

AusNet Transmission Group Pty Ltd

Transmission Revenue Review 2017-2022

Revised Revenue Proposal

Appendix 8A: Fitting probability distributions to Service Component data

Submitted: 21 September 2016





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Fitting probability distributions to Service Component data

Updated for 2015 data

Submitted: 21 September 2016



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Table of Contents

1	Service Component Parameters	4
1.1	Service parameter 1 – Average circuit outage rate	5
1.2	Service parameter 2 – Loss of supply event frequency	12
1.3	Service parameter 3 – Average outage duration	14
1.4	Service parameter 4 – Proper operation of equipment	15

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 8.3 of the Revised 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 the Draft Decision and in recent determinations for TransGrid and TasNetworks. The distributions and caps and collars have been revised since the AusNet Services' Revenue Proposal to take account of 2015 actual data, which was unavailable at the time. Consistent with the requirements of the STPIS, the caps and collars set out in this document are based on the five most recent years of performance data (2011-15).

In the Draft Decision, the AER disagreed with AusNet Services' preference to adopt distributions based on the Anderson-Daring (A-D) fit statistics test where the data was more skewed to the tails of the preferred distribution. Instead, the AER relied solely on the Kolmogorov-Smirnov (K-S) method of fitting probability distributions. For this Revised Revenue Proposal, AusNet Services has followed the AER's preferred method of using only the K-S method to determine the most appropriate distribution.

For the loss of supply event frequency parameters (>0.05 and >0.30 system minutes) performance data is not conducive to statistical analysis. This is due to the small number of events usually, but not always, recorded in any one year of a five year data series. To align with the Draft Decision and to ensure consistency between the two indicators, the Poisson distribution has been used to set caps and collars for these sub-parameters.

Similarly, caps and collars for the proper operation of equipment sub-parameters have been derived using the Poisson distribution. This is again due to the nature of the performance data not lending itself well to fitting probability distributions. As these are all indicators with discrete values, AusNet Services has adopted the Poisson distribution which has been used for the other discrete distributions in the Service Component (the loss of supply event frequency distributions).

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

Parameter	Preferred Distribution	5th percentile	95th percentile
Line outage rate (fault)	Weibull	0.1597	0.3381
Line outage rate (forced)	Weibull	0.1233	0.1705
Reactive plant outage rate (fault)	Pearson5	0.1840	0.6117
Reactive plant outage rate (forced)	Weibull	0.1989	0.4068
Transformer outage rate (fault)	Weibull	0.0916	0.3177
Transformer outage rate (forced)	Weibull	0.0610	0.1440
Number of events >0.05 system minutes	Poisson	0.0000	5.0000
Number of events >0.30 system minutes	Poisson	0.0000	2.0000
Average outage duration	Lognormal	3.3786	334.2004
Failure of protection equipment	Poisson	23.0000	42.0000
Material failure of SCADA system	Poisson	0.0000	4.0000
Incorrect operational isolation of primary or secondary equipment	Poisson	2.0000	10.0000

Table 1.1: Summary of probability distributions and percentiles

The remainder of this document sets out the underlying data which supports AusNet Services' proposed distributions, caps and collars.

1.1 Service parameter 1 – Average circuit outage rate

1.1.1 Lines outage rate – fault (continuous)

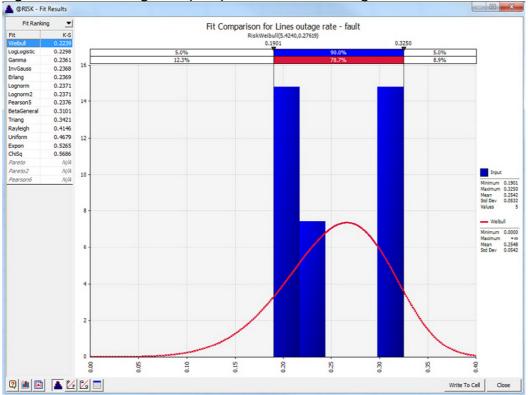


Figure 1.1: Lines outage rate (fault) – distribution fit using K-S

Figure 1.2: Lines outage rate (fault) - s	statistics table using K-S
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Fit Ranking	•		Input	Weibull	LogLogistic	Gamma	InvGauss	Erlang	Lognorm	Lognorm2	Pearson5	BetaGeneral	Triang	
it	K-S	- Fit												
	0.2239	Function		RiskWeibu :	=RiskLogLo =	RiskGamm =	RiskInvGa =	RiskErlang =	=RiskLogno :	=RiskLogno	=RiskPears	=RiskBetaG =	RiskTriang	=Ri
LogLogistic	0.2298	 Distribution Statistic 												
Gamma	0.2361	Minimum	0.1901	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
InvGauss	0.2368	Maximum	0.3250	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	0.3250	0.3250	
	0.2368	Mean	0.2542	0.2548	0.2553	0.2542	0.2542	0.2542	0.2543	0.2543	0.2544	0.2638	0.2167	
Erlang		Mode	0.2069 [est]	0.2660	0.2395	0.2431	0.2377	0.2432	0.2379	0.2379	0.2331	0.3250	0.3250	
Lognorm	0.2371	Median	0.2437	0.2581	0.2480	0.2505	0.2487	0.2506	0.2487	0.2487	0.2469	0.2925	0.2298	
Lognorm2	0.2371	Std. Deviation	0.0595	0.0542	0.0634	0.0532	0.0539	0.0530	0.0541	0.0541	0.0556	0.0703	0.0766	
Pearson5	0.2376	Skewness	0.1568	-0.3091	1.3142	0.4187	0.6363	0.4170	0.6479	0.6479	0.9173	-1.3521	-0.5657	
BetaGeneral	0.3101	Kurtosis	1.3524	2.9455	9.0549	3.2630	3.6748	3.2609	3.7555	3.7555	4.6451	4.0811	2.4000	
Triang	0.3421	- Percentiles												
Rayleigh	0.4146	5%	0.1901	0.1597	0.1681	0.1735	0.1761	0.1738	0.1759	0.1759	0.1781	0.1098	0.0727	
Uniform	0.4679	10%	0.1901	0.1824	0.1856	0.1889	0.1900	0.1891	0.1899	0.1899	0.1908	0.1537	0.1028	
Expon	0.5265	15%	0.1901	0.1976	0.1972	0.1997	0.2000	0.2000	0.2000	0.2000	0.2001	0.1851	0.1259	
ChiSq	0.5686	20%	0.1901	0.2095	0.2065	0.2087	0.2083	0.2089	0.2083	0.2083	0.2079	0.2098	0.1453	
Pareto	N/A	25%	0.2066	0.2195	0.2145	0.2166	0.2157	0.2168	0.2158	0.2158	0.2150	0.2300	0.1625	
Pareto2	N/A	30%	0.2066	0.2284	0.2218	0.2239	0.2226	0.2240	0.2227	0.2227	0.2216	0.2469	0.1780	
Pearson6	N/A	35%	0.2066	0.2365	0.2286	0.2307	0.2293	0.2308	0.2293	0.2293	0.2279	0.2612	0.1923	
		40%	0.2066	0.2440	0.2351	0.2374	0.2357	0.2375	0.2358	0.2358	0.2342	0.2733	0.2055	
		45%	0.2437	0.2512	0.2416	0.2440	0.2422	0.2440	0.2422	0.2422	0.2405	0.2837	0.2180	
		50%	0.2437	0.2581	0.2480	0.2505	0.2487	0.2506	0.2487	0.2487	0.2469	0.2925	0.2298	
		55%	0.2437	0.2650	0.2547	0.2572	0.2553	0.2572	0.2553	0.2553	0.2535	0.3000	0.2410	
		60%	0.3058	0.2718	0.2617	0.2641	0.2623	0.2641	0.2623	0.2623	0.2605	0.3063	0.2517	
		65%	0.3058	0.2787	0.2692	0.2714	0.2697	0.2714	0.2697	0.2697	0.2680	0.3114	0.2620	
		70%	0.3058	0.2858	0.2774	0.2792	0.2777	0.2791	0.2777	0.2777	0.2762	0.3156	0.2719	
		75%	0.3058	0.2933	0.2868	0.2878	0.2867	0.2877	0.2866	0.2866	0.2854	0.3189	0.2815	
		80%	0.3058	0.3015	0.2979	0.2976	0.2969	0.2974	0.2969	0.2969	0.2962	0.3214	0.2907	
		85%	0.3250	0.3108	0.3119	0.3093	0.3093	0.3091	0.3093	0.3093	0.3094	0.3232	0.2996	
		90%	0.3250	0.3221	0.3316	0.3244	0.3257	0.3241	0.3256	0.3256	0.3272	0.3243	0.3083	
		95%	0.3250	0.3381	0.3660	0.3476	0.3513	0.3473	0.3515	0.3515	0.3561	0.3249	0.3168	
		- Chi-Squared Test	0.0200	0.0001	0.0000	0.0170	0.0010	0.5175	0.0010	0.0010	0.0001	0.0210	0.5100	
		Chi-Sq Statistic		0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	-
		P-Value		0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	
		Cr. Value @ 0.250		2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	
		Cr. Value @ 0.100		2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	
		Cr. Value @ 0.050		3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	
		Cr. value @ 0.050		3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	5.0415	
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1.1.2 Lines outage rate - forced (continuous)

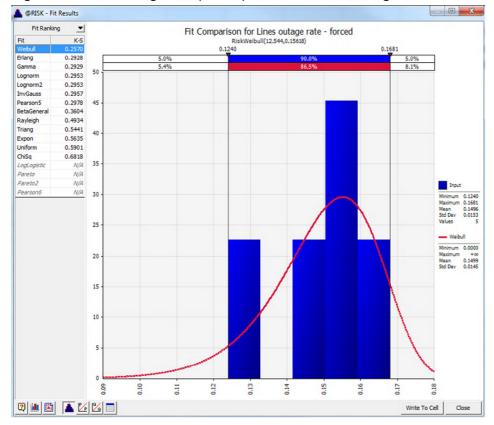


Figure 1.3: Lines outage rate (forced) – distribution fit using K-S

Fit Rankin	ng 💌		Input	Weibull	Erlang	Gamma	Lognorm	Lognorm2	InvGauss	Pearson5 8	BetaGeneral	
Fit	K-S	- Fit										
Vebul	0.2570	Function		RiskWeibu	=RiskErlang =	RiskGamm :	=RiskLogno	=RiskLogno	=RiskInvGa =	=RiskPears =	RiskBetaG	=R
Frlang	0.2928	- Distribution Statistic										
Samma	0.2929	Minimum	0.1240	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Lognorm	0.2953	Maximum	0.1681	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	0.1681	
.ognorm2	0.2953	Mean	0.1496	0.1499	0.1496	0.1496	0.1496	0.1496	0.1496	0.1496	0.1508	
InvGauss	0.2955	Mode	0.1559 [est]	0.1551	0.1479	0.1479	0.1471	0.1471	0.1470	0.1462	0.1681	
Pearson5	0.2937	Median	0.1570	0.1517	0.1490	0.1490	0.1487	0.1487	0.1487	0.1484	0.1598	
BetaGeneral	0.3604	Std. Deviation	0.0171	0.0145	0.0157	0.0157	0.0159	0.0159	0.0159	0.0162	0.0219	
Rayleigh	0.4934	Skewness	-0.5605	-0.7270	0.2097	0.2095	0.3206	0.3206	0.3193	0.4393	-1.9013	
Triang	0.4934	Kurtosis	2.0267	3.8139	3.0659	3.0659	3.1833	3.1833	3.1699	3.3653	6.8792	
		- Percentiles										
Expon	0.5635	5%	0.1240	0.1233	0.1247	0.1247	0.1249	0.1249	0.1249	0.1250	0.1033	
		10%	0.1240	0.1305	0.1298	0.1299	0.1298	0.1298	0.1298	0.1298	0.1199	
ChiSq	0.6818	15%	0.1240	0.1351	0.1334	0.1334	0.1332	0.1332	0.1332	0.1331	0.1302	
LogLogistic	N/A	20%	0.1240	0.1386	0.1362	0.1362	0.1360	0.1360	0.1360	0.1358	0.1376	
Pareto	N/A	25%	0.1417	0.1414	0.1387	0.1387	0.1385	0.1385	0.1384	0.1382	0.1434	
Pareto2	N/A	30%	0.1417	0.1439	0.1410	0.1410	0.1407	0.1407	0.1407	0.1404	0.1480	
Pearson6	N/A	35%	0.1417	0.1460	0.1431	0.1431	0.1428	0.1428	0.1427	0.1425	0.1517	
		40%	0.1417	0.1480	0.1451	0.1451	0.1448	0.1448	0.1448	0.1445	0.1549	
		45%	0.1570	0.1499	0.1470	0.1470	0.1468	0.1468	0.1467	0.1465	0.1575	
		50%	0.1570	0.1517	0.1490	0.1490	0.1487	0.1487	0.1487	0.1484	0.1598	
		55%	0.1570	0.1534	0.1510	0.1510	0.1507	0.1507	0.1507	0.1505	0.1616	
		60%	0.1570	0.1551	0.1530	0.1530	0.1528	0.1528	0.1528	0.1526	0.1632	
		65%	0.1570	0.1568	0.1551	0.1551	0.1549	0.1549	0.1549	0.1548	0.1645	
		70%	0.1570	0.1585	0.1574	0.1574	0.1572	0.1572	0.1572	0.1571	0.1656	
		75%	0.1570	0.1603	0.1598	0.1598	0.1598	0.1598	0.1598	0.1597	0.1664	
	L.	80%	0.1570	0.1622	0.1626	0.1626	0.1626	0.1626	0.1626	0.1627	0.1671	
		85%	0.1681	0.1644	0.1658	0.1658	0.1660	0.1660	0.1660	0.1663	0.1675	
		90%	0.1681	0.1669	0.1700	0.1699	0.1704	0.1704	0.1704	0.1709	0.1679	
		95%	0.1681	0.1705	0.1762	0.1762	0.1771	0.1771	0.1771	0.1781	0.1680	
		- Chi-Squared Test										
		Chi-Sq Statistic		0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	1.8000	
		P-Value		0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.1797	
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	
		Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	
		Cr. Value @ 0.100		2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	
		Cr. Value @ 0.050		3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	3.8415	
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Figure 1.4: Lines outage rate (forced) – statistics table using K-S

1.1.3 Reactive plant outage - fault (continuous)

The @RISK software found the Pearson5 distribution is the most appropriate fit.

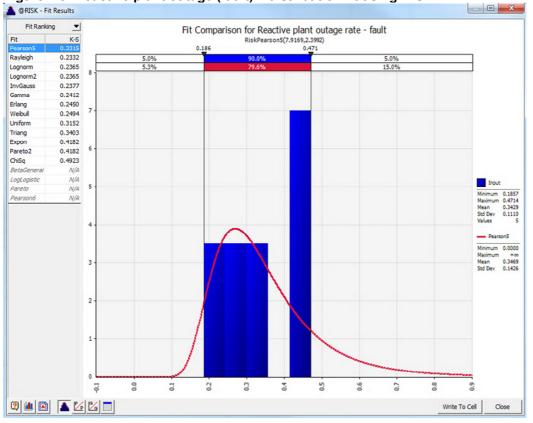


Figure 1.5: Reactive plant outage (fault) – distribution fit using K-S

Fit Ranking	•		Input	Pearson5	Rayleigh	Lognorm	Lognorm2	InvGauss	Gamma	Erlang	Weibull	Uniform
Fit	K-S	- Fit										
Pearson5	0.2315	Function		=RiskPears	=RiskRaylei	=RiskLogno	=RiskLogno	=RiskInvGa	=RiskGamm	=RiskErlang	=RiskWeibu =	RiskUnifor.
Rayleigh	0.2332	 Distribution Statistic 										
Lognorm	0.2365	Minimum	0.1857	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lognorm2	0.2365	Maximum	0.4714	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	0.5893
InvGauss	0.2303	Mean	0.3429	0.3469	0.3194	0.3441	0.3441	0.3429	0.3429	0.3429	0.3445	0.294€
	0.2377	Mode	0.2500 [est]	0.2691	0.2548	0.2852	0.2852	0.2819	0.3032	0.3048	0.3490	0.0000
Gamma		Median	0.3429	0.3163	0.3000	0.3232	0.3232	0.3219	0.3297	0.3302	0.3453	0.294
Erlang	0.2450	Std. Deviation	0.1241	0.1426	0.1669	0.1256	0.1256	0.1243	0.1166	0.1143	0.1069	0.1701
Weibull	0.2494	Skewness	-0.1304	1.9789	0.6311	1.1438	1.1438	1.0873	0.6801	0.6667	0.0055	0.0000
Uniform	0.3152	Kurtosis	1.4579	11.9052	3.2451	5.4129	5.4129	4.9703	3.6938	3.6667	2.7158	1.8000
Triang	0.3403	- Percentiles										
Expon	0.4182	5%	0.1857	0.1840	0.0816	0.1807	0.1807	0.1811	0.1761	0.1789	0.1668	0.0295
Pareto2	0.4182	10%	0.1857	0.2056	0.1170	0.2054	0.2054	0.2050	0.2045	0.2070	0.2040	0.0589
ChiSq	0.4923	15%	0.1857	0.2222	0.1453	0.2240	0.2240	0.2232	0.2253	0.2275	0.2302	0.0884
BetaGeneral	N/A	20%	0.1857	0.2367	0.1702	0.2400	0.2400	0.2389	0.2429	0.2449	0.2515	0.117
LogLogistic	N/A	25%	0.2571	0.2501	0.1933	0.2546	0.2546	0.2534	0.2587	0.2605	0.2700	0.147
Pareto	N/A	30%	0.2571	0.2631	0.2152	0.2685	0.2685	0.2672	0.2735	0.2750	0.2868	0.1768
Pearson6	N/A	35%	0.2571	0.2760	0.2365	0.2821	0.2821	0.2807	0.2878	0.2890	0.3023	0.2063
		40%	0.2571	0.2890	0.2576	0.2955	0.2955	0.2941	0.3017	0.3027	0.3170	0.2357
		45%	0.3429	0.3023	0.2786	0.3092	0.3092	0.3078	0.3156	0.3164	0.3313	0.2652
		50%	0.3429	0.3163	0.3000	0.3232	0.3232	0.3219	0.3297	0.3302	0.3453	0.294
		55%	0.3429	0.3311	0.3220	0.3232	0.3232	0.3219	0.3297	0.3445	0.3455	0.324
		60%	0.4571	0.3471	0.3450	0.3535	0.3535	0.3524	0.3595	0.3594	0.3732	0.353
		65%	0.4571	0.3648	0.3693	0.3704	0.3704	0.3694	0.3756	0.3752	0.3877	0.3830
		70%	0.4571	0.3847	0.3954	0.3891	0.3891	0.3881	0.3932	0.3924	0.4028	0.4125
		75%	0.4571	0.4078	0.4243	0.4103	0.4103	0.4094	0.4127	0.4115	0.4190	0.4420
		80%	0.4571	0.4358	0.4572	0.4353	0.4353	0.4345	0.4352	0.4335	0.4369	0.4714
		85%	0.4714	0.4716	0.4964	0.4664	0.4664	0.4655	0.4624	0.4601	0.4574	0.5009
		90%	0.4714	0.5225	0.5469	0.5086	0.5086	0.5075	0.4982	0.4950	0.4828	0.5304
		95%	0.4714	0.6117	0.6238	0.5783	0.5783	0.5761	0.5544	0.5499	0.5197	0.5598
		 Chi-Squared Test 										
		Chi-Sq Statistic		0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
		P-Value		0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.654
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.101
		Cr. Value @ 0.500	N	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549
		Cr. Value @ 0.250	4	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233
		Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.072
		Cr. Volue @ 0 100		2 2055	2 2055	2 2055	2 7055	2 2055	2 2055	2 2055	2 2055	2 205

Figure 1.6: Reactive plant outage (fault) – statistics table using K-S

1.1.4 Reactive plant outage – forced (continuous)

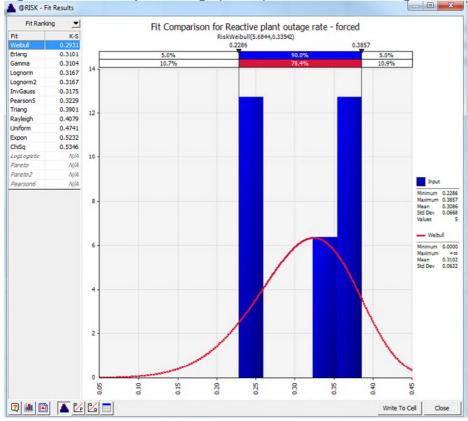


Figure 1.7: Reactive plant outage (forced) – distribution fit using K-S

Figure 1.8: Reactive plant outage (forced) – statistics table using K-S

Fit Ranki	ng 💌		Input	Weibull	Erlang	Gamma	Lognorm	Lognorm2	InvGauss	Pearson5
Fit	K-S	- Fit								
//ebul	0.2931	Function		=RiskWeibu =	RiskErlang =	=RiskGamm =	=RiskLogno :	=RiskLogno :	=RiskInvGa =	RiskPears =Ris
rlang	0.3101	 Distribution Statistic 								
Samma	0.3104	Minimum	0.2286	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ognorm	0.3167	Maximum	0.3857	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity
-		Mean	0.3086	0.3102	0.3086	0.3086	0.3088	0.3088	0.3086	0.3093
ognorm2	0.3167	Mode	0.2325 [est]	0.3242	0.2931	0.2932	0.2857	0.2857	0.2851	0.2785
nvGauss	0.3175	Median	0.3429	0.3145	0.3034	0.3035	0.3009	0.3009	0.3007	0.2983
earson5	0.3229	Std. Deviation	0.0746	0.0632	0.0690	0.0689	0.0712	0.0712	0.0709	0.0747
riang	0.3901	Skewness	-0.2756	-0.3394	0.4472	0.4463	0.7043	0.7043	0.6894	1.0260
layleigh	0.4079	Kurtosis	1.2512	2.9862	3.3000	3.2988	3.8948	3.8948	3.7920	5.0796
hiform	0.4741	- Percentiles								
xpon	0.5232	5%	0.2286	0.1989	0.2045	0.2047	0.2069	0.2069	0.2071	0.2089
thiSq	0.5346	10%	0.2286	0.2258	0.2241	0.2243	0.2248	0.2248	0.2247	0.2251
ogLogistic	N/A	15%	0.2286	0.2437	0.2380	0.2382	0.2377	0.2377	0.2375	0.2371
Pareto	N/A	20%	0.2286	0.2576	0.2495	0.2496	0.2484	0.2484	0.2482	0.2472
Pareto2	N/A	25%	0.2286	0.2694	0.2597	0.2598	0.2581	0.2581	0.2578	0.2564
Pearson6	N/A	30%	0.2286	0.2798	0.2690	0.2691	0.2671	0.2671	0.2668	0.2650
		35%	0.2286	0.2892	0.2779	0.2779	0.2756	0.2756	0.2754	0.2733
		40%	0.2286	0.2980	0.2865	0.2865	0.2841	0.2841	0.2838	0.2815
		45%	0.3429	0.3064	0.2949	0.2950	0.2924	0.2924	0.2922	0.2898
		50%	0.3429	0.3145	0.3034	0.3035	0.3009	0.3009	0.3007	0.2983
		55%	0.3429	0.3224	0.3121	0.3121	0.3097	0.3097	0.3094	0.3071
		60%	0.3571	0.3303	0.3211	0.3211	0.3188	0.3188	0.3186	0.3164
		65%	0.3571	0.3383	0.3305	0.3305	0.3285	0.3285	0.3283	0.3264
		70%	0.3571	0.3466	0.3407	0.3406	0.3391	0.3391	0.3389	0.3374
		75%	0.3571	0.3553	0.3519	0.3518	0.3509	0.3509	0.3507	0.3498
		80%	0.3571	0.3647	0.3646	0.3645	0.3645	0.3645	0.3643	0.3644
		85%	0.3857	0.3754	0.3799	0.3797	0.3810	0.3810	0.3808	0.3824
		90%	0.3857	0.3884	0.3996	0.3994	0.4029	0.4029	0.4026	0.4068
		95%	0.3857	0.4068	0.4301	0.4299	0.4376	0.4376	0.4370	0.4468
		- Chi-Squared Test	0.0007	0.1000	0.1001	0.1200	0.1570	0.1570	0.1570	0.1100
		Chi-Sq Statistic		0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
		P-Value		0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233
		Cr. Value @ 0.250 Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723
										2.0723
		Cr. Value @ 0.100		2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055
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1.1.5 Transformers outage – fault (continuous)

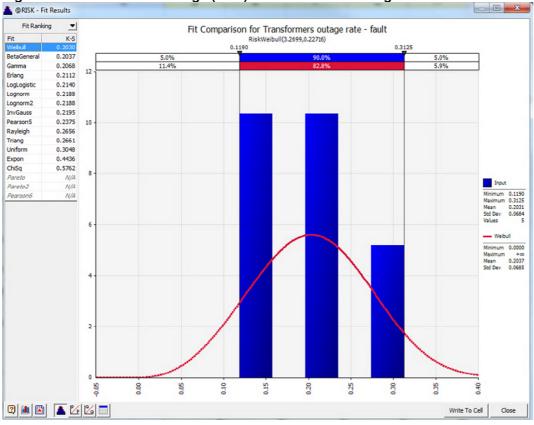




Figure 1.10: Transformers outage (fault) – statistics table using K-S

Fit Ranking	•	1.00	Input	Weibull	BetaGeneral	Gamma	Erlang	LogLogistic	Lognorm	Lognorm2	InvGauss	Pearson5	
it	K-S	- Fit											
Veibul	0.2030	Function		RiskWeibu	=RiskBetaG	=RiskGamm	=RiskErlang	=RiskLogLo	=RiskLogno	=RiskLogno	=RiskInvGa =	RiskPears	=R
BetaGeneral	0.2037	- Distribution Statistic											
Gamma	0.2068	Minimum	0.1190	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
Erlang	0.2112	Maximum	0.3125	+Infinity	0.3661	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	
LogLogistic	0.2112	Mean	0.2031	0.2037	0.2050	0.2031	0.2031	0.2077	0.2033	0.2033	0.2031	0.2042	
	0.2140	Mode	0.1432 [est]	0.2032	0.2153	0.1798	0.1805	0.1760	0.1701	0.1701	0.1687	0.1619	
.ognorm		Median	0.2126	0.2031	0.2074	0.1954	0.1956	0.1927	0.1916	0.1916	0.1913	0.1878	
.ognorm2	0.2188	Std. Deviation	0.0765	0.0685	0.0675	0.0687	0.0677	0.0877	0.0722	0.0722	0.0716	0.0792	
InvGauss	0.2195	Skewness	0.3225	0.0863	-0.1573	0.6765	0.6667	2.7756	1.1098	1.1098	1.0578	1.8246	
Pearson5	0.2375	Kurtosis	1.8900	2.7115	2.3843	3.6865	3.6667	41.0700	5.2673	5.2673	4.8648	10.3547	
Rayleigh	0.2656	- Percentiles											
Triang	0.2661	5%	0.1190	0.0916	0.0898	0.1047	0.1059	0.1035	0.1087	0.1087	0.1092	0.1117	
Jniform	0.3048	10%	0.1190	0.1141	0.1129	0.1215	0.1226	0.1212	0.1232	0.1232	0.1232	0.1243	
Expon	0.4436	15%	0.1190	0.1303	0.1298	0.1338	0.1348	0.1336	0.1340	0.1340	0.1339	0.1339	
ChiSq	0.5762	20%	0.1190	0.1436	0.1438	0.1442	0.1450	0.1438	0.1433	0.1433	0.1431	0.1423	
Pareto	N/A	25%	0.1429	0.1552	0.1562		0.1543	0.1528	0.1518	0.1518	0.1515	0.1501	
Pareto2	N/A	30%	0.1429	0.1657	0.1675	0.1623	0.1629	0.1612	0.1599	0.1599	0.1595	0.1575	
Pearson6	N/A	35%	0.1429	0.1756	0.1781	0.1706	0.1712	0.1691	0.1678	0.1678	0.1674	0.1649	
in the second		40%	0.1429	0.1850	0.1882		0.1793	0.1769	0.1756	0.1756	0.1752	0.1723	
		45%	0.2126	0.1941	0.1979	0.1871	0.1874	0.1847	0.1835	0.1835	0.1831	0.1799	
		50%	0.2126	0.2031	0.1979	0.1871	0.1956	0.1947	0.1835	0.1835	0.1913	0.1733	
		55%	0.2126	0.2121	0.2169	0.2039	0.2040	0.2011	0.2000	0.2000	0.1998	0.1962	
		60%	0.2283	0.2212	0.2263	0.2129	0.2129	0.2100	0.2090	0.2090	0.2089	0.2052	
		65%	0.2283	0.2306	0.2359	0.2224	0.2222	0.2197	0.2188	0.2188	0.2187	0.2152	
		70%	0.2283	0.2404	0.2458	0.2327	0.2324	0.2305	0.2295	0.2295	0.2295	0.2264	
		75%	0.2283	0.2510	0.2561	0.2443	0.2437	0.2431	0.2417	0.2417	0.2418	0.2393	
		80%	0.2283	0.2628	0.2671	0.2575	0.2568	0.2583	0.2560	0.2560	0.2562	0.2549	
		85%	0.3125	0.2763	0.2793	0.2735	0.2725	0.2781	0.2738	0.2738	0.2740	0.2748	
		90%	0.3125	0.2932	0.2934	0.2946	0.2932	0.3066	0.2979	0.2979	0.2980	0.3028	
		95%	0.3125	0.3177	0.3116	0.3277	0.3257	0.3590	0.3376	0.3376	0.3372	0.3515	
		- Chi-Squared Test											
		Chi-Sq Statistic		0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	
		P-Value		0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	0.6547	
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	
		Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	
		Cr. Value @ 0.100		2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	2.7055	
		4						2.7555					
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1.1.6 Transformers outage – forced (continuous)

The @RISK software found that the Weibull distribution is the most appropriate fit.

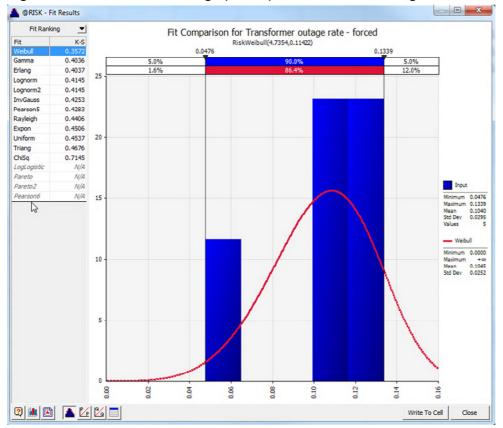


Figure 1.11: Transformers outage (forced) – distribution fit using K-S

Figure 1.12: Transformers outage (forced) – statistics table using K-S

N Fit Rank	ing 💌		Input	Weibull	Gamma	Erlang	Lognorm	Lognorm2	InvGauss	Pearson5	Ray
Fit	K-S	- Fit									
Vebul	0.3572	Function		=RiskWeibu	=RiskGamm	=RiskErlang	=RiskLogno	=RiskLogno	=RiskInvGa	=RiskPears	=RiskRa
Gamma	0.4036	 Distribution Statistic 									
Erlang	0.4038	Minimum	0.0476	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0
-		Maximum	0.1339	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	+I
Lognorm	0.4145	Mean	0.1040	0.1045	0.1040	0.1040	0.1052	0.1052	0.1040	0.1073	0
.ognorm2	0.4145	Mode	0.1101 [est]	0.1086	0.0923	0.0925	0.0857	0.0857	0.0837	0.0787	0
InvGauss	0.4253	Median	0.1111	0.1057	0.1002	0.1002	0.0982	0.0982	0.0970	0.0956	0
Pearson5	0.4283	Std. Deviation	0.0330	0.0252	0.0348	0.0347	0.0402	0.0402	0.0397	0.0506	0
Rayleigh	0.4406	Skewness	-1.1654	-0.2157	0.6699	0.6667	1.2014	1.2014	1.1456	2.4276	0
Expon	0.4506	Kurtosis	2.8953	2.8411	3.6731	3.6667	5.6719	5.6719	5.1874	17.7934	3
Uniform	0.4537	- Percentiles									
Triang	0.4676	5%	0.0476	0.0610	0.0541	0.0543	0.0535	0.0535	0.0530	0.0528	0
ChiSq	0.7145	10%	0.0476	0.0710	0.0626	0.0628	0.0612	0.0612	0.0604	0.0596	0
LogLogistic	N/A	15%	0.0476	0.0778	0.0689	0.0690	0.0670	0.0670	0.0660	0.0648	0
Pareto	N/A	20%	0.0476	0.0832	0.0742	0.0743	0.0720	0.0720	0.0709	0.0695	0
Pareto2	N/A	25%	0.1094	0.0878	0.0789	0.0790		0.0766	0.0754	0.0738	0
Pearson6	N/A	30%	0.1094	0.0919	0.0833	0.0834		0.0810	0.0798	0.0781	
		35%	0.1094	0.0956	0.0876	0.0877		0.0852	0.0840	0.0823	0
		40%	0.1094	0.0991	0.0918	0.0918		0.0895	0.0882	0.0865	
		45%	0.1111	0.1025	0.0959	0.0960		0.0938	0.0926	0.0910	0
		50%	0.1111	0.1057	0.1002	0.1002		0.0982	0.0970	0.0956	0
		55%	0.1111	0.1089	0.1045	0.1045		0.1029	0.1017	0.1006	0
		60%	0.1181	0.1121	0.1090	0.1090	0.1079	0.1079	0.1067	0.1061	0
		65%	0.1181	0.1154	0.1139	0.1138	0.1132	0.1132	0.1121	0.1121	0
		70%	0.1181	0.1184	0.1191	0.1190		0.1192	0.1121	0.1121	0
		75%	0.1181	0.1224	0.1249	0.1248		0.1192	0.1249	0.1269	0
		80%	0.1181	0.1224	0.1249	0.1248		0.1260	0.1249	0.1269	
		85%	0.1339	0.1308	0.1398	0.1396		0.1440	0.1430	0.1494	
		90%	0.1339	0.1362		0.1502		0.1576	0.1566	0.1677	
		95%	0.1339	0.1440	0.1672	0.1668	0.1802	0.1802	0.1789	0.2004	0
		- Chi-Squared Test									
		Chi-Sq Statistic		1.8000	1.8000	1.8000		1.8000	1.8000	1.8000	
		P-Value		0.1797	0.1797	0.1797		0.1797	0.1797		
		Cr. Value @ 0.750		0.1015	0.1015	0.1015		0.1015	0.1015		
		Cr. Value @ 0.500		0.4549	0.4549	0.4549		0.4549	0.4549	0.4549	0
		Cr. Value @ 0.250		1.3233	1.3233	1.3233		1.3233	1.3233	1.3233	1
		Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2.0723	2
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ISSUE 3 UNCONTROLLED WHEN PRINTED

1.2 Service parameter 2 – Loss of supply event frequency

1.2.1 Number of events >0.05 system minutes (discrete)

Whilst @RISK found that the HyperGeometric distribution is the best fit, the Poisson distribution has been adopted, consistent with both the loss of supply event frequency (>0.30 system minutes) parameter and the Draft Decision. The HyperGeometric and Poisson distributions are almost identical.

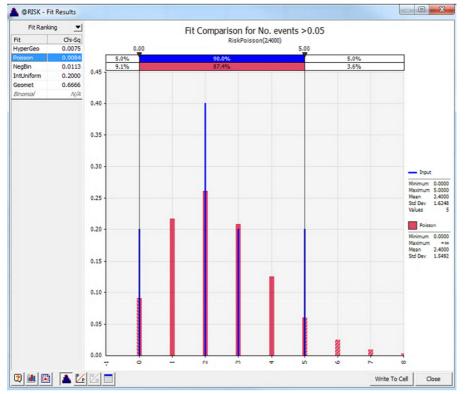


Figure 1.13: Number of events >0.05 system minutes - Poisson distribution

Figure 1.14: Number of events >0	0.05 system minutes – statistics table

Fit Rank	ing 💌		Input	HyperGeo	Poisson	NegBin	IntUniform	Geomet
Fit	Chi-Sq	- Fit						
HyperGeo	0.0075	Function		=RiskHyper	=RiskPoisso	=RiskNegBi	=RiskIntUni	=RiskGeom
oisson	0.0084	 Distribution Statistics 						
VegBin	0.0113	Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ntUniform	0.2000	Maximum	5.0000	76.0000	+Infinity	+Infinity	5.0000	+Infinity
eomet	0.6666	Mean	2.4000	2.3885	2.4000	2.4000	2.5000	2.4000
inomia/	N/A	Mode	2.0000	2.0000	2.0000	2.0000	0.0000	
u Ioninai	Пул	Median	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000
		Std. Deviation	1.8166	1.5192	1.5492	1.6492	1.7078	2.8566
		Skewness	0.1790	0.6139	0.6455	0.7680	0.0000	2.0304
		Kurtosis	2.2686	3.3489	3.4167	3.7010	1.7314	9.1225
		- Percentiles						
		5%	0.0000	0.0000	0.0000	0.0000	0.0000	
		10%	0.0000	1.0000	1.0000	0.0000	0.0000	0.0000
		15%	0.0000	1.0000	1.0000	1.0000	0.0000	0.0000
		20%	0.0000	1.0000	1.0000	1.0000	1.0000	0.0000
		25%	2.0000	1.0000	1.0000	1.0000	1.0000	0.0000
		30%	2.0000	1.0000	1.0000	1.0000	1.0000	1.0000
		35%	2.0000	2.0000	2.0000	2.0000	2.0000	1.0000
		40%	2.0000	2.0000	2.0000	2.0000	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	3.0000	3.0000	3.0000	3.0000	2.0000
		65%	3.0000	3.0000	3.0000	3.0000	3.0000	3.0000
		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	4.0000	4.0000	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	5.0000	5.0000	8.0000
		- Chi-Squared Test						
		Chi-Sq Statistic		0.0075	0.0084	0.0113	0.2000	0.6666
		P-Value		0.9309	0.9269	0.9154	0.6547	0.4142
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	0.4549
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233
		Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723	

1.2.2 Number of events >0.30 system minutes (discrete)

The data does not lend itself easily to statistical analysis, as it is comprised of either zero or one events. To retain consistency with the 0.05 minutes parameter and the Draft Decision, the Poisson distribution has been adopted.

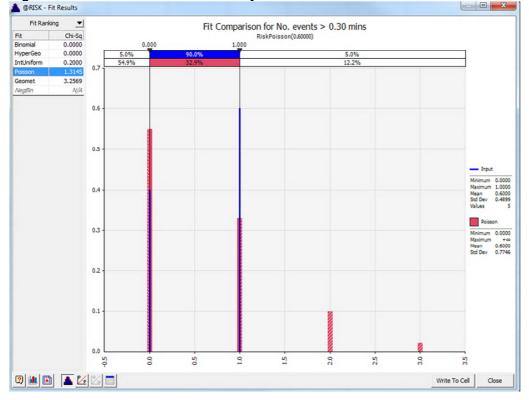


Figure 1.15: Number of events >0.30 system minutes – Poisson distribution

Figure 1.16: Number of events >0.30	system minutes – statistics table
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Fit Rank	ing 💌		Input	Binomial	HyperGeo	IntUniform	Poisson	Geomet
Fit	-	- Fit						
Binomial	Chi-Sq	Function		=RiskBinomi	=RiskHyper	=RiskIntUni	=RiskPoisso	=RiskGeom
	0.0000	 Distribution Statistics 						
HyperGeo	0.0000	Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
IntUniform	0.2000	Maximum	1.0000	1.0000	1.0000	1.0000	+Infinity	+Infinity
Poisson	1.3145	Mean	0.6000	0.6000	0.6000	0.5000	0.6000	0.6000
Seomet	3.2569	Mode	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
VegBin	N/A	Median	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
		Std. Deviation	0.5477	0.4899	0.4899	0.5000	0.7746	0.9798
		Skewness	-0.4082	-0.4082	-0.4082	0.0000	1.2910	2.2454
		Kurtosis	1.1667	1.1667	1.1667	1.0000	4.6667	10.0417
		- 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	
		25%	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%	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
		50%	1.0000	1.0000	1.0000	0.0000	0.0000	
		55%	1.0000	1.0000	1.0000	1.0000	1.0000	
		60%	1.0000	1.0000	1.0000	1.0000	1.0000	
		65%	1.0000	1.0000	1.0000	1.0000	1.0000	
		70%	1.0000	1.0000	1.0000	1.0000	1.0000	
		75%	1.0000	1.0000	1.0000	1.0000	1.0000	
		80%	1.0000	1.0000	1.0000	1.0000	1.0000	
		85%	1.0000	1.0000	1.0000	1.0000	1.0000	
		90%	1.0000	1.0000	1.0000	1.0000	2.0000	
		95%	1.0000	1.0000	1.0000	1.0000	2.0000	
		- Chi-Squared Test	1.0000	1.0000	1.0000	1.0000	2.0000	5.0000
		Chi-Sq Statistic		0.0000	0.0000	0.2000	1.3145	3.2569
		P-Value		1.0000	1.0000	0.6547	0.2516	
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233

28/10/2015

1.3 Service parameter 3 – Average outage duration

1.3.1 Average outage duration (continuous)

The @RISK software found the Lognormal distribution is the most appropriate fit.

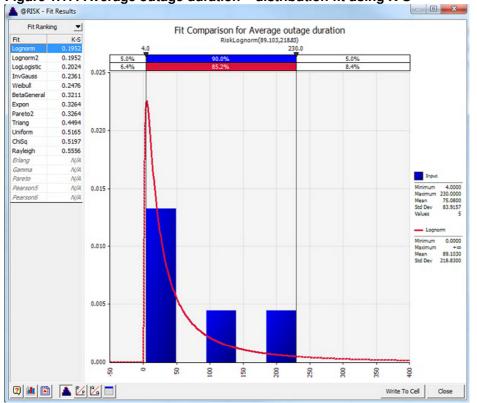




	Figure 1.18: Average	outage duration -	- distribution fit using K-S
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Fit Rankin	9 💌		Input	Lognorm	Lognorm2	LogLogistic	InvGauss	Weibull	BetaGeneral	Expon	
Fit	K-S	- Fit									
.ognorm	0.1952	Function		=RiskLogno	=RiskLogno	=RiskLogLo	=RiskInvGa	=RiskWeibu	=RiskBetaG	=RiskExpon	=Ris
.ognorm2	0.1952	- Distribution Statistic									
ogLogistic	0.2024	Minimum	4.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
InvGauss	0.2361	Maximum	230.0000	+Infinity	+Infinity	+Infinity	+Infinity	+Infinity	230.0000	+Infinity	
Weibull	0.2476	Mean	75.0800	89.1030	89.1030	187.6857	75.0800	74.8684	111.8404	75.0800	
BetaGeneral	0.3211	Mode	20.9500 [e	4.7789	4.7789	4.3410	5.7153	0.0000	0.0000	0.0000	
Expon	0.3264	Median	24.0000	33.6025	33.6025	34.0375	24.8144	42.6115	107.6855		
Pareto2	0.3264	Std. Deviation	93.8206	218.8274	218.8274	+Infinity	156.6554	92.6827	89.2368	75.0800	
Triang	0.4494	Skewness	1.0387	22.1802	22.1802	+Infinity	6.2595	2.7412	0.0533	2.0000	
Uniform	0.5165	Kurtosis	2.4920	3284.9782	3284.9782	+Infinity	68.3031	15.0225	1.3635	9.0000	
ChiSg	0.5105	- Percentiles	4 00000	0.0001		0.000					_
Rayleigh	0.5556	5%	4.0000	3.3786	3.3786	2.8614	4.0857	1.7361	0.1101	3.8511	
Erlang	N/A	10%	4.0000	5.6116	5.6116	5.3639	5.6254	4.2059	0.9544	7.9105	
Gamma	N/A	15%	4.0000	7.9023	7.9023	7.9149	7.1377	7.1651	3.3613		
Pareto	N/A	20%	4.0000	10.3732	10.3732	10.6085	8.7486	10.5794	8.1559	16.7536	
Pearson5	N/A	25%	19.9000	13.1003	13.1003	13.5120	10.5305	14.4570	16.0643		
Pearson6	N/A	30%	19.9000	16.1552	16.1552	16.6919	12.5494	18.8294	27.6039	26.7792	
r coroono	190	35%	19.9000	19.6186	19.6186	20.2242	14.8794	23.7473	42.9709	32.3432	
		40%	19.9000	23.5891	23.5891	24.2032	17.6125	29.2815	61.9502		
		45%	24.0000	28.1939	28.1939	28.7520	20.8694	35.5271	83.8786	44.8856	
		50%	24.0000	33.6025	33.6025	34.0375	24.8144	42.6115	107.6855		
		55%	24.0000	40.0486	40.0486	40.2946	29.6798	50.7068	132.0178	59.9520	
		60%	97.5000	47.8665	47.8665	47.8676	35.8045	60.0505	155.4289	68.7951	
		65%	97.5000	57.5540	57.5540	57.2854	43.7037	70.9808	176.5929	78.8206	
		70%	97.5000	69.8925	69.8925	69.4079	54.2003	84.0001	194.4928	90.3943	
		75%	97.5000	86.1911	86.1911	85.7422	68.6912	99.8976	208.5436	104.0830	1
		80%	97.5000	108.8506	108.8506	109.2100	89.7554	120.0136	218.6296	120.8366	1
		85%	230.0000	142.8855	142.8855	146.3765	122.7597	146.8997	225.0641		1
		90%	230.0000	201.2135	201.2135	215.9890	181.2269	186.3901	228.4970	172.8781	1
		95%	230.0000	334.2004	334.2004	404.8840	314.6566	257.5760	229.8051	224.9196	2
		- Chi-Squared Test									
		Chi-Sq Statistic		0.2000	0.2000	0.2000	0.2000	0.2000	1.8000	0.2000	
		P-Value		0.6547	0.6547	0.6547	0.6547	0.6547	0.1797		
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	0.1015	
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	0.4549	
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	1.3233	
		•									•
2 🛍 🗈	A P/	2							Write T	a Call C	lose

28/10/2015

1.4 Service parameter 4 – Proper operation of equipment

1.4.1 Failure of protection system (discrete)

Whilst @RISK found that the IntUniform distribution is the best fit, the Poisson distribution has been adopted, consistent with distribution used for the other sub-parameters with discrete distributions (loss of supply event frequency).

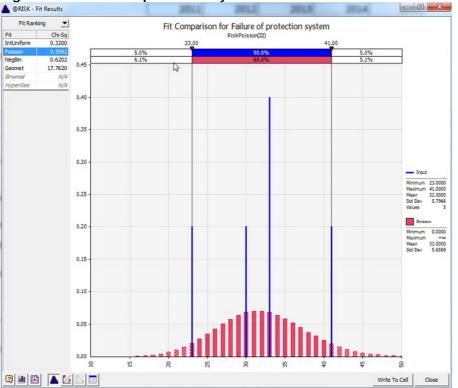


Figure 1.19: Failure of protection system – Poisson distribution



Fit Rank	ng 💌		Input	IntUniform	Poisson	NegBin	Geomet
it		- Fit					
ntUniform	Chi-Sq 0.3200	Function	=	RiskIntUni =	RiskPoisso =	RiskNegBi =	RiskGeom
	0.5992	- Distribution Statistics					
oisson egBin	0.6202	Minimum	23.0000	23.0000	0.0000	0.0000	0.0000
eomet	17.7620	Maximum	41.0000	41.0000	+Infinity	+Infinity	+Infinity
Rinomial		Mean	32.0000	32.0000	32.0000	32.0000	32.0000
	N/A	Mode	33.0000	23.0000	31.0000	31.0000	0.0000
lyperGeo	N/A	Median	33.0000	32.0000	32.0000	32.0000	22.0000
		Std. Deviation	6.4807	5.4772	5.6569	5.7999	32.4962
		Skewness	-0.0062	0.0000	0.1768	0.1901	2.0002
		Kurtosis	2.3278	1.7933	3.0313	3.0393	9.0009
		- Percentiles					
		5%	23.0000	23.0000	23.0000	23.0000	1.0000
		10%	23.0000	24.0000	25.0000	25.0000	3.0000
		15%	23.0000	25.0000	26.0000	26.0000	5.0000
		20%	23.0000	26.0000	27.0000	27.0000	7.0000
		25%	30.0000	27.0000	28.0000	28.0000	9.0000
		30%	30.0000	28.0000	29.0000	29.0000	11.0000
		35%	30.0000	29.0000	30.0000	30.0000	13.0000
		40%	30.0000	30.0000	30.0000	30.0000	16.0000
		45%	33.0000	31.0000	31.0000	31.0000	19.0000
		50%	33.0000	32.0000	32.0000	32.0000	22.0000
		55%	33.0000	33.0000	33.0000	33.0000	25.0000
		60%	33.0000	34.0000	33.0000	33.0000	29.0000
		65%	33.0000	35.0000	34.0000	34.0000	34.0000
		70%	33.0000	36.0000	35.0000	35.0000	39.0000
		75%	33.0000	37.0000	36.0000	36.0000	45.0000
		80%	33.0000	38.0000	37.0000	37.0000	52.0000
		85%	41.0000	39.0000	38.0000	38.0000	61.0000
		90%	41.0000	40.0000	39.0000	40.0000	74.0000
		95%	41.0000	41.0000	42.0000	42.0000	97.0000
		- Chi-Squared Test	41.0000	41.0000	12.0000	-12.0000	37.0000
		Chi-Sq Statistic		0.3200	0.5992	0.6202	17.7620
		P-Value		0.5200		0.4310	0.0000
					0.4389		
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233
		Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723
		Cr. Value @ 0.100		2.7055	2.7055	2.7055	2.7055
		Cr. Value @ 0.050		3.8415	3.8415	3.8415	3.8415
		Cr. Value @ 0.025		5.0239	5.0239	5.0239	5.0239

1.4.2 Material failure of SCADA system (discrete)

Whilst @RISK found that the Geometric distribution is the best fit, the Poisson distribution has been adopted, consistent with distribution used for the other sub-parameters with discrete distributions (loss of supply event frequency).

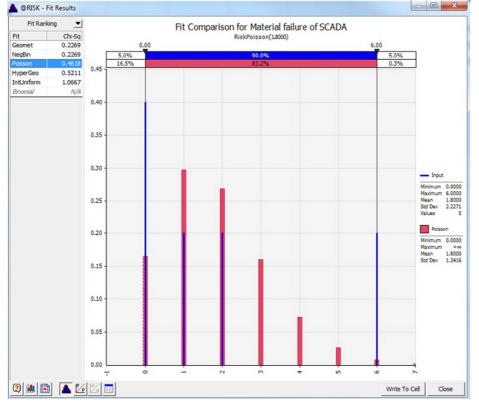


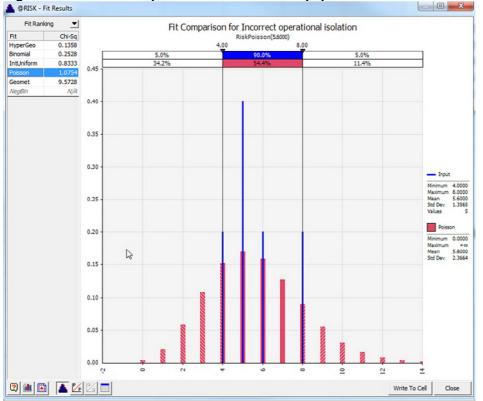
Figure 1.21: Material failure of SCADA system – Poisson distribution



Fit Rank	ng 💌		Input	Geomet	NegBin	Poisson	HyperGeo	IntUniform
		- Fit						
Fit	Chi-Sq	Function		=RiskGeom	=RiskNegBi	=RiskPoisso	=RiskHyper	=RiskIntUni
Geomet	0.2269	- Distribution Statistics						
VegBin	0.2269	Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
oisson	0.4518	Maximum	6.0000	+Infinity	+Infinity	+Infinity	57.0000	6.0000
yperGeo	0.5211	Mean	1.8000	1.8000	1.8000	1.8000	1.7916	3.0000
ntUniform	1.0667	Mode	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000
linomial	N/A	Median	1.0000	1.0000	1.0000	2.0000	2.0000	3.0000
		Std. Deviation	2.4900	2.2450	2.2450	1.3416	1.3162	2.0000
		Skewness	1.1211	2.0490	2.0490	0.7454	0.7096	0.0000
		Kurtosis	2.7037	9.1984	9.1984	3.5556	3.4668	1.7500
		- 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	1.0000
		20%	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
		25%	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
		30%	0.0000	0.0000	0.0000	1.0000	1.0000	2.0000
		35%	0.0000	0.0000	0.0000	1.0000	1.0000	2.0000
		40%	0.0000	1.0000	1.0000	1.0000	1.0000	2.0000
		45%	1.0000	1.0000	1.0000	1.0000	1.0000	3.0000
		50%	1.0000	1.0000	1.0000	2.0000	2.0000	3.0000
		55%	1.0000	1.0000	1.0000	2.0000	2.0000	3.0000
		60%	1.0000	2.0000	2.0000	2.0000	2.0000	4.0000
		65%	2.0000	2.0000	2.0000	2.0000	2.0000	4.0000
		70%	2.0000	2.0000	2.0000	2.0000	2.0000	4.0000
		75%	2.0000	3.0000	3.0000	3.0000	3.0000	5.0000
		80%	2.0000	3.0000	3.0000	3.0000	3.0000	5.0000
		85%	6.0000	4.0000	4.0000	3.0000	3.0000	5.0000
		90%	6.0000	5.0000	5.0000	4.0000	4.0000	6.0000
		95%	6.0000	6.0000	6.0000	4.0000	4.0000	6.0000
		- Chi-Squared Test	0.0000	0.0000	0.0000			0.0000
		Chi-Sq Statistic		0.2269	0.2269	0.4618	0.5211	1.0667
		P-Value		0.6338	0.6338	0.4968	0.4704	0.3017
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	0.4549
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233
		Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723	2.0723
		Cr. value @ 0.150		2.0723	2.0725	2.0725	2.0723	2.0723

1.4.3 Incorrect operational isolation of primary or secondary equipment (discrete)

Whilst @RISK found that the HyperGeometric distribution is the best fit, the Poisson distribution has been adopted, consistent with distribution used for the other sub-parameters with discrete distributions (loss of supply event frequency).





igure 1.24: Incorrect operational isolation of equipment – statistics table	

Fit Ranki	ng 💌		Input	HyperGeo	Binomial	IntUniform	Poisson	Geomet
	Chi-Sq	- Fit						
erGeo	0.1358	Function		=RiskHyper =	RiskBinomi	=RiskIntUni :	=RiskPoisso =	RiskGeom
mial	0.2528	- Distribution Statistics	4 0000	0.0000	0.0000	4 0000	0.0000	0.0000
Uniform	0.8333	Minimum	4.0000	0.0000	0.0000	4.0000	0.0000	0.0000
sson	1.0754	Maximum	8.0000	13.0000	9.0000	8.0000	+Infinity	+Infinity
eomet	9.5728	Mean	5.6000	5.6333	5.6000	6.0000	5.6000	5.6000
aBin	N/A	Mode	5.0000	6.0000	6.0000	4.0000	5.0000	0.0000
9007	14/14	Median	5.0000	6.0000	6.0000	6.0000	5.0000	4.0000
		Std. Deviation	1.5166	1.3680	1.4545	1.4142	2.3664	6.0795
		Skewness	0.7500	0.0139	-0.1681	0.0000	0.4226	2.0068
		Kurtosis	2.3639	2.9256	2.8060	1.7000	3.1786	9.0271
		- Percentiles						
		5%	4.0000	3.0000	3.0000	4.0000	2.0000	0.0000
		10%	4.0000	4.0000	4.0000	4.0000	3.0000	0.0000
		15%	4.0000	4.0000	4.0000	4.0000	3.0000	0.0000
		20%	4.0000	4.0000	4.0000	4.0000	4.0000	1.0000
		25%	5.0000	5.0000	5.0000	5.0000	4.0000	1.0000
		30%	5.0000	5.0000	5.0000	5.0000	4.0000	2.0000
		35%	5.0000	5.0000	5.0000	5.0000	5.0000	2.0000
		40%	5.0000	5.0000	5.0000	5.0000	5.0000	3.0000
		45%	5.0000	5.0000	5.0000	6.0000	5.0000	3.0000
		50%	5.0000	6.0000	6.0000	6.0000	5.0000	4.0000
		55%	5.0000	6.0000	6.0000	6.0000	6.0000	4.0000
		60%	5.0000	6.0000	6.0000	7.0000	6.0000	5.0000
		65%	6.0000	6.0000	6.0000	7.0000	6.0000	6.0000
		70%	6.0000	6.0000	6.0000	7.0000	7.0000	7.0000
		75%	6.0000	7.0000	7.0000	7.0000	7.0000	8.0000
		80%	6.0000	7.0000	7.0000	7.0000	8.0000	9.0000
		85%	8.0000	7.0000	7.0000	8.0000	8.0000	11.0000
		90%	8.0000	7.0000	7.0000	8.0000	9.0000	14.0000
		95%	8.0000	8.0000	8.0000	8.0000	10.0000	18.0000
		 Chi-Squared Test 						
		Chi-Sq Statistic		0.1358	0.2528	0.8333	1.0754	9.5728
		P-Value		0.7125	0.6151	0.3613	0.2997	0.0020
		Cr. Value @ 0.750		0.1015	0.1015	0.1015	0.1015	0.1015
		Cr. Value @ 0.500		0.4549	0.4549	0.4549	0.4549	0.4549
		Cr. Value @ 0.250		1.3233	1.3233	1.3233	1.3233	1.3233
		Cr. Value @ 0.150		2.0723	2.0723	2.0723	2.0723	2.0723
	1	Cr. Value @ 0.100		2 2055	2 2055	2 2022	2 2055	2 2055