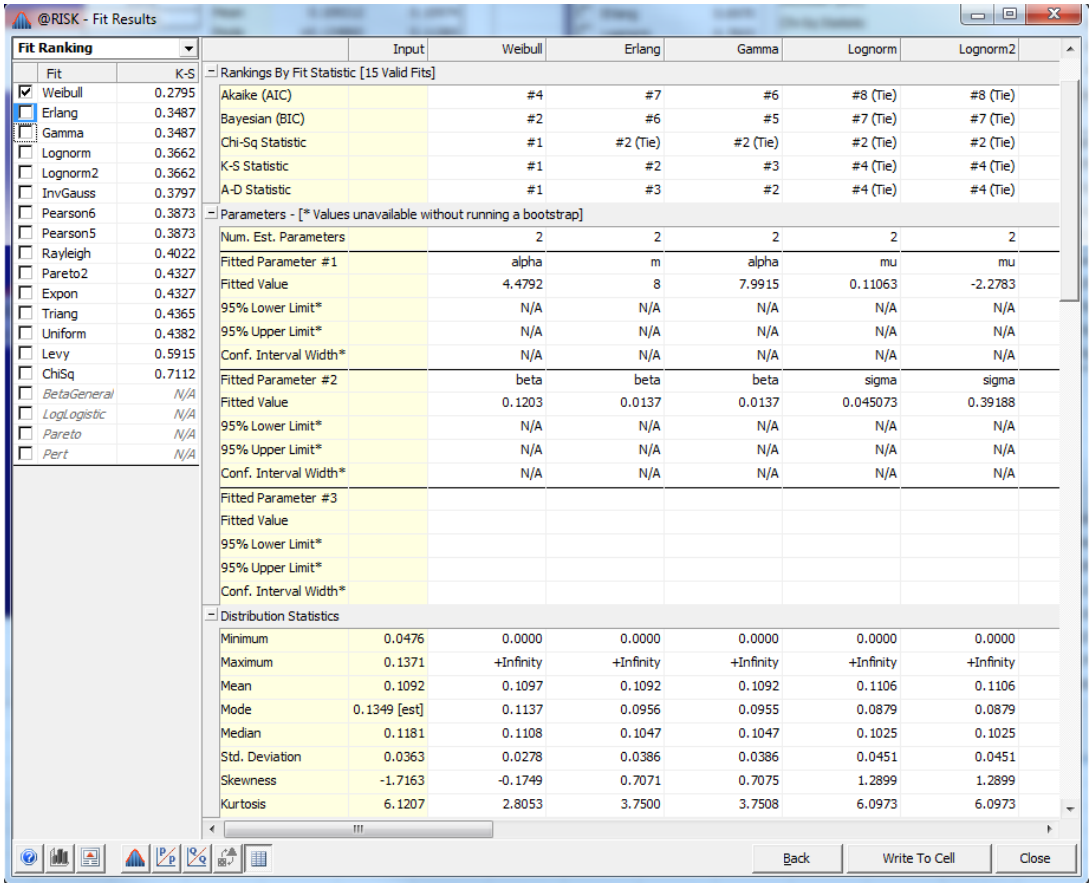


Figure 6.4: Transformers outage (forced) – statistics table using K-S



1.2 Service parameter 2 – loss of supply event frequency

5. Number of events >0.05 system minutes (discrete)

Findings:

- Chi Squared fit statistic: Geometric distribution best fit, standard deviation 2.2450.
- Large variance in standard deviations of better fitting distributions
- **Best fit distribution (Geometric) preferred, noting variability in std dev.**

Figure 7.1: Number of events >0.05 system minutes – geometric distribution

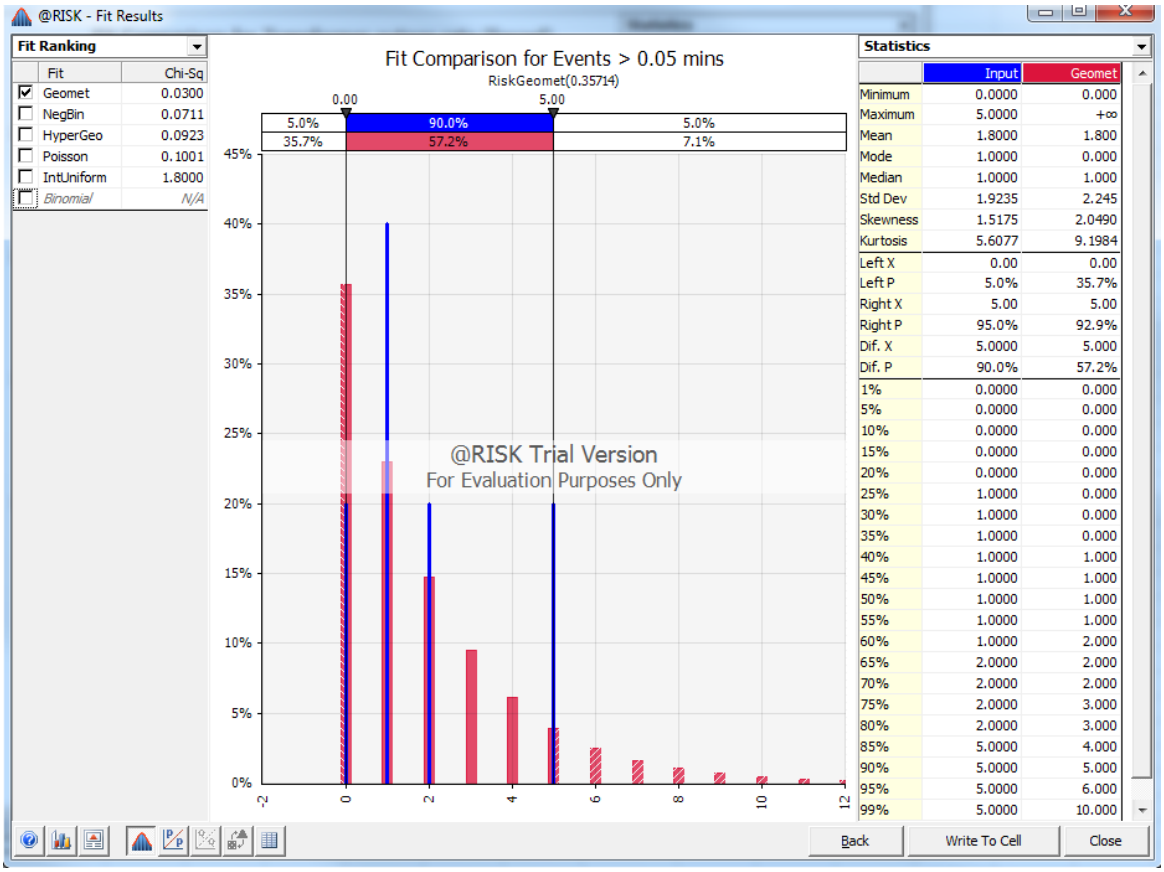
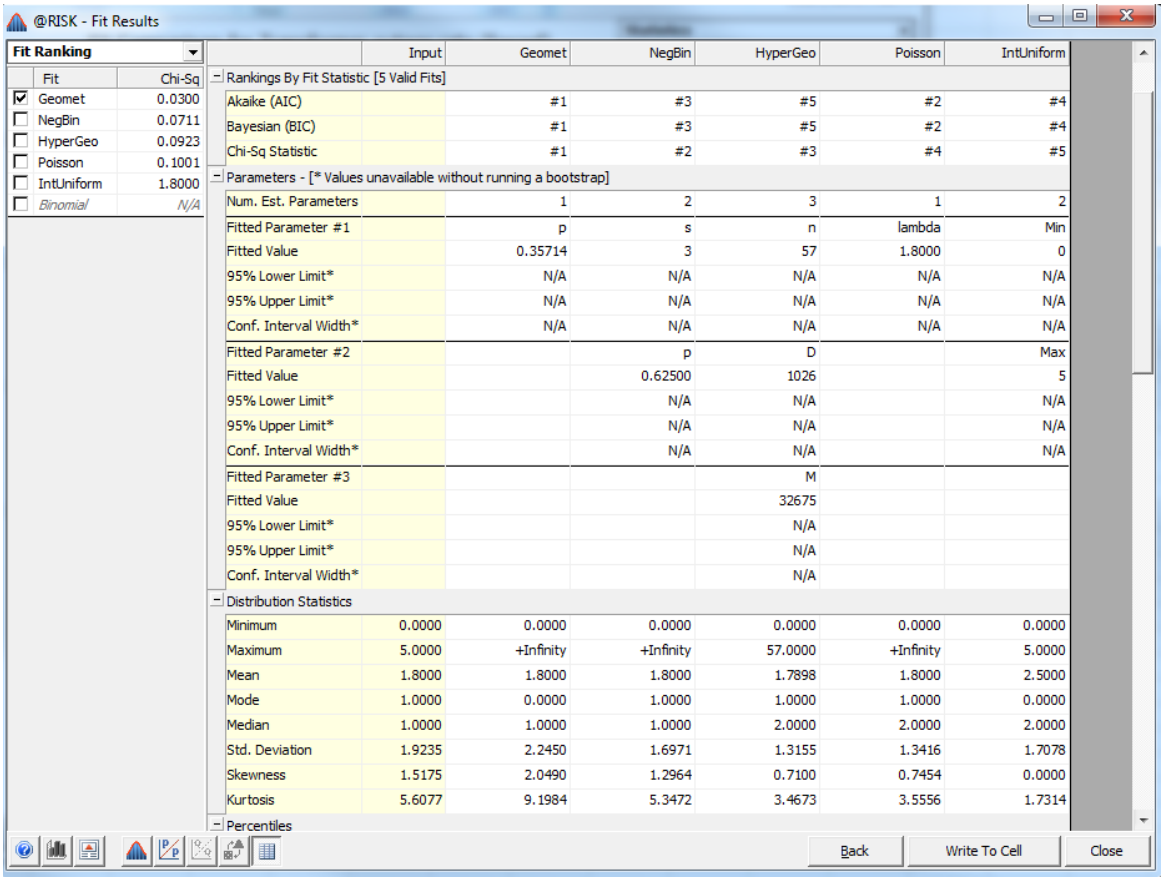


Figure 7.2: Number of events >0.05 system minutes – statistics table



	Input	Geomet	NegBin	HyperGeo	Poisson	IntUniform
Rankings By Fit Statistic [5 Valid Fits]						
Akaike (AIC)		#1	#3	#5	#2	#4
Bayesian (BIC)		#1	#3	#5	#2	#4
Chi-Sq Statistic		#1	#2	#3	#4	#5
Parameters - [* Values unavailable without running a bootstrap]						
Num. Est. Parameters		1	2	3	1	2
Fitted Parameter #1		p	s	n	lambda	Min
Fitted Value		0.35714	3	57	1.8000	0
95% Lower Limit*		N/A	N/A	N/A	N/A	N/A
95% Upper Limit*		N/A	N/A	N/A	N/A	N/A
Conf. Interval Width*		N/A	N/A	N/A	N/A	N/A
Fitted Parameter #2			p	D		Max
Fitted Value			0.62500	1026		5
95% Lower Limit*			N/A	N/A		N/A
95% Upper Limit*			N/A	N/A		N/A
Conf. Interval Width*			N/A	N/A		N/A
Fitted Parameter #3				M		
Fitted Value				32675		
95% Lower Limit*				N/A		
95% Upper Limit*				N/A		
Conf. Interval Width*				N/A		
Distribution Statistics						
Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	5.0000	+Infinity	+Infinity	57.0000	+Infinity	5.0000
Mean	1.8000	1.8000	1.8000	1.7898	1.8000	2.5000
Mode	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000
Median	1.0000	1.0000	1.0000	2.0000	2.0000	2.0000
Std. Deviation	1.9235	2.2450	1.6971	1.3155	1.3416	1.7078
Skewness	1.5175	2.0490	1.2964	0.7100	0.7454	0.0000
Kurtosis	5.6077	9.1984	5.3472	3.4673	3.5556	1.7314
Percentiles						

6. Number of events >0.30 system minutes (discrete)

Findings:

- Chi Squared fit statistic: input data does not lend itself easily to statistical analysis, as it is comprised of either zero or one events, suggesting a binomial or hypergeometric distribution. However, more than one event is possible (in 2009 there were two events).
- **Since the 9 out of the last 10 years have resulted in either zero or one events, recommend using the IntUniform distribution with a mean of 0.5 and standard deviation of 0.5, noting the difficulty in fitting a curve to this data.**

Figure 8.1: Number of events >0.30 system minutes – IntUniform distribution

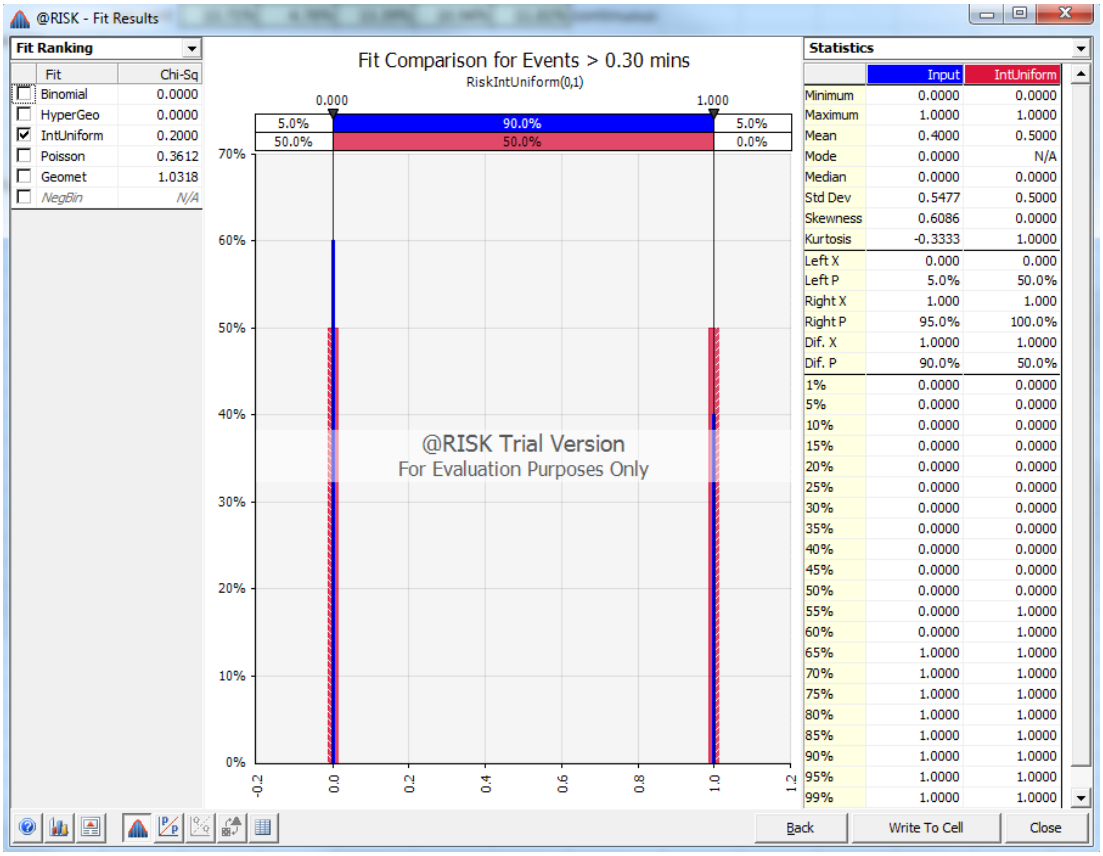
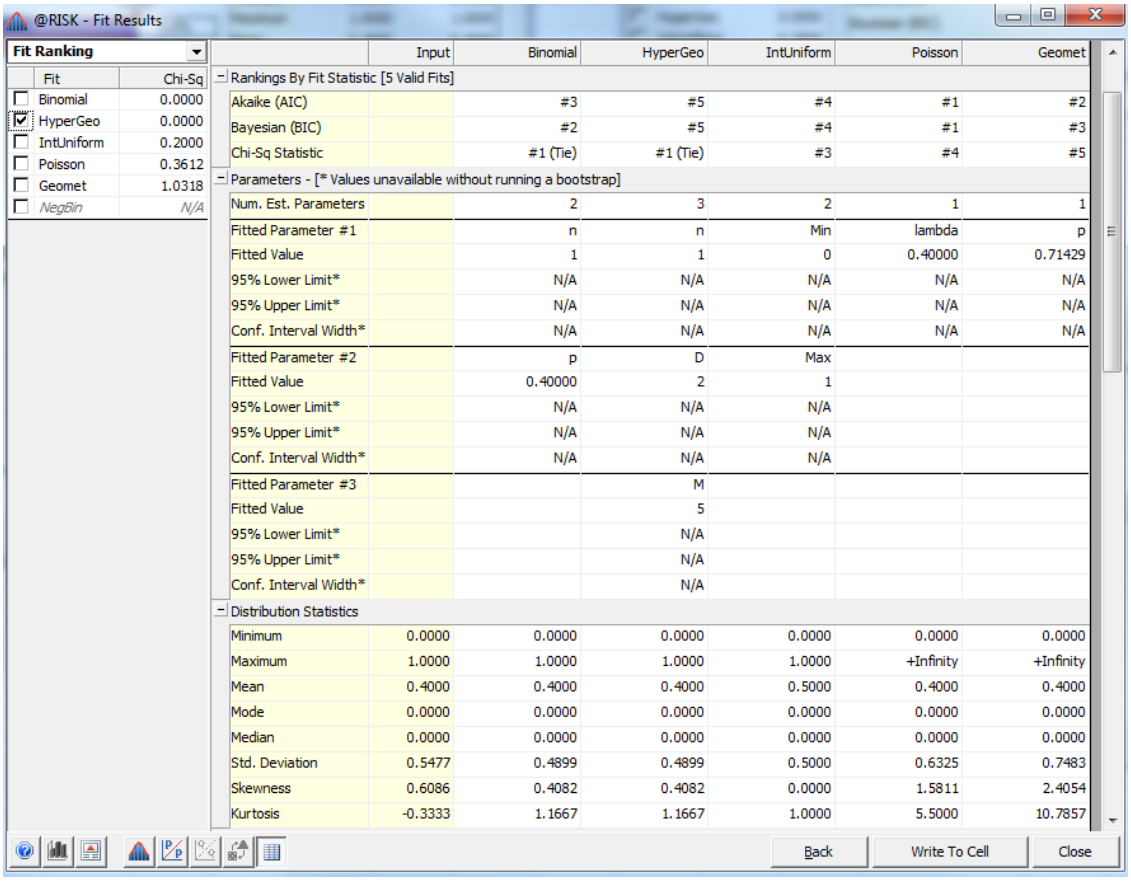


Figure 8.2: Number of events >0.30 system minutes – statistics table



	Input	Binomial	HyperGeo	IntUniform	Poisson	Geomet
Rankings By Fit Statistic [5 Valid Fits]						
Akaike (AIC)		#3	#5	#4	#1	#2
Bayesian (BIC)		#2	#5	#4	#1	#3
Chi-Sq Statistic		#1 (Tie)	#1 (Tie)	#3	#4	#5
Parameters - [* Values unavailable without running a bootstrap]						
Num. Est. Parameters		2	3	2	1	1
Fitted Parameter #1		n	n	Min	lambda	p
Fitted Value		1	1	0	0.40000	0.71429
95% Lower Limit*		N/A	N/A	N/A	N/A	N/A
95% Upper Limit*		N/A	N/A	N/A	N/A	N/A
Conf. Interval Width*		N/A	N/A	N/A	N/A	N/A
Fitted Parameter #2		p	D	Max		
Fitted Value		0.40000	2	1		
95% Lower Limit*		N/A	N/A	N/A		
95% Upper Limit*		N/A	N/A	N/A		
Conf. Interval Width*		N/A	N/A	N/A		
Fitted Parameter #3			M			
Fitted Value			5			
95% Lower Limit*			N/A			
95% Upper Limit*			N/A			
Conf. Interval Width*			N/A			
Distribution Statistics						
Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	1.0000	1.0000	1.0000	1.0000	+Infinity	+Infinity
Mean	0.4000	0.4000	0.4000	0.5000	0.4000	0.4000
Mode	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Median	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Deviation	0.5477	0.4899	0.4899	0.5000	0.6325	0.7483
Skewness	0.6086	0.4082	0.4082	0.0000	1.5811	2.4054
Kurtosis	-0.3333	1.1667	1.1667	1.0000	5.5000	10.7857

1.3 Service parameter 3 – average outage duration

7. Average outage duration (continuous)

Findings:

- A-D fit statistic: LogLogistic distribution best fit, however this returns an undefined standard deviation
    - The Lognorm distribution is also a close fit to the data and is very close to the LogLogistic distribution (0.2278 v. 0.2190) and returns a standard deviation of 211.4355.
    - The Weibull distribution is also a close fit and compares well to LogLogistic (0.2435 v. 0.2190). The Weibull distribution has the advantage of a far superior standard deviation of 91.3057.
- K-S fit statistic: Lognorm distribution best fit, standard deviation 211.4355.
- **A-D preferred due to data falling near tails of distribution. There is some question as to which distribution is the most appropriate to use (Lognorm or Weibull), however on balance, Weibull is preferred due to its standard deviation.**

Figure 9.1: Average outage duration– distribution fit using A-D (LogLogistic)

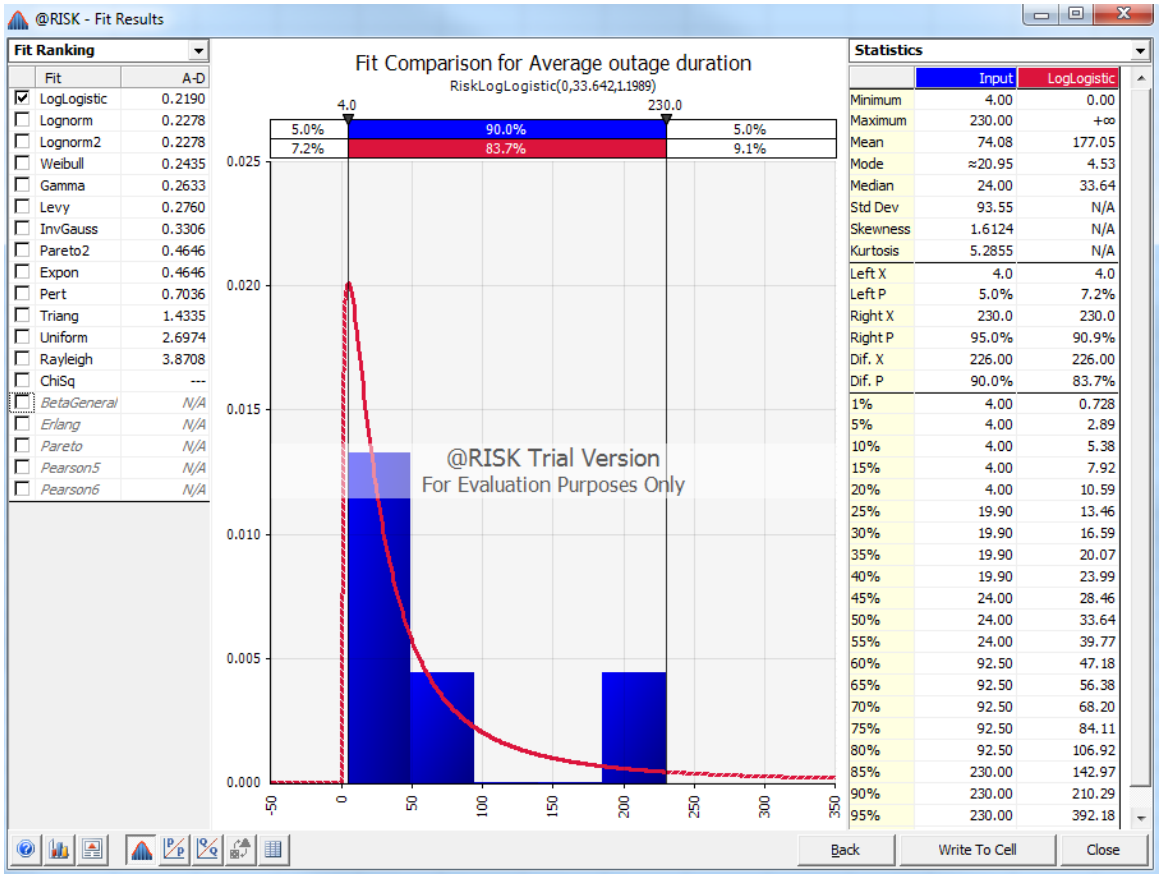


Figure 9.2: Average outage duration– distribution fit using A-D (Lognorm)

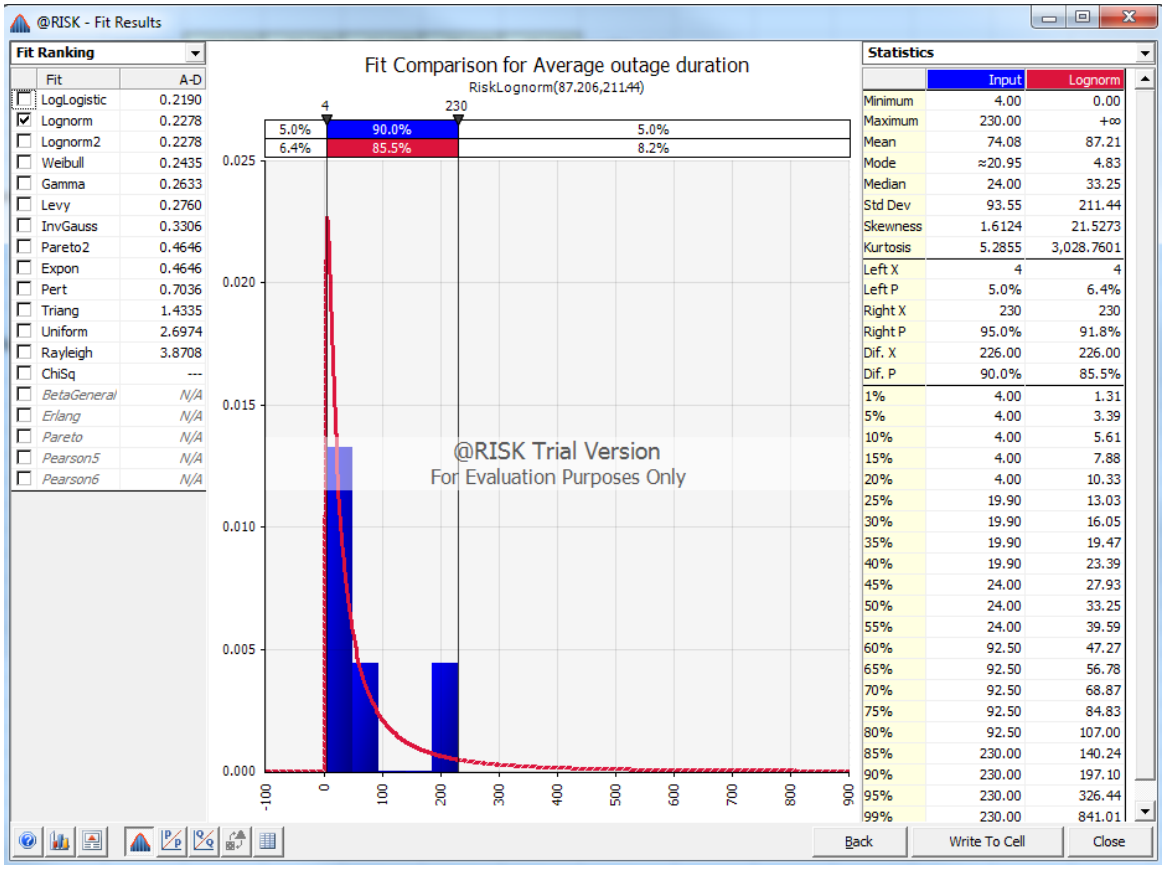


Figure 9.2: Average outage duration– distribution fit using A-D (Weibull)

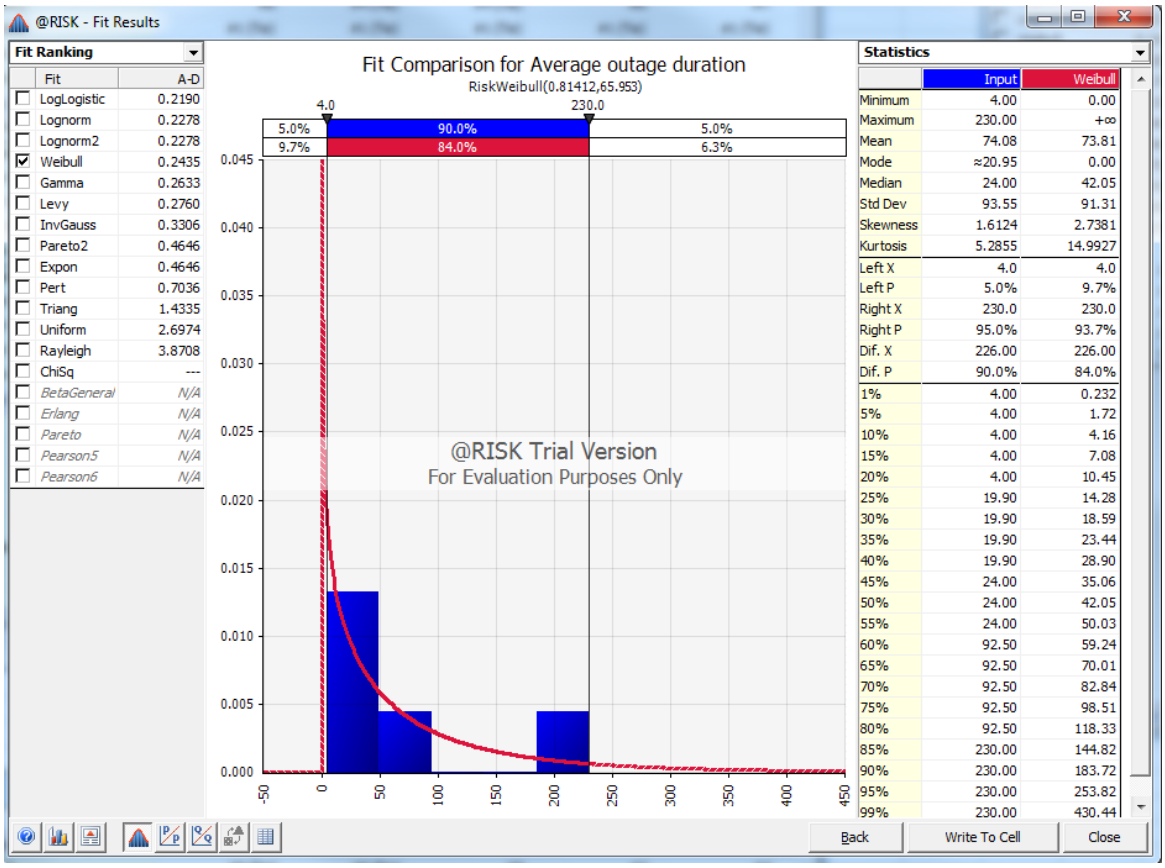


Figure 9.4: Average outage duration – statistics table using A-D

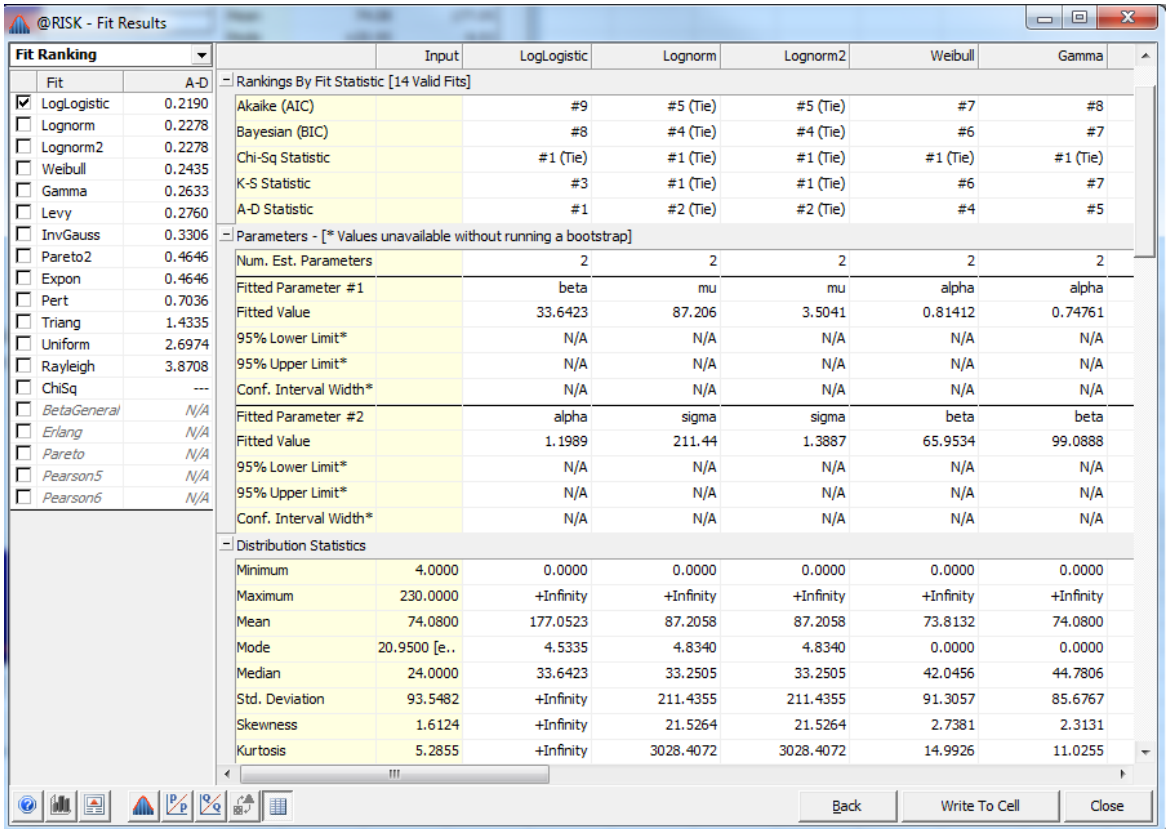


Figure 9.5: Average outage duration – distribution fit using K-S

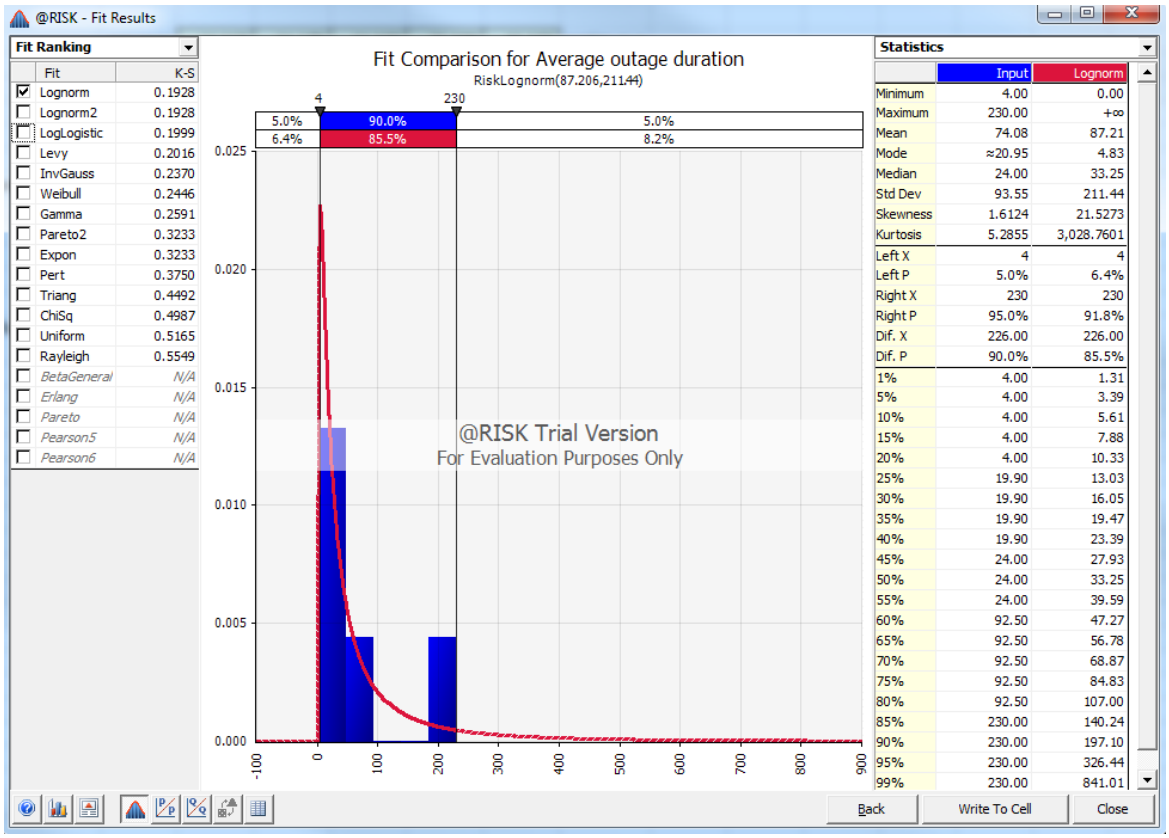
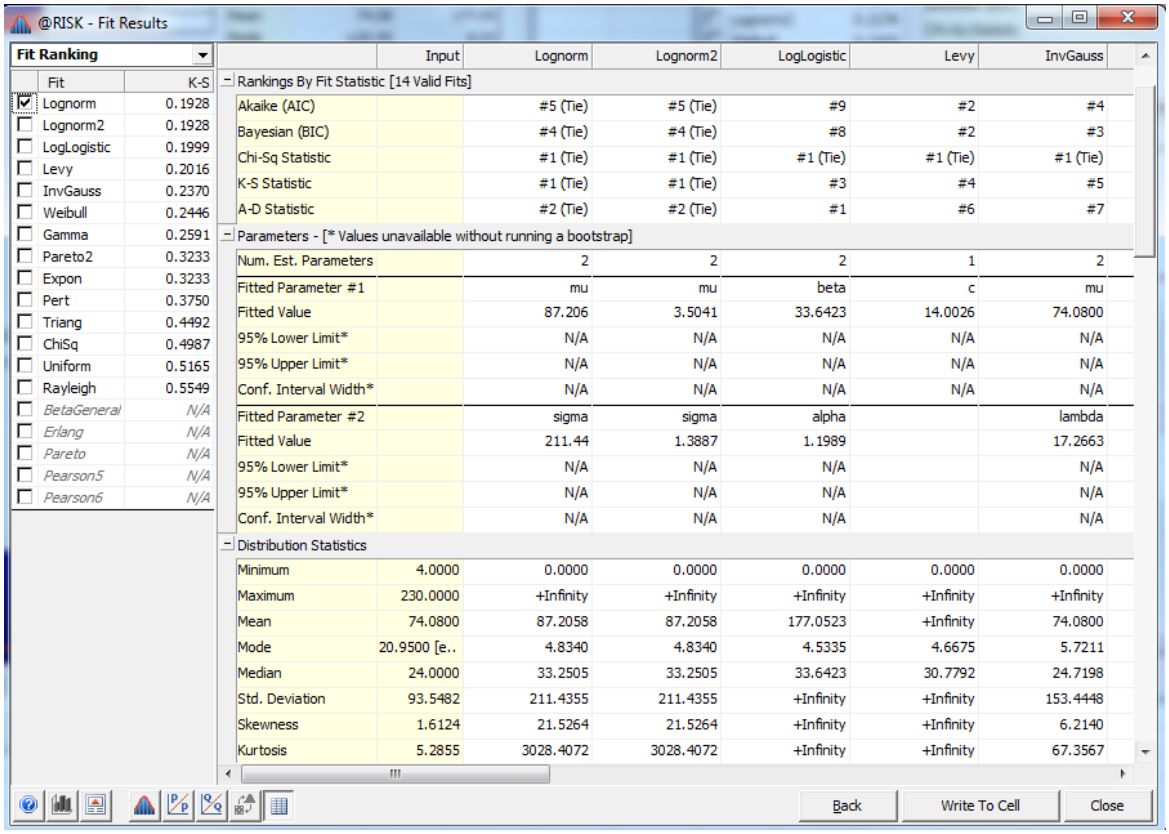


Figure 6.4: Transformers outage (forced) – statistics table using K-S



1.4 Service parameter 4 – Proper operation of equipment

8. Failure of protection system (discrete)

Findings:

- Chi Squared fit statistic: Hypergeometric distribution best fit, standard deviation 4.9336
- Poisson distribution next best fit
- **Best fit distribution (Hypergeometric) preferred.**

Figure 10.1: Failure of protection system – hypergeometric distribution

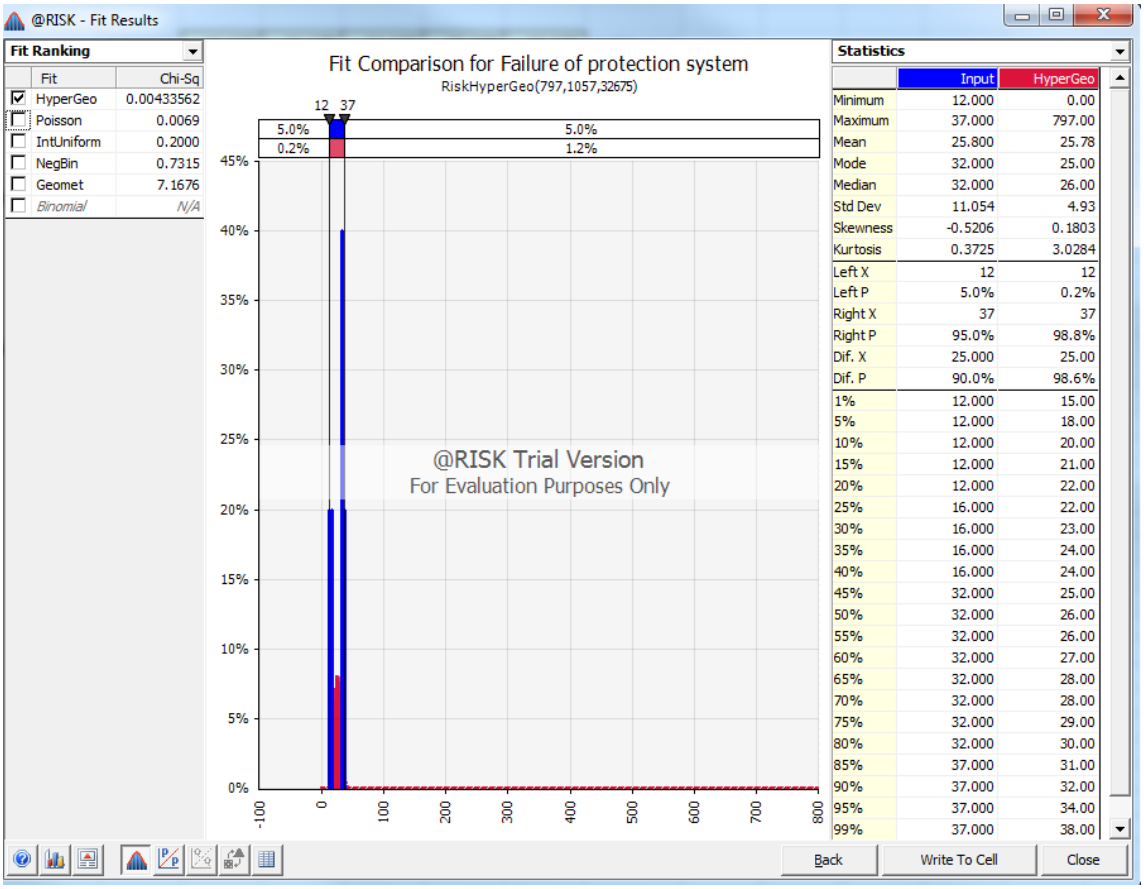
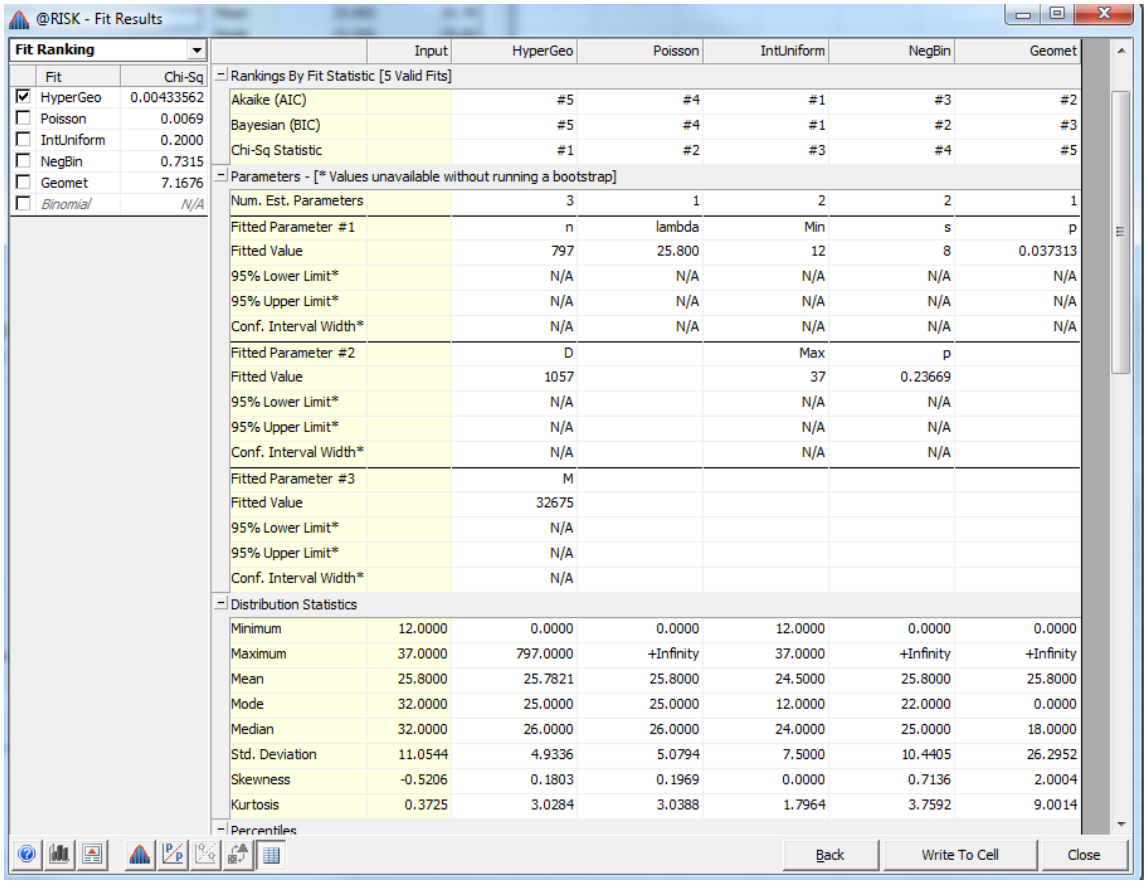


Figure 10.2 Failure of protection system– statistics table



9. Material failure of SCADA system (discrete)

Findings:

- Chi Squared fit statistic: Tie between geometric and NegBin distributions for both best fit (0.2269) and standard deviation 2.245
- Identical results on all other parameters and statistics
- **No preference between Geometric and NegBin distributions.**

Figure 11.1: Material failure of SCADA system –geometric distribution

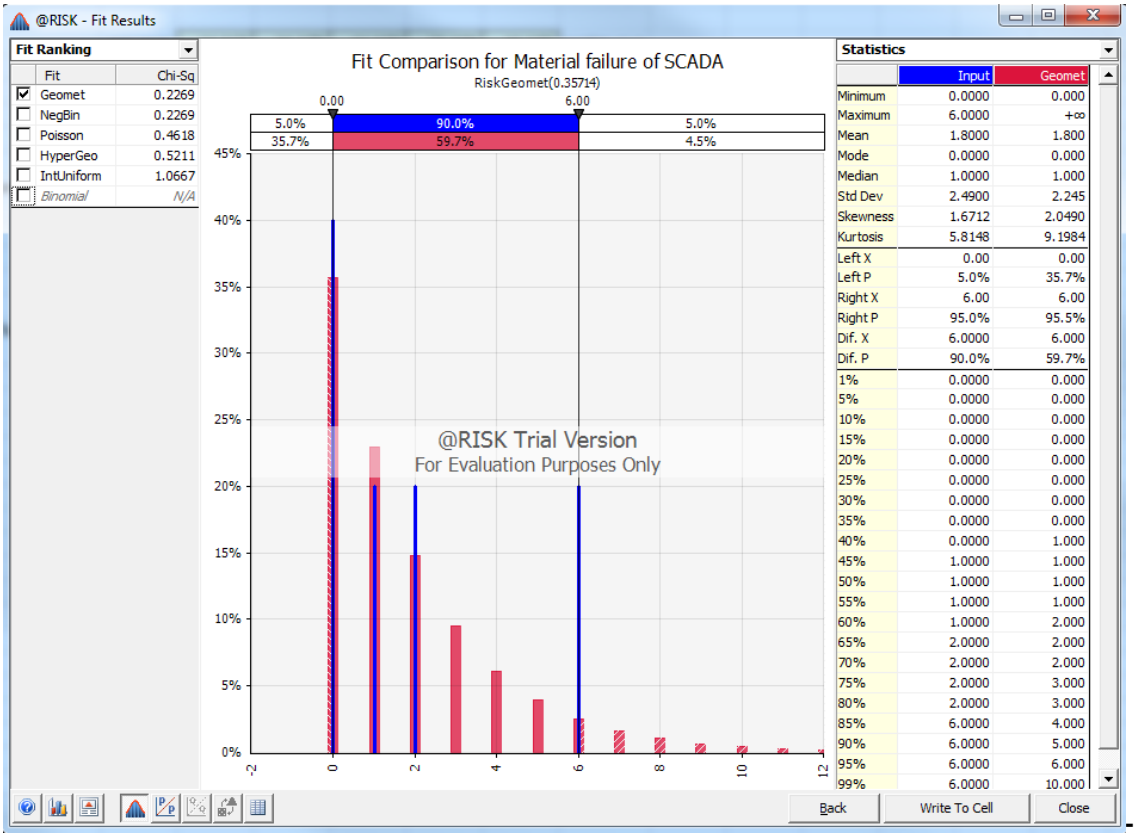


Figure 11.2: Material failure of SCADA system– NegBin distribution

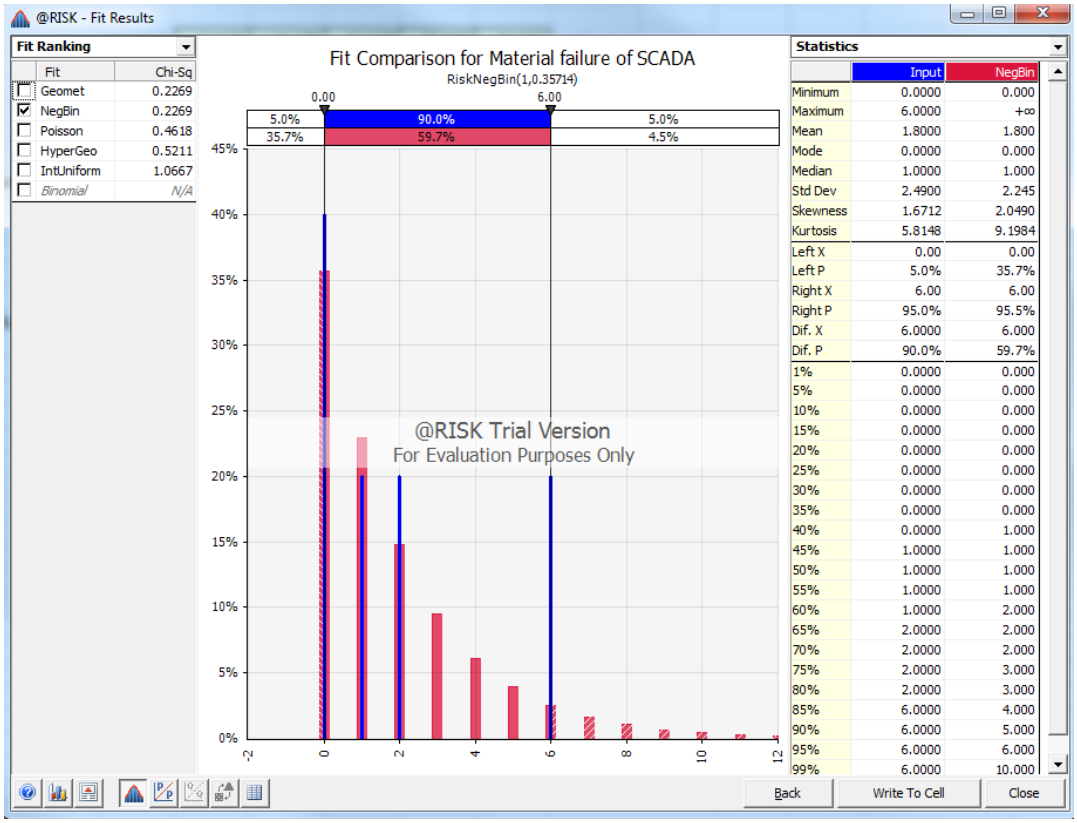
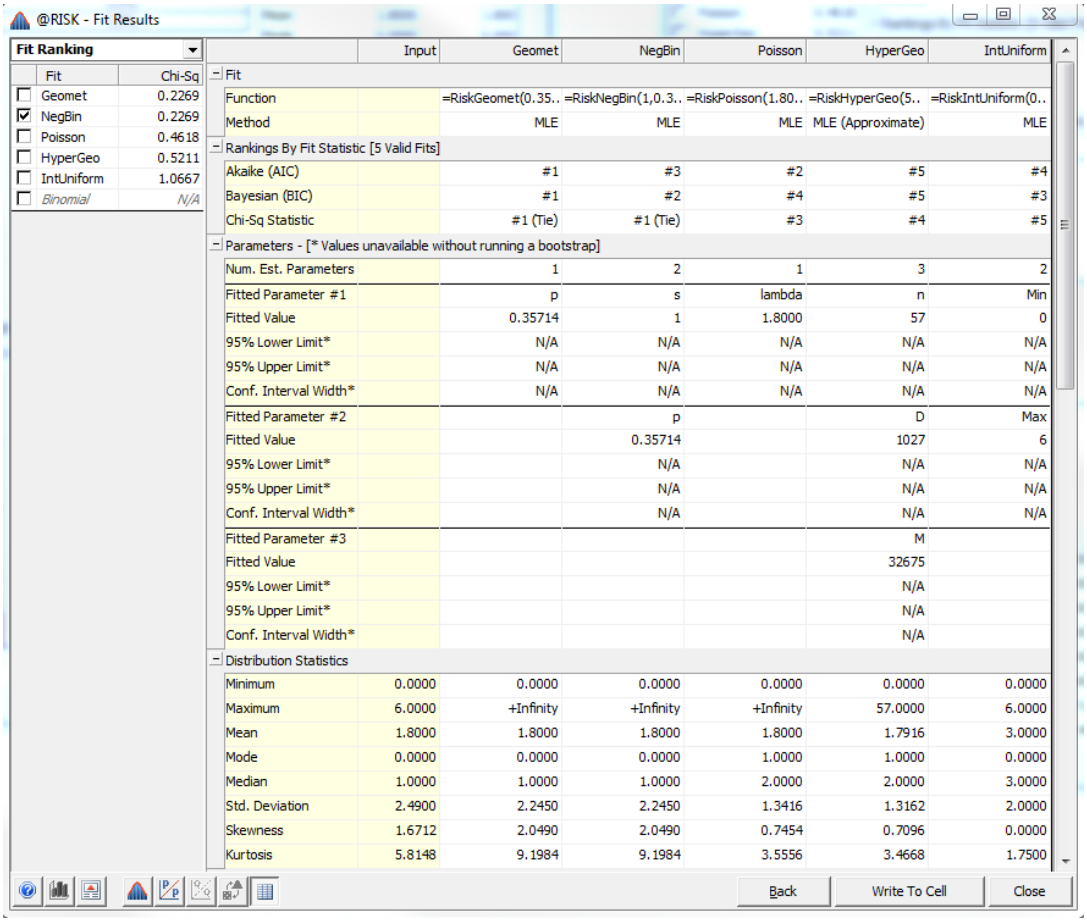


Figure 11.3: Material failure of SCADA system– statistics table



10. Incorrect operational isolation of primary or secondary equipment (discrete)

Findings:

- Chi Squared fit statistic: IntUniform distribution best fit, standard deviation 1.4142
- This is due to the nature of the data (five years with results of 4,5,6,7,8)
- Binominal and hypergeometric are the next best fits, with the same standard deviation to IntUniform
- **Best fit distribution (IntUniform) preferred**

Figure 12.1: Incorrect operational isolation of equipment –geometric distribution

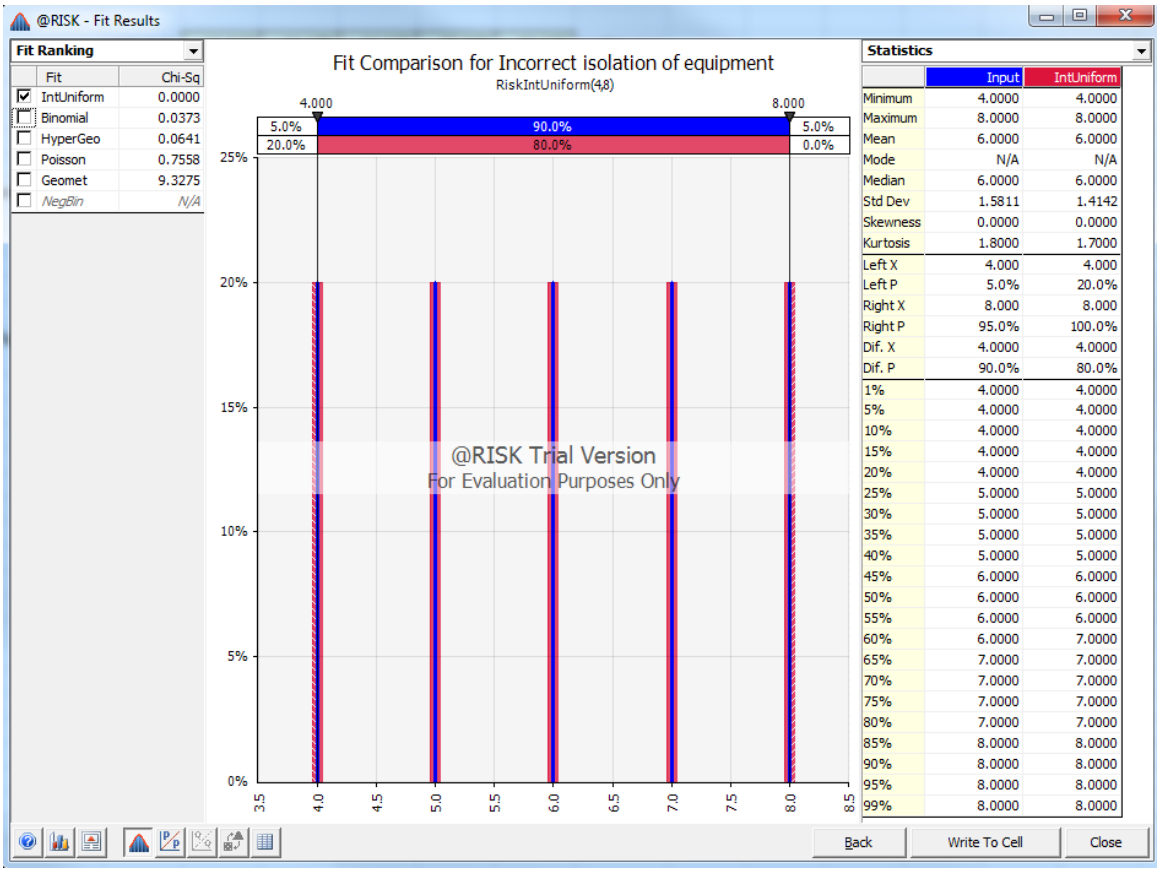
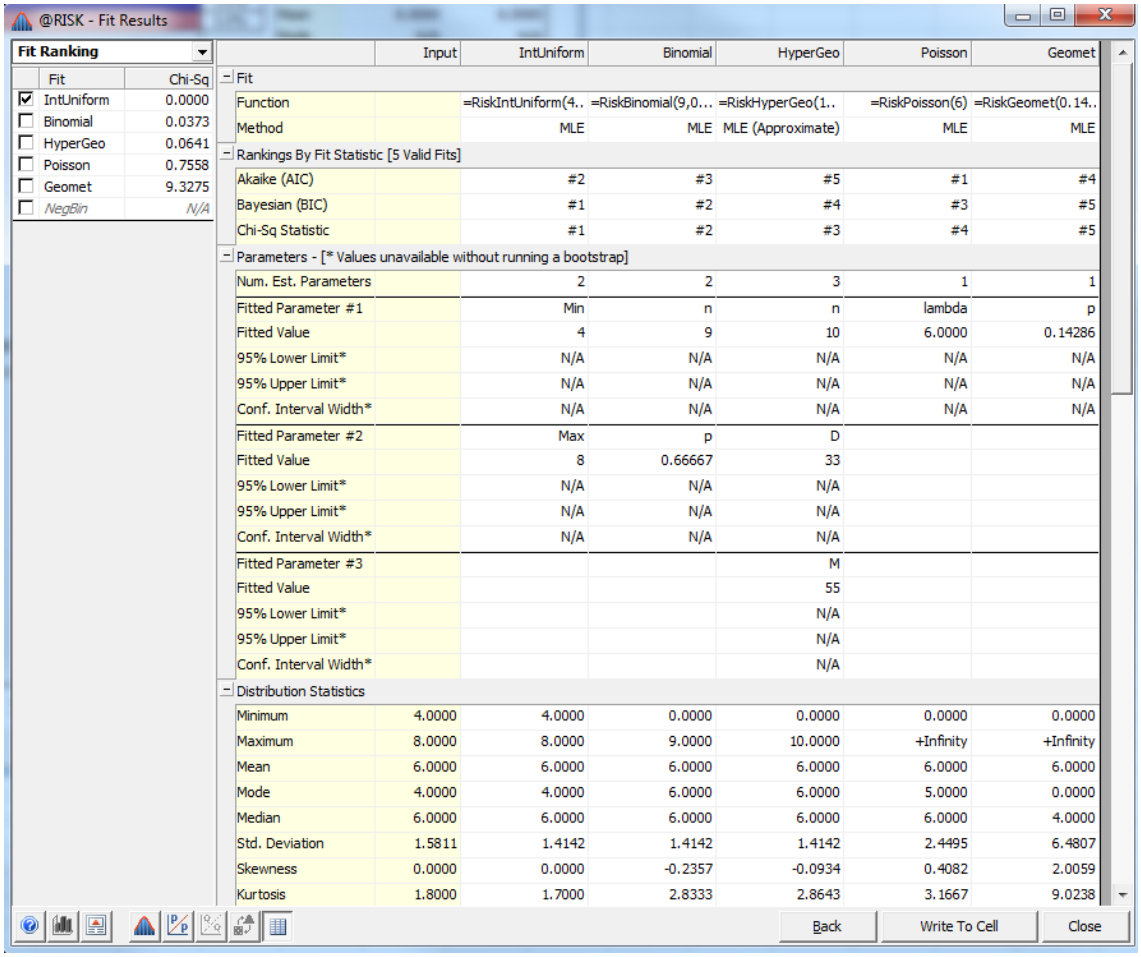


Figure 12.1: Incorrect operational isolation of equipment –statistics table



2 Addendum 14 September 2015

Since the initial version of this report, a number of changes or requests for additional information have been received. These are addressed below.

2.1 Correction of Typographical Errors

2.1.1 Error in standard deviation for parameter 'Number of events >0.05 system minutes'

The first version of this report contained two typographical errors relating to the standard deviation of the 'number of events >0.05 system minutes' parameter in which the text in the report did not reflect the outcome of the analysis. The standard deviation in the first report should have been noted as 2.2450 instead of 0.0606. The correct standard deviation has been updated in this document (sections 7 and 13), however an error in the input data as originally provided has rendered this analysis redundant. See the discussion under 'Correction of input data', below, for an updated analysis of this parameter.

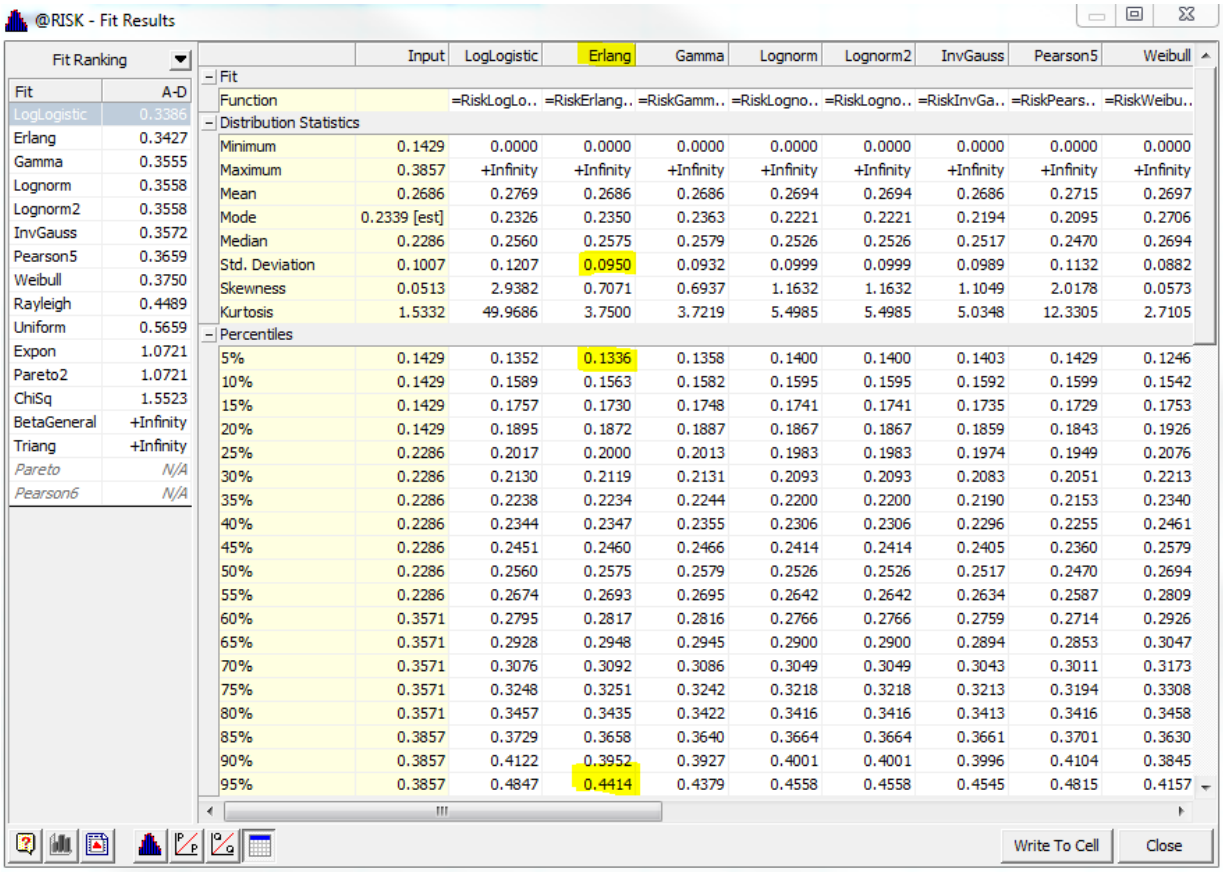
2.2 Additional Data Required

2.2.1 Additional parameters for 'Reactive plant outage rate (forced)'

Subsequent to the first report, the 5th and 95th percentiles of each performance parameter were added to the data required, instead of just the standard deviation. The screenshots for each parameter contained the 5th and

95th percentiles, except the 'reactive plant outage rate (forced)' parameter. The 5th and 95th percentiles for this parameter are included in Figure A.1:

Figure 2.1: Reactive plant outage (forced) – statistics table using A-D



	Input	LogLogistic	Erlang	Gamma	Lognorm	Lognorm2	InvGauss	Pearson5	Weibull
Fit									
Function		=RiskLogLo..	=RiskErlang..	=RiskGamm..	=RiskLogno..	=RiskLogno..	=RiskInvGa..	=RiskPears..	=RiskWeibu..
Distribution Statistics									
Minimum	0.1429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	0.3857	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity
Mean	0.2686	0.2769	0.2686	0.2686	0.2694	0.2694	0.2686	0.2715	0.2697
Mode	0.2339 [est]	0.2326	0.2350	0.2363	0.2221	0.2221	0.2194	0.2095	0.2706
Median	0.2286	0.2560	0.2575	0.2579	0.2526	0.2526	0.2517	0.2470	0.2694
Std. Deviation	0.1007	0.1207	0.0950	0.0932	0.0999	0.0999	0.0989	0.1132	0.0882
Skewness	0.0513	2.9382	0.7071	0.6937	1.1632	1.1632	1.1049	2.0178	0.0573
Kurtosis	1.5332	49.9686	3.7500	3.7219	5.4985	5.4985	5.0348	12.3305	2.7105
Percentiles									
5%	0.1429	0.1352	0.1336	0.1358	0.1400	0.1400	0.1403	0.1429	0.1246
10%	0.1429	0.1589	0.1563	0.1582	0.1595	0.1595	0.1592	0.1599	0.1542
15%	0.1429	0.1757	0.1730	0.1748	0.1741	0.1741	0.1735	0.1729	0.1753
20%	0.1429	0.1895	0.1872	0.1887	0.1867	0.1867	0.1859	0.1843	0.1926
25%	0.2286	0.2017	0.2000	0.2013	0.1983	0.1983	0.1974	0.1949	0.2076
30%	0.2286	0.2130	0.2119	0.2131	0.2093	0.2093	0.2083	0.2051	0.2213
35%	0.2286	0.2238	0.2234	0.2244	0.2200	0.2200	0.2190	0.2153	0.2340
40%	0.2286	0.2344	0.2347	0.2355	0.2306	0.2306	0.2296	0.2255	0.2461
45%	0.2286	0.2451	0.2460	0.2466	0.2414	0.2414	0.2405	0.2360	0.2579
50%	0.2286	0.2560	0.2575	0.2579	0.2526	0.2526	0.2517	0.2470	0.2694
55%	0.2286	0.2674	0.2693	0.2695	0.2642	0.2642	0.2634	0.2587	0.2809
60%	0.3571	0.2795	0.2817	0.2816	0.2766	0.2766	0.2759	0.2714	0.2926
65%	0.3571	0.2928	0.2948	0.2945	0.2900	0.2900	0.2894	0.2853	0.3047
70%	0.3571	0.3076	0.3092	0.3086	0.3049	0.3049	0.3043	0.3011	0.3173
75%	0.3571	0.3248	0.3251	0.3242	0.3218	0.3218	0.3213	0.3194	0.3308
80%	0.3571	0.3457	0.3435	0.3422	0.3416	0.3416	0.3413	0.3416	0.3458
85%	0.3857	0.3729	0.3658	0.3640	0.3664	0.3664	0.3661	0.3701	0.3630
90%	0.3857	0.4122	0.3952	0.3927	0.4001	0.4001	0.3996	0.4104	0.3845
95%	0.3857	0.4847	0.4414	0.4379	0.4558	0.4558	0.4545	0.4815	0.4157

2.3 Correction of input data

2.3.1 Error in input data for 'Number of events >0.05 system minutes'

The input data received for this parameter contained an error in the final year of data. A corrected data set was provided, in which the final year value was 3, rather than 1. The distribution fitting exercise was performed on the new data, which suggested the HyperGeo distribution was the best fit, with a standard deviation of 1.4576. The detailed results are included below.

Figure 2.2: Number of events >0.05 system minutes – HyperGeo distribution

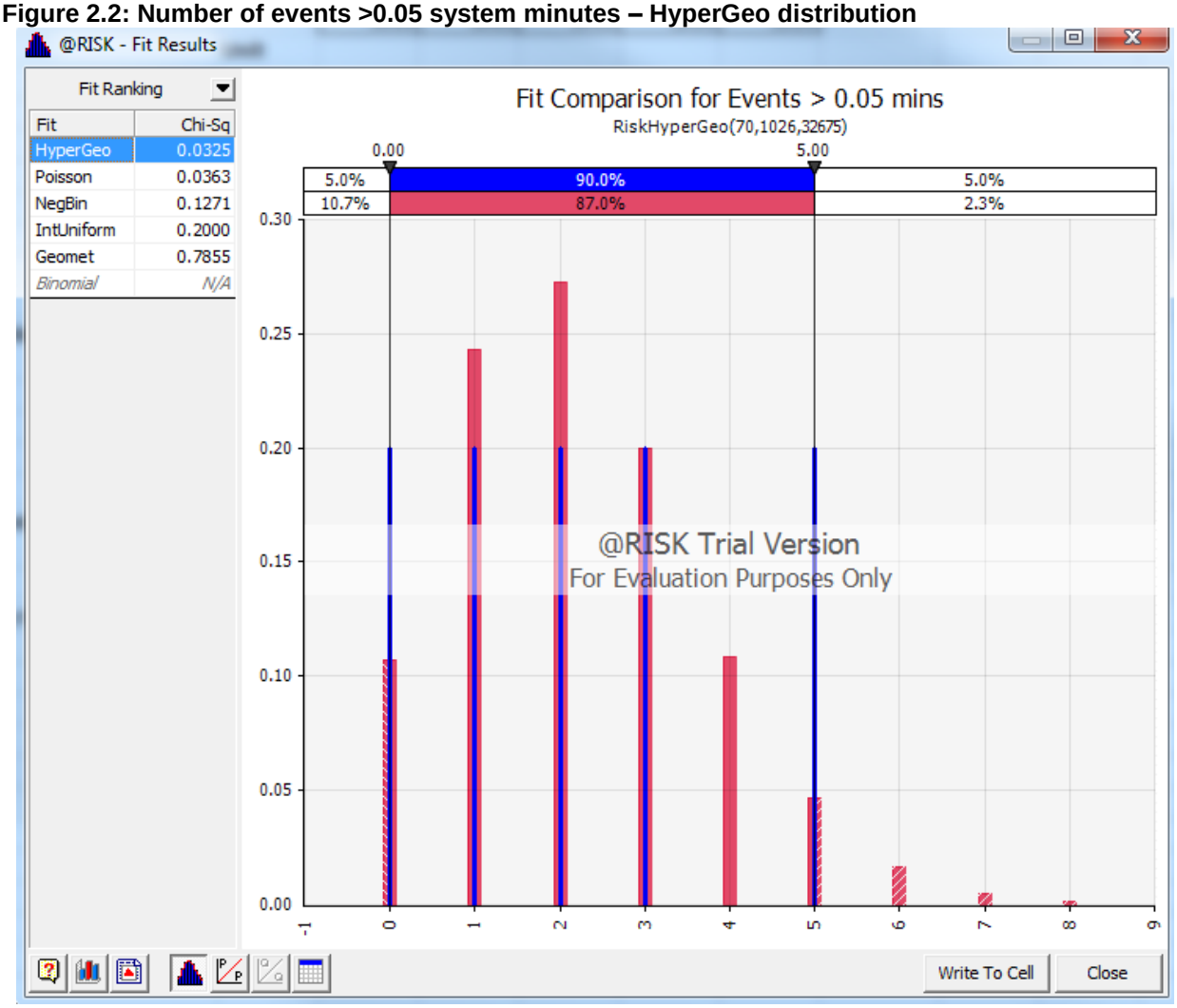
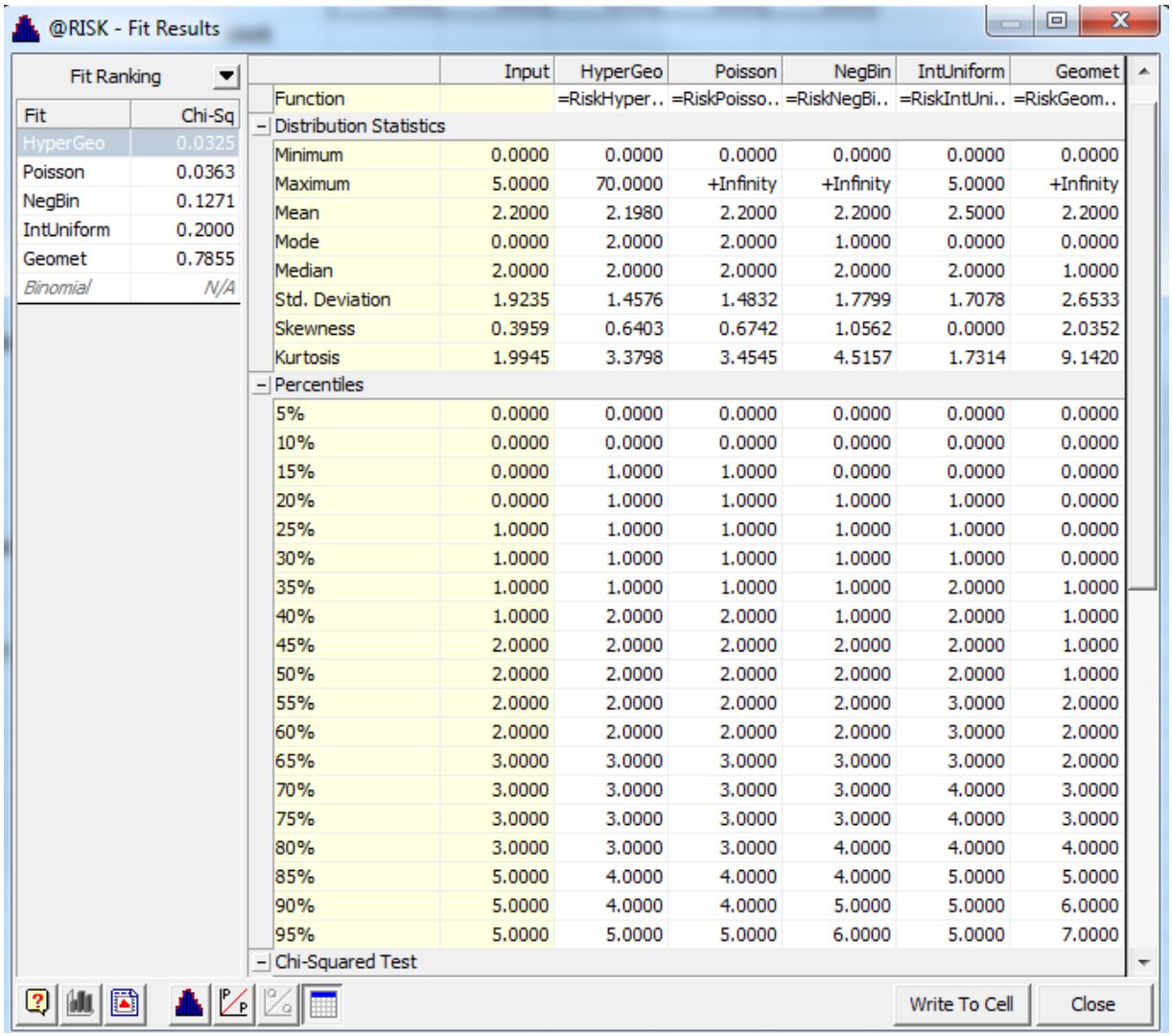


Figure 2.3: Number of events >0.05 system minutes – statistics table



	Input	HyperGeo	Poisson	NegBin	IntUniform	Geomet
Function		=RiskHyper..	=RiskPoisso..	=RiskNegBi..	=RiskIntUni..	=RiskGeom..
Distribution Statistics						
Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	5.0000	70.0000	+Infinity	+Infinity	5.0000	+Infinity
Mean	2.2000	2.1980	2.2000	2.2000	2.5000	2.2000
Mode	0.0000	2.0000	2.0000	1.0000	0.0000	0.0000
Median	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000
Std. Deviation	1.9235	1.4576	1.4832	1.7799	1.7078	2.6533
Skewness	0.3959	0.6403	0.6742	1.0562	0.0000	2.0352
Kurtosis	1.9945	3.3798	3.4545	4.5157	1.7314	9.1420
Percentiles						
5%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15%	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000
20%	0.0000	1.0000	1.0000	1.0000	1.0000	0.0000
25%	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000
30%	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000
35%	1.0000	1.0000	1.0000	1.0000	2.0000	1.0000
40%	1.0000	2.0000	2.0000	1.0000	2.0000	1.0000
45%	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000
50%	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000
55%	2.0000	2.0000	2.0000	2.0000	3.0000	2.0000
60%	2.0000	2.0000	2.0000	2.0000	3.0000	2.0000
65%	3.0000	3.0000	3.0000	3.0000	3.0000	2.0000
70%	3.0000	3.0000	3.0000	3.0000	4.0000	3.0000
75%	3.0000	3.0000	3.0000	3.0000	4.0000	3.0000
80%	3.0000	3.0000	3.0000	4.0000	4.0000	4.0000
85%	5.0000	4.0000	4.0000	4.0000	5.0000	5.0000
90%	5.0000	4.0000	4.0000	5.0000	5.0000	6.0000
95%	5.0000	5.0000	5.0000	6.0000	5.0000	7.0000
Chi-Squared Test						

2.4 Updated recommendations

2.4.1 Use of Poisson distribution instead of IntUniform

In the last TRR, the AER rejected the proposal to use the IntUniform distribution for the 'number of events >0.3 system minutes' indicator and instead preferred to use the Poisson distribution. The IntUniform distribution is again the distribution that best fit the performance data in the original version of this report.

In order to be consistent with the last determination, it is now recommended that the Poisson distribution is adopted for both this parameter, and also the 'Incorrect operational isolation of primary or secondary equipment' parameter, which also led to the IntUniform parameter being recommended in the initial report. The distribution fit analysis using the Poisson distribution for both of these parameters is included below.

Figure 2.4 Number of events >0.30 system minutes – Poisson distribution

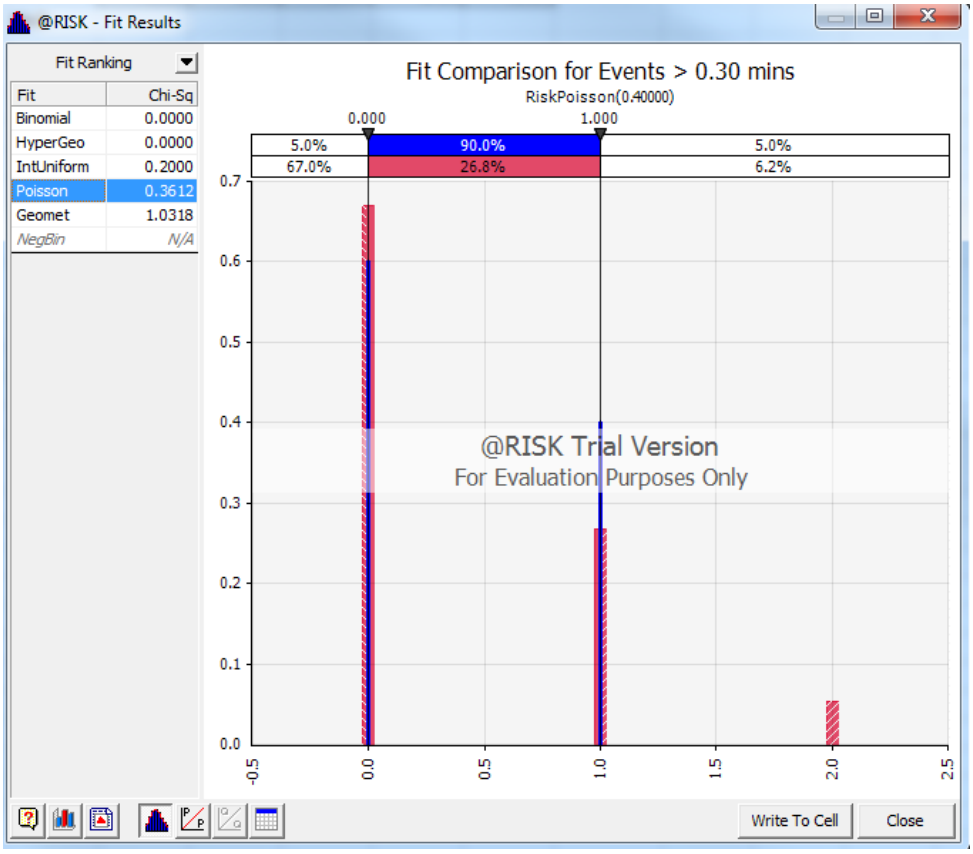
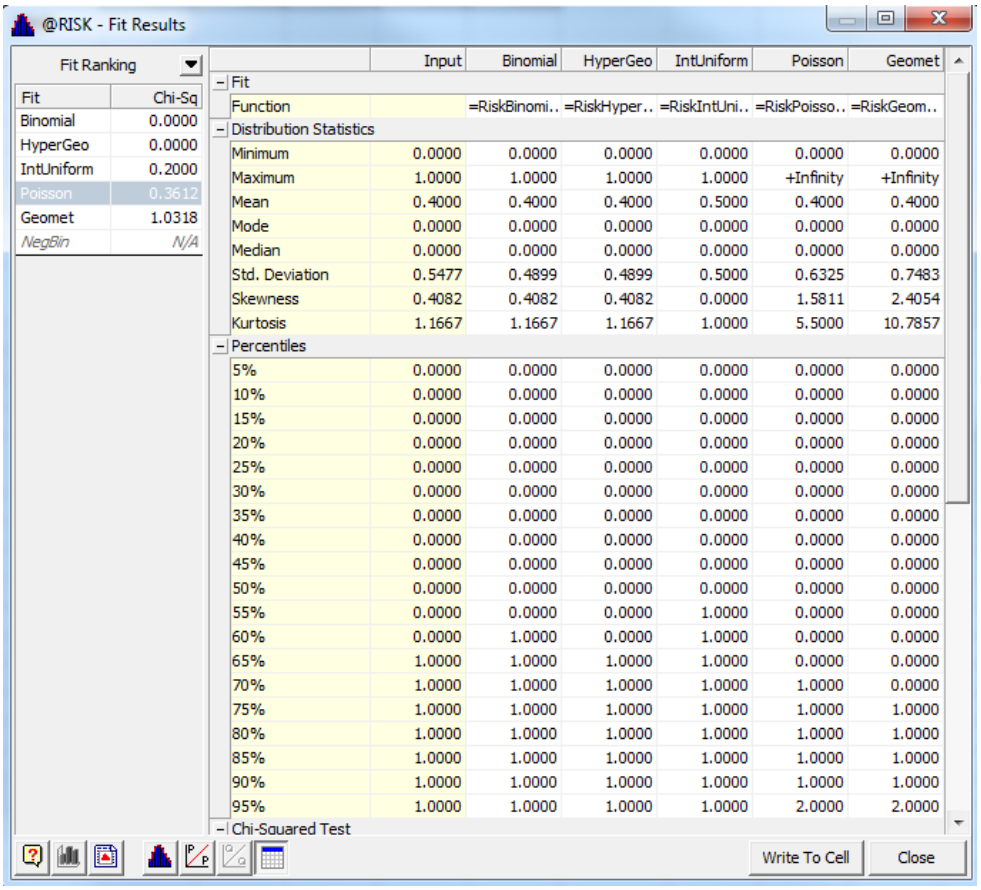


Figure 2.5 Number of events >0.30 system minutes – statistics table



	Input	Binomial	HyperGeo	IntUniform	Poisson	Geomet
Fit						
Function		=RiskBinomi..	=RiskHyper..	=RiskIntUni..	=RiskPoisso..	=RiskGeom..
Distribution Statistics						
Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Maximum	1.0000	1.0000	1.0000	1.0000	+Infinity	+Infinity
Mean	0.4000	0.4000	0.4000	0.5000	0.4000	0.4000
Mode	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Median	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Deviation	0.5477	0.4899	0.4899	0.5000	0.6325	0.7483
Skewness	0.4082	0.4082	0.4082	0.0000	1.5811	2.4054
Kurtosis	1.1667	1.1667	1.1667	1.0000	5.5000	10.7857
Percentiles						
5%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
25%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
30%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
35%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
40%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
45%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
50%	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
55%	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
60%	0.0000	1.0000	0.0000	1.0000	0.0000	0.0000
65%	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000
70%	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000
75%	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
80%	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
85%	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
90%	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
95%	1.0000	1.0000	1.0000	1.0000	2.0000	2.0000
Chi-Squared Test						

Figure 2.6: Incorrect operational isolation – Poisson distribution

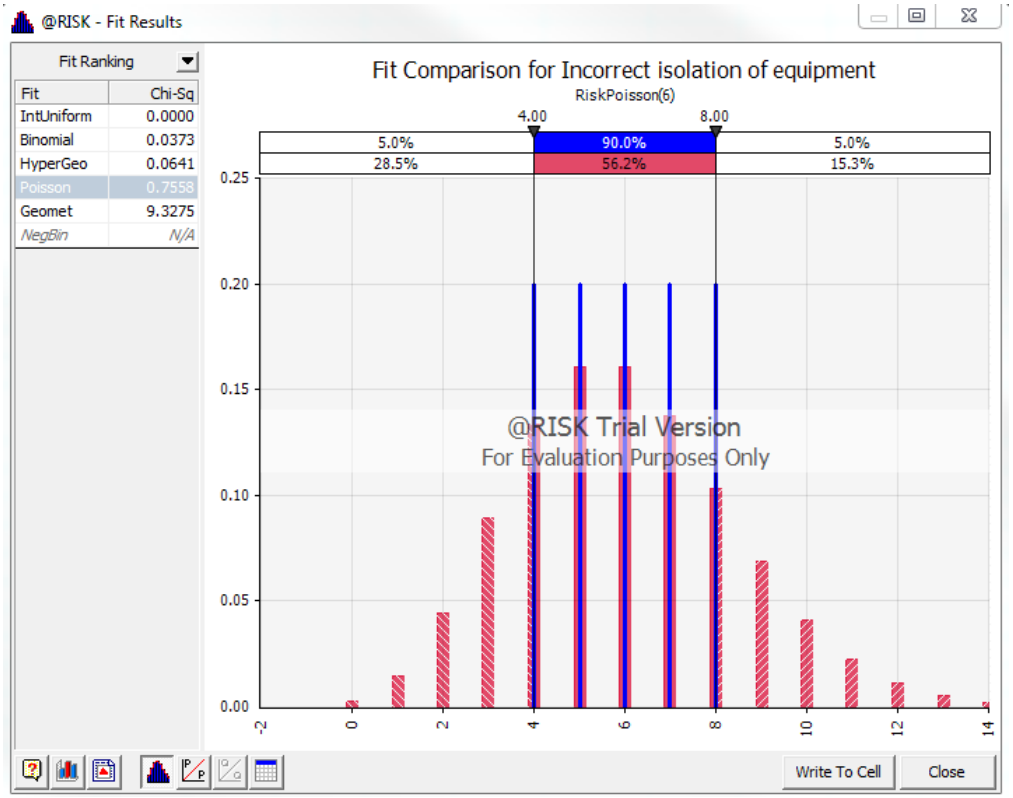
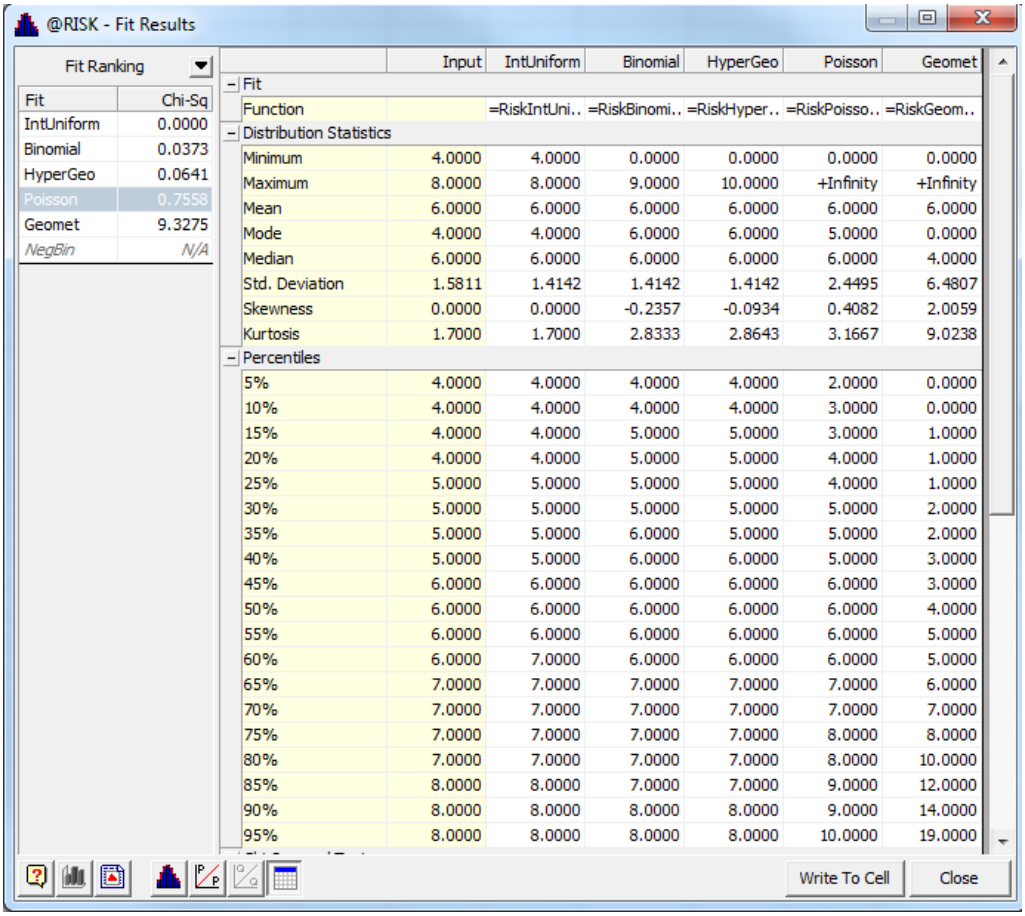


Figure 2.7: Incorrect operational isolation of equipment –statistics table



3 Addendum 28 October 2015

A second addendum was required to reflect the revision of some previously incorrectly stated data.

3.1 Correction of input data

3.1.1 Revised input data for parameter 'Failure of protection system'

The audit of AusNet Services' performance data resulted in changes to the input data for the 'Failure of protection system parameter' to reflect the AER's stated intent in the STPIS Version 5 final decision to include both protection and control systems in the scope of this sub-parameter.

Using the revised data, the recommended distribution has changed from the Hypergeometric distribution (standard deviation 4.9336) to the Poisson distribution (standard deviation 5.3666). The detailed results from this exercise are presented below.

Figure 3.1: Failure of protection system – Poisson distribution

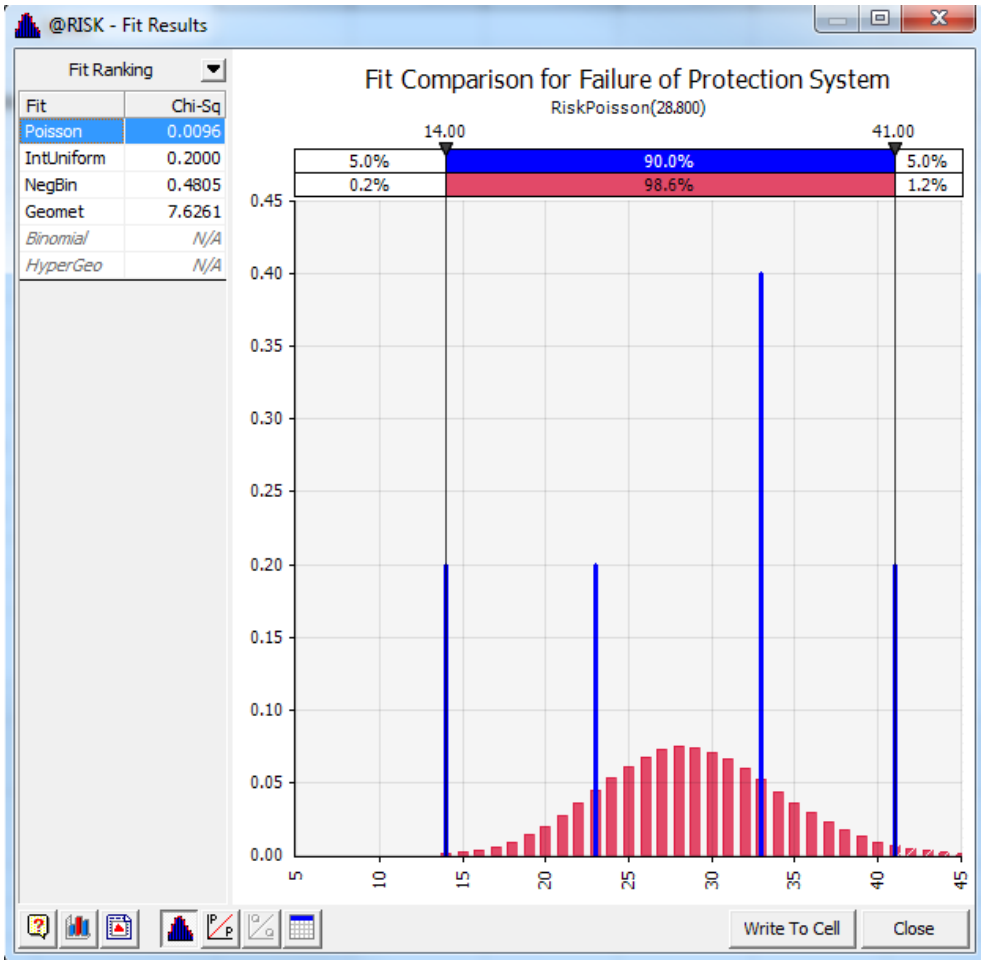


Figure 3.2: Failure of protection system – statistics table