Fitting probability distributions to reliability data for calculation of STPIS values

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ElectraNet

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Contents

Appendices

1. Introduction

Parsons Brinckerhoff was engaged by ElectraNet to assist with the determination of suitable targets and other attributes for the parameters of its service target performance incentive scheme (STIPS).

The service component of ElectraNet's STIPS will measure performance against the following parameters:

- Transmission circuit availability
- Average outage duration
- Loss of supply event frequency.

Parsons Brinckerhoff calculated the proposed performance targets, caps and collars for this scheme based on ElectraNet's reliability data from the past five years 2007-2011.

1.1 Approach

Parsons Brinckerhoff used the @RISK product, a risk analysis and simulation add-in tool for Microsoft Excel, to determine the type of probability distribution that best fit the reliability data.

Two key fit statistics were used to measure how well the distribution functions fit the input data, the Kolmogorov-Smirnov (K-S) and the Anderson-Darling (A-D) fit statistic. The K-S fit statistic focuses on the differences between the middle of the fitted distribution and the input data. The A-D fit statistic focuses on the difference between the tails of fitted distribution and input data. Where the input data was concentrated around the middle of a distribution curve the K-S fit statistic was used and where the data was near the tails the A-D fit statistic was used. The results from both were compared in each case.

Where the input data was both in the middle and the tails of a distribution, the result from the A-D fit statistic was favoured, because the best fit of the data and the distribution curve at the tails improves the calculation of the scheme measures (caps and collars at two standard deviations).

Once the distribution function of best fit was determined for each parameter the target, caps and collars were calculated from the mean and standard deviation of the distribution function.

2. Results of distribution fitting

2.1 Transmission circuit availability

Availability

The Availability data is spread across both the middle and tails of the distribution. The best fit distribution for the Availability data using the A-D fit statistic was a normal distribution (Figure 1). This was also confirmed using the K-S fit statistic (Figure 2).

Figure 1 Availability - distribution fit comparison using A-D fit statistic

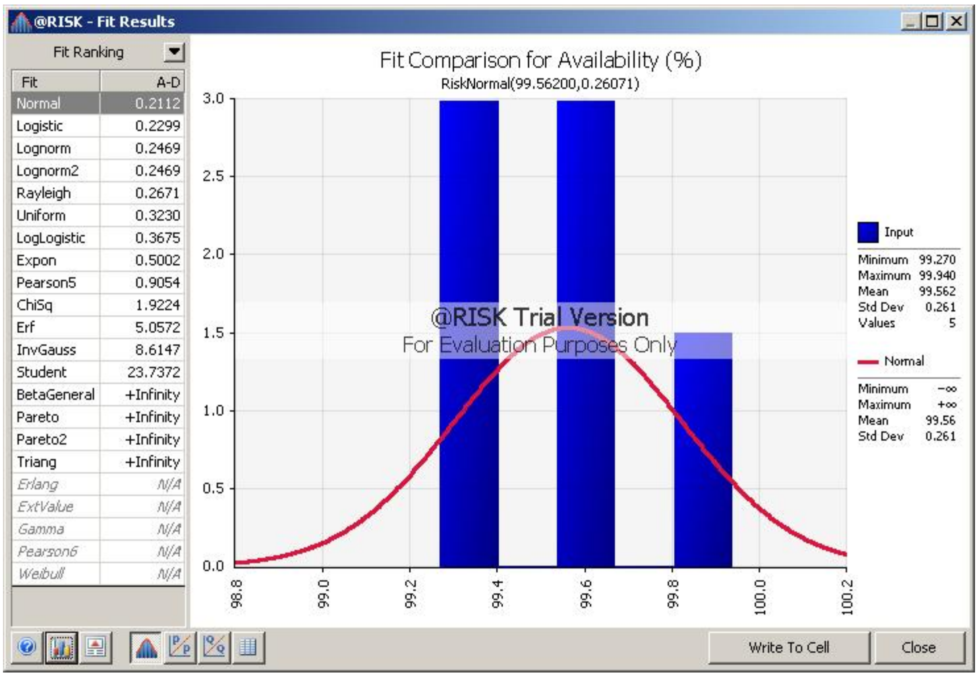
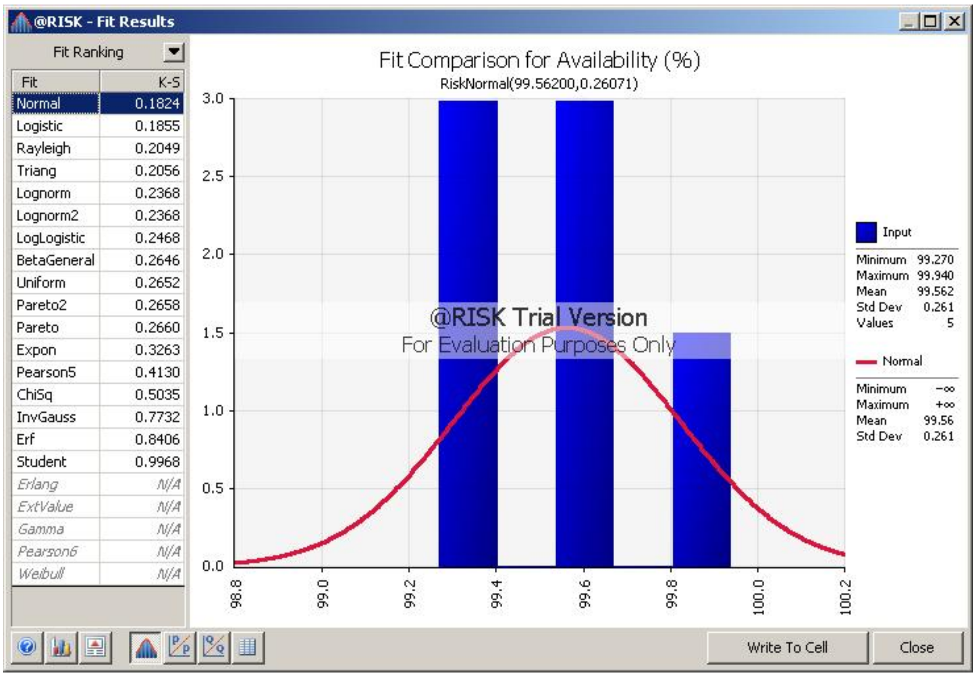


Figure 2 Availability – distribution fit comparison using K-S fit statistic



Availability Critical Peak

The Availability Critical Peak data is spread across both the middle and tails of the distribution. The best fit distribution for the Availability Critical Peak data using both the A-D and the K-S fit statistic was a logistic distribution (Figure 3 and Figure 4). The second best fit distribution is a normal distribution for both fit statistics. However, given that the best fit distribution for both the Availability and Availability Critical Non Peak data is a normal distribution and that the difference between the fit ranking of the logistic and normal distribution is small, for consistency a normal distribution has also been chosen for the Availability Critical Peak data.

Figure 3 Availability Critical Peak – distribution fit comparison using A-D

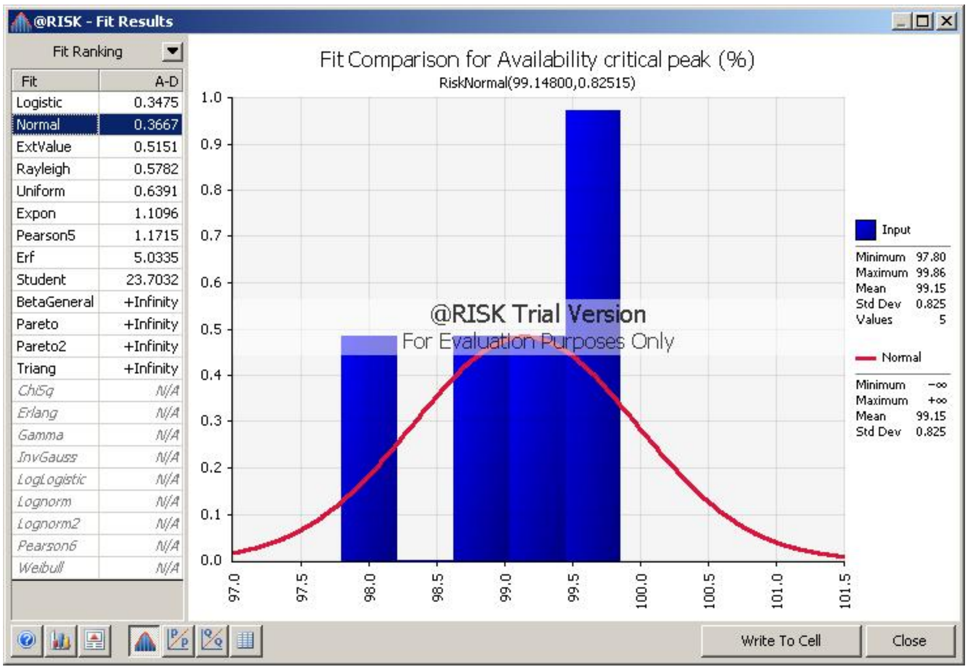
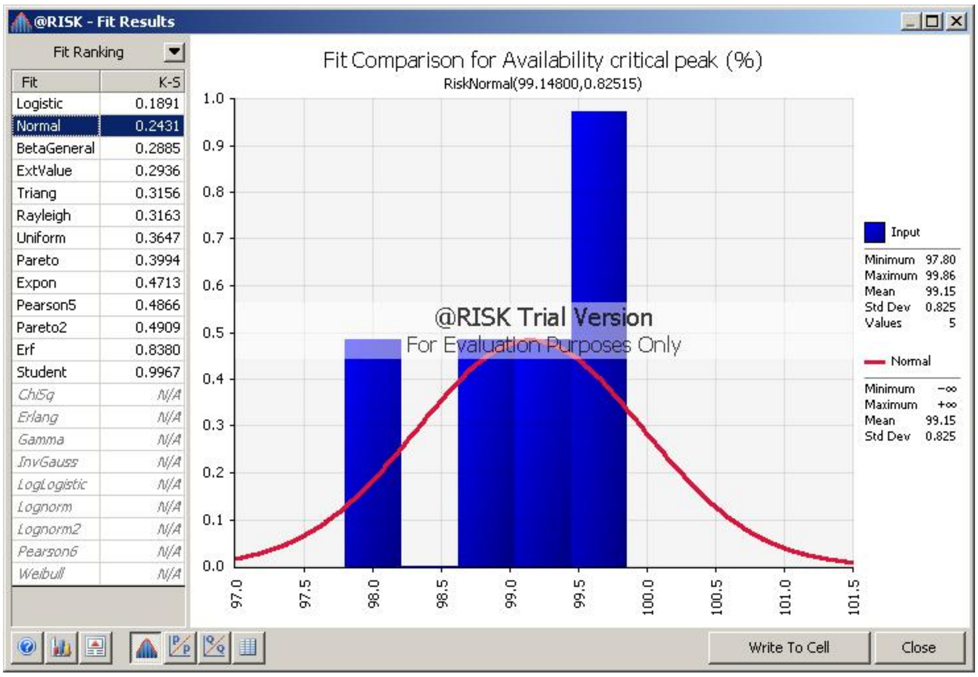


Figure 4 Availability Critical Peak – distribution fit comparison using K-S



Availability Critical Non Peak

The Availability Critical Non Peak data is spread across both the middle and tails of the distribution. The best fit distribution for the Availability Critical Non Peak data using the A-D fit statistic was a normal distribution (Figure 5). This was also confirmed using the K-S fit statistic (Figure 6).

Figure 5 Availability Critical Non Peak – distribution fit comparison using A-D

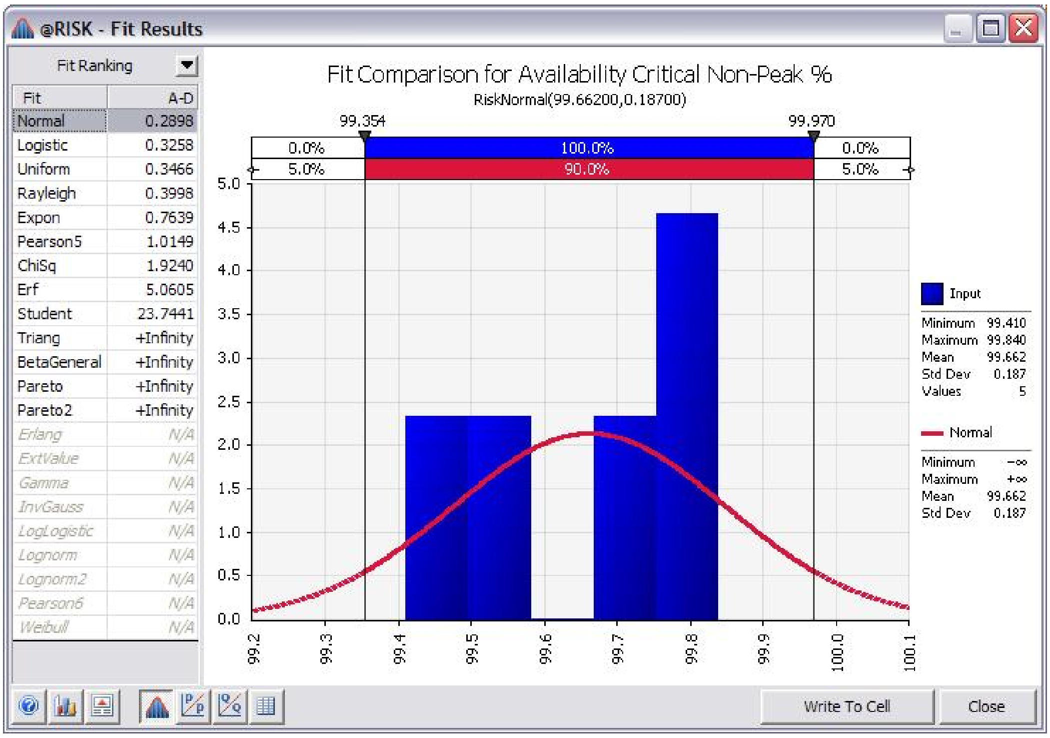
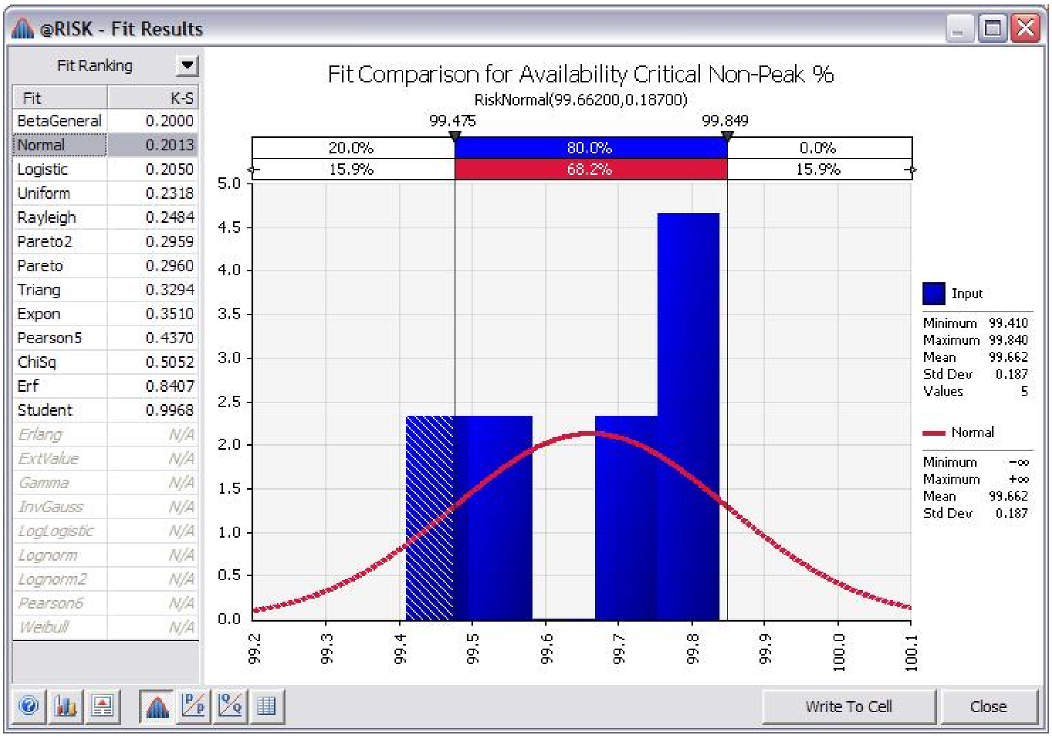


Figure 6 Availability Critical Non Peak – distribution fit comparison using K-S



2.2 Average outage duration

The Average Outage Duration data is spread across both the middle and tails of the distribution. The best fit distribution for the Average Outage Duration data using the A-D fit statistic was a normal distribution (Figure 7).

Using the K-S fit statistic a uniform and then beta-general distribution had marginally better fits (Figure 8). The beta-general distribution is disregarded, because it does not converge in the A-D fit statistic, indicating a poor fit in the tail of the distribution. The uniform and normal distributions are similar fits to the data from both the K-S and A-D fit statistic. The normal distribution has been chosen, because it has the best fit according to the A-D fit statistic, which approximates the tails of the data better, where we calculate the caps and collars for the scheme measures.

Figure 7 Average Outage Duration – distribution fit comparison using A-D

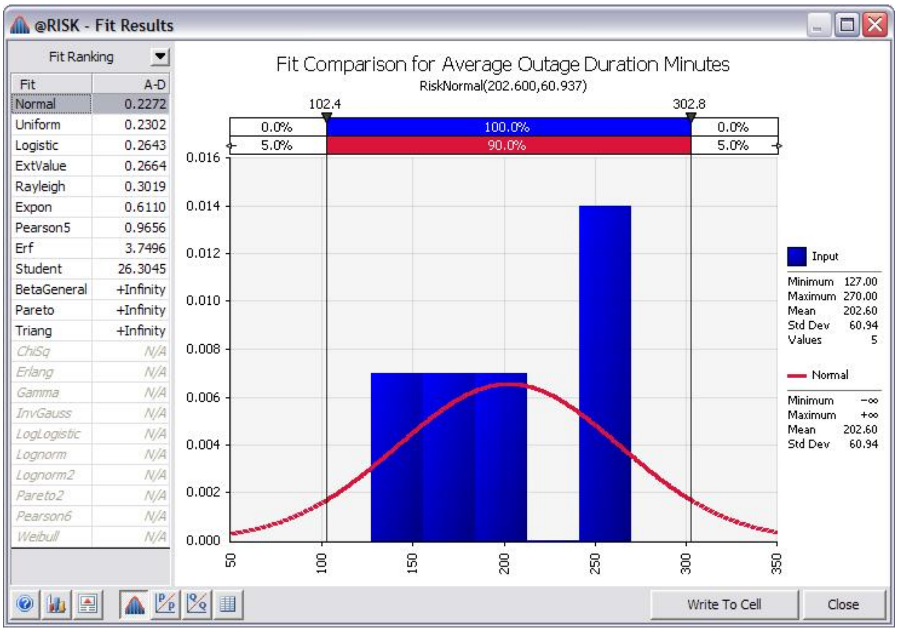
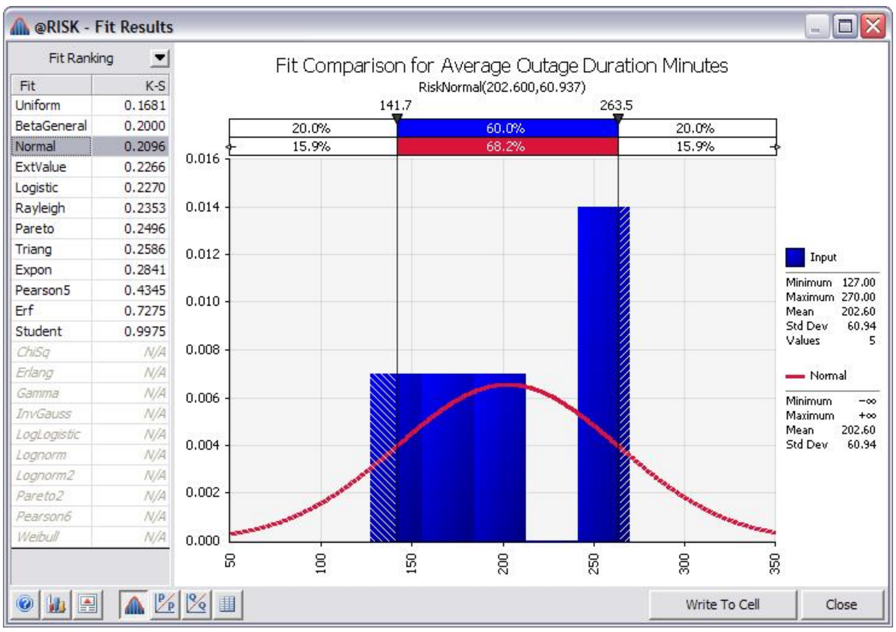


Figure 8 Average Outage Duration – distribution fit comparison using K-S



2.3 Loss of supply event frequency

Number of Events > 0.2 System Minutes

The No. of Events > 0.2 System Minutes data is located near to the middle and at the tail of the distribution. The exponential distribution was disregarded as it does not allow for a performance of zero events, which is an obvious potential outcome of actual performance. Hence, the best fit distribution using the A-D fit statistic was a logistic distribution (Figure 9). This was also confirmed using the K-S fit statistic (Figure 10).

Figure 9 No. of Events > 0.2 System min – distribution fit comparison using A-D

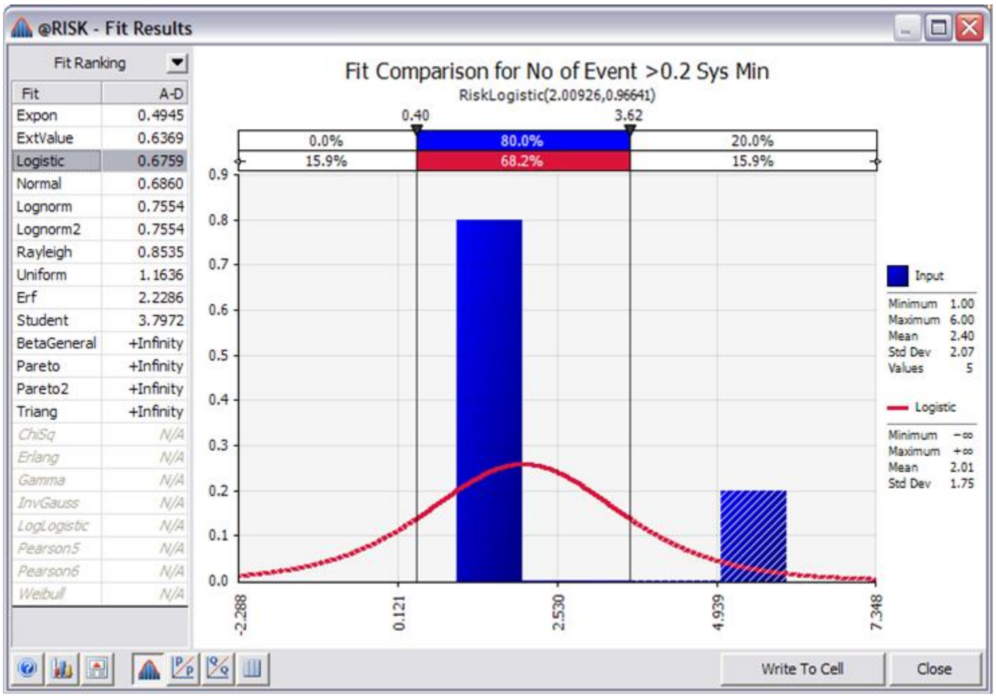
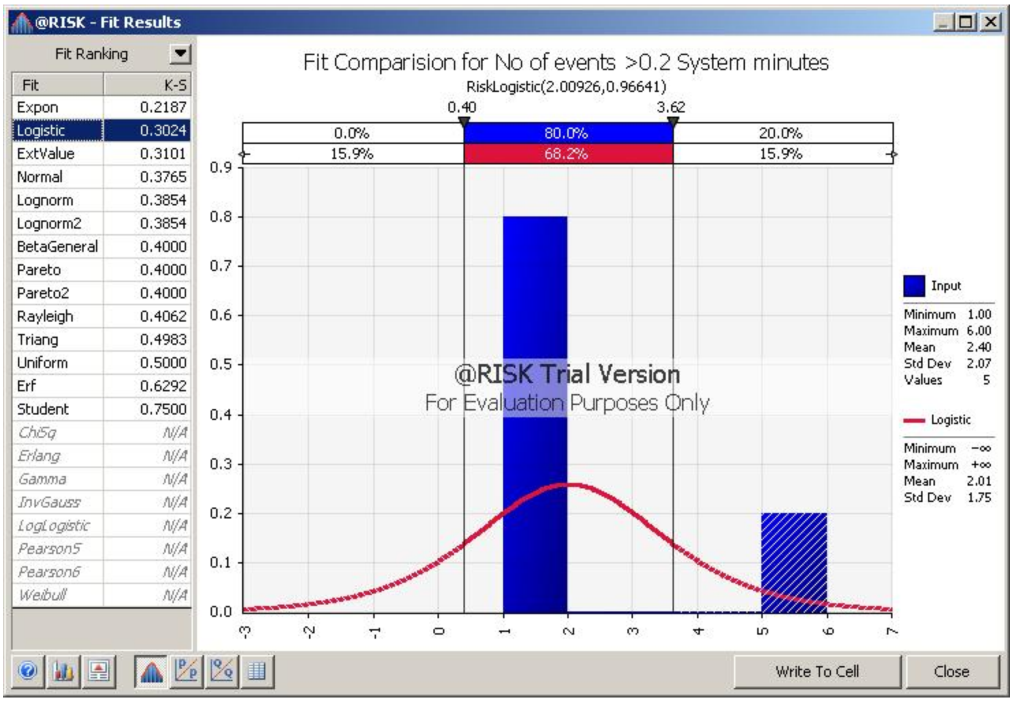


Figure 10 No. of Events > 0.2 System min – distribution fit comparison using K-S



Number of Events > 0.05 System Minutes

The No. of Events > 0.05 System Minutes data is located in the middle and tails of the distribution. The best fit distribution using the A-D fit statistic was a normal distribution (Figure 11), while the best fit distribution using the K-S fit statistic was a logistic distribution (Figure 12). Given that the data for the Number of Events > 0.2 System Minutes and > 0.05 System Minutes are subsets of the same data set, the logistic distribution has been chosen for consistency.

Figure 11 No. of Events > 0.05 Sys min – distribution fit comparison using A-D

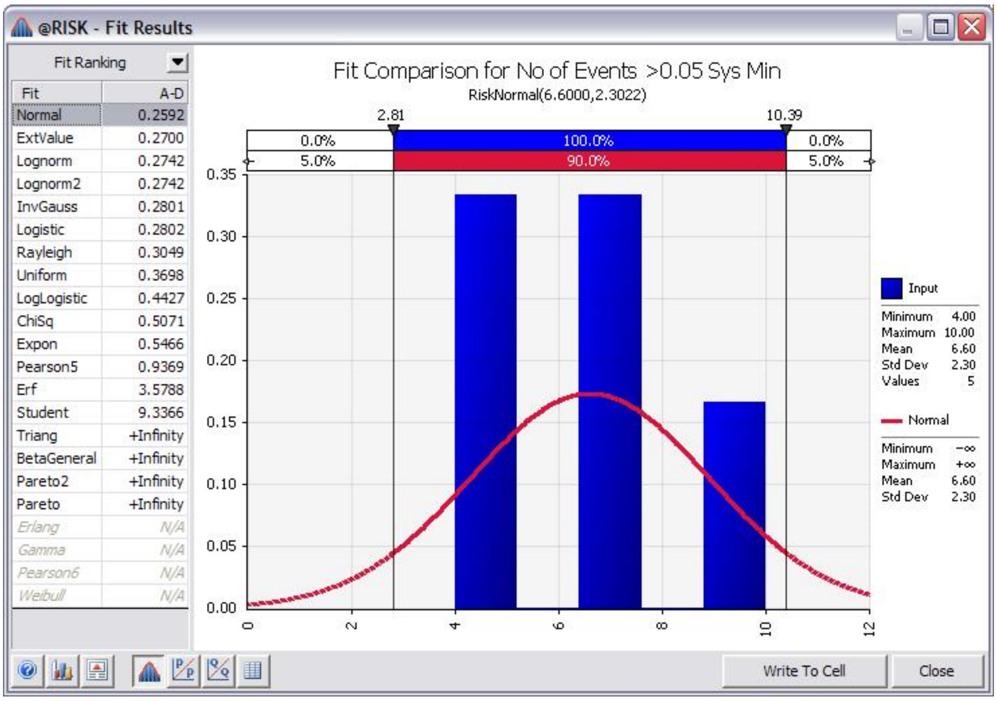
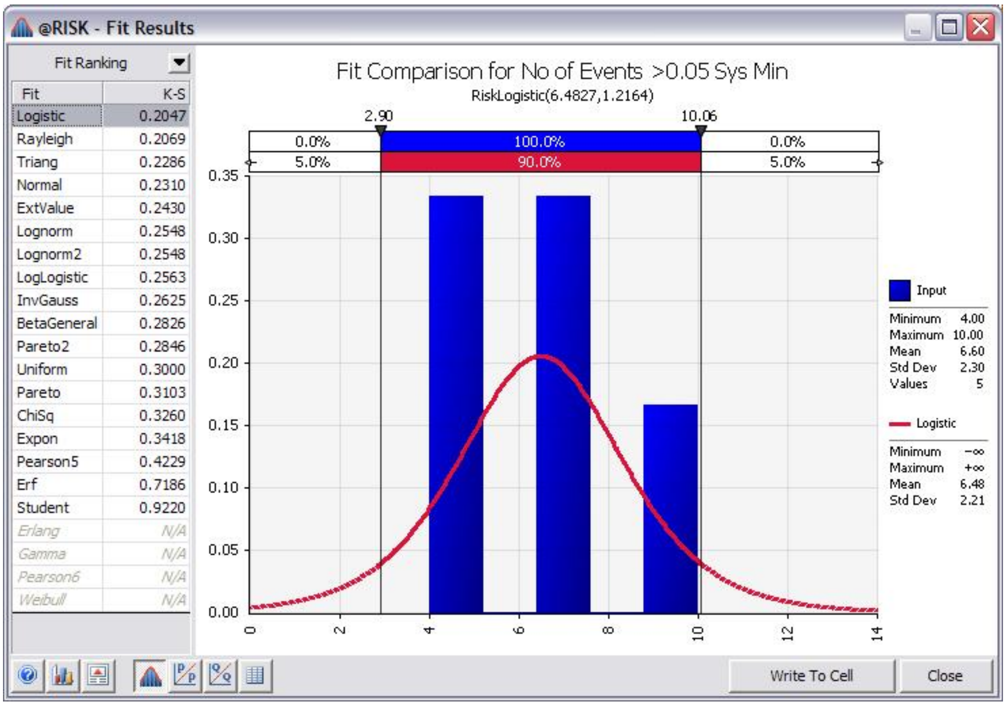


Figure 12 No. of Events > 0.05 Sys min – distribution fit comparison using K-S



2.4 Summary of findings

The following table summarises the distribution functions that have been chosen to best fit the parameter data. In Parsons Brinckerhoff's view this approach is robust and does not seem to be sensitive to the choice of distribution function, because the results were close for the next best fit distributions. The approach is also consistent with the Australian Energy Regulator's (AER) previous decision for ElectraNet to use a curve of best fit approach.

Table 1 Summary of best fit distributions

Parameter	Best fit distribution
Availability (%)	Normal
Availability Critical Peak (%)	Normal
Availability Critical Non Peak (%)	Normal
Average Outage Duration (Minutes)	Normal
No of events >0.2 System minutes	Logistic
No of events >0.05 System minutes	Logistic

3. Outcomes for scheme measures

The target (mean of sample), caps and collars were calculated from the mean and standard deviation of the chosen best fit distribution function for each parameter.

Table 2 Target (mean), cap and collar calculated from best fit distribution

Parameter	Mean of sample	Mean of distribution	SD	cap at 1SD	cap at 2SD	collar at 1SD	collar at 2SD
Availability (%)	99.56	99.56	0.261	99.82	100.08	99.30	99.04
Availability Critical Peak (%)	99.15	99.15	0.825	99.97	100.80	98.32	97.50
Availability Critical Non Peak (%)	99.66	99.66	0.187	99.85	100.04	99.47	99.29
Average Outage Duration (Minutes)	202.60	202.60	60.94	141.66	80.73	263.54	324.47
No of events >0.2 System minutes	2.40	2.01	1.75	0.65	-	4.15	-
No of events >0.05 System minutes	6.60	6.48	2.21	4.39	-	8.81	-

Appendix A

2007-11 Reliability Data

Input Reliability Data

	2007	2008	2009	2010	2011
Availability (%)	99.37	99.27	99.94	99.64	99.59
Availability Critical Peak (%)	99.03	97.80	99.86	99.75	99.30
Availability Critical Non Peak (%)	99.53	99.82	99.84	99.71	99.41
Average Outage Duration (Minutes)	270	199	161	127	256
No of events >0.2 System minutes	2	1	2	6	1
No of events >0.05 System minutes	7	5	4	10	7
Market Impact Parameter	2427	1834	515	1789	1375