Item No.	Workstream	Parameter affected	Assumption	Rationale for quantification purposes	Plan to reduce or eliminate	CTV Activity	Limitations or Biases Introduced	Future steps to reduce limitations or biases
1	End of Life Modifier	EOL conditional probability of failure	Assume all end of life failure curves follow the Weibull distribution given by earliest and latest onset of failure.	Weibull distribution is a standard distribution for modelling failure e.g. 'Using the Weibull Distribution: Reliability, Modeling and Inference' by John McCool	Review during testin, validation and calibration	2.3.3 Test Assumptions	Model may not always reflect reality - particularly with truncated datasets	Review observed asset health changes against trends
2	End of Life Modifier	EOL conditional probability of failure	An asset is in very poor health (e.g. score >90) when the conditional probability of failure has reached a level of 10%	Translation from existing methodology	Review during testin, validation and calibration	2.2.1 Eol Modifier		Expert Review supported by available data
3	End of Life Modifier	Transformer and Reactor EOL modifier	Other Components Factor (OCF) set to zero due to data availability	Data not currently available, but aspects of transformer scoring methodology adequetly address this			May cause under estimation of risk	Collect more data
4	End of Life Modifier	all EOL modifiers	The age of an asset is given by current year- installation year. Where installation year is uncertain an estimate of the likely year is determined from available data.	Age=Current Year - Installation			May not account for data errors	Data cleansing
5	End of Life Modifier	all EOL modifiers	When data is not available then the affected component of EOL modifier is set to zero.		Review during testing, validation and calibration			
6	End of Life Modifier	Transformers/Reactors	When preparing older datasets an assumption is made that component values for mechanic, thermal, dielectric are reasonably consistent with scoring categories proposed in this document in order to allow for a comparison.		Review during testing, validation and calibration		Historic data may not have been scored in the same way	
7	End of Life Modifier	Transformers/Reactors	Dielectric, thermal, mechanical and other component factors that compose the transformer EOL modifier are independent of each other.		Review during testing, validation and calibration	2.3.3 Test Assumptions	May have mutual dependence with each other	
8	End of Life Modifier	Transformers/Reactors	EOL modifier, and subsequent PoF, can be determined using discrete scores	Required to keep calculation process tractable	Review during testing, validation and calibration	2.3.3 Test Assumptions		
9	End of Life Modifier	Transformers/Reactors	There is repeatability in the scores generated given transformer with known condition information and data		Review during testing, validation and calibration	2.3.3 Test Assumptions		
10	End of Life Modifier	Cables	Taking the maximum of defects and severity gives the most accurate view of PoF	Identify most severe issue	Obtain more performance data (e.g., Sheath, SVL, oil sampling, C tan D)		Only a proxy for asset health	Review performance against previous AHI
11	End of Life Modifier	Cables	The Generic Family Issues value can be represented by a single value that multiplies the AAL score					
12	End of Life Modifier	Cables	Duty score is set to zero	No data currently available to support this score				Collect more data
13	End of Life Modifier	OHL conductors	EOL modifier can accurately be represented by age, AAL and number of repairs when actual condition information is not available.	Need score even when condition data is not available	Condition data is being collected from more OHL conductors to address this			Collect more data
14	End of Life Modifier	OHL conductors	The family weighting can be represented by a single value derived from sample results from OHL conductor assets of the same asset family type.	Assets from the same family are expected to suffer from similar problems when considered as a whole group	These family weightings will improve as more sample data is collected		Limited by number of data points available in each family	Collect more data
15	End of Life Modifier	OHL conductors	The individual conductor sample result is represented by a single number determined by summing the underlying sample values.	The higher the number of individual issues (combined with their severity) the closer an asset is to its EOL				
16	End of Life Modifier	OHL conductors	The overall OHL sample result can be determine as a single number determined by the maximum of the individual conductor samples and corrosion survey.	The higher the number of individual issues (combined with their severity) the closer an asset is to its EOL				
17	End of Life Modifier	OHL fittings	EOL modifier can accurately be represented by age when actual condition information is not available.	Need score even when condition data is not available	There is ongoing work to complete a Level 1 visual inspection for all fittings, which should mean we don't need to use the Preliminary multiplier here			Collect more data
18	End of Life Modifier	OHL fittings and OHL conductors	EOL modifier, and subsequent PoF, can be determined using discrete scores	Required to keep calculation process tractable	Review during testing, validation and calibration	2.3.3 Test Assumptions		
19	End of Life Modifier	OHL fittings	When the level 2 condition assessment score is unknown, the family score can be used as a proxy.	Need score even when condition data is not available	Review during testing, validation and calibration	2.3.3 Test Assumptions		
20	End of Life Modifier	Circuit Beaker	The maximum of AGE FACTOR, DUTY_FACTOR, and SF6 FACTOR gives an reasonable representation of EOL modifier and therefore PoF.	The weakest link in the chain is identified through taking the maximum of these values.	Review during testing, validation and calibration	2.3.3 Test Assumptions		
21	End of Life Modifier	Circuit Beaker	The AGE _FACTOR and DUTY_FACTOR utilise a family specific deterioration value. Assume this can be represented by a single value for a given age/duty.	A family of asset should have similar deterioration mechanisms so would be expected to reach a poor condition at a similar time				
22	End of Life Modifier	Circuit Beaker	The SF6 factor can be realistically represented through discrete scoring.					
23	End of Life Modifier	Circuit Beaker	Assume SF6 only becomes material to EOL modifier once high leakage thresholds are reached.	A high SF6 leakage is a key indicator for end of life of a circuit breaker	Review during testing, validation and calibration	2.3.3 Test Assumptions		
24	FMEA	PoF	Asset failures are independent of other assets		Review during testing, validation and calibration process.			
25	FMEA	PoF	Failure modes are independent		Review during testing, validation and calibration process.	3.2.1 Assumption of independence		3.2.2 In the case some of the inter-dependent failure modes has to be modelled, there are chances the data above is not sufficient to address those inter-dependence. Further justification, including impact study, workshops, etc. may be needed to model/ignore those inter-dependence
26	FMEA	PoF	Assets can be grouped into similar categories that share similar characteristics		Refine groupings to improve agreement between model and expected events			
27	FMEA	PoF	Only failure modes and consequences that are materially significant are considered		Review against faults, failures, defects in testing, validation and calibration phase to assess materiality	2.4.3 Uncertainties from inputs and 3.1.1 failure mode, failure rate, frequency of events and detection and Validation case 3.6.0: where possible, use the fault, failure, and defect database to validate the probability of event	May cause under-estimation of risk	3.1.1 failure mode, failure rate, frequency of events and detection and Validation case 3.6.0: where possible, use the fault, failure, and defect database to validate the probability of event
28	FMEA	PoF	Each asset can be modelled with one end of life failure mode representing failure due to wear-out that can't be addressed through maintenance interventions, and multiple non-end of life failure modes that can be addressed through maintenance interventions.		Review during testing, validation and calibration process	2.3.2 Test health score formula and 3.1.1 failure mode, failure rate, frequency of events and detection and Validation case 3.6.0: where possible, use the fault, failure, and defect database to validate the probability of event		3.1.2 review guided by subject matter experts and possibly re-calibration of the failure modes, event types, and corresponding probabilities, based on the data analyses performed in case 3.1.1

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29	FMEA	P(Event)	Event groupings are structured to be disjoint as these groups are nested to form a hierarchy of expected events e.g. a transformer fire also includes asset replacement, possible tank breach, trip and alarm.		Review during testing, validation and calibration process	3.2.1 Assumption of independence and Testing case 3.3.1: Confirm that the failure modes identified in the FMEA are not mutually exclusive and Validation case 3.6.0: where possible, use the fault, failure, and defect database to validate the probability of event, on a like-for-like basis		3.2.2 In the case some of the inter-dependent failure modes has to be modelled, there are chances the data above is not sufficient to address those inter-dependence. Further justification, including impact study, workshops, etc. may be needed to model/ignore those inter-dependence
30	FMEA	PoF	The asset groups are assessed in isolation.		As further asset groups are included within FMEA, the interactions between all assets groups will be reflected in the risk score.			
31	FMEA	PoF	The FMEA earliest and latest onset parameters assume that the protection system designed to protect the asset are operational and functioning as expected		As further asset groups are included within FMEA, i.e. protection, the interactions between assets groups will be reflected in the risk score.			
32	FMEA	PoF	Assume that when a non-end of life intervention is carried out, that all tasks associated with that intervention are successfully completed. Similarly, where any non end-of-life activity that identifies the need for a repair, that the repair is undertaken		Review during testing, validation and calibration process	3.2.5: Test the assumption of perfect intervention, using techniques such as expertise survey, data deep dive, or scenario test (to compare the outcomes of perfect and imperfect interventions) in order to understand the importance of the imperfect intervention, i.e., whether needed to be modelled in the monetised risk.	May cause under-estimation of risk	Validation case 3.4.2: Use the balance between cost and risk to validate the probability of detection and the validity period of inspection. Calibration case 3.4.3: If large discrepancies are found in the above exercise, the values obtained from the FMEA workshops need to be re-calibrated.
33	FMEA	PoF	Non-end-of life FMs ignore impact of operational restrictions		Determine whether this is material and then whether to include these in a further iteration of FMEA			
34	FMEA	PoF	The model parameters can be tuned through calibration against expected number of events		Review during testing, validation and calibration process	6.1.7 Network Level Aggregation; and Validation case 3.6.0: where possible, use the fault, failure, and defect database to validate the probability of event, on a like-for-like basis.		
35	FMEA	PoF	Time based FMs: PoF curves are defined by Weibull curves with two values - earliest and latest onset of failure values for each failure mode. Assume these can be determined based TO experience using all available information: manufacturer information, understanding of asset design, innovation project results, failure investigation reports, failure, faults and defects data, forensics results, evidence from interventions, reviews of intervention policy, information from other network operators (international)		Review against faults, failures, defects in testing, validation and calibration phase to understand that PoF matches expected number of events	3.5.3 Policy Asset Life changes and 3.1.1 failure mode, failure rate, frequency of events and detection and Validation case 3.6.0: where possible, use the fault, failure, and defect database to validate the probability of event		
36	FMEA	PoF	Random FMs: a constant failure rate represented by a single number. Assume this can be determined based TO experience using all available information: manufacturer information, understanding of asset design, innovation project results, failure investigation reports, failure, faults and defects data, forensics results, evidence from interventions, reviews of intervention policy, information from other network operators (international)		Review against faults, failures, defects in testing, validation and calibration phase to understand that PoF matches expected number of events	3.1.1 failure mode, failure rate, frequency of events and detection and Validation case 3.6.0: where possible, use the fault, failure, and defect database to validate the probability of event, on a like-for-like basis.		
37	FMEA	PoF/P(Event)	Assume that certain failure modes will only materialise under particular operating conditions e.g. circuit breaker interrupters once in a failed state will result in an event only when required to operate to break load/fault. Probability of needing to operate based on historic operations data.		Review during testing, validation and calibration process			
38	System Consequence	X	Methodology only considers the loss of customers who are disconnected by the least number of circuits which includes the asset in question (X=Xmin)	Probability of disconnection deceases by a factor of 10 to 100 with each additional connection circuit. Complexity of calculation would increase exponentially if risks of losing X > Xmin circuits were considered.	Then Standard Operating Procedure for assigning asset specific variable such as Xmin will include an instruction that for network areas where it is suspected that this assumption leads to significant error, customer disconnection events with X > Xmin will be considered.			
39	System Consequence	MN	The equation for MN assumes that the quantity and importance of customers lost at each site within the lost area are equal		Example areas could be tested with explicit calculation of all loss events vs the method used to test validity of assumption	4.3.6 direct customer connection - system consequence		
40	System Consequence	PI	Both potential values of PI assume that circuit capacities are designed to SQSS requirements with no additional spare capacity		A survey of circuit capacities vs design requirements could potentially modify the values of PI to take into account any average spare capacity			

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41	System Consequence	Poc	The probability of disconnection is independent of the duration of asset unavailability due to the failure mode. It is assumed that if customer disconnection does not occur at the inception of the fault, it will not occur later.		Pf could be modified to include a term that involves Df			
42	System Consequence	Poc	The probability of disconnection is independent of the health of assets neighbouring the asset in question. Often neighbouring assets will be of similar condition and health to the asset in question		Pf could be modified to include a term that involves the health of the asset			
43	System Consequence	D	Disconnection duration is calculated by the minimum of all the mean restoration times of the events that have lead to the disconnection. The restoration time will in reality be of a function that is a composite of all the individual event restoration time functions.		Data could be gathered to construct the individual event restoration times. The probabilistic function for minimum restoration could then be created and the mean of that function taken			
44	System Consequence	VOLL	VOLL is assumed to be constant across GB except where Vital Infrastructure is connected.		If more research on locational VOLL was available then this data could be incorporated in the model			
45	System Consequence	Cn	It is assumed that the boundary transfer impact of each circuit that is material to a boundary is comparable.		If boundary impacts of each circuit were calculated by the SO the costs could be scaled accordingly			
46	System Consequence	Cn	It is assumed that asset failures are equally likely across the year		If data on the seasonality of a failure mode and the seasonality of boundary costs were available then each season could be treated separately			
47	System Consequence	PY	The probability of coincident faults is independent of the health of assets neighbouring the asset in question. Often neighbouring assets will be of similar condition and health to the asset in question		PY could be modified to include a term that involves the health of the asset			
48	System Consequence	RRC	It is assumed that alternative voltage support can be obtained through the ancillary services when compensation assets are unavailable. In reality this is sometimes not the case.		If research on the cost impacts of overvoltage on TOs and customers were available these could be included in the model			
49	System Consequence	RRC	It is assumed that the full capacity of a compensation asset is purchased when it is unavailable		If the SO could provide data on the relationship between asset availability and SO costs this could be incorporated			
50	System Consequence	CMVArh	It is assumed that the cost to procure MVArh across the network is equal		If the SO could provide locational cost data this could be incorporated			
51	Safety Consequence	Probability of injury	The probability of injury is assessed on a per person basis, i.e. one individual. The probabilities add up to 1		Review during testing, validation and calibration process	4.2.1 safety and environmental consequences		
52	Safety Consequence	Probability of injury	Probabilities assume an individual within the vicinity of the asset when event occurs. The vicinity of an asset is 50m as described in TGN 227		Review during testing, validation and calibration process	4.2.1 safety and environmental consequences		
53	Safety Consequence	civil fines	Mean value used for civil damage results; enough information from reference book to normally distribute fines		Review during testing, validation and calibration process	4.1.2 cost of (material) consequence - the model		
54	Safety Consequence	Probability of injury	Probability values based on expert opinion.		Review during testing, validation and calibration process as data becomes available	4.2.1 safety and environmental consequences		
55	Safety Consequence	Probability of injury	Assume 0.5m wide person, 2m tall probability of injury for a category 4 - possibility of fatality event. Use calculations from a high pressure bushing disruptive failure. Full text in Knock C., Horsfall I, and Champion S.M (2013). Development of a computer model to prefict risks from an electrical bushing failure. Elsevier. This includes a spreadsheet of research carried out by Cranfield University, analysing the probability of fatality, being lacerated/penetrated by shrapnel with permanent injury (Major), and being lacerated/penetrated by shrapnel with no sustained injury (LTI). The analysis averaged (mean) their values across the different 'zones' for a vertical bushing, which related to the areas around a bushing ie directly in front, to the side etc, and averaging (mean) their values for a person at 15m,25m,35m,45m,and 55m.					
56	Safety Consequence	Probability of injury	For probability of injury for category 2 calculated on a centre-post rotating disconnector for 400kV, with dimensions 6.21mx0.38m, each disconnector is 3m apart		Review during testing, validation and calibration process	4.2.1 safety and environmental consequences		
57	Safety Consequence	Probability of injury	Probability of injury attributed to maximum injury sustained		Review during testing, validation and calibration process	4.2.1 safety and environmental consequences		
58	Environment Consequence	Probability of environmental impact	Expert opinion used to create values		Review during testing, validation and calibration process	4.2.1 safety and environmental consequences		
59	Environment Consequence	Probability of environmental impact	Probability of environmental impact relates to maximum impact occurred		Review during testing, validation and calibration process	4.2.1 safety and environmental consequences		
60	Environment Consequence	Probability of environmental impact	Category 3 based on CB failures - majority of gas CB failures have resulted in category 1 (major) SF6 loss					
61	Environment Consequence	Probability of environmental impact	All CB probabilities of environmental impact based on gas CBs					
62	Environment Consequence	Probability of environmental impact	All cable probabilities of environmental impact based on oil-filled cables					
63	Safety and Environment Consequence	Exposure score	Safety exposure: Holiday cover is in place to ensure routine activities are carried out every week of the year		Review during testing, validation and calibration process	4.1.2 cost of (material) consequence - the model		
64	Safety and Environment Consequence	Exposure score	Exposure scores are a weighting, the same matrix is used for both safety and environment criticalities		Review during testing, validation and calibration process	4.1.2 cost of (material) consequence - the model		
65	Financial	Cost of intervention	Financial cost of intervention including replacement is based on an averaged value determined for each asset.		Review during testing, validation and calibration process	4.1.4 financial consequence		
66	Financial	Cost of intervention	The cost value is not flexed based on underlying specifications of the asset or the location of the asset.		Review during testing, validation and calibration process	4.1.4 financial consequence		
67	Target Setting	Transformer and Reactor EOL modifier score	2010 values for mechanic, thermal, dielectric are consistent with updated NOMs methodology		Review during testing, validation and calibration process	2.3.1 Factors and ingredients included in the formulae		
68	Target Setting	All EOL modifier scores	Where health score cannot be calculated, use previous AHI to estimate a value. Typically less than 2% of assets affected by this assumption.					
69	Target Setting	Cable EOL modifier	No Adjustment applied					
70	Target Setting	Circuit Breaker EOL modifier	Current age=installation year-report year					
71	Target Setting	Circuit Breaker EOL modifier	Deterioration groups based on reporting year					
72	Target Setting	Circuit Breaker EOL modifier	No SF6 data or fault current data available for 2010 asset data. These factors are currently set to zero.		Consider estimating values and review during testing, validation and calibration process. Consider refinement for future.	2.3.1 Factors and ingredients included in the formulae		
73	Target Setting	All EOL modifier scores	Where data is not available then the affected component is currently set to zero		Consider estimating values and review during testing, validation and calibration process. Consider refinement for future.	2.3.1 Factors and ingredients included in the formulae		
74	Target Setting	OHL fittings	No 2010 OHL fittings data due to sample data availability/consistency with new method		Consider estimating values and review during testing, validation and calibration process. Consider refinement for future.	2.3.1 Factors and ingredients included in the formulae		

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75	Target Setting	All PoF	2010 EOL modifier to PoF mapping function parameters are the same as 2016		Review during testing, validation and calibration process	2.3.1 Factors and ingredients included in the formulae		
76	Target Setting	Interventions - All Assets	Applying NLR replacement dates from the NOMs submission in the reporting year					
77	Target Setting	All Assets	2016 asset inventory from 2016 RRP (NLR), 2010 asset inventory from March 2012 RIIO submission, which was frozen at Nov 2010					
78	Uncertainty	Confidence Interval	Estimating the CI of MC trials of a single risk methodology (as defined in the document) is sufficient to generate reliable estimates of uncertainty.		As part of testing, validation and calibration alternative formulations for generating Risk maybe developed and the spread of results across many methods used to assess the level of uncertainty.	6.3.1 Uncertainty bandings generation		
79	Safety Consequence	Probability of injury	For a category 4 asset failure ie disruptive. The minimum injury sustained will be an LTI/HSE letter of concern (safety category 3), due to the psychological affect of being within 50m of the asset failure					
80	Safety Consequence	Probability of injury	For safety consequence 2, assumed person stood directly under the disconnector to receive an injury. Hence, ratio of a disconnector (3 phases) : 50m area					
81	Safety Consequence	Probability of injury	For safety category 3, there is no FMEA to reference. If in the future, there is an appropriate mapping the values shall be reviewed to fit as appropriate.					
82	Environment Consequence	Probability of environmental impact	For environment category 3, probability of environmental damage determined for an average CB, proportion of gas CBs to total CB NG population. Such that if a gas CB disruptively fails a major spillage of SF6 will occur					
83	Environment Consequence	Probability of environmental impact	For environment categories 4 and 5, there are no FMEA to reference. If in the future, there is an appropriate mapping the values shall be reviewed to fit as appropriate.					
84	Safety and Environment Consequence	Exposure score	Safety exposure: substation offices are within 50m of assets					
85	Safety and Environment Consequence	Exposure score	Safety exposure: Assumed outage work ie replacement and maintenance activities, precautions are taken in line with TP 139 so that staff are not exposed to live assets within 50m					
86	Safety and Environment Consequence	Exposure score	Safety exposure: Category 2 (high) public exposure comprises of footpaths and A-roads					
87	Safety and Environment Consequence	Exposure score	safety exposure: Category 1 (very high) public exposure comprises of motorways					
88	Safety and Environment Consequence	Exposure score	safety exposure: 43800 (average ~480000 cars on A roads a day (DfT), assume each car goes past a substation in 1 second. Then have 5 cars go past a substation every second) http://www.dft.gov.uk/traffic-counts/download.php - analysed East Midlands data					
89	Safety and Environment Consequence	Exposure score	safety exposure: 43800 (average ~480000 cars on M roads a day (DfT), assume each car goes past a substation in 1 second. Then have 5 cars go past a substation every second) http://www.dft.gov.uk/traffic-counts/download.php - analysed East Midlands data					
90	Safety and Environment Consequence	Exposure score	Safety exposure: Assumed for a 'high' level safety site that staff exposure hours is half of a 'very high' exposure site					
91	Safety and Environment Consequence	Exposure score	Safety exposure: Public access to a 'medium' exposure site is 0, as assumed to be classed as having access more than 50m from the assets					
92	Safety and Environment Consequence	Exposure score	Environmental exposure: Use same exposure scoring for environmental exposure, and see whether reasonable values come out in CVT		CTV to validate if safety exposure scores apply for environmental exposure	4.2.1 Safety and environmental consequence		