

2023-27 Transmission Revenue Reset

PUBLIC

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Contents

1	Service Component Parameters3
1.1	Service parameter 1 – Average circuit outage rate4
1.1.1	Lines outage rate – fault (continuous)4
1.1.2	Lines outage rate – forced (continuous)5
1.1.3	Reactive plant outage – fault (continuous)6
1.1.4	Reactive plant outage – forced (continuous)7
1.1.5	Transformers outage – fault (continuous)8
1.1.6	Transformers outage – forced (continuous)9
1.2	Service parametrr 2 – loss of supply event frequency11
1.2.1	Number of events > 0.05 system minutes (discrete)11
1.2.2	Number of events > 0.30 system minutes (dscrete)12
1.3	Service parameter 3 – average outage duration13
1.3.1	Average outage duration (continuous)13
1.4	Service parameter 4 – proper operation of equipment14
1.4.1	Failure of protection system (discrete)14
1.4.2	Material failure of SCADA system (discrete)15
1.4.3	Incorrect operational isolation of primary or secondary equipment (discrete)

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 ElectraNet, 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.

Parameter	Preferred Distribution	5th percentile	95th percentile
Line outage rate (fault)	Normal	0.1160	0.2315
Line outage rate (forced)	Normal	0.0192	0.2176
Reactive plant outage rate (fault)	InvGauss	0.1548	0.3171
Reactive plant outage rate (forced)	Normal	0.2474	0.3665
Transformer outage rate (fault)	Logistic	0.0663	0.1749
Transformer outage rate (forced)	Laplace	0.0732	0.1612
Number of events >0.05 system minutes	Poisson	0	3
Number of events >0.30 system minutes	Poisson	0	2
Average outage duration	InvGauss	19	159
Failure of protection equipment	Poisson	23	42
Material failure of SCADA system	Poisson	0	2
Incorrect operational isolation of primary or secondary equipment	Poisson	2	11

Table 1.1: Summary of probability distributions and percentiles

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:

Contra m

- A-D fit statistic: Normal distribution best fit, standard deviation 0.0351
- K-S fit statistic: Normal distribution best fit, standard deviation 0.0351
- A-D preferred (Normal) due to data concentrated in middle of distribution •

Figure 1-1: Lines outage rate (fault) – distribution fit using A-D

Name	A-D 🔺	Name	Rayleigh	Pareto	Normal	ExtValue	ExtValueMin	Uniform	Logistic	HypSecant	Laplace	Expon	Cauchy	Levy	Er
Normal	0.1749										Λ	N	1		
Logistic	0.2045	Graph													
HypSecant	0.2083			 ~	/	/								N	~
FatigueLife	0.2142	Distribution Statistics													
ExtValueMin	0.22142	Minimum	0.11459850	0.1300813	-00	-00	-00	0.1077236	-00	-00	-00	0.12134699	-00	0.126627	
		Maximum	+00	+00	+00	+00	+00	0.2418699	+00	+00	+00	+00	+00	+00	
Frechet	0.2407	Mean	0.17395829	0.1788473	0.17375287	0.17432227	0.172987	0.1747967	0.17395505	0.17481450	0.180328	0.16501855	N/A	N/A	
ExtValue	0.2407	Mode	0.16196076	0.1300813	0.17375287	0.15813004	0.189395	0.1077236	0.17395505	0.17481450	0.180328	0.12134699	0.17995494	0.131015	
Uniform	0.2421	Median	0.17036330	0.1571434	0.17375287	0.16841157	0.178976	0.1747967	0.17395505	0.17481450	0.180328	0.15161781	0.17995494	0.155563	
Cauchy	0.2496	Std Deviation	0.03102874	0.0723222	0.03512706	0.03597847	0.036456	0.0387247	0.03470980	0.03666067	0.036983	0.04367157	N/A	N/A	
Rayleigh	0.2558	Skewness	0.6311	9.4304	0.0000	1.1395	-1.1395	0.0000	0.0000	0.0000	0.0000	2.0000	N/A	N/A	
Laplace	0.2952	Kurtosis	3.2451	N/A	3.0000	5.4000	5.4000	1.8000	4.2000	5.0000	6.0000	9.0000	N/A	N/A	
LogLogistic	0.5095	Percentiles													
Levy	0.5447	1%	0.12131337	0.1304383	0.09203511	0.11528915	0.058635	0.1090650	0.08602047	0.07787622	0.078026	0.12178590	-0.49163087	0.128611	
		2.5%	0.12525613	0.1309824	0.10490510	0.12151274	0.084897	0.1110772	0.10384725	0.09927152	0.101988	0.12245266	-0.08821503	0.129247	
Expon	0.6087	5%	0.12976823	0.1319134	0.11597400	0.12735138	0.104967	0.1144309	0.11760875	0.11548488	0.120114	0.12358705	0.04670047	0.130054	
Pearson5	0.9670	10%	0.13633984	0.1338725	0.12873573	0.13473352	0.125428	0.1211382	0.13190783	0.13180719	0.138240	0.12594825	0.11499909	0.131493	
Burr 12	1.3693	20%	0.14623873	0.1382417	0.14418919	0.14478037	0.146759	0.1345528	0.14742620	0.14857743	0.156366	0.13109202	0.15090580	0.134642	
Pert	2.3608	25%	0.15052408	0.1406960	0.15006003	0.14896720	0.153980	0.1412602	0.15293144	0.15424420	0.162202	0.13391051	0.15884951	0.136575	
Erf	4.1610	30%	0.15460069	0.1433678	0.15533222	0.15292278	0.160090	0.1479675	0.15774072	0.15907764	0.166969	0.13692354	0.16462095	0.138882	
BetaGeneral		35%	0.15856042	0.1462943	0.16021769	0.15676612	0.165456	0.1546748	0.16210879	0.16338507	0.171001	0.14015995	0.16920119	0.141698	
Pareto		40%	0.16247074	0.1495223	0.16485353	0.16058242	0.170301	0.1613821	0.16619586	0.16735869	0.174493	0.14365554	0.17309737	0.145212	
Pareto2		45%	0.16638765	0.1531122	0.16933875	0.16444211	0.174772	0.1680894	0.17011491	0.17113326	0.177573	0.14745547	0.17661217	0.149696	
		50%	0.17036330	0.1571434	0.17375287	0.16841157	0.178976	0.1747967	0.17395505	0.17481450	0.180328	0.15161781	0.17995494	0.155563	
Triang		55%	0.17445164	0.1617234	0.17816698	0.17256118	0.182999	0.1815041	0.17779519	0.17849573	0.183083	0.15621907	0.18329771	0.163469	
ChiSq	N/A	60%	0.17871415	0.1670015	0.18265221	0.17697352	0.186910	0.1882114	0.18171424	0.18227030	0.186163	0.16136284	0.18681251	0.174498	
] Erlang	N/A	65%	0.18322712	0.1731941	0.18728804	0.18175431	0.190777	0.1949187	0.18580130	0.18624392	0.189655	0.16719436	0.19070870	0.190562	
Gamma	N/A	70%	0.18809316	0.1806289	0.19217352	0.18705001	0.194671	0.2016260	0.19016938	0.19055135	0.193686	0.17392637	0.19528894	0.215292	
InvGauss	N/A	75%	0.19346184	0.1898355	0.19744571	0.19308038	0.198679	0.2083333	0.19497866	0.19538479	0.198454	0.18188863	0.20106038	0.256284	
Lognorm	N/A	80%	0.19957220	0.2017445	0.20331655	0.20020680	0.202922	0.2150407	0.20048389	0.20105156	0.204289	0.19163366	0.20900408	0.331726	
Lognorm2	N/A	90%	0.21623630	0.2437155	0.21877000	0.22125801	0.213102	0.2284553	0.21600227	0.21782180	0.222416	0.22190449	0.24491079	0.960294	
Pearson6	N/A	95%	0.23052932	0.2944181	0.23153174	0.24145084	0.220582	0.2351626	0.23030135	0.23414411	0.240542	0.25217531	0.31320941	3.474485	
Student		97.5%	0.24324402	0.3556688	0.24260064	0.26125722	0.226498	0.2385163	0.24406285	0.25035747	0.258668	0.28244613	0.44812491	13.531230	
	N/A	99%	0.25833606	0.4566163	0.25547063	0.28717479	0.232805	0.2405285	0.26188963	0.27175277	0.282630	0.32246199	0.85154075	83.928435	
Webul	N/A	Information Criteria													
Dagum	N/A	Akaike (AIC)	-10.78792892	-10.6642673	-10.29845014	-10.16766845	-10.102090	-10.0882397	-9.94769812	-9.64624642	-9.507344	-9.31058025	-7.62002200	-6.770107	
Kumaraswamy	N/A	Bayesian (BIC)	-17.56905309	-17.4453915	-17.07957431	-16.94879263	-16.883214	-16.8693639	-16.72882229	-16.42737060	-16.288468	-16.09170443	-14.40114618	-13.551231	
		Average Log-Likelhood	2.07879289	2.0664267	2.02984501	2.01676685	2.010209	2.0088240	1.99476981	1.96462464	1.950734	1.93105803	1.76200220	1.677011	
		Chi-Squared Test (Binning	Information)												
		Bin #1: Minimum	0.11459850	0.1300813	-00	-00	-00	0.1077236	-00	-00	-00	0.12134699	-00	0.126627	
		Bin #1: Maximum	0.17036330	0.1571434	0.17375287	0.16841157	0.178976	0.1747967	0.17395505	0.17481450	0.180328	0.15161781	0.17995494	0.155563	
		Bin #1: Input	2.00000000	2.0000000	2.00000000	2.00000000	2.000000	2.0000000	2.00000000	2.00000000	3.000000	2.00000000	2.00000000	2.000000	
		Bin #1: Fit	2.50000000	2.5000000	2.50000000	2.50000000	2.500000	2.5000000	2.50000000	2.50000000	2.500000	2.50000000	2.50000000	2.500000	
		Bin #2: Minimum	0.17036330	0.1571434	0.17375287	0.16841157	0.178976	0,1747967	0.17395505	0.17481450	0.180328	0.15161781	0.17995494	0.155563	
		Din #7: Massimum	1.00	1.00	1	1.00	1	0.0410600	1.00	1.00	1.00	1	1.00	1	
		4													

Figure 1-2: Lines outage rate (fault) – distribution fit using K-S

Name		K-S ▲	Name	Rayleigh	Pareto	Normal	ExtValue	ExtValueMin	Uniform	Logistic	HypSecant	Laplace	Expon	Cauchy	Levy	
Normal		0.1742			k.							٨	N	1	1	
Uniform		0.1861	Graph													
Fatiguel	ife	0.1868		/	~					/ ···	<u> </u>				N	
ExtValue		0.1871	Distribution Statistics													
Logistic		0.1886	Minimum	0.11459850	0.1300813	-00	-00	- 00	0.1077236	- 00	- 00	-00	0.12134699	-00	0.126627	
-typSeca		0.1985	Maximum	+00	+00	+00	+00	+00	0.2418699	+00	+00	+00	+00	+00	+00	
	ant		Mean	0.17395829	0.1788473	0.17375287	0.17432227	0.172987	0.1747967	0.17395505	0.17481450	0.180328	0.16501855	N/A	N/A	
Cauchy		0.2107	Mode	0.16196076	0.1300813	0.17375287	0.15813004	0.189395	0.1077236	0.17395505	0.17481450	0.180328	0.12134699	0.17995494	0.131015	
Rayleigh	1	0.2183	Median	0.17036330	0.1571434	0.17375287	0.16841157	0.178976	0.1747967	0.17395505	0.17481450	0.180328	0.15161781	0.17995494	0.155563	
ExtValue	2	0.2356	Std Deviation	0.03102874	0.0723222	0.03512706	0.03597847	0.036456	0.0387247	0.03470980	0.03666067	0.036983	0.04367157	N/A	N/A	
Frechet		0.2356	Skewness	0.6311	9.4304	0.0000	1.1395	-1.1395	0.0000	0.0000	0.0000	0.0000	2.0000	N/A	N/A	
LogLogis	stic	0.2427	Kurtosis	3.2451	N/A	3.0000	5.4000	5.4000	1.8000	4.2000	5.0000	6.0000	9.0000	N/A	N/A	
Laplace		0.2505	Percentiles													
BetaGer	peral	0.2508	1%	0.12131337	0.1304383	0.09203511	0.11528915	0.058635	0.1090650	0.08602047	0.07787622	0.078026	0.12178590	-0.49163087	0.128611	
Triang	incir car	0.2675	2.5%	0.12525613	0.1309824	0.10490510	0.12151274	0.084897	0.1110772	0.10384725	0.09927152	0.101988	0.12245266	-0.08821503	0.129247	
			5%	0.12976823	0.1319134	0.11597400	0.12735138	0.104967	0.1144309	0.11760875	0.11548488	0.120114	0.12358705	0.04670047	0.130054	
Pareto2		0.2835	10%	0.13633984	0.1338725	0.12873573	0.13473352	0.125428	0.1211382	0.13190783	0.13180719	0.138240	0.12594825	0.11499909	0.131493	
Pert		0.2850	20%	0.14623873	0.1382417	0.14418919	0.14478037	0.146759	0.1345528	0.14742620	0.14857743	0.156366	0.13109202	0.15090580	0.134642	
Levy		0.2934	25%	0.15052408	0.1406960	0.15006003	0.14896720	0.153980	0.1412602	0.15293144	0.15424420	0.162202	0.13391051	0.15884951	0.136575	
Pareto		0.2982	30%	0.15460069	0.1433678	0.15533222	0.15292278	0.160090	0.1479675	0.15774072	0.15907764	0.166969	0.13692354	0.16462095	0.138882	
Expon		0.3409	35%	0.15856042	0.1462943	0.16021769	0.15676612	0.165456	0.1546748	0.16210879	0.16338507	0.171001	0.14015995	0.16920119	0.141698	
Pearson	5	0.4296	40%	0.16247074	0.1495223	0,16485353	0.16058242	0.170301	0.1613821	0,16619586	0.16735869	0.174493	0.14365554	0,17309737	0.145212	
Burr 12		0.4632	45%	0.16638765	0.1531122	0.16933875	0.16444211	0.174772	0.1680894	0.17011491	0.17113326	0.177573	0.14745547	0.17661217	0.149696	
			50%	0.17036330	0,1571434	0.17375287	0.16841157	0.178976	0.1747967	0.17395505	0,17481450	0.180328	0.15161781	0,17995494	0.155563	
Erf		0.7694	55%	0.17445164	0.1617234	0.17816698	0.17256118	0.182999	0.1815041	0.17779519	0.17849573	0.183083	0.15621907	0.18329771	0.163469	
ChiSq		N/A	60%	0.17871415	0.1670015	0.18265221	0.17697352	0,186910	0.1882114	0.18171424	0,18227030	0.186163	0.16136284	0,18681251	0.174498	
Erlang		N/A	65%	0.18322712	0.1731941	0.18728804	0.18175431	0.190777	0.1949187	0.18580130	0.18624392	0.189655	0.16719436	0.19070870	0.190562	
Gamma		N/A	70%	0.18809316	0,1806289	0.19217352	0.18705001	0.194671	0.2016260	0.19016938	0.19055135	0.193686	0.17392637	0.19528894	0.215292	
InvGaus	is	N/A	75%	0.19346184	0.1898355	0.19744571	0.19308038	0.198679	0.2083333	0.19497866	0.19538479	0.198454	0.18188863	0.20106038	0.256284	
Lognorm	1	N/A	80%	0.19957220	0.2017445	0.20331655	0.20020680	0.202922	0.2150407	0.20048389	0.20105156	0.204289	0.19163366	0.20900408	0.331726	
Lognorm		N/A	90%	0.21623630	0.2437155	0.21877000	0.22125801	0.213102	0.2284553	0.21600227	0.21782180	0.222416	0.22190449	0.24491079	0.960294	
			95%	0.23052932	0.2944181	0.23153174	0.24145084	0.220582	0.2351626	0.23030135	0.23414411	0.240542	0.25217531	0.31320941	3.474485	
Pearson	6	N/A	97.5%	0.24324402	0.3556688	0.24260064	0.26125722	0.226498	0.2385163	0.24406285	0.25035747	0.258668	0.28244613	0.44812491	13,531230	
Student		N/A	99%	0.25833606	0.4566163	0.25547063	0.28717479	0.232805	0.2405285	0.26188963	0.27175277	0.282630	0.32246199	0.85154075	83.928435	
Weibull		N/A	Information Criteria	0120000000	011000100	01200110000	0120727175	01202000	012 100200	0120100500	012/1/02//	01202000	01022-10133	0100101070	001720100	
Dagum		N/A	Akaike (AIC)	-10.78792892	-10.6642673	-10.29845014	-10.16766845	-10.102090	-10.0882397	-9.94769812	-9.64624642	-9.507344	-9.31058025	-7.62002200	-6.770107	
Kumaras	swamy	N/A	Bayesian (BIC)	-17.56905309	-10.6642675	-17.07957431	-16.94879263	-16.883214	-16.8693639	-16.72882229	-16.42737060	-16.288468	-16.09170443	-14.40114618	-13.551231	
			Average Log-Likelihood	2.07879289	2.0664267	2.02984501	2.01676685	-16.883214 2.010209	2.0088240	-16.72882229	1.96462464	-16.288468	1.93105803	1.76200220	1.677011	
					2.0004207	2.02909501	2.010/0085	2.010209	2.0066240	1.994/0981	1.90402404	1.950/34	1.92102003	1.76200220	1.677011	
			Chi-Squared Test (Binning													
			Bin #1: Minimum	0.11459850	0.1300813	- 00	-00	-00	0.1077236	-00	-00	-00	0.12134699	-00	0.126627	
			Bin #1: Maximum	0.17036330	0.1571434	0.17375287	0.16841157	0.178976	0.1747967	0.17395505	0.17481450	0.180328	0.15161781	0.17995494	0.155563	
			Bin #1: Input	2.00000000	2.0000000	2.00000000	2.0000000	2.000000	2.0000000	2.00000000	2.00000000	3.000000	2.00000000	2.00000000	2.000000	
			Bin #1: Fit	2.50000000	2.5000000	2.50000000	2.5000000	2.500000	2.5000000	2.5000000	2.50000000	2.500000	2.50000000	2.5000000	2.500000	
			Bin #2: Minimum	0.17036330	0.1571434	0.17375287	0.16841157	0.178976	0.1747967	0.17395505	0.17481450	0.180328	0.15161781	0.17995494	0.155563	

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AV

1.1.2 Lines outage rate – forced (continuous)

- A-D fit statistic: Uniform distribution best fit, standard deviation 0.0540
- A-D fit statistic: Normal distribution second best fit, standard deviation 0.0603
- K-S fit statistic: HypSecant distribution best fit, standard deviation 0.0660
- A-D preferred (Normal) due to data concentrated closer to the centre and near tails of distribution

Figure 1-3: Lines outage rate (forced) – distribution fit using A-D

	Name	A-D 🔺	Name	Frechet	FatigueLife	Uniform	ExtValueMin	Pareto	Rayleigh	Normal	Expon	ExtValue	Logistic	Laplace	HypSecant	Let
1	Uniform	0.5149		1				1								1
	Normal	0.5711	Graph									LI				1.
	Levy	0.5954										1-				
	Logistic	0.6217	Distribution Statistics													
	HypSecant	0.6343	Minimum	0.048780487804	0.048780487804	0.0175872	-00	0.04878049	0.01669699	-00	0.03485629	-00	-00	-00	-00	
			Maximum	+00	+00	0.2047470	+00	+00	+00	+00	+00	+00	+00	+00	+00	
	ExtValueMin	0.6659	Mean	N/A	0.083590971324	0.1111671	0.120465	0.19562645	0.11872841	0.11840145	0.10447726	0.11957203	0.12282932	0.155738	0.12980189	
	ExtValue	0.6838	Mode	0.048780487804	1.311E-008	0.0175872	0.143947	0.04878049	0.09810628	0.11840145	0.03485629	0.09066743	0.12282932	0.155738	0.12980189	
	Gamma	0.7088	Median	0.048780487805	0.048780487804	0.1111671	0.129037	0.08207534	0.11254911	0.11840145	0.08311387	0.10902090	0.12282932	0.155738	0.12980189	
	Erlang	0.7125	Std Deviation	N/A	0.077838607480	0.0540284	0.052175	N/A	0.05333419	0.06032358	0.06962097	0.06422486	0.06190995	0.063608	0.06597572	
	Pearson5	0.7695	Skewness	N/A	3.9355	0.0000	-1.1395	N/A	0.6311	0.0000	2.0000	1.1395	0.0000	0.0000	0.0000	
	Rayleigh	0.7788	Kurtosis	N/A	25.3200	1.8000	5.4000	N/A	3.2451	3.0000	9.0000	5.4000	4.2000	6.0000	5.0000	
	Expon	0.8385	Percentiles													
	Pert	0.8453	1%	0.048780487804	0.048780487804	0.0194588	-0.043189	0.04914989	0.02823894	-0.02193218	0.03555601	0.01419251	-0.03401473	-0.020215	-0.04465135	
			2.5%	0.048780487804		0.0222662	-0.005604	0.04971641	0.03501600	0.00016941	0.03661894	0.02530220	-0.00221809	0.020997	-0.00614767	
	Cauchy	1.2137	5%	0.048780487804		0.0269452	0.023118	0.05069531	0.04277169	0.01917799	0.03842738	0.03572470	0.02232754	0.052173	0.02303041	
	Laplace	1.2209	10%	0.048780487804		0.0363032	0.052401	0.05279512	0.05406740	0.04109367	0.04219160	0.04890249	0.04783202	0.083349	0.05240455	
	Burr 12	1.2613	20%	0.048780487804		0.0550191	0.082929	0.05767547	0.07108224	0.06763185	0.05039176	0.06683705	0.07551129	0.114525	0.08258481	
	Frechet	2.1904	25%		0.048780487804	0.0643771	0.093263	0.06053837	0.07844819	0.07771382	0.05488500	0.07431092	0.08533067	0.124562	0.09278292	
	FatigueLife	2.5632		0.048780487804		0.0737351	0.102008	0.06375621	0.08545531	0.08676774	0.05968835	0.08137200	0.09390872	0.132762	0.10148134	
	Erf	3.1509			0.048780487804	0.0830931	0.109688	0.06740339	0.09226156	0.09515754	0.06484782	0.08823270	0.10169982	0.139695	0.10923313	
	BetaGeneral		- 40%	0.048780487804		0.0924511	0.116621	0.07157737	0.09898287	0.10311865	0.07042047	0.09504515	0.10898969	0.145701	0.11638418	
	Pareto		45%		0.048780487804	0.1018091	0.123019	0.07640847	0.10571551	0.11082111	0.07647828	0.10193505	0.11597988	0.150999	0.12317701	
			50%		0.048780487804	0.1111671	0.129037	0.08207534	0.11254911	0.11840145	0.08311387	0.10902090	0.12282932	0.155738	0.12980189	
	Triang		55%		0.049879856767	0.1205251	0.134793	0.08883014	0.11957642	0.12598180	0.09044917	0.11642834	0.12967876	0.160477	0.13642676	
	ChiSq	N/A	60%		0.053249092494	0.1298831	0.140390	0.09704155	0.12690309	0.13368426	0.09864934	0.12430477	0.13666896	0.165774	0.14321959	
	InvGauss	N/A	65%		0.059117242403	0.1392411	0.145925	0.10727266	0.13466027	0.14164537	0.10794593	0.13283891	0.14395883	0.171780	0.15037064	
	LogLogistic	N/A	70%		0.067925968136	0.1485991	0.151498	0.12043211	0.14302432	0.15003517	0.11867805	0.14229222	0.15174992	0.178713	0.15812243	
	Loanorm	N/A	75%		0.080453601524	0.1579571	0.157234	0.13809543	0.15225235	0.15908909	0.13137145	0.15305698	0.16032798	0.186914	0.16682085	
	Lognorm2	N/A	80%		0.098094849846	0.1673151	0.163306	0.16327673	0.16275524	0.16917106	0.14690692	0.16577830	0.17014735	0.196950	0.17701896	
	Pareto2	N/A	90%		0.163124182829	0.1860310	0.177876	0.27472037	0.19139857	0.19570924	0.19516450	0.20335663	0.19782663	0.228126	0.20719922	
	Pearson6	N/A	95%		0.237143039448	0.1953890	0.188581	0.46222926	0.21596633	0.21762492	0.24342207	0.23940267	0.22333111	0.259302	0.23657337	
			97.5%		0.316226565746	0.2000680	0.197048	0.77772133	0.23782116	0.23663350	0.29167965	0.27475888	0.22333111	0.290478	0.26575144	
	Student	N/A	99%		0.425561811614	0.2028754	0.206073	1.54716125	0.26376233	0.25873509	0.35547270	0.32102411	0.27967338	0.331691	0.30425512	
	Welbull	N/A	Information Criteria	1.1/36+02/	0.423301011014	0.2020734	0.200075	1.34/10123	0.20370233	0.23073309	0.33347270	0.52102411	0.27907556	0.331091	0.30423312	
	Dagum	N/A		24 2200 2244 45	10.0001766400	6 7570000	5 7 (0500	-5.56602982	5 00404000		-4.64689506	4 400000000	4.00004000		0.00000000	
1	Kumaraswamy	N/A	Akaike (AIC)	-24.7789721145	-18.3391766430	-6.7579223	-5.740580		-5.28101892	-4.89093641		-4.40375550	-4.33621928	-4.084459	-3.90923008	
			Bayesian (BIC)	-49.9506583772	-43.5108629057	-13.5390465	-12.521704	-12.34715399	-12.06214310	-11.67206058	-11.42801924	-11.18487967	-11.11734345	-10.865583	-10.69035425	
			Average Log-Likelihood		4.833917664304	1.6757922	1.574058	1.55660298	1.52810189	1.48909364	1.46468951	1.44037555	1.43362193	1.408446	1.39092301	
			Chi-Squared Test (Binni													
			Bin #1: Minimum	0.048780487804		0.0175872	-00	0.04878049	0.01669699	-00	0.03485629	-00	-00	-00	-00	
			Bin #1: Maximum		0.048780487804	0.1111671	0.129037	0.08207534	0.11254911	0.11840145	0.08311387	0.10902090	0.12282932	0.155738	0.12980189	
			Bin #1: Input		1.00000000000	2.0000000	2.000000	2.0000000	2.00000000	2.00000000	2.00000000	2.00000000	2.00000000	3.000000	2.00000000	
			Bin #1: Fit		2.50000000000	2.5000000	2.500000	2.50000000	2.50000000	2.50000000	2.50000000	2.50000000	2.50000000	2.500000	2.50000000	
			Bin #2: Minimum	0.048780487805	0.048780487804	0.1111671	0.129037	0.08207534	0.11254911	0.11840145	0.08311387	0.10902090	0.12282932	0.155738	0.12980189	
			4													

Figure 1-4: Lines outage rate (forced) – distribution fit using K-S

Nam	ne	K-S 🔺	Name	Frechet	FatigueLife	Uniform	ExtValueMin	Pareto	Rayleigh	Normal	Expon	ExtValue	Logistic	Laplace	HypSecant	Le
Beta	aGeneral	0.2000		1				1 .								1
Hyps	Secant	0,2889	Graph									LI				Δ.
Logis		0.3239				▞▇──▇へ╷					N					
Norn		0.3320	Distribution Statistics													
	/alueMin	0.3372	Minimum	0.048780487804		0.0175872	-00	0.04878049	0.01669699	-00	0.03485629	-00	-00	-00	-00	
Unifo		0.3381	Maximum	+00	+00	0.2047470	+00	+00	+00	+00	+00	+00	+00	+00	+00	
			Mean		0.083590971324	0.1111671	0.120465	0.19562645	0.11872841	0.11840145	0.10447726	0.11957203	0.12282932	0.155738	0.12980189	
Lapla		0.3444	Mode	0.048780487804	1.311E-008	0.0175872	0.143947	0.04878049	0.09810628	0.11840145	0.03485629	0.09066743	0.12282932	0.155738	0.12980189	
Caud	chy	0.3528	Median	0.048780487805		0.1111671	0.129037	0.08207534	0.11254911	0.11840145	0.08311387	0.10902090	0.12282932	0.155738	0.12980189	
Levy	y	0.3544	Std Deviation		0.077838607480	0.0540284	0.052175	N/A	0.05333419	0.06032358	0.06962097	0.06422486	0.06190995	0.063608	0.06597572	
Pear	rson5	0.3545	Skewness	N/A	3.9355	0.0000	-1.1395	N/A	0.6311	0.0000	2.0000	1.1395	0.0000	0.0000	0.0000	
ExtV	/alue	0.3613	Kurtosis	N/A	25.3200	1.8000	5.4000	N/A	3.2451	3.0000	9.0000	5.4000	4.2000	6.0000	5.0000	
Gam	ma	0.3646	Percentiles													
Erlan		0.3654	1%	0.048780487804		0.0194588	-0.043189	0.04914989	0.02823894	-0.02193218	0.03555601	0.01419251	-0.03401473	-0.020215	-0.04465135	
Erlan		0.3674	2.5%		0.048780487804	0.0222662	-0.005604	0.04971641	0.03501600	0.00016941	0.03661894	0.02530220	-0.00221809	0.020997	-0.00614767	
	-		5%	0.048780487804	0.048780487804	0.0269452	0.023118	0.05069531	0.04277169	0.01917799	0.03842738	0.03572470	0.02232754	0.052173	0.02303041	
Pert		0.3717	10%		0.048780487804	0.0363032	0.052401	0.05279512	0.05406740	0.04109367	0.04219160	0.04890249	0.04783202	0.083349	0.05240455	
Pare		0.3870	20%	0.048780487804	0.048780487804	0.0550191	0.082929	0.05767547	0.07108224	0.06763185	0.05039176	0.06683705	0.07551129	0.114525	0.08258481	
Trian	ng	0.4032	25%	0.048780487804	0.048780487804	0.0643771	0.093263	0.06053837	0.07844819	0.07771382	0.05488500	0.07431092	0.08533067	0.124562	0.09278292	
Burr	12	0.4112	30%	0.048780487804	0.048780487804	0.0737351	0.102008	0.06375621	0.08545531	0.08676774	0.05968835	0.08137200	0.09390872	0.132762	0.10148134	
Expo	on	0.4238	35%	0.048780487804	0.048780487804	0.0830931	0.109688	0.06740339	0.09226156	0.09515754	0.06484782	0.08823270	0.10169982	0.139695	0.10923313	
Fatio	queLife	0.5000	40%		0.048780487804	0.0924511	0.116621	0.07157737	0.09898287	0.10311865	0.07042047	0.09504515	0.10898969	0.145701	0.11638418	
Fred		0.5964	45%	0.048780487804	0.048780487804	0.1018091	0.123019	0.07640847	0.10571551	0.11082111	0.07647828	0.10193505	0.11597988	0.150999	0.12317701	
Erf	anex	0.6461	50%		0.048780487804	0.1111671	0.129037	0.08207534	0.11254911	0.11840145	0.08311387	0.10902090	0.12282932	0.155738	0.12980189	
			55%	0.048780487812	0.049879856767	0.1205251	0.134793	0.08883014	0.11957642	0.12598180	0.09044917	0.11642834	0.12967876	0.160477	0.13642676	
ChiS		N/A	60%	0.048780488032	0.053249092494	0.1298831	0.140390	0.09704155	0.12690309	0.13368426	0.09864934	0.12430477	0.13666896	0.165774	0.14321959	
InvG		N/A	65%	0.048780496731	0.059117242403	0.1392411	0.145925	0.10727266	0.13466027	0.14164537	0.10794593	0.13283891	0.14395883	0.171780	0.15037064	
LogL	Logistic	N/A	70%	0.048781006435	0.067925968136	0.1485991	0.151498	0.12043211	0.14302432	0.15003517	0.11867805	0.14229222	0.15174992	0.178713	0.15812243	
Logn	norm	N/A	75%	0.048833423557	0.080453601524	0.1579571	0.157234	0.13809543	0.15225235	0.15908909	0.13137145	0.15305698	0.16032798	0.186914	0.16682085	
Logn	norm2	N/A	80%	0.061305162484	0.098094849846	0.1673151	0.163306	0.16327673	0.16275524	0.16917106	0.14690692	0.16577830	0.17014735	0.196950	0.17701896	
Pare	eto2	N/A	90%	128,982.825402	0.163124182829	0.1860310	0.177876	0.27472037	0.19139857	0.19570924	0.19516450	0.20335663	0.19782663	0.228126	0.20719922	
Pear		N/A	95%	6.876E+011	0.237143039448	0.1953890	0.188581	0.46222926	0.21596633	0.21762492	0.24342207	0.23940267	0.22333111	0.259302	0.23657337	
Stud		N/A	97.5%	2.725E+018	0.316226565746	0.2000680	0.197048	0.77772133	0.23782116	0.23663350	0.29167965	0.27475888	0.24787674	0.290478	0.26575144	
			99%	1.173E+027	0.425561811614	0.2028754	0.206073	1.54716125	0.26376233	0.25873509	0.35547270	0.32102411	0.27967338	0.331691	0.30425512	
Web		N/A	Information Criteria													
] Dagu		N/A	Akaike (AIC)	-24.7789721145	-18.3391766430	-6.7579223	-5.740580	-5.56602982	-5.28101892	-4.89093641	-4.64689506	-4.40375550	-4.33621928	-4.084459	-3.90923008	
Kumi	araswamy	N/A	Bayesian (BIC)	-49.9506583772	-43.5108629057	-13.5390465	-12.521704	-12.34715399	-12.06214310	-11.67206058	-11.42801924	-11.18487967	-11.11734345	-10.865583	-10.69035425	
			Average Log-Likelihood	5.477897211458	4.833917664304	1.6757922	1.574058	1.55660298	1.52810189	1.48909364	1.46468951	1.44037555	1.43362193	1.408446	1.39092301	
			Chi-Squared Test (Binni	ng Information)												
			Bin #1: Minimum	0.048780487804	0.048780487804	0.0175872	-00	0.04878049	0.01669699		0.03485629	-00	-00	-00	-00	
			Bin #1: Maximum	0.048780487805	0.048780487804	0.1111671	0.129037	0.08207534	0.11254911	0.11840145	0.08311387	0.10902090	0.12282932	0.155738	0.12980189	
			Bin #1: Input	1.000000000000	1.000000000000	2.0000000	2.000000	2.00000000	2.00000000	2.00000000	2.00000000	2.00000000	2.00000000	3.000000	2.00000000	
			Bin #1: Fit		2.500000000000	2.5000000	2.500000	2.50000000	2.50000000	2.50000000	2.50000000	2.50000000	2.50000000	2.500000	2.50000000	
			Bin #2: Minimum		0.048780487804	0.1111671	0.129037	0.08207534	0.11254911	0.11840145	0.08311387	0,10902090	0,12282932	0.155738	0.12980189	
			Din 47: Maximum	1.00	1	0.2047470	1.00	1	1.00	1	1.00	1.00	1	1.00	1.00	
			4													

1.1.3 Reactive plant outage – fault (continuous)

Findings:

- A-D fit statistic: Frechet distribution best fit, however this returns an undefined standard deviation
 - The InvGauss distribution is also a close fit to the data and is close to the Frechet distribution (0.27370 v. 0.2387) and returns a standard deviation of 0.0638
- K-S fit statistic: Frechet distribution best fit, however this returns an undefined standard deviation
 - The InvGauss distribution is also a close fit to the data and is close to the Frechet distribution (0.1976 v. 0.1892) and returns a standard deviation of 0.0638

• K-S preferred (InvGauss) due to data falling near tails of distribution

Figure 1-5: Reactive plant outage (fault) – distribution fit using A-D

Name	A-D 🔺	Name		Laplace	Rayleigh	HypSecant	Logistic	Normal	Uniform	ExtValueMin	Erf	Pareto2	InvGauss	Triang	Frechet	Pear
Frechet	0.2387			1								Δ	£		٨	
InvGauss	0.2737	Graph											À.		N	
Cauchy	0.3033								 L.							
Expon	0.3881	Distribution Statistics														^
Levy	0.4125	Minimum	00	-00	0.12420425	-00	-00	-00	0.1197183	-00	-00	0.154930	0.14828633	0.1549296	0.13788912	0.15
		Maximum	00	+00	+00	+00	+00	+00	0.3309859	+00	+00	+00	+00	0.3274041	+00	
ExtValue	0.4941	Mean	/A	0.185714	0.20376126	0.18362315	0.18829604	0.19876768	0.2253521	0.193215	0.0000000	0.198768	0.19876768	0.2124211	0.21218981	
Laplace	0.5040	Mode	19	0.185714	0.18768156	0.18362315	0.18829604	0.19876768	0.1197183	0.226452	0.0000000	0.154930	0.15840168	0.1549296	0.16202640	0.1
HypSecant	0.5865	Median	39	0.185714	0.19894307	0.18362315	0.18829604	0.19876768	0.2253521	0.205347	0.0000000	0.185316	0.17700306	0.2054462	0.17840695	0.1
Logistic	0.6020	Std Deviation	/A	0.045322	0.04158630	0.04458622	0.04714243	0.05589089	0.0609877	0.073852	0.2049576	0.043838	0.06378915	0.0406526	N/A	
Normal	0.6278	Skewness	/A	0.0000	0.6311	0.0000	0.0000	0.0000	0.0000	-1.1395	0.0000	2.0000	3.7909	0.5657	N/A	
Rayleigh	0.7245	Kurtosis	(A)	6.0000	3.2451	5.0000	4.2000	3.0000	1.8000	5.4000	3.0000	9.0000	26.9510	2.4000	N/A	
ExtValueMin	0.7681	Percentiles														~
Pearson5	0.8460	1%	16	0.060344	0.13320386	0.06572812	0.06886436	0.06874602	0.1218310	-0.038435	-0.4768027	0.155370	0.15238137	0.1557941	0.15057562	0.1
Uniform	0.9652	2.5%	15	0.089709	0.13848814	0.09174881	0.09307647	0.08922354	0.1250000	0.014765	-0.4017095	0.156039	0.15349102	0.1570992	0.15242442	0.1
		5%	24	0.111923	0.14453549	0.11146727	0.11176718	0.10683534	0.1302817	0.055422	-0.3371253	0.157178	0.15479917	0.1592967	0.15440309	0.1
Burr 12	1.2673	10%	32	0.134136	0.15334311	0.13131824	0.13118801	0.12714062	0.1408451	0.096871	-0.2626638	0.159548	0.15691471	0.1637804	0.15729494	0.1
FatigueLife	2.1908	20%	26	0.156350	0.16661009	0.15171398	0.15226489	0.15172872	0.1619718	0.140082	-0.1724967	0.164712	0.16085129	0.1731382	0.16206094	0.1
Erf	3.9646	25%	76	0.163501	0.17235355	0.15860583	0.15974203	0.16106984	0.1725352	0.154710	-0.1382418	0.167541	0.16293198	0.1780368	0.16437753	0.1
BetaGeneral		30%	70	0.169344	0.17781722	0.16448420	0.16627394	0.16945847	0.1830986	0.167089	-0.1074799	0.170566	0.16517426	0.1831016	0.16676979	0.1
Pareto		35%	57	0.174284	0.18312425	0.16972284	0.17220660	0.17723177	0.1936620	0.177959	-0.0789744	0.173814	0.16763412	0.1883507	0.16930093	0.1
Pareto2		40%	77	0.178563	0.18836506	0.17455550	0.17775760	0.18460788	0.2042254	0.187772	-0.0519254	0.177323	0.17037303	0.1938059	0.17203372	0.1
Triang		45%	58	0.182338	0.19361471	0.17914608	0.18308041	0.19174435	0.2147887	0.196830	-0.0257552	0.181138	0.17346478	0.1994936	0.17503948	0.1
ChiSq	N/A	50%	39	0.185714	0.19894307	0.18362315	0.18829604	0.19876768	0.2253521	0.205347	0.0000000	0.185316	0.17700306	0.2054462	0.17840695	0.1
Erlang	N/A	55%	łO	0.189091	0.20442248	0.18810022	0.19351167	0.20579100	0.2359155	0.213495	0.0257552	0.189935	0.18111210	0.2117047	0.18225401	0.1
		60%	21	0.192865	0.21013531	0.19269081	0.19883448	0.21292747	0.2464789	0.221418	0.0519254	0.195098	0.18596320	0.2183216	0.18674613	0.1
Gamma	N/A	65%	31	0.197145	0.21618382	0.19752346	0.20438548	0.22030358	0.2570423	0.229252	0.0789744	0.200952	0.19180251	0.2253668	0.19212817	0.1
LogLogistic	N/A	70%	28	0.202085	0.22270553	0.20276210	0.21031815	0.22807689	0.2676056	0.237141	0.1074799	0.207709	0.19900126	0.2329359	0.19878465	0.1
Lognorm	N/A	75%	22	0.207928	0.22990091	0.20864047	0.21685006	0.23646551	0.2781690	0.245260	0.1382418	0.215702	0.20815417	0.2411668	0.20736486	0.2
Lognorm2	N/A	80%	72	0.215079	0.23809033	0.21553232	0.22432720	0.24580664	0.2887324	0.253855	0.1724967	0.225484	0.22029464	0.2502712	0.21907605	0.3
Pearson6	N/A	90%	i6	0.237293	0.26042440	0.23592806	0.24540407	0.27039474	0.3098592	0.274477	0.2626638	0.255871	0.26434433	0.2728629	0.26651561	2.2
Pert	N/A	95%	74	0.259506	0.27958064	0.25577903	0.26482491	0.29070001	0.3204225	0.289631	0.3371253	0.286257	0.31711400	0.2888376	0.33788723	27.6
Student	N/A	97.5%	13	0.281720	0.29662152	0.27549750	0.28351561	0.30831181	0.3257042	0.301615	0.4017095	0.316643	0.37731340	0.3001335	0.44624535	366.3
Weibul	N/A	99%	14	0.311084	0.31684864	0.30151818	0.30772773	0.32878934	0.3288732	0.314390	0.4768027	0.356812	0.46622653	0.3101567	0.68125782	11,240.
Dagum	N/A	Information Criteria														^
	N/A	Akaike (AIC)	15	-7.473934	-7.37137426	-6.48322418	-6.02874139	-5.65415313	-5.5462968	-3.737618	1.6731978	8.727480	9.54291295	9.8809647	9.95867316	12.18
Kumaraswamy	N/A	Bayesian (BIC)	33	-14.255058	-14.15249843	-13.26434835	-12.80986556	-12.43527731	-12.3274209	-10.518742	-0.0506976	-16.444206	-15.62877331	-15.2907216	-15.21301310	-12.9
		Average Log-Likeliho	od 22	1.747393	1.73713743	1.64832242	1.60287414	1.56541531	1.5546297	1.373762	0.1660135	2.127252	2.04570870	2.0119035	2.00413268	1.78
		Chi-Squared Test (B	nning Info	rmation)												~
		Bin #1: Minimum	00	-00	0.12420425	-00	-00	-00	0.1197183	-00	-00	0.154930	0.14828633	0.1549296	0.13788912	0.1
		Bin #1: Maximum)9	0.185714	0.19894307	0.18362315	0.18829604	0.19876768	0.2253521	0.205347	0.0000000	0.185316	0.17700306	0.2054462	0.17840695	0.1
		Bin #1: Input)0	3.000000	4.00000000	2.00000000	3.00000000	4.00000000	4.0000000	4.000000	0.0000000	2.000000	2.0000000	4.0000000	2.00000000	1.0
		Bin #1: Fit)0	2.500000	2.50000000	2.50000000	2.50000000	2.50000000	2.5000000	2.500000	2.5000000	2.500000	2.50000000	2.5000000	2.50000000	2.5
		Bin #2: Minimum	19	0.185714	0.19894307	0.18362315	0.18829604	0.19876768	0.2253521	0.205347	0.0000000	0.185316	0.17700306	0.2054462	0.17840695	0.1
		4														
	6 🔀 ±													[2	Back Write To	Excel

Name	K-S 🔺	Name	auchy	Laplace	Rayleigh	HypSecant	Logistic	Normal	Uniform	ExtValueMin	Erf	Pareto2	InvGauss	Triang	Frechet
Frechet	0,1892		1									N		-	
InvGauss	0,1976	Graph									. I. I.		Δ.		A
Expon	0.2052														
		Distribution Statistics													
Pareto	0.2144	Minimum	-00	-00	0.12420425	- 00	-00	- 00	0.1197183	-00	-00	0.154930	0.14828633	0.1549296	0.137889
Cauchy	0.2239	Maximum	+00	+00	+00	+00	+00	+00	0.3309859	+00	+00	+00	+00	0.3274041	+
HypSecant	0.2466	Mean	N/A	0.185714	0.20376126	0.18362315	0.18829604	0.19876768	0.2253521	0.193215	0.0000000	0.198768	0.19876768	0.2124211	0.212189
Levy	0.2488	Mode	0.17980699	0.185714	0.18768156	0.18362315	0.18829604	0.19876768	0.1197183	0.226452	0.0000000	0.154930	0.15840168	0.1549296	0.162026
Laplace	0.2597	Median	0.17980699	0.185714	0.19894307	0.18362315	0.18829604	0.19876768	0.2253521	0.205347	0.0000000	0.185316	0.17700306	0.2054462	0.178406
Pareto2	0.2660	Std Deviation	N/A	0.045322	0.04158630	0.04458622	0.04714243	0.05589089	0.0609877	0.073852	0.2049576	0.043838	0.06378915	0.0406526	N. 170 100.
Logistic	0.2989	Skewness	N/A	0.0000	0.6311	0.0000	0.0000	0.0000	0.0000	-1.1395	0.0000	2.0000	3.7909	0.5657	N
ExtValue	0.3064	Kurtosis	N/A	6.0000	3,2451	5.0000	4.2000	3.0000	1.8000	5,4000	3.0000	9,0000	26.9510	2,4000	N
		Percentiles	19/6	0.0000	3.2431	5.0000	4.2000	3.0000	1.0000	3.4000	5.0000	5.0000	20.9310	2,4000	N,
BetaGeneral	0.3365	1%	0.27854316	0.060344	0.13320386	0.06572812	0.06886436	0.06874602	0.1218310	-0.038435	-0.4768027	0.155370	0.15238137	0.1557941	0.1505756
Normal	0.3735	2.5%	0.27854516	0.089709	0.13320386	0.09174881	0.09307647	0.08922354	0.1218310	0.014765	-0.4/6802/	0.155370	0.15238137	0.1570992	0.1505750
ExtValueMin	0.3966														
Rayleigh	0.3996	5%	0.08886224	0.111923	0.14453549	0.11146727	0.11176718	0.10683534	0.1302817	0.055422	-0.3371253	0.157178	0.15479917	0.1592967	0.1544030
Pearson5	0.4232	10% 20%	0.13547532	0.134136	0.15334311	0.13131824	0.13118801	0.12714062	0.1408451	0.096871	-0.2626638	0.159548	0.15691471	0.1637804	0.157294
Triang	0.4495		0.15998126	0.156350	0.16661009	0.15171398	0.15226489	0.15172872	0.1619718	0.140082	-0.1724967	0.164712	0.16085129	0.1731382	0.162060
Burr 12	0.4588	25%	0.16540276	0.163501	0.17235355	0.15860583	0.15974203	0.16106984	0.1725352	0.154710	-0.1382418	0.167541	0.16293198	0.1780368	0.164377
Uniform	0.4749	30% 35%	0.16934170	0.169344	0.17781722	0.16448420	0.16627394	0.16945847	0.1830986	0.167089	-0.1074799 -0.0789744	0.170566	0.16517426	0.1831016	0.1667693
			0.17246767		0.18312425		0.17220660	0.17723177	0.1936620	0.177959		0.173814	0.16763412	0.1883507	0.169300
FatigueLife	0.5146	40%	0.17512677	0.178563	0.18836506	0.17455550	0.17775760	0.18460788	0.2042254	0.187772	-0.0519254	0.177323	0.17037303	0.1938059	0.172033
] Erf	0.7751	45%	0.17752558	0.182338	0.19361471	0.17914608	0.18308041	0.19174435	0.2147887	0.196830	-0.0257552	0.181138	0.17346478	0.1994936	0.1750394
] ChiSq	N/A	50%	0.17980699	0.185714	0.19894307	0.18362315	0.18829604	0.19876768	0.2253521	0.205347	0.0000000	0.185316	0.17700306	0.2054462	0.1784069
] Erlang	N/A	55%	0.18208840	0.189091	0.20442248	0.18810022	0.19351167	0.20579100	0.2359155	0.213495	0.0257552	0.189935	0.18111210	0.2117047	0.1822540
Gamma	N/A	60%	0.18448721	0.192865	0.21013531	0.19269081	0.19883448	0.21292747	0.2464789	0.221418	0.0519254	0.195098	0.18596320	0.2183216	0.1867461
LogLogistic	N/A	65%	0.18714631	0.197145	0.21618382	0.19752346	0.20438548	0.22030358	0.2570423	0.229252	0.0789744	0.200952	0.19180251	0.2253668	0.1921281
Lognorm	N/A	70%	0.19027228	0.202085	0.22270553	0.20276210	0.21031815	0.22807689	0.2676056	0.237141	0.1074799	0.207709	0.19900126	0.2329359	0.1987846
		75%	0.19421122	0.207928	0.22990091	0.20864047	0.21685006	0.23646551	0.2781690	0.245260	0.1382418	0.215702	0.20815417	0.2411668	0.2073648
Lognorm2	N/A	80%	0.19963272	0.215079	0.23809033	0.21553232	0.22432720	0.24580664	0.2887324	0.253855	0.1724967	0.225484	0.22029464	0.2502712	0.2190760
Pearson6	N/A	90%	0.22413866	0.237293	0.26042440	0.23592806	0.24540407	0.27039474	0.3098592	0.274477	0.2626638	0.255871	0.26434433	0.2728629	0.2665156
] Pert	N/A	95%	0.27075174	0.259506	0.27958064	0.25577903	0.26482491	0.29070001	0.3204225	0.289631	0.3371253	0.286257	0.31711400	0.2888376	0.3378872
Student	N/A	97.5%	0.36283013	0.281720	0.29662152	0.27549750	0.28351561	0.30831181	0.3257042	0.301615	0.4017095	0.316643	0.37731340	0.3001335	0.4462453
Webull	N/A	99%	0.63815714	0.311084	0.31684864	0.30151818	0.30772773	0.32878934	0.3288732	0.314390	0.4768027	0.356812	0.46622653	0.3101567	0.6812578
Dagum	N/A	Information Criteria													
Kumaraswamy		Akaike (AIC)	8.00553215	-7.473934	-7.37137426	-6.48322418	-6.02874139	-5.65415313	-5.5462968	-3.737618	1.6731978	8.727480	9.54291295	9.8809647	9.9586731
- Kumarasmanny	0/6	Bayesian (BIC)	4.78665633	-14.255058	-14.15249843	-13.26434835	-12.80986556	-12.43527731	-12.3274209	-10.518742	-0.0506976	-16.444206	-15.62877331	-15.2907216	-15.2130131
		Average Log-Likeliho	od 1.80055322	1.747393	1.73713743	1.64832242	1.60287414	1.56541531	1.5546297	1.373762	0.1660135	2.127252	2.04570870	2.0119035	2.0041326
		Chi-Squared Test (Bir	nning Information)												
		Bin #1: Minimum	-00	-00	0.12420425	-00	- 00	-00	0.1197183	-00	-00	0.154930	0.14828633	0.1549296	0.1378891
		Bin #1: Maximum	0.17980699	0.185714	0.19894307	0.18362315	0.18829604	0.19876768	0.2253521	0.205347	0.0000000	0.185316	0.17700306	0.2054462	0.178406
		Bin #1: Input	2.00000000	3.000000	4.00000000	2.00000000	3.00000000	4.00000000	4.0000000	4.000000	0.0000000	2.000000	2.00000000	4.0000000	2.000000
		Bin #1: Fit	2.50000000	2.500000	2.50000000	2.50000000	2.50000000	2.50000000	2.5000000	2.500000	2.5000000	2.500000	2.50000000	2.5000000	2.500000
		Bin #2: Minimum	0.17980699	0.185714	0.19894307	0.18362315	0.18829604	0.19876768	0.2253521	0.205347	0.0000000	0.185316	0.17700306	0.2054462	0.178406
		4			_										

Figure 1-6: Reactive plant outage (fault) – distribution fit using K-S

1.1.4 Reactive plant outage – forced (continuous)

- A-D fit statistic: Cauchy distribution best fit, however this returns an undefined standard deviation
 - The Normal distribution is also a close fit to the data and is close to the Cauchy distribution (0.2663 v. 0.2564) and returns a standard deviation of 0.0326
- K-S fit statistic: Cauchy distribution best fit, however this returns an undefined standard deviation
 - The Normal distribution is also a close fit to the data and is close to the Cauchy distribution (0.2050 v. 0.2015) and returns a standard deviation of 0.0326
- K-S preferred (Normal) due to data falling in the middle and near tails of distribution

Name		A-D ▲	Name	ExtValueMin	Uniform	Normal	Rayleigh	Logistic	HypSecant	Laplace	ExtValue	Pareto	Cauchy	Expon	Levy	E
Cauch		0.2564	Graph	- 4	┍╋╋╋┑						d.	N		N		
Norma		0.2663														
HypSe		0.2810	Distribution Statistics													
Logist	5c	0.2857	Minimum	-00	0.2311871	-00	0.23864204	-00	-00	-00	-00	0.2535211	-00	0.24284420	0.248463	
Fatigu	JeLife	0.3114	Maximum	+00	0.3651911	+00	+00	+00	+00	+00	+00	+00	+00	+00	+00	
ExtVa	lueMin	0.3200	Mean	0.307398	0.2981891	0.30690578	0.30559901	0.30897623	0.30952809	0.304348	0.30879331	0.3111776	N/A	0.29622885	N/A	
Laplac	ce .	0.3310	Mode	0.322247	0.2311871	0.30690578	0.29206597	0.30897623	0.30952809	0.304348	0.29009581	0.2535211	0.30777290	0.24284420	0.254911	
Frech		0.3579	Median	0.312818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2882640	0.30777290	0.27984762	0.290980	
ExtVa		0.3583	Std Deviation	0.032995	0.0386836	0.03619900	0.03499996	0.03508248	0.03677326	0.037219	0.04154509	0.0726731	N/A	0.05338466	N/A	
			Skewness	-1.1395	0.0000	0.0000	0.6311	0.0000	0.0000	0.0000	1,1395	4,2345	N/A	2,0000	N/A	
aylei		0.3956	Kurtosis	5.4000	1.8000	3.0000	3.2451	4.2000	5.0000	6,0000	5,4000	53.4425	N/A	9.0000	N/A	
Inifor	rm	0.4013	Percentiles	011000	1,0000	010000	012102	112000	010000	010000	011000	0011120		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
amm	na	0.5732	1%	0.203903	0.2325272	0.22269432	0.24621632	0.22009749	0.21229210	0.201392	0.24062653	0.2539937	-0.38464764	0.24338073	0.251378	
evy		0.7343	2.5%	0.227671	0.2325272	0.23595705	0.25066368	0.23811568	0.23375311	0.225506	0.24082855	0.2547132	0.03128345	0.24338073	0.252313	
xpon	1	0.9020	2.5%	0.22/6/1	0.2345372			0.25202494			0.25455505	0.2559420	0.17038446	0.24919578	0.252313	
ears		1.1074	10%			0.24736373	0.25575327		0.25001626	0.243749						
urr 13		1.4664		0.264354	0.2445875	0.26051490	0.26316595	0.26647755	0.26638870	0.261991	0.26307935	0.2585189	0.24080192	0.24846883	0.255612	
	4		20%	0.283659	0.2579879	0.27643994	0.27433175	0.28216255	0.28321044	0.280233	0.27468067	0.2642227	0.27782257	0.25475664	0.260240	
ert		1.6531	25%	0.290195	0.2646881	0.28248993	0.27916557	0.28772689	0.28889461	0.286106	0.27951529	0.2674012	0.28601271	0.25820200	0.263080	
f		4.5504	30%	0.295725	0.2713883	0.28792301	0.28376391	0.29258781	0.29374290	0.290904	0.28408288	0.2708414	0.29196320	0.26188516	0.266470	
taG	General		35%	0.300582	0.2780885	0.29295757	0.28823044	0.29700279	0.29806356	0.294961	0.28852086	0.2745860	0.29668553	0.26584139	0.270608	
lang	,		40%	0.304966	0.2847887	0.29773487	0.29264122	0.30113373	0.30204938	0.298475	0.29292762	0.2786887	0.30070259	0.27011445	0.275770	
areto	0		45%	0.309013	0.2914889	0.30235697	0.29705944	0.30509486	0.30583554	0.301575	0.29738448	0.2832181	0.30432643	0.27475952	0.282358	
areto			50%	0.312818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2882640	0.30777290	0.27984762	0.290980	
			55%	0.316458	0.3048893	0.31145460	0.30615550	0.31285760	0.31322063	0.307121	0.30675975	0.2939467	0.31121938	0.28547225	0.302595	
iang			60%	0.319998	0.3115895	0.31607669	0.31096355	0.31681873	0.31700679	0.310220	0.31185477	0.3004321	0.31484322	0.29176006	0.318800	
niSq		N/A	65%	0.323498	0.3182897	0.32085400	0.31605411	0.32094968	0.32099261	0.313735	0.31737525	0.3079579	0.31886027	0.29888859	0.342403	
vGa	BUSS	N/A	70%	0.327023	0.3249899	0.32588856	0.32154293	0.32536466	0.32531327	0.317792	0.32349030	0.3168806	0.32358261	0.30711787	0.378739	
gLo	gistic	N/A	75%	0.330650	0.3316901	0.33132164	0.32759872	0.33022558	0.33016156	0.322590	0.33045369	0.3277681	0.32953309	0.31685104	0.438969	
ano	orm	N/A	80%	0.334490	0.3383903	0.33737163	0.33449112	0.33578992	0.33584573	0.328463	0.33868272	0.3416037	0.33772324	0.32876348	0.549816	
-	vrm2	N/A	90%	0.343704	0.3517907	0.35329667	0.35328798	0.35147492	0.35266747	0.346705	0.36299099	0.3884176	0.37474389	0.36576691	1.473373	
	on6	N/A	95%	0.350474	0.3584909	0.36644784	0.36941029	0.36592753	0.36903991	0.364947	0.38630807	0.4416468	0.44516135	0.40277033	5.167483	
			97.5%	0.355828	0.3618410	0.37785452	0.38375228	0.37983679	0.38530306	0.383189	0.40917891	0.5021707	0.58426236	0.43977376	19.943893	
ude		N/A	99%	0.361536	0.3638511	0.39111725	0.40077588	0.39785498	0.40676407	0.407304	0.43910647	0.5950912	1.00019344	0.48868962	123.378754	
eibu		N/A	Information Criteria													
agur	m	N/A	Akaike (AIC)	-10.639126	-10.0988545	-9.99785288	-9.86435397	-9.74562390	-9.51745957	-9.443585	-9.10880848	-8.7288512	-7.58319809	-7.30231920	-4.069356	
ımar	raswamy	N/A	Bayesian (BIC)	-17.420250	-16.8799787	-16.77897706	-16.64547815	-16,52674808	-16.29858375	-16.224709	-15.88993266	-15.5099754	-14.36432226	-14.08344337	-10.850480	
			Average Log-Likelihood	2.063913	2.0098854	1.99978529	1.98643540	1.97456239	1.95174596	1.944358	1.91088085	1.8728851	1.75831981	1.73023192	1.406936	
			Chi-Squared Test (Binning													
			Bin #1: Minimum	-00	0.2311871	-00	0.23864204	- 00	-00	-00	-00	0.2535211	-00	0.24284420	0.248463	
			Bin #1: Maximum	0.312818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2882640	0.30777290	0.27984762	0.290980	
			Bin #1: Input	3.000000	2.0000000	3.00000000	2.00000000	3.00000000	3.00000000	3.000000	2.00000000	1.0000000	3.00000000	1.00000000	1.000000	
			Bin #1: Fit	2.500000	2.5000000	2.50000000	2.50000000	2.50000000	2.50000000	2,500000	2.50000000	2,5000000	2,50000000	2.50000000	2.500000	
			Bin #1: Ht Bin #2: Minimum	0.312818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2882640	0.30777290	0.27984762	0.290980	
			Din #2: Minimum Din #2: Movieum	0.512818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2002040	0.30777290	0.2/904/02	0.290980	
			4.0									1.00				

Figure 1-7: Reactive plant outage (forced) – distribution fit using A-D

Figure 1-8: Reactive plant outage (forced) – distribution fit using K-S

Name	K-S 🔺	Name	ExtValueMin	Uniform	Normal	Rayleigh	Logistic	HypSecant	Laplace	ExtValue	Pareto	Cauchy	Expon	Levy	Erf
Cauchy	0.2015							11			N III	1	N II	10	
Normal	0.2050	Graph									NL III		NL I	N	
HypSecant	0.2168	Distribution Statistics					_								
Logistic	0.2179	Minimum	-00	0.2311871	- 00	0.23864204	-00		-00	-00	0.2535211	-00	0.24284420	0.248463	
FatigueLife	0.2318	Maximum	+00	0.3651911	+00	+00	+00	+00	+00	+00	+00	+00	+00	+00	
Frechet	0.2319	Mean	0.307398	0.2981891	0.30690578	0.30559901	0.30897623	0.30952809	0.304348	0.30879331	0.3111776	N/A	0.29622885	N/A	
ExtValue	0.2321	Mode	0.322247	0.2311871	0.30690578	0.29206597	0.30897623	0.30952809	0.304348	0.29009581	0.2535211	0.30777290	0.24284420	0.254911	
Ravleigh	0.2355	Median	0.312818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2882640	0.30777290	0.27984762	0.290980	
ExtValueMin	0.2422	Std Deviation	0.032995	0.0386836	0.03619900	0.03499996	0.03508248	0.03677326	0.037219	0.04154509	0.0726731	N/A	0.05338466	N/A	Ċ
Laplace	0.2609	Skewness	-1.1395	0.0000	0.0000	0.6311	0.0000	0.0000	0.0000	1.1395	4.2345	N/A	2.0000	N/A	
BetaGeneral	0.2691	Kurtosis	5,4000	1.8000	3.0000	3.2451	4.2000	5.0000	6.0000	5,4000	53,4425	N/A	9,0000	N/A	
		Percentiles	5. 1000	10000	510000	012101		510000	0.0000	51 1000	0011120	140		1475	
Uniform	0.2820	1%	0.203903	0.2325272	0.22269432	0.24621632	0.22009749	0.21229210	0.201392	0.24062653	0.2539937	-0.38464764	0.24338073	0.251378	-
Pert	0.2913	2.5%	0.227671	0.2345372	0.23595705	0.25066368	0.23811568	0.23375311	0.225506	0.24781305	0.2547132	0.03128345	0.24419578	0.252313	
Triang	0.3166	5%	0.245835	0.2378873	0.24736373	0.25575327	0.25202494	0.25001626	0.243749	0.25455505	0.2559420	0.17038446	0.24558247	0.253498	
Gamma	0.3184	10%	0.264354	0.2445875	0.26051490	0.26316595	0.26647755	0.26638870	0.261991	0.26307935	0.2585189	0.24080192	0.24846883	0.255612	
Erlang	0.3468	20%	0.283659	0.2579879	0.27643994	0.27433175	0.28216255	0.28321044	0.280233	0.27468067	0.2563183	0.27782257	0.25475664	0.260240	
Levy	0.3492	25%	0.290195	0.2646881	0.28248993	0.27916557	0.28772689	0.28889461	0.286106	0.27951529	0.2674012	0.28601271	0.25820200	0.263080	
Pareto	0.3648	30%	0.295725	0.2713883	0.28792301	0.28376391	0.29258781	0.29374290	0.290904	0.28408288	0.2708414	0.29196320	0.26188516	0.266470	
Expon	0.4290	35%	0.300582	0.2780885	0.29295757	0.28823044	0.29700279	0.29806356	0.294961	0.28852086	0.2745860	0.29668553	0.26584139	0.270608	
	0.4290	40%	0.304966	0.2847887	0.29773487	0.29264122	0.30113373	0.30204938	0.298475	0.29292762	0.2786887	0.30070259	0.27011445	0.275770	
Pearson5		45%	0.309013	0.2914889	0.30235697	0.29705944	0.30509486	0.30583554	0.301575	0.29738448	0.2832181	0.30432643	0.27475952	0.282358	
Pareto2	0.4817	50%	0.312818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2882640	0.30777290	0.27984762	0.290980	
Burr 12	0.4911	55%	0.316458	0.3048893	0.31145460	0.30615550	0.31285760	0.31322063	0.307121	0.30675975	0.2939467	0.31121938	0.28547225	0.302595	
Erf	0.7943	60%	0.319998	0.3115895	0.31607669	0.31096355	0.31681873	0.31700679	0.310220	0.31185477	0.3004321	0.31484322	0.29176006	0.318800	
ChiSq	N/A	65%	0.323498	0.3182897	0.32085400	0.31605411	0.32094968	0.32099261	0.313735	0.31737525	0.3079579	0.31886027	0.29888859	0.342403	
InvGauss	N/A	70%	0.327023	0.3249899	0.32588856	0.32154293	0.32536466	0.32531327	0.317792	0.32349030	0.3168806	0.32358261	0.30711787	0.378739	
LogLogistic	N/A	75%	0.330650	0.3316901	0.33132164	0.32759872	0.33022558	0.33016156	0.322590	0.33045369	0.3277681	0.32953309	0.31685104	0.438969	
Lognorm	N/A	80%	0.334490	0.3383903	0.33737163	0.33449112	0.33578992	0.33584573	0.328463	0.33868272	0.3416037	0.33772324	0.32876348	0.549816	
Lognorm2	N/A	90%	0.343704	0.3517907	0.35329667	0.35328798	0.35147492	0.35266747	0.346705	0.36299099	0.3884176	0.37474389	0.36576691	1.473373	
Pearson6	N/A	95%	0.350474	0.3584909	0.36644784	0.36941029	0.36592753	0.36903991	0.364947	0.38630807	0.4416468	0.44516135	0.40277033	5.167483	
		97.5%	0.355828	0.3618410	0.37785452	0.38375228	0.37983679	0.38530306	0.383189	0.40917891	0.5021707	0.58426236	0.43977376	19,943893	
Student	N/A	99%	0.361536	0.3638511	0.39111725	0.40077588	0.39785498	0.40676407	0.407304	0.43910647	0.5950912	1.00019344	0.48868962	123.378754	
Weibull	N/A	Information Criteria													
Dagum	N/A	Akake (AIC)	-10.639126	-10.0988545	-9,99785288	-9.86435397	-9,74562390	-9.51745957	-9,443585	-9,10880848	-8,7288512	-7,58319809	-7,30231920	-4.069356	
Kumaraswamy	N/A	Bayesian (BIC)	-17.420250	-16.8799787	-16.77897706	-16.64547815	-16.52674808	-16.29858375	-16.224709	-15.88993266	-15.5099754	-14.36432226	-14.08344337	-10.850480	
		Average Log-Likelhood	2.063913	2.0098854	1.99978529	1.98643540	1.97456239	1.95174596	1.944358	1.91088085	1.8728851	1.75831981	1.73023192	1.406936	-
		Chi-Squared Test (Binning		210030031	1177770325	21300 133 15	1107 100200	1.5517 1550	21011000	1.5 1000005	1.0720001	1175051501	1170020172	1. 100500	
		Bin #1: Minimum	-00	0.2311871	- 00	0.23864204	-00			-00	0.2535211		0.24284420	0.248463	
		Bin #1: Maximum	0.312818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2882640	0.30777290	0.27984762	0.290980	
		Bin #1: Input	3.000000	2.0000000	3.00000000	2.00000000	3.00000000	3.00000000	3.000000	2.00000000	1.0000000	3.00000000	1.00000000	1.000000	
		Bin #1: Input Bin #1: Fit	2,500000	2.5000000	2,50000000	2.50000000	2,50000000	2,50000000	2,500000	2,50000000	2,5000000	2.50000000	2,50000000	2,500000	
		Bin #1: Ht Bin #2: Minimum	0.312818	0.2981891	0.30690578	0.30154391	0.30897623	0.30952809	0.304348	0.30196811	0.2882640	0.30777290	0.27984762	0.290980	
		Bin #2: Minimum	0.312018	0.2981891	0.30090378	0.30134391	0.30097023	0.30932009	0.004048	0.30190811	0.2002040	0.30777290	0.2/304/62	0.290980	-

1.1.5 Transformers outage – fault (continuous)

- A-D fit statistic: ExtValueMin distribution best fit, standard deviation 0.0295
- K-S fit statistic: Logistic distribution best fit, standard deviation 0.0334
- K-S preferred (Logistic) due to data concentrated closer to the centre and near • tails of distribution

Name	A-D 🔺	Name	ExtValueMin	Uniform	Normal	Logistic	HypSecant	Rayleigh	Laplace	ExtValue	Cauchy	Pareto	Expon	Levy	E
ExtValueMin	0.2567										1	k		1	
Normal	0.2804	Graph							• 4						
Logistic	0.2831													N	
HypSecant	0.2834	Distribution Statistics													
Laplace	0.3203	Minimum	-00	0.0407234	- 00	-00	- 00	0.04798931	- 00	-00	-00	0.06250000	0.05160209	0.057240	
FatigueLife	0.3203	Maximum	+00	0.1713829	+00	+00	+00	+00	+00	+00	+00	+00	+00	+00	
		Mean	0.118099	0.1060531	0.11698954	0.12061350	0.12298365	0.11519884	0.125984	0.11930515	N/A	0.14950250	0.10609163	N/A	
Cauchy	0.3672	PIOUC	0.131381	0.0407234	0.11698954	0.12061350	0.12298365	0.10161476	0.125984	0.10029159	0.13076158	0.06250000	0.05160209	0.063945	
ExtValue	0.4051		0.122947	0.1060531	0.11698954	0.12061350	0.12298365	0.11112845	0.125984	0.11236457	0.13076158	0.09355424	0.08937136	0.101456	
Frechet	0.4058	Std Deviation	0.029511	0.0377181	0.03518426	0.03343608	0.03460353	0.03513198	0.035628	0.04224735	N/A	N/A	0.05448954	N/A	
Rayleigh	0.4521	Skewness	-1.1395	0.0000	0.0000	0.0000	0.0000	0.6311	0.0000	1.1395	N/A	N/A	2.0000	N/A	
Uniform	0.4771	Kurtosis	5.4000	1.8000	3.0000	4.2000	5.0000	3.2451	6.0000	5.4000	N/A	N/A	9.0000	N/A	
Gamma	0.6554	Percentiles													
Levy	0.7652	1%	0.025534	0.0420300	0.03513871	0.03590579	0.03148486	0.05559216	0.027430	0.04998610	-0.45040471	0.06286662	0.05214973	0.060272	
Expon	0.9775	2.5%	0.046792	0.0439899	0.04802965	0.05307840	0.05167962	0.06005630	0.050514	0.05729409	-0.10130310	0.06342767	0.05298165	0.061244	
Pearson5	1.1266	5%	0.063038	0.0472564	0.05911658	0.06633490	0.06698319	0.06516508	0.067976	0.06415006	0.01544794	0.06439375	0.05439704	0.062477	
		10%	0.079601	0.0537894	0.07189909	0.08010926	0.08238961	0.07260573	0.085438	0.07281846	0.07455112	0.06645206	0.05734314	0.064675	
Burr 12	1.4887	20%	0.096868	0.0668553	0.08737772	0.09505817	0.09821882	0.08381364	0.102900	0.08461588	0.10562349	0.07116664	0.06376108	0.069488	
Erf	3.8074	25%	0.102713	0.0733883	0.09325812	0.10036138	0.10356761	0.08866570	0.108522	0.08953222	0.11249769	0.07389035	0.06727776	0.072441	
BetaGeneral		30%	0.107660	0.0799213	0.09853889	0.10499418	0.10812983	0.09328139	0.113115	0.09417702	0.11749209	0.07691742	0.07103715	0.075966	
Erlang		35%	0.112003	0.0864542	0.10343232	0.10920196	0.11219556	0.09776476	0.116999	0.09869002	0.12145566	0.08030720	0.07507525	0.080270	
Pareto		40%	0.115925	0.0929872	0.10807571	0.11313905	0.11594621	0.10219218	0.120363	0.10317127	0.12482728	0.08413645	0.07943674	0.085639	
Pareto2		45%	0.119544	0.0995202	0.11256824	0.11691429	0.11950898	0.10662706	0.123330	0.10770347	0.12786886	0.08850649	0.08417795	0.092490	
Triang		50%	0.122947	0.1060531	0.11698954	0.12061350	0.12298365	0.11112845	0.125984	0.11236457	0.13076158	0.09355424	0.08937136	0.101456	
ChiSq	N/A	55%	0.126203	0.1125861	0.12141084	0.12431272	0.12645832	0.11575744	0.128639	0.11723722	0.13365429	0.09946994	0.09511241	0.113535	
InvGauss		60%	0.129369	0.1191191	0.12590337	0.12808795	0.13002109	0.12058362	0.131606	0.12241836	0.13669587	0.10652706	0.10153035	0.130387	
	N/A	65%	0.132499	0.1256521	0.13054675	0.13202504	0.13377173	0.12569338	0.134970	0.12803215	0.14006749	0.11513521	0.10880642	0.154934	
LogLogistic	N/A	70%	0.135652	0.1321850	0.13544018	0.13623283	0.13783746	0.13120290	0.138853	0.13425057	0.14403107	0.12594114	0.11720602	0.192722	
Lognorm	N/A	75%	0.138896	0.1387180	0.14072096	0.14086563	0.14239968	0.13728154	0.143446	0.14133167	0.14902546	0.14003832	0.12714063	0.255359	
Lognorm2	N/A	80%	0.142330	0.1452510	0.14660136	0.14616884	0.14774848	0.14419994	0.149068	0.14969981	0.15589966	0.15945692	0.13929962	0.370635	
Pearson6	N/A	90%	0.150571	0.1583169	0.16207998	0.16111775	0.16357769	0.16306770	0.166530	0.17441898	0.18697204	0.23868592	0.17706889	1.331095	
Pert	N/A	95%	0.156626	0.1648499	0.17486250	0.17489211	0.17898410	0.17925083	0.183993	0.19813020	0.24607522	0.35728125	0.21483816	5.172812	
Student	N/A	97.5%	0.161415	0.1681164	0.18594942	0.18814861	0.19428768	0.19364691	0.201455	0.22138764	0.36282626	0.53480279	0.25260743	20.539651	
Webull	N/A	99%	0.166520	0.1700763	0.19884037	0.20532122	0.21448243	0.21073473	0.224539	0.25182109	0.71192786	0.91153547	0.30253569	128.107510	
Dagum	N/A	Information Criteria													
Kumaraswam		Akaike (AIC)	-11.464079	-10.3516097	-10.28217901	-10.12260328	-9.98498821	-9.89861335	-9.880543	-9.06145585	-8.56652770	-7.32018227	-7.09746544	-3.762255	
Numbraswan	iy N/A	Bayesian (BIC)	-18.245203	-17.1327339	-17.06330318	-16.90372745	-16.76611239	-16.67973753	-16.661667	-15.84258003	-15.34765188	-14.10130645	-13.87858962	-10.543379	
		Average Log-Likelihood	2.146408	2.0351610	2.02821790	2.01226033	1.99849882	1.98986134	1.988054	1.90614559	1.85665277	1.73201823	1.70974654	1.376225	
		Chi-Squared Test (Binnin	g Information)												
		Bin #1: Minimum	-00	0.0407234	-00	-00	-00	0.04798931	-00	-00	-00	0.06250000	0.05160209	0.057240	
		Bin #1: Maximum	0.122947	0.1060531	0.11698954	0.12061350	0.12298365	0.11112845	0.125984	0.11236457	0.13076158	0.09355424	0.08937136	0.101456	
		Bin #1: Input	2.000000	2.0000000	2.00000000	2.00000000	2.00000000	2.00000000	3.000000	2.00000000	3.00000000	1.00000000	1.00000000	1.000000	
		Bin #1: Fit	2.500000	2.5000000	2.50000000	2.50000000	2.50000000	2.50000000	2.500000	2.50000000	2.5000000	2.50000000	2.50000000	2.500000	
		Bin #2: Minimum	0.122947	0.1060531	0.11698954	0.12061350	0.12298365	0.11112845	0.125984	0.11236457	0.13076158	0.09355424	0.08937136	0.101456	

Figure 1-9: Transformers outage (fault) – distribution fit using A-D

0 0 A 12 8 ± 1

Figure 1-10: Transformers outage (fault) – distribution fit using K-S

Name	K-S 🔺	Name	ExtValueMin	Uniform	Normal	Logistic	HypSecant	Rayleigh	Laplace	ExtValue	Cauchy	Pareto	Expon	Levy	Er
Logistic	0.1723										1 1			1	
HypSecant	0.1848	Graph	• 4												
Laplace	0.1958											H			
	0.2009	Distribution Statistics													
Normal		Minimum	-00	0.0407234	-00	-00	-00	0.04798931	-00	-00	-00	0.06250000	0.05160209	0.057240	
ExtValueMin	0.2073	Maximum	+00	0.1713829	+00	+00	+00	+00	+00	+00	+00	+00	+00	+00	
FatigueLife	0.2125	Mean	0.118099	0.1060531	0.11698954	0.12061350	0.12298365	0.11519884	0.125984	0.11930515	N/A	0.14950250	0.10609163	N/A	(
ExtValue	0.2323	Mode	0.131381	0.0407234	0.11698954	0.12061350	0.12298365	0.10161476	0.125984	0.10029159	0.13076158	0.06250000	0.05160209	0.063945	
Frechet	0.2327	Median	0.122947	0.1060531	0.11698954	0.12061350	0.12298365	0.11112845	0.125984	0.11236457	0.13076158	0.09355424	0.08937136	0.101456	
Cauchy	0.2450	Std Deviation	0.029511	0.0377181	0.03518426	0.03343608	0.03460353	0.03513198	0.035628	0.04224735	N/A	N/A	0.05448954	N/A	
Ravleigh	0.2527	Skewness	-1.1395	0.0000	0.0000	0.0000	0.0000	0.6311	0.0000	1.1395	N/A	N/A	2.0000	N/A	
BetaGeneral	0.2681	Kurtosis	5.4000	1.8000	3.0000	4.2000	5.0000	3.2451	6.0000	5.4000	N/A	N/A	9.0000	N/A	
Triang	0.2802	Percentiles													
Uniform	0.2843	1%	0.025534	0.0420300	0.03513871	0.03590579	0.03148486	0.05559216	0.027430	0.04998610	-0.45040471	0.06286662	0.05214973	0.060272	-
		2.5%	0.046792	0.0439899	0.04802965	0.05307840	0.05167962	0.06005630	0.050514	0.05729409	-0.10130310	0.06342767	0.05298165	0.061244	
Gamma	0.3065	5%	0.063038	0.0472564	0.05911658	0.06633490	0.06698319	0.06516508	0.067976	0.06415006	0.01544794	0.06439375	0.05439704	0.062477	
Erlang	0.3331	10%	0.079601	0.0537894	0.07189909	0.08010926	0.08238961	0.07260573	0.085438	0.07281846	0.07455112	0.06645206	0.05734314	0.064675	
Levy	0.3593	20%	0.096868	0.0668553	0.08737772	0.09505817	0.09821882	0.08381364	0.102900	0.08461588	0.10562349	0.07116664	0.06376108	0.069488	
Pareto	0.3832	25%	0.102713	0.0733883	0.09325812	0.10036138	0.10356761	0.08866570	0.108522	0.08953222	0.11249769	0.07389035	0.06727776	0.072441	
Expon	0.4177	30%	0.107660	0.0799213	0.09853889	0.10499418	0.10812983	0.09328139	0.113115	0.09417702	0.11749209	0.07691742	0.07103715	0.075966	
Pearson5	0.4730	35%	0.112003	0.0864542	0.10343232	0.10920196	0.11219556	0.09776476	0.116999	0.09869002	0.12145566	0.08030720	0.07507525	0.080270	
Pareto2	0.4776	40%	0.115925	0.0929872	0.10807571	0.11313905	0.11594621	0.10219218	0.120363	0.10317127	0.12482728	0.08413645	0.07943674	0.085639	
	0,4900	45%	0.119544	0.0995202	0.11256824	0.11691429	0.11950898	0.10662706	0.123330	0.10770347	0.12786886	0.08850649	0.08417795	0.092490	
Burr 12 Erf	0.6970	50%	0.122947	0.1060531	0.11698954	0.12061350	0.12298365	0.11112845	0.125984	0.11236457	0.13076158	0.09355424	0.08937136	0.101456	
		55%	0.126203	0.1125861	0.12141084	0.12431272	0.12645832	0.11575744	0.128639	0.11723722	0.13365429	0.09946994	0.09511241	0.113535	
ChiSq	N/A	60%	0.129369	0.1191191	0.12590337	0.12808796	0.13002109	0.12058362	0.131606	0.12241836	0.13669587	0.10652706	0.10153035	0.130387	
InvGauss	N/A	65%	0.132499	0.1256521	0.13054675	0.13202504	0.13377173	0.12569338	0.134970	0.12803215	0.14006749	0.11513521	0.10880642	0.154934	
LogLogistic	N/A	70%	0.135652	0.1321850	0.13544018	0.13623283	0.13783746	0.13120290	0.138853	0.13425057	0.14403107	0.12594114	0.11720602	0.192722	
Lognorm	N/A	75%	0.138896	0.1387180	0.14072096	0.14086563	0.14239968	0.13728154	0.143446	0.14133167	0.14902546	0.14003832	0.12714063	0.255359	
Lognorm2	N/A	80%	0.142330	0.1452510	0.14660136	0.14616884	0.14774848	0.14419994	0.149068	0.14969981	0.15589966	0.15945692	0.13929962	0.370635	
Pearson6	N/A	90%	0.150571	0.1583169	0.16207998	0.16111775	0.16357769	0.16306770	0.166530	0.17441898	0.18697204	0.23868592	0.17706889	1.331095	
Pert	N/A	95%	0.156626	0.1648499	0.17486250	0.17489211	0.17898410	0.17925083	0.183993	0.19813020	0.24607522	0.35728125	0.21483816	5.172812	
Student	N/A	97.5%	0.161415	0.1681164	0.18594942	0.18814861	0.19428768	0.19364691	0.201455	0.22138764	0.36282626	0.53480279	0.25260743	20.539651	
		99%	0.166520	0.1700763	0.19884037	0.20532122	0.21448243	0.21073473	0.224539	0.25182109	0.71192786	0.91153547	0.30253569	128.107510	
Weibull	N/A	Information Criteria													
Dagum	N/A	Akaike (AIC)	-11.464079	-10.3516097	-10.28217901	-10.12260328	-9.98498821	-9.89861335	-9.880543	-9.06145585	-8.56652770	-7.32018227	-7.09746544	-3.762255	-
Kumaraswam	y N/A	Bayesian (BIC)	-18.245203	-17.1327339	-17.06330318	-16.90372745	-16.76611239	-16.67973753	-16.661667	-15.84258003	-15.34765188	-14.10130645	-13.87858962	-10.543379	
		Average Log-Likelihood	2.146408	2.0351610	2.02821790	2.01226033	1.99849882	1.98986134	1.988054	1.90614559	1.85665277	1.73201823	1.70974654	1.376225	
		Chi-Squared Test (Binnin	g Information)												
		Bin #1: Minimum	-00	0.0407234	-00	-00	-00	0.04798931	-00	-00	-00	0.06250000	0.05160209	0.057240	
		Bin #1: Maximum	0.122947	0.1060531	0.11698954	0.12061350	0.12298365	0.11112845	0.125984	0.11236457	0.13076158	0.09355424	0.08937136	0.101456	
		Bin #1: Input	2.000000	2.0000000	2.00000000	2.00000000	2.00000000	2.00000000	3.000000	2.00000000	3.00000000	1.00000000	1.00000000	1.000000	
		Bin #1: Fit	2.500000	2.5000000	2.50000000	2.50000000	2.50000000	2.50000000	2.500000	2.50000000	2.50000000	2.50000000	2.50000000	2.500000	
		Bin #2: Minimum	0.122947	0.1060531	0.11698954	0.12061350	0.12298365	0.11112845	0.125984	0.11236457	0.13076158	0.09355424	0.08937136	0.101456	
		Dia 40. Mariana		0.4740000											

1.1.6 Transformers outage – forced (continuous)

Findings:

- A-D fit statistic: Cauchy distribution best fit, however this returns an undefined • standard deviation
 - The Laplace distribution is also a close fit to the data and is close to the 0 Cauchy distribution (0.1875 v. 0.1409) and returns a standard deviation of 0.0271

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- K-S fit statistic: Cauchy distribution best fit, however this returns an undefined standard deviation
 - The Laplace distribution is also a close fit to the data and is close to the Cauchy distribution (0.1639 v. 0.1349) and returns a standard deviation of 0.0271
- K-S preferred (Laplace) due to data falling in the middle and near tails of distribution

Figure 1-11: Transformers outage (forced) – distribution fit using A-D

Name	A-D 🔺	Name	FatigueLife	Laplace	Rayleigh	Normal	Logistic	HypSecant	ExtValueMin	ExtValue	Uniform	Cauchy	Pareto	Expon	Lev
Cauchy	0.1409											1		N II I	ί
Laplace	0.1875	Graph											NL I		
HypSecant	0.1964] 🖬 🖬 🖬 🗠		N		N
Normal	0.2009	Distribution Statistics													
	0.2036	Minimum	0.078740157480	-00	0.06711164	-00	-00	-00	-00	-00	0.0590551	-00	0.07874016	0.07078743	
		Maximum	+00	+00	+00	+00	+00	+00	+00	+00	0.1771654	+00	+00	+00	
Pert	0.2595	Mean	0.098621987095	0.117188	0.11794841	0.11850382	0.11863442	0.11862308	0.117527	0.11961506	0.1181102	N/A	0.12786742	0.11055108	
ExtValueMin	0.2678		2.116E-008	0.117188	0.10767351	0.11850382	0.11863442	0.11862308	0.131193	0.10571897	0.0590551	0.11790813	0.07874016	0.07078743	
ExtValue	0.2831	Median	0.078740157480	0.117188	0.11486960	0.11850382	0.11863442	0.11862308	0.122515	0.11454253	0.1181102	0.11790813	0.10276694	0.09834949	
Frechet	0.2831	Std Deviation	0.044457122536	0.027048	0.02657356	0.02849069	0.02665255	0.02674800	0.030365	0.03087655	0.0340955	N/A	0.10208504	0.03976366	
Rayleigh	0.2949	Skewness	3.9355	0.0000	0.6311	0.0000	0.0000	0.0000	-1.1395	1.1395	0.0000	N/A	N/A	2.0000	
Uniform	0.3443	Kurtosis	25.3200	6.0000	3.2451	3.0000	4.2000	5.0000	5.4000	5,4000	1.8000	N/A	N/A	9.0000	
Gamma	0.4864	Percentiles													
	0.7178	1%	0.078740157480	0.042367	0.07286237	0.05222455	0.05111225	0.04789592	0.022283	0.06895312	0.0602362	-0.26093128	0.07904479	0.07118706	
,		2.5%	0.078740157480	0.059892	0.07623902	0.06266309	0.06480087	0.06350615	0.044157	0.07429418	0.0620079	-0.03336570	0.07950982	0.07179415	
Expon	0.8258	5%	0.078740157480	0.073149	0.08010326	0.07164080	0.07536789	0.07533558	0.060873	0.07930487	0.0649606	0.04273971	0.08030729	0.07282703	
Pearson5	1.0978	10%	0.078740157480	0.086406	0.08573131	0.08199152	0.08634769	0.08724451	0.077915	0.08564018	0.0708661	0.08126674	0.08199295	0.07497695	
Burr 12	1.4608	20%	0.078740157480	0.099663	0.09420889	0.09452544	0.09826376	0.09948024	0.095681	0.09426235	0.0826772	0.10152160	0.08578860	0.07966043	
FatigueLife	2.9413		0.078740157480	0.103930	0.09787894	0.09928714	0.10249106	0.10361478	0.101696	0.09785546	0.0885827	0.10600262	0.08794240	0.08222672	
1 Erf	4.0210		0.078740157480	0.107418	0.10137022	0.10356328	0.10618395	0.10714131	0.106785	0.10125013	0.0944882	0.10925827	0.09030470	0.08497013	
BetaGeneral		35%	0.078740157480	0.110366	0.10476140	0.10752577	0.10953806	0.11028405	0.111255	0.10454846	0.1003937	0.11184197	0.09291286	0.08791693	
Erlang			0.078740157480	0.112920	0.10811027	0.11128578	0.11267638	0.11318324	0.115289	0.10782359	0.1062992	0.11403979	0.09581458	0.09109972	
Pareto		45%	0.078740157480	0.115172	0.11146478	0.11492364	0.11568570	0.11593721	0.119013	0.11113596	0.1122047	0.11602248	0.09907182	0.09455961	
		50%	0.078740157480	0.117188	0.11486960	0.11850382	0.11863442	0.11862308	0.122515	0.11454253	0.1181102	0.11790813	0.10276694	0.09834949	
Pareto2		55%	0.079368056440	0.119203	0.11837093	0.12208400	0.12158314	0.12130895	0.125866	0.11810371	0.1240157	0.11979377	0.10701229	0.10253901	
Triang		60%	0.081292378192	0.121455	0.12202142	0.12572185	0.12459245	0.12406291	0.129123	0.12189036	0.1299213	0.12177646	0.11196614	0.10722250	
ChiSq	N/A	65%	0.084643941999	0.124009	0.12588640	0.12948186	0.12773078	0.12696210	0.132344	0.12599321	0.1358268	0.12397429	0.11786028	0.11253219	
InvGauss	N/A	70%	0.089675000647	0.126957	0.13005376	0.13344435	0.13108488	0.13010485	0.135587	0.13053795	0.1417323	0.12655798	0.12505146	0.11866179	
LogLogistic	N/A		0.096830094380	0.130445	0.13465159	0.13772050	0.13477778	0.13363138	0.138926	0.13571318	0.1476378	0.12981363	0.13412525	0.12591156	
Lognorm	N/A		0.106905803129	0.134712	0.13988462	0.14248219	0.13900507	0.13776591	0.142459	0.14182905	0.1535433	0.13429465	0.14613150	0.13478457	
Lognorm2	N/A		0.144046974052	0.147969	0.15415605	0.15501611	0.15092114	0.15000165	0.150939	0.15989510	0.1653543	0.15454951	0.19072208	0.16234663	
Pearson6		95%	0.186322465421	0.161226	0.16639684	0.16536684	0.16190095	0.16191057	0.157169	0.17722449	0.1712598	0.19307655	0.24891904	0.18990870	
	N/A	97.5%	0.231490616972	0.174483	0.17728593	0.17434455	0.17246797	0.17374000	0.157189	0.19422223	0.1712398	0.26918195	0.32487423	0.21747077	
] Student	N/A	99%	0.293936883426	0.192008	0.19021102	0.18478308	0.18615658	0.18935024	0.167349	0.21646456	0.1759843	0.49674754	0.46196139	0.25390584	
Weibull	N/A	Information Criteria	0.295950005920	0.192008	0.19021102	0.104/0300	0.10013030	0.10933024	0.107349	0.21040430	0.1759045	0.49074754	0.40130133	0.25590564	
] Dagum	N/A														
Kumaraswamy	N/A	Akaike (AIC)	-22.7037776134	-12.635694	-12.54921457	-12.39239282	-12.30261856	-12.28204384	-12.073726	-11.95551612	-11.3613689	-11.28776585	-11.13977085	-10.24801868	
		Bayesian (BIC)	-47.8754638761	-19.416818	-19.33033874	-19.17351699	-19.08374274	-19.06316802	-18.854850	-18.73664030	-18.1424930	-18.06889003	-17.92089502	-17.02914286	-
		Average Log-Likeliho		2.263569	2.25492146	2.23923928	2.23026186	2.22820438	2.207373	2.19555161	2.1361369	2.12877659	2.11397708	2.02480187	
		Chi-Squared Test (Bir													
		Bin #1: Minimum	0.078740157480	-00	0.06711164	-00	-00	-00	-00	-00	0.0590551	-00	0.07874016	0.07078743	
		Bin #1: Maximum	0.078740157480	0.117188	0.11486960	0.11850382	0.11863442	0.11862308	0.122515	0.11454253	0.1181102	0.11790813	0.10276694	0.09834949	
		Bin #1: Input	1.00000000000	3.000000	2.00000000	3.00000000	3.00000000	3.00000000	3.000000	2.00000000	3.0000000	3.00000000	1.00000000	1.00000000	
		Bin #1: Fit	2.50000000000	2.500000	2.50000000	2.5000000	2.50000000	2.50000000	2.500000	2.50000000	2.5000000	2.50000000	2.50000000	2.50000000	
		Bin #2: Minimum	0.078740157480	0.117188	0.11486960	0.11850382	0.11863442	0.11862308	0.122515	0.11454253	0.1181102	0.11790813	0.10276694	0.09834949	
		4													

Figure 1-12: Transformers outage (forced) – distribution fit using K-S

Name		K-S ▲	Name	FatigueLife	Laplace	Rayleigh	Normal	Logistic	HypSecant	ExtValueMin	ExtValue	Uniform	Cauchy	Pareto	Expon	Le
Cauchy		0.1349											1	k. 1	N I	1.
Laplace		0.1639	Graph											NL I		AL
HypSeca	nt	0.1639												J B J		
Logistic		0.1747	Distribution Statistics													
Pert		0.1853	Minimum	0.078740157480	-00	0.06711164	-00	-00	-00	-00	-00	0.0590551	-00	0.07874016	0.07078743	
Normal		0.1976	Maximum	+00	+00	+00	+00	+00	+00	+00	+00	0.1771654	+00	+00	+00	
			Mean	0.098621987095	0.117188	0.11794841	0.11850382	0.11863442	0.11862308	0.117527	0.11961506	0.1181102	N/A	0.12786742	0.11055108	
ExtValuel	Mn	0.2173	Mode	2.116E-008	0.117188	0.10767351	0.11850382	0.11863442	0.11862308	0.131193	0.10571897	0.0590551	0.11790813	0.07874016	0.07078743	
Uniform		0.2407	Median	0.078740157480	0.117188	0.11486960	0.11850382	0.11863442	0.11862308	0.122515	0.11454253	0.1181102	0.11790813	0.10276694	0.09834949	
Rayleigh		0.2448	Std Deviation	0.044457122536	0.027048	0.02657356	0.02849069	0.02665255	0.02674800	0.030365	0.03087655	0.0340955	N/A	0.10208504	0.03976366	
ExtValue		0.2496	Skewness	3.9355	0.0000	0.6311	0.0000	0.0000	0.0000	-1.1395	1.1395	0.0000	N/A	N/A	2.0000	
Frechet		0.2496	Kurtosis	25.3200	6.0000	3.2451	3.0000	4.2000	5.0000	5.4000	5.4000	1.8000	N/A	N/A	9.0000	
BetaGen	eral	0.2753	Percentiles													
Triang		0.2878	1%	0.078740157480	0.042367	0.07286237	0.05222455	0.05111225	0.04789592	0.022283	0.06895312	0.0602362	-0.26093128	0.07904479	0.07118706	
Gamma		0.3268	2.5%	0.078740157480	0.059892	0.07623902	0.06266309	0.06480087	0.06350615	0.044157	0.07429418	0.0620079	-0.03336570	0.07950982	0.07179415	
Levy		0.3296	5%	0.078740157480	0.073149	0.08010326	0.07164080	0.07536789	0.07533558	0.060873	0.07930487	0.0649606	0.04273971	0.08030729	0.07282703	
			10%	0.078740157480	0.086406	0.08573131	0.08199152	0.08634769	0.08724451	0.077915	0.08564018	0.0708661	0.08126674	0.08199295	0.07497695	
Erlang		0.3570	20%	0.078740157480	0.099663	0.09420889	0.09452544	0.09826376	0.09948024	0.095681	0.09426235	0.0826772	0.10152160	0.08578860	0.07966043	
Pareto2		0.3570	25%	0.078740157480	0.103930	0.09787894	0.09928714	0.10249106	0.10361478	0.101696	0.09785546	0.0885827	0.10600262	0.08794240	0.08222672	
Pareto		0.3919	30%	0.078740157480	0.107418	0.10137022	0.10356328	0.10618395	0.10714131	0.106785	0.10125013	0.0944882	0.10925827	0.09030470	0.08497013	
xpon		0.4373	35%	0.078740157480	0.110366	0.10476140	0.10752577	0.10953806	0.11028405	0.111255	0.10454846	0.1003937	0.11184197	0.09291286	0.08791693	
earson5	5	0.4803	40%	0.078740157480	0.112920	0.10811027	0.11128578	0.11267638	0.11318324	0.115289	0.10782359	0.1062992	0.11403979	0.09581458	0.09109972	
iurr 12		0.4937	45%	0.078740157480	0.115172	0.11146478	0.11492364	0.11568570	0.11593721	0.119013	0.11113596	0.1122047	0.11602248	0.09907182	0.09455961	
atiqueLi	fa	0.6165	50%	0.078740157480	0.117188	0.11486960	0.11850382	0.11863442	0.11862308	0.122515	0.11454253	0.1181102	0.11790813	0.10276694	0.09834949	
rf		0.7420	55%	0.079368056440	0.119203	0.11837093	0.12208400	0.12158314	0.12130895	0.125866	0.11810371	0.1240157	0.11979377	0.10701229	0.10253901	
			60%	0.081292378192	0.121455	0.12202142	0.12572185	0.12459245	0.12406291	0.129123	0.12189036	0.1299213	0.12177646	0.11196614	0.10722250	
hiSq		N/A	65%	0.084643941999	0.124009	0.12588640	0.12948186	0.12773078	0.12696210	0.132344	0.12599321	0.1358268	0.12397429	0.11786028	0.11253219	
nvGauss		N/A	70%	0.089675000647	0.126957	0.13005376	0.13344435	0.13108488	0.13010485	0.135587	0.13053795	0.1417323	0.12655798	0.12505146	0.11866179	
ogLogist		N/A	75%	0.096830094380	0.130445	0.13465159	0.13772050	0.13477778	0.13363138	0.138926	0.13571318	0.1476378	0.12981363	0.13412525	0.12591156	
.ognorm		N/A	80%	0.106905803129	0.134712	0.13988462	0.14248219	0.13900507	0.13776591	0.142459	0.14182905	0.1535433	0.13429465	0.14613150	0.13478457	
ognorm:	2	N/A	90%	0.144046974052	0.147969	0.15415605	0.15501611	0.15092114	0.15000165	0.150939	0.15989510	0.1653543	0.15454951	0.19072208	0.16234663	
- earson6	5	N/A	95%	0.186322465421	0.161226	0.16639684	0.16536684	0.16190095	0.16191057	0.157169	0.17722449	0.1712598	0.19307655	0.24891904	0.18990870	
tudent		N/A	97.5%	0.231490616972	0.174483	0.17728593	0.17434455	0.17246797	0.17374000	0.162096	0.19422223	0.1742126	0.26918195	0.32487423	0.21747077	
Velbull		N/A	99%	0.293936883426	0.192008	0.19021102	0.18478308	0.18615658	0.18935024	0.167349	0.21646456	0.1759843	0.49674754	0.46196139	0.25390584	
)agum		N/A	Information Criteria													
			Akaike (AIC)	-22.7037776134	-12.635694	-12,54921457	-12.39239282	-12.30261856	-12.28204384	-12.073726	-11.95551612	-11.3613689	-11.28776585	-11.13977085	-10.24801868	
Kumarası	wamy	N/A	Bayesian (BIC)	-47.8754638761	-19.416818	-19.33033874	-19.17351699	-19.08374274	-19.06316802	-18.854850	-18.73664030	-18.1424930	-18.06889003	-17.92089502	-17.02914286	
			Average Log-Likelihoo	5.270377761345	2.263569	2.25492146	2.23923928	2.23026186	2.22820438	2.207373	2.19555161	2.1361369	2.12877659	2.11397708	2.02480187	
			Chi-Squared Test (Bin	ing Information)												
			Bin #1: Minimum	0.078740157480		0.06711164	-00		-00	-00	-00	0.0590551	-00	0.07874016	0.07078743	
			Bin #1: Maximum	0.078740157480	0.117188	0.11486960	0.11850382	0.11863442	0.11862308	0.122515	0.11454253	0.1181102	0.11790813	0.10276694	0.09834949	
			Bin #1: Input	1.0000000000000	3.000000	2.00000000	3.00000000	3.00000000	3.00000000	3.000000	2.00000000	3.0000000	3.00000000	1.00000000	1.00000000	
			Bin #1: Fit	2.500000000000	2,500000	2,50000000	2.50000000	2.50000000	2.50000000	2,500000	2.50000000	2,5000000	2.50000000	2,50000000	2.50000000	
			Bin #2: Minimum	0.078740157480	0.117188	0.11485950	0.11850382	0.11863442	0.11862308	0.122515	0.11454253	0.1181102	0.11790813	0.10276694	0.09834949	

1.2 Service parameter 2 – loss of supply event frequency

1.2.1 Number of events > 0.05 system minutes (discrete)

Findings:

- Akaike information criterion (AIC) fit statistic: Poisson distribution best fit, standard deviation 1.0954
- Bayesian information criterion (BIC) fit statistic: Poisson distribution best fit, standard deviation 1.0954
- Large variance in standard deviations of better fitting distributions
- Best fit distribution (Poisson) preferred

Figure 1-13: Number of events >0.05 system minutes – AIC distribution



USK - Fit Resu							
lame	BIC 🔺	Name	Poisson	Geomet	IntUniform	NegBin	HyperGeo
oisson	16.3914		1.1	1	1	i i	1
Seomet	16.7676	Graph		11a			
ntUniform	17.0818					TITTE	-
legBin	17.9355	Distribution Statistics					^
lyperGeo	19.6349	Minimum	0.000000	0.000000	0.000000	0.000000	0.000000
linomial	N/A	Maximum	+00	+00	3.000000	+00	38.000000
anoma	DI/A	Mean	1.200000	1.200000	1.500000	1.200000	1.192114
		Mode	1.000000	0.000000	0.000000	0.000000	1.000000
		Median	1.000000	1.000000	1.000000	1.000000	1.000000
		Std Deviation	1.095445	1.624808	1.118034	1.219836	1.073944
		Skewness	0.9129	2.0926	0.0000	1.2133	0.8707
		Kurtosis	3.8333	9.3788	1.6400	4.8720	3.7038
		Percentiles					^
		1%	0.000000	0.000000	0.000000	0.000000	0.000000
		2.5%	0.000000	0.000000	0.000000	0.000000	0.000000
		5%	0.000000	0.000000	0.000000	0.000000	0.000000
		10%	0.000000	0.000000	0.000000	0.000000	0.000000
		20%	0.000000	0.000000	0.000000	0.000000	0.000000
		25%	0.000000	0.000000	0.000000	0.000000	0.000000
		30%	0.000000	0.000000	1.000000	0.000000	1.000000
		35%	1.000000	0.000000	1.000000	1.000000	1.000000
		40%	1.000000	0.000000	1.000000	1.000000	1.000000
		45%	1.000000	0.000000	1.000000	1.000000	1.000000
		50%	1.000000	1.000000	1.000000	1.000000	1.000000
		55%	1.000000	1.000000	2.000000	1.000000	1.000000
		60%	1.000000	1.000000	2.000000	1.000000	1.000000
		65%	1.000000	1.000000	2.000000	1.000000	1.000000
		70%	2.000000	1.000000	2.000000	2.000000	2.000000
		75%	2.000000	2.000000	2.000000	2.000000	2.000000
		80%	2.000000	2.000000	3.000000	2.000000	2.000000
		90%	3.000000	3.000000	3.000000	3.000000	3.000000
		95%	3.000000	4.000000	3.000000	4.000000	3.000000
		97.5%	4.000000	6.000000	3.000000	4.000000	4.000000
		99%	4.000000	7.000000	3.000000	5.000000	4.000000
		Information Criteria					^
		Akaike (AIC)	18.115288	18.491537	23.862944	24.716629	44.806571
		Bayesian (BIC)	16.391393	16.767641	17.081819	17.935505	19.634885
		Average Log-Likelihood	-1.478195	-1.515820	-1.386294	-1.471663	-1.480657
		Chi-Squared Test (Binnir	g Information)				^
		Bin #1: Minimum	0.000000	0.000000	0.000000	0.000000	0.000000
		Bin #1: Maximum	+00	+00	3.000000	+00	38.000000
		Bin #1: Input	5.000000	5.000000	5.000000	5.000000	5.000000
		Bin #1: Fit	5.000000	5.000000	5.000000	5.000000	5.000000
		Chi-Squared Test - [* Va	lues unavailable witho	ut running a bootstra	p]		^
		Statistic	0.000000	0.000000	0.000000	0.000000	0.000000
0 🛕 🛛	6 % ±	m					

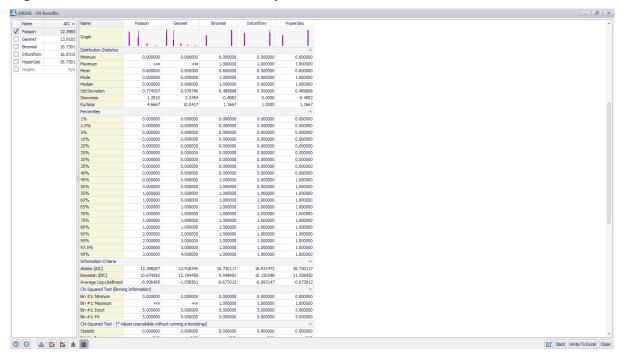
Figure 1-14: Number of events >0.05 system minutes – BIC distribution

1.2.2 Number of events > 0.30 system minutes (discrete)

Findings:

- Akaike information criterion (AIC) fit statistic: Poisson distribution best fit, standard deviation 0.7746
- Bayesian information criterion (BIC) fit statistic: Binomial distribution best fit, standard deviation 0.4899
- Best fit distribution (Poisson) preferred

Figure 1-15: Number of events >0.30 system minutes – AIC distribution



@RISK - Fit Res	ults						
Name	BIC 🔺	Name	Poisson	Geomet	Binomial	IntUniform	HyperGeo
Binomial	9.9490		1.1	11	1	1 A	1
IntUniform	10.1503	Graph					
Poisson	10.6744		1.1.1.1	1.1.1.2.2	1 1	1 1	1 1
HyperGeo	11.5584	Distribution Statistics					^
Geomet	12.1944	Minimum	0.000000	0.000000	0.000000	0.000000	0.000000
NegBin	N/A	Maximum	+00	+00	1.000000	1.000000	1.000000
		Mean	0.600000	0.600000	0.600000	0.500000	0.600000
		Mode	0.000000	0.000000	1.000000	0.000000	1.000000
		Median	0.000000	0.000000	1.000000	0.000000	1.000000
		Std Deviation	0.774597	0.979796	0.489898	0.500000	0.489898
		Skewness	1.2910	2.2454	-0.4082	0.0000	-0.4082
		Kurtosis	4.6667	10.0417	1.1667	1.0000	1.1667
		Percentiles					^
		1%	0.000000	0.000000	0.000000	0.000000	0.000000
		2.5%	0.000000	0.000000	0.000000	0.000000	0.000000
		5%	0.000000	0.000000	0.000000	0.000000	0.000000
		10%	0.000000	0.000000	0.000000	0.000000	0.000000
		20%	0.000000	0.000000	0.000000	0.000000	0.000000
		25%	0.000000	0.000000	0.000000	0.000000	0.000000
		30%	0.000000	0.000000	0.000000	0.000000	0.000000
		35%	0.000000	0.000000	0.000000	0.000000	0.000000
		40%	0.000000	0.000000	0.000000	0.000000	0.000000
		45%	0.000000	0.000000	1.000000	0.000000	1.000000
		50%	0.000000	0.000000	1.000000	0.000000	1.000000
		55%	1.000000	0.000000	1.000000	1.000000	1.000000
		60% 65%	1.000000	0.000000	1.000000	1.000000	1.000000
		70%	1.000000	1.000000	1.000000	1.000000	1.000000
		70%	1.000000		1.000000	1.000000	
				1.000000			1.000000
		80% 90%	1.000000 2.000000	1.000000 2.000000	1.000000 1.000000	1.000000	1.000000
		95%	2.000000	3.000000	1.000000	1.000000	1.000000
		95%	2.000000	3.000000	1.000000	1.000000	1.000000
		99%	3.000000	4.000000	1.000000	1.000000	1.000000
		Information Criteria	5.000000	4.00000	1.000000	1.000000	1.000000
			10.000007	10.010045	46 700447	10,004,470	
		Akaike (AIC)	12.398287 10.674392	13.918345 12.194450	16.730117 9.948992	16.931472 10.150348	36.730117 11.558430
		Bayesian (BIC) Average Log-Likelihood	-0.906495	-1.058501	-0.673012	-0.693147	-0.673012
				-1.058501	-0.673012	-0.693147	
		Chi-Squared Test (Binnin		0.000000	0.000000	0.000000	^
		Bin #1: Minimum	0.000000	0.000000	0.000000	1.000000	0.000000
		Bin #1: Maximum	+00	+00	1.000000		
		Bin #1: Input Bin #1: Fit	5.000000	5.000000	5.000000	5.000000	5.000000
						5.000000	5.000000
		Chi-Squared Test - [* Vi					
		Statistic	0.000000	0.000000	0.000000	0.000000	0.000000
	12 12 ±	s 🏢					

Figure 1-16: Number of events >0.30 system minutes - BIC distribution

1.3 Service parameter 3 – average outage duration

1.3.1 Average outage duration (continuous)

- A-D fit statistic: Frechet distribution best fit, however this returns an undefined standard deviation
 - The InvGauss distribution is also a close fit to the data and is close to the Cauchy distribution (0.3861 v. 0.3367) and returns a standard deviation of 60.73
- K-S fit statistic: Frechet distribution best fit, however this returns an undefined standard deviation
 - The InvGauss distribution is also a close fit to the data and is close to the Frechet distribution (0.2624 v. 0.2000) and returns a standard deviation of 60.73
- K-S is preferred (InvGauss) due to data concentrated in the middle and at the tail end of the curve

N	ame	A-D ▲	Name	tValue	Erf	Normal	ExtValueMin	Logistic	HypSecant	Laplace	Cauchy	Triang	Pert	Pareto2	InvGauss	Frechet
Fr	echet	0.3367			1.1			1.1	1.1	1.1	11		1.1			A
Le	evy	0.3563	Graph												L I	A
U	hiform	0.3572														
In	vGauss	0.3861	Distribution Statistics													
	ormal	0.3933	Minimum	-00	-00	-00	-00	-00	-00	-00	-00	19.0000	19.0000	19.000000	15.52564	17.24999
	gistic	0.4378	Maximum	+00	+00	+00	+00	+00	+00	+00	+00	124.6342	224.8015	+00	+00	+
	-		Mean	52.66083	0.00000	53.56000	52.845418	51.38922	48.18417	39.800000	N/A	54.2114	53.3003	53.560000	53.56000	N/
	ypSecant	0.4436	Mode	38.03863	0.00000	53.56000	70.174764	51.38922	48.18417	39.800000	33.46594	19.0000	19.0000	19.000000	20.41593	19.6142
	rpon	0.4441	Median	47.32324	0.00000	53.56000	59.171200	51.38922	48.18417	39.800000	33.46594	49.9396	45.6409	42.955164	32.82850	31.13169
	dValue	0.4475	Std Deviation	32.48994	62.64270	36.32207	38.505104	37.12799	39.78238	39.880822	N/A	24.8982	28.9890	34.560006	60.73184	N/
Đ	dValueMin	0.4920	Skewness	1.1395	0.0000	0.0000	-1.1395	0.0000	0.0000	0.0000	N/A	0.5657	1.1832	2.0000	4.7903	N/
R	ayleigh	0.5417	Kurtosis	5.4000	3.0000	3.0000	5.4000	4.2000	5.0000	6.0000	N/A	2.4000	4.2000	9.0000	41.2448	N/
La	place	0.6126	Percentiles													
C	suchy	0.6856	1%	-0.64835	-145.72871	-30.93778	-67.932326	-42.67165	-57.00855	-70.519049	-551.08631	19.5295	19.4133	19.347340	17.56321	18.19834
	arson5	0.7002	2.5%	4.97180	-122.77744	-17.62996	-40.194658	-23.60291	-33.79140	-44.679650	-199.95078	20.3288	20.0395	19.874983	18.14780	18.54869
	urr 12	1.2115	5%	10.24431	-103.03807	-6.18449	-18.997349	-8.88266	-16.19745	-25.132900	-82.51953	21.6747	21.1005	20.772696	18.85281	18.99423
			10%	16.91067	-80.27985	7.01139	2.613546	6.41262	1.51472	-5.586149	-23.07201	24.4208	23.2913	22.641259	20.02698	19.78259
	atigueLife	2.1929	20%	25.98336	-52.72143	22.99057	25.143106	23.01215	19.71297	13.960601	8.18140	30.1521	27.9827	26.711840	22.31415	21.45714
Er		2.5024	25%	29.76423	-42.25186	29.06113	32.769992	28.90092	25.86228	20.253250	15.09565	33.1523	30.5069	28.942291	23.57222	22.44809
Pe	ert	4.2511	30%	33.33627	-32.84986	34.51269	39.223854	34.04526	31.10730	25.394717	20.11914	36.2543	33.1695	31.326685	24.96311	23.5978
St	udent	17.8141	35%	36.80695	-24.13751	39.56436	44.891448	38.71766	35.78151	29.741767	24.10581	39.4692	35.9888	33.887856	26.52840	24.9581
Be	taGeneral		40%	40.25322	-15.87035	44.35791	50.007970	43.08946	40.09349	33.507352	27.49707	42.8103	38.9873	36.654132	28.31692	26.5970
Pa	areto		45%	43.73866	-7.87177	48.99572	54.730174	47.28155	44.18947	36.828833	30.55637	46.2938	42.1930	39.661245	30.39006	28.60938
	areto2		50%	47.32324	0.00000	53.56000	59.171200	51.38922	48.18417	39.800000	33.46594	49.9396	45.6409	42.955164	32.82850	31.13169
	iang		55%	51.07050	7.87177	58.12428	63.419424	55.49690	52.17887	42.771167	36.37551	53.7726	49.3767	46.596424	35.74231	34.36916
			60%	55.05502	15.87035	62.76209	67.550166	59.68898	56.27485	46.092648	39.43481	57.8253	53.4608	50.667005	39.28708	38.64374
C		N/A	65%	59.37225	24.13751	67.55564	71.634471	64.06079	60.58682	49.858233	42.82607	62.1402	57.9761	55.281850	43.69161	44.48794
	lang	N/A	70%	64.15447	32.84986	72.60731	75.747707	68.73318	65.26104	54.205283	46.81274	66.7760	63.0409	60.609298	49.30874	52.84251
G	amma	N/A	75%	69.60012	42.25186	78.05887	79.981078	73.87752	70.50606	59.346750	51.83624	71.8171	68.8331	66.910331	56.71650	65.51823
Lo	gLogistic	N/A	80%	76.03556	52.72143	84.12943	84.461929	79.76630	76.65536	65.639399	58.75048	77.3932	75.6408	74.622173	66.94223	86.43483
Lo	ignorm	N/A	90%	95.04561	80.27985	100.10861	95.214341	96.36582	94.85361	85.186149	90.00389	91.2298	94.9495	98.577343	106.96403	217.63341
	ignorm2	N/A	95%	113.28050	103.03807	113.30449	103.114899	111.66110	112.56579	104.732900	149.45142	101.0137	111.7588	122.532516	158.99552	573.00093
	arson6	N/A	97.5%	131.16642	122.77744	124.74996	109.363563	126.38135	130.15973	124.279650	266.88266	107.9320	126.3921	146.487692	221.71169	1,528.79201
	ebul	N/A	99%	154.57099	145.72871	138.05778	116.024218	145.45010	153.37688	150.119049	618.01819	114.0708	142.8704	178.154716	318.30814	5,615.29127
			Information Criteria													
	agum	N/A	Akaike (AIC)	58.44791	58.89719	59.11364	59.553546	59.64356	60.07119	60.324692	61.82550	74.9964	75.2954	75.426970	76.59156	77.32410
K	umaraswamy	N/A	Bayesian (BIC)	51.66679	57.17329	52.33252	52.772422	52.86243	53.29006	53.543567	55.04437	49.8247	50.1238	50.255284	51.41987	52.15241
			Average Log-Likelhood	-4.84479	-5.55639	-4.91136	-4.955355	-4.96436	-5.00712	-5.032469	-5.18255	-4.4996	-4.5295	-4.542697	-4.65916	-4.7324
			Chi-Squared Test (Binni	ing Information)												
			Bin #1: Minimum	-00	-00	-00	-00	-00	-00	-00	-00	19.0000	19.0000	19.000000	15.52564	17.24999
			Bin #1: Maximum	47.32324	0.00000	53,56000	59,171200	51.38922	48, 18417	39,800000	33,46594	49,9396	45,6409	42,955164	32,82850	31,1316
			Bin #1: Input	3.00000	0.00000	3.00000	3.000000	3.00000	3.00000	3.000000	2.00000	2.0000	3.0000	2.000000	2.00000	2.0000
			Bin #1: Fit	2,50000	2,50000	2,50000	2,500000	2,50000	2,50000	2,500000	2,50000	2,5000	2,5000	2,500000	2,50000	2.5000
			Bin #2: Minimum	47.32324	0.00000	53,56000	59.171200	51.38922	48.18417	39,800000	33,46594	49.9396	45,6409	42.955164	32.82850	31.1316
			4													

Figure 1-17: Average outage duration – distribution fit using A-D

Figure 1-18: Average outage duration – distribution fit using K-S

Name		K-S ▲	Name	ExtValueMin	Logistic	HypSecant	Laplace	Cauchy	Triang	Pert	Pareto2	InvGauss	Frechet	Pearson5	Student	BetaGener
BetaGen	eral	0.2000			1.1.1	1.1.1	1.1.1	11			h		1	1	1	
Frechet		0.2113	Graph									1	L _			
Levy		0.2129										M				
Pareto		0.2400	Distribution Statistics													^
Normal		0.2476	Minimum	-00	-00	-00	-00	-00	19.0000	19.0000	19.000000	15.52564	17.249990	18.8274067	-00	19.
			Maximum	+00	+00	+00	+00	+00	124.6342	224.8015	+00	+00	+00	+00	+00	97.
Logistic		0.2506	Mean	52.845418	51.38922	48.18417	39.800000	N/A	54.2114	53.3003	53.560000	53.56000	N/A	N/A	+00	57.
Uniform		0.2567	Mode	70.174764	51.38922	48.18417	39.800000	33.46594	19.0000	19.0000	19.000000	20.41593	19.614212	19.0073065	0.000000	19.
Pareto2		0.2602	Median	59.171200	51.38922	48.18417	39.800000	33.46594	49.9396	45.6409	42.955164	32.82850	31.131694	22.6933104	0.000000	54.
Rayleigh		0.2619	Std Deviation	38.505104	37.12799	39.78238	39.880822	N/A	24.8982	28.9890	34.560006	60.73184	N/A	N/A	+00	34.
InvGauss	3	0.2624	Skewness	-1.1395	0.0000	0.0000	0.0000	N/A	0.5657	1.1832	2.0000	4.7903	N/A	N/A	+00	0
HypSeca	nt	0.2646	Kurtosis	5.4000	4.2000	5.0000	6.0000	N/A	2.4000	4.2000	9.0000	41.2448	N/A	N/A	+00	1
ExtValue		0.2652	Percentiles													^
Pert		0.2733	1%	-67.932326	-42.67165	-57.00855	-70.519049	-551.08631	19.5295	19.4133	19.347340	17.56321	18.198341	18.9175137	-31.820516	19.
		0.2755	2.5%	-40.194658	-23.60291	-33.79140	-44.679650	-199.95078	20.3288	20.0395	19.874983	18.14780	18.548696	18.9536200	-12,706205	19.
Expon			5%	-18.997349	-8.88266	-16.19745	-25.132900	-82.51953	21.6747	21.1005	20.772696	18.85281	18.994233	19.0038970	-6.313752	19.
Cauchy		0.2948	10%	2.613546	6.41262	1.51472	-5.586149	-23.07201	24.4208	23.2913	22.641259	20.02698	19.782590	19.1054842	-3.077684	19.
ExtValue	Min	0.2952	20%	25.143106	23.01215	19.71297	13.960601	8.18140	30.1521	27.9827	26.711840	22.31415	21.457146	19.3778230	-1.376382	19.
Triang		0.2986	25%	32.769992	28.90092	25.86228	20.253250	15.09565	33.1523	30.5069	28.942291	23.57222	22.448095	19.5770305	-1.000000	19.
Laplace		0.3062	30%	39.223854	34.04526	31.10730	25.394717	20.11914	36.2543	33.1695	31.326685	24.96311	23.597862	19.8453134	-0.726543	20
Pearson!	5	0.3487	35%	44.891448	38.71766	35.78151	29.741767	24.10581	39.4692	35.9888	33.887856	26.52840	24.958112	20.2162758	-0.509525	23
Burr 12		0,4281	40%	50.007970	43.08946	40.09349	33.507352	27.49707	42.8103	38.9873	36.654132	28.31692	26.597069	20.7436899	-0.324920	29.
FatigueL	fa	0,5000	45%	54.730174	47.28155	44.18947	36.828833	30.55637	46.2938	42.1930	39.661245	30.39006	28.609384	21.5172197	-0.158384	39.
Erf	iic	0.6192	50%	59.171200	51.38922	48.18417	39.800000	33.46594	49.9396	45.6409	42.955164	32.82850	31.131694	22.6933104	0.000000	54.
			55%	63.419424	55.49690	52.17887	42.771167	36.37551	53.7726	49.3767	46.596424	35.74231	34.369164	24.5597433	0.158384	69.
Student		0.9833	60%	67.550166	59.68898	56.27485	46.092648	39.43481	57.8253	53.4608	50.667005	39.28708	38.643740	27.6806542	0.324920	82.
ChiSq		N/A	65%	71.634471	64.06079	60.58682	49.858233	42.82607	62.1402	57.9761	55.281850	43.69161	44.487942	33.2522807	0.509525	90.
Erlang		N/A	70%	75.747707	68.73318	65.26104	54.205283	46.81274	66.7760	63.0409	60.609298	49.30874	52.842518	44.0775755	0.726543	94.
Gamma		N/A	75%	79.981078	73.87752	70.50606	59.346750	51.83624	71.8171	68.8331	66.910331	56.71650	65.518237	67.6485632	1.000000	96.
LogLogis	tic	N/A	80%	84.461929	79.76630	76.65536	65.639399	58.75048	77.3932	75.6408	74.622173	66.94223	86.434834	128.0026395	1.376382	97.
Lognorm		N/A	90%	95.214341	96.36582	94.85361	85.186149	90.00389	91.2298	94.9495	98.577343	106.96403	217.633418	1,342.3509074	3.077684	97.
Lognorm	2	N/A	95%	103.114899	111.66110	112.56579	104.732900	149.45142	101.0137	111.7588	122.532516	158.99552	573.000935	16,041.5751542	6.313752	97.
Pearsone		N/A	97.5%	109.363563	126.38135	130.15973	124.279650	266.88266	107.9320	126.3921	146.487692	221.71169	1,528.792017	193,970.1089745	12.706205	97.
Weibull	,		99%	116.024218	145.45010	153.37688	150.119049	618.01819	114.0708	142.8704	178.154716	318.30814	5,615.291273	5,239,359.50107	31.820516	97.
		N/A	Information Criteria													~
Dagum		N/A	Akaike (AIC)	59,553546	59.64356	60.07119	60,324692	61.82550	74,9964	75.2954	75.426970	76.59156	77.324102	78.2997088	90,282189	
Kumaras	wamy	N/A	Bayesian (BIC)	52.772422	52.86243	53.29006	53.543567	55.04437	49.8247	50.1238	50.255284	51.41987	52.152416	53.1280226	88.558293	
			Average Log-Likelhood	-4.955355	-4.96436	-5.00712	-5.032469	-5.18255	-4,4996	-4.5295	-4.542697	-4.65916	-4,732410	-4.8299709	-8,694886	
			Chi-Squared Test (Binni	on Information)												~
			Bin #1: Minimum	-00	- 00	-00		-00	19.0000	19.0000	19.000000	15.52564	17.249990	18.8274067	-00	19.
			Bin #1: Maximum	59.171200	51.38922	48, 18417	39,800000	33,46594	49.9396	45,6409	42.955164	32.82850	31.131694	22.6933104	0.000000	54.
			Bin #1: Input	3.000000	3.00000	3.00000	3.000000	2.00000	2.0000	3.0000	2.000000	2.00000	2.000000	1.0000000	0.000000	2.
			Bin #1: Fit	2,500000	2,50000	2,50000	2,500000	2,50000	2,5000	2,5000	2.500000	2.50000	2,500000	2,5000000	2,500000	2.
			Bin #2: Minimum	59.171200	51.38922	48.18417	39.800000	33.46594	49.9396	45.6409	42.955164	32.82850	31.131694	22.6933104	0.000000	54.
			Diri #2, Piriningin	00.1/1200	51.00922	10/10/11/	55100000	00,10001	15.5550	10.0109	.2.933104	52.02030	52.151054	2210933101	0.00000	51.

1.4 Service parameter 4 – proper operation of equipment

1.4.1 Failure of protection system (discrete)

- Akaike information criterion (AIC) fit statistic: Poisson distribution best fit, standard • deviation 5.6570
- Bayesian information criterion (BIC) fit statistic: IntUniform distribution best fit, • standard deviation 6.9220

• Best fit distribution (Poisson) preferred

Figure 1-19: Failure of protection system – AIC distribution



Figure 1-20: Failure of protection system – BIC distribution

lame	BIC 🔺	Name	Poisson	IntUniform	NegBin	Geomet	HyperGeo
ntUniform	34.9994		1.01	1.11.1	10.1		
oisson	36.8973	Comple					
legBin	37.3948						L
iyperGeo	40.4113	Distribution Statistics					^
		Minimum	0.000000	23.000000	0.000000	0.000000	0.000000
Seomet	46.4214	Maximum	+00	46.000000	+00	+00	981.000000
linomial	N/A	Mean	32.000000	34.500000	32.000000	32.000000	31.974445
		Mode	31.000000	23.000000	31.000000	0.000000	32.000000
		Median	32.000000	34.000000	32.000000	22.000000	32.000000
		Std Deviation	5.656854	6.922187	7.548219	32.496154	5.477638
		Skewness	0.1768	0.0000	0.3393	2.0002	0.1604
		Kurtosis	3.0313	1.7958	3.1639	9.0009	3.0221
		Percentiles					~
		1%	20.000000	23.000000	16.000000	0.000000	20.000000
		2.5%	21.000000	23.000000	18.000000	0.000000	22.000000
		5%	23.000000	24.000000	20.000000	1.000000	23.000000
		10%	25.000000	25.000000	23.000000	3.000000	25.000000
		20%	27.000000	27.000000	26.000000	7.000000	27.000000
		25%	28.000000	28.000000	27.000000	9.000000	28.000000
		30%	29.000000	30.000000	28.000000	11.000000	29.000000
		35%	30.000000	31.000000	29.000000	13.000000	30.000000
		. 40%	30.000000	32.000000	30.000000	16.000000	30.000000
		45%	31.000000	33.000000	31.000000	19.000000	31.000000
		50%	32.000000	34.000000	32.000000	22.000000	32.000000
		55%	33.000000	36.000000	33.000000	25.000000	33.000000
		60%	33.000000	37.000000	34.000000	29.000000	33.000000
		65%	34.000000	38.000000	35.000000	34.000000	34.000000
		70%	35.000000	39.000000	36.000000	39.000000	35.000000
		75%	36.000000	40.000000	37.000000	45.000000	36.000000
		80%	37.000000	42.000000	38.000000	52.000000	37.000000
		90%	39.000000	44.000000	42.000000	74.000000	39.000000
		95%	42.000000	45.000000	45.000000	97.000000	41.000000
		97.5%	44.000000	46.000000	48.000000	119.000000	43.000000
		99%	46.000000	46.000000	51.000000	149.000000	45.000000
		Information Criteria					^
		Akaike (AIC)	38.621239	41.780538	44.175948	48.145340	65.582964
		Bayesian (BIC)	36.897343	34.999414	37.394824	46.421444	40.411278
		Average Log-Likelhood	-3.528791	-3.178054	-3.417595	-4.481201	-3.558296
		Chi-Squared Test (Binning	Information)				^
		Bin #1: Minimum	0.000000	23.000000	0.000000	0.000000	0.000000
		Bin #1: Maximum	+00	46.000000	+00	+00	981.000000
		Bin #1: Input	5.000000	5.000000	5.000000	5.000000	5.000000
		Bin #1: Fit	5.000000	5.000000	5.000000	5.000000	5.000000
		Chi-Squared Test - [* Valu					^
		Statistic	0.000000	0.000000	0.000000	0.000000	0.000000

1.4.2 Material failure of SCADA system (discrete)

- Akaike information criterion (AIC) fit statistic: Geometric distribution best fit, standard deviation 1.200
- Akaike information criterion (AIC) fit statistic: Poisson distribution best fit, standard deviation 0.8944

- Bayesian information criterion (BIC) fit statistic: Geometric distribution best fit, standard deviation 1.200
- Best fit distribution (Poisson) preferred

Figure 1-21: Material failure of SCADA system – AIC distribution

@RISK - Fit Re	sults						
Name	AIC 🔺	Name	Geomet	Poisson	IntUniform	NegBin	HyperGeo
Geomet	15.6986			1	1	1	1
Poisson	15.8911	Graph		1 1 1		1.1	1 C
IntUniform							
	20.9861	Distribution Statistics					~
NegBin	22.3571	Minimum	0.000000	0.000000	0.000000	0.000000	0.000000
HyperGeo	42.5944	Maximum	+00	+00	2.000000	+00	25.000000
Binomial	N/A	Mean	0.800000	0.800000	1.000000	0.800000	0.783489
		Mode	0.000000	0.000000	0.000000	0.000000	0.000000
		Median	0.000000	1.000000	1.000000	0.000000	1.000000
		Std Deviation	1.200000	0.894427	0.816497	1.058301	0.870836
		Skewness	2.1667	1.1180	0.0000	1.7008	1.0747
		Kurtosis	9.6944	4.2500	1.5000	6.8929	4.0733
		Percentiles					^
		1%	0.000000	0.000000	0.000000	0.000000	0.000000
		2.5%	0.000000	0.000000	0.000000	0.000000	0.000000
		5%	0.000000	0.000000	0.000000	0.000000	0.000000
		10%	0.000000	0.000000	0.000000	0.000000	0.000000
		20%	0.000000	0.000000	0.000000	0.000000	0.000000
		25%	0.000000	0.000000	0.000000	0.000000	0.000000
		30%	0.000000	0.000000	0.000000	0.000000	0.000000
		35%	0.000000	0.000000	1.000000	0.000000	0.000000
		40%	0.000000	0.000000	1.000000	0.000000	0.000000
		45%	0.000000	1.000000	1.000000	0.000000	0.000000
		50%	0.000000	1.000000	1.000000	0.000000	1.000000
		55%	0.000000	1.000000	1.000000	1.000000	1.000000
		60%	1.000000	1.000000	1.000000	1.000000	1.000000
		65%	1.000000	1.000000	1.000000	1.000000	1.000000
		70%	1.000000	1.000000	2.000000	1.000000	1.000000
		75%	1.000000	1.000000	2.000000	1.000000	1.000000
		80%	1.000000	1.000000	2.000000	1.000000	1.000000
		90%	2.000000	2.000000	2.000000	2.000000	2.000000
		95%	3.000000	2.000000	2.000000	3.000000	2.000000
		97.5%	4.000000	3.000000	2.000000	4.000000	3.000000
		99%	5.000000	3.000000	2.000000	4.000000	3.000000
		Information Criteria					^
		Akaike (AIC)	15.698642	15.891070	20.986123	22.357099	42.594398
		Bayesian (BIC)	13.974746	14.167175	14.204999	15.575975	17.422711
		Average Log-Likelhood		-1.255774	-1.098612	-1.235710	-1.259440
		Chi-Squared Test (Binn		1.233774	1.090012	1.233710	-1.233440
		Bin #1: Minimum	0.000000	0.000000	0.000000	0.000000	0.000000
						+00	
		Bin #1: Maximum Bin #1: Input	+∞	+00	2.000000 5.000000	+00	25.000000 5.000000
		Bin #1: Fit	5.000000	5.000000	5.000000	5.000000	5.000000
						5.000000	
		Chi-Squared Test - [* \					^
		Statistic	0.000000	0.000000	0.000000	0.000000	0.000000
۵	🕑 🖄 ±						

Figure 1-22: Material failure of SCADA system – BIC distribution

BIC	 Name 	Geomet	Poisson	IntUniform	NegBin	HyperGeo
Geomet 13.97	7		1	1	1	1
Poisson 14.16	Crank	1.1	1 1 1	1 1 1	1	
IntUniform 14.20		111				
	Distribution Statistics					~
NegBin 15.576	Minimum	0.000000	0.000000	0.000000	0.000000	0.000000
HyperGeo 17.42	7 Maximum	+00	+00	2.000000	+00	25.000000
Binomial N	A Mean	0.800000	0.800000	1.000000	0.800000	0.783489
	Mode	0.000000	0.000000	0.000000	0.000000	0.000000
	Median	0.000000	1.000000	1.000000	0.000000	1.000000
	Std Deviation	1.200000	0.894427	0.816497	1.058301	0.870836
	Skewness	2.1667	1.1180	0.0000	1.7008	1.0747
	Kurtosis	9,6944	4.2500	1.5000	6.8929	4.0733
	Percentiles					^
	1%	0.000000	0.000000	0.000000	0.000000	0.000000
	2.5%	0.000000	0.000000	0.000000	0.000000	0.000000
	5%	0.000000	0.000000	0.000000	0.000000	0.000000
	10%	0.000000	0.000000	0.000000	0.000000	0.000000
	20%	0.000000	0.000000	0.000000	0.000000	0.000000
	25%	0.000000	0.000000	0.000000	0.000000	0.000000
	30%	0.000000	0.000000	0.000000	0.000000	0.000000
	35%	0.000000	0.000000	1.000000	0.000000	0.000000
	40%	0.000000	0.000000	1.000000	0.000000	0.000000
	45%	0.000000	1.000000	1.000000	0.000000	0.000000
	50%	0.000000	1.000000	1.000000	0.000000	1.000000
	55%	0.000000	1.000000	1.000000	1.000000	1.000000
	60%	1.000000	1.000000	1.000000	1.000000	1.000000
	65%	1.000000	1.000000	1.000000	1.000000	1.000000
	70%	1.000000	1.000000	2.000000	1.000000	1.000000
	75%	1.000000	1.000000	2.000000	1.000000	1.000000
	80%	1.000000	1.000000	2.000000	1.000000	1.000000
	90%	2.000000	2.000000	2.000000	2.000000	2.000000
	95%	3.000000	2.000000	2.000000	3.000000	2.000000
	97.5%	4.000000	3.000000	2.000000	4.000000	3.000000
	99%	5.000000	3.000000	2.000000	4.000000	3.000000
	Information Criteria	0.000000	51000000	2.000000		^
	Akaike (AIC)	15.698642	15.891070	20.986123	22.357099	42.594398
	Bavesian (BIC)	13.974746	14,167175	14.204999	15.575975	17,422711
	Average Log-Likelihood	-1.236531	-1.255774	-1.098612	-1.235710	-1.259440
	Chi-Squared Test (Binnin		1.200774	1.050012	2.255710	-1.255440
	Bin #1: Minimum	0.000000	0.000000	0.000000	0.000000	0.000000
	Bin #1: Maximum	+00	+00	2.000000	+00	25.000000
	Bin #1: Input	5.000000	5.000000	5.000000	5.000000	5.000000
	Bin #1: Input Bin #1: Fit	5.000000	5.000000	5.000000	5.000000	5.000000
					5.000000	
	Chi-Squared Test - [* Va					^
	Statistic	0.000000	0.000000	0.000000	0.000000	0.000000
O 🔺 🖄 🖄	± 🔳					

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

Findings:

• Akaike information criterion (AIC) fit statistic: Poisson distribution best fit, standard deviation 2.490

- Akaike information criterion (AIC) fit statistic: IntUniform distribution best fit, standard deviation 3.452
- Bayesian information criterion (BIC) fit statistic: Poisson distribution best fit, standard deviation 2.490
- Best fit distribution (Poisson) preferred

Figure 1-23: Incorrect operational isolation of equipment – AIC distribution

Poisson Geomet IntUn	rm NegBin	HyperGeo
1 10 1 10 1 10 1	1 1 10 1	
	un dillo.	
	l I I 🔄 dillillilli	
stics		^
	0.00000 0.000000	
	+000000	
	6.20000	
	4.00000	
	6.00000	
	152053 3.726661	
0.4016 2.0056	0.0000 0.9338	
3.1613 9.0224	1.7832 4.2720	
		^
1.000000 0.000000	0.00000 0.000000	1.000000
	1.00000	
2.000000 0.000000	1.00000	2.000000
	2.00000	
	3.00000	
	3.00000	
	4.00000	
	4.00000	
	5.00000	
6.000000 3.000000	5.00000	
	6.00000	
6.000000 5.000000	6.00000	6.000000
	7.00000	
	7.00000	
	8.00000	
	8.00000	
	9.00000	
	000000 11.000000	
	13.00000	
	15.00000	
	000000 17.000000	
ria		^
31.969515 32.345111 3	349066 36.791368	58.839203
30.245619 30.621216 2	67942 30.010244	33.667516
elhood -2.863618 -2.901178 -	84907 -2.679137	-2.883920
t (Binning Information)		^
0.000000 0.000000	0.00000 0.000000	0.000000
+00 +00 1	+000000	196.000000
5.000000 5.000000	5.00000	5.000000
5.000000 5.000000	5.00000	5.000000
t - [* Values unavailable without running a bootstrap]		^
	0.00000 0.000000	0.000000
5.000000 5.00 t - [* Values unavailable without running a b	ootstrap]	0000 5.000000 5.000000 ootstrap]

Figure 1-24: Incorrect operational isolation of equipment – BIC distribution

lame	BIC 🔺	Name	Poisson	Geomet	IntUniform	NegBin	HyperGeo
IntUniform	28.0679			1.0.1			
NegBin	30.0102	Graph					
Poisson	30.2456					dillin	
		Distribution Statistics					^
Geomet	30.6212	Minimum	0.000000	0.000000	1.000000	0.000000	0.000000
HyperGeo	33.6675	Maximum	+00	+00	12.000000	+00	196.000000
Binomial	N/A	Mean	6.200000	6.200000	6.500000	6.200000	6.196419
		Mode	6.000000	0.000000	1.000000	4.000000	6.000000
		Median	6.000000	4.000000	6.000000	6.000000	6.000000
		Std Deviation	2.489980	6.681317	3.452053	3.726661	2.442276
		Skewness	0.4016	2.0056	0.0000	0.9338	0.3790
		Kurtosis	3.1613	9.0224	1.7832	4.2720	3.1318
		Percentiles					^
		1%	1.000000	0.000000	1.000000	0.000000	1.000000
		2.5%	2.000000	0.000000	1.000000	1.000000	2.000000
		5%	2.000000	0.000000	1.000000	1.000000	2.000000
		10%	3.000000	0.000000	2.000000	2.000000	3.000000
		20%	4.000000	1.000000	3.000000	3.000000	4.000000
		25%	4.000000	1.000000	3.000000	3.000000	4.000000
		30%	5.000000	2.000000	4.000000	4.000000	5.000000
		35%	5.000000	2.000000	5.000000	4.000000	5.000000
		40%	5.000000	3.000000	5.000000	5.000000	5.000000
		45%	6.000000	3.000000	6.000000	5.000000	6.000000
		50%	6.000000	4.000000	6.000000	6.000000	6.000000
		55%	6.000000	5.000000	7.000000	6.000000	6.000000
		60%	7.000000	6.000000	8.000000	7.000000	7.000000
		65%	7.000000	7.000000	8.000000	7.000000	7.000000
		70%	7.000000	8.000000	9.000000	8.000000	7.000000
		75%	8.000000	9.000000	9.000000	8.000000	8.000000
		80%	8.000000	10.000000	10.000000	9.000000	8.000000
		90%	9.000000	15.000000	11.000000	11.000000	9.000000
		95%	11.000000	20.000000	12.000000	13.000000	10.000000
		97.5%	11.000000	24.000000	12.000000	15.000000	11.000000
		99%	13.000000	30.000000	12.000000	17.000000	12.000000
		Information Criteria					^
		Akaike (AIC)	31.969515	32.345111	34.849066	36.791368	58.839203
		Bayesian (BIC)	30.245619	30.621216	28.067942	30.010244	33.667516
		Average Log-Likelihood	-2.863618	-2.901178	-2.484907	-2.679137	-2.883920
		Chi-Squared Test (Binnin					^
		Bin #1: Minimum	0.000000	0.000000	1.000000	0.000000	0.000000
		Bin #1: Maximum	+00	+00	12.000000	+00	196.000000
		Bin #1: Input	5.000000	5.000000	5.000000	5.000000	5.000000
		Bin #1: Fit	5.000000	5.000000	5.000000	5.000000	5.000000
		Chi-Squared Test - [* Va					^
		Statistic	0.000000	0.000000	0.000000	0.000000	0.000000
	/ 10/ .1.						
🗢 🗥 🕻	<u>%</u> 🖄 ±						