AusNet

AMS 01-09-02
Event Trees

Group Operations Asset Management

7 September 26

Contents

01 Distribution

Coverage

Customer, safety and environment event trees have been developed for each asset class where it is affected by that risk.

Asset Classes – Hyperlinked (If Applicable)	CoF		
	Customer	Safety	Environment
Power Transformers	Expected outage hours	Public and Staff	Bushfire, Oil Spill
PT Bushings	Expected outage hours	Staff	Oil Spill
Current Transformers	Expected outage hours	Staff	
Conductors	Expected outage hours	Public and Staff	Bushfire
Circuit Breakers	Expected outage hours	Staff	
ACR / Sectionalisers	Expected outage hours	Public	Bushfire
Control Boxes	Expected outage hours		
Switches	Expected outage hours		
Disconnectors (Isolators and Earth Switches)[1]			
Fuses	Expected outage hours	Public	Bushfire
Cables[1]			
Communication Systems	Related to safety (expected outage hours) for primary asset*	Related to safety for primary asset*	Related to environment (Bushfire) for primary asset*
Protection Systems			
Poles and Pole Top Structures[1]			

1. Due to drivers such as compliance requirements, low cost and low consequence, a proactive risk-based proposal was not developed for the marked asset classes. Instead, a replace on fail or replace on inspection program was adapted and hence event trees were not developed.

Legend:

- Not Considered
- Completed

The Consequence of Failure represents the expected or mean cost associated with the failure of an asset. However, it's important to recognise that assets can experience multiple failure modes, each with a range of potential outcomes—from negligible costs to catastrophic consequences, such as a bushfire resulting in multiple fatalities.

The event trees provides a structured approach to assessing the equipment. It allows for the calculation of the average Consequence of Failure over the asset's lifetime, considering some possible scenarios. By mapping out the different pathways and their associated probabilities, the event tree offers a mechanism to estimate the overall risk and prioritise assets based on the severity of their potential failure impacts.

This approach ensures that resources are allocated effectively, targeting those assets whose failures could have the most significant consequences.

Power Transformers

Power Transformers - Customer

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Key Concepts

For multi-bank stations, the remaining Tx banks are assumed to cover the full station output, except the identified load at risk. For simplicity, only a 2nd Tx failure was considered, even if there were more than 2 banks.

For single-bank stations, another station is assumed to cover the full station output, except the identified load at risk.

Units

LoC

MW

%, hrs

Count

%

CoC

$/kWh

CoF

Events

Failure HAS Occurred

ZSS Avg Demand Output

Phase	Load at Risk (%)	Duration
T2	**Multiple Tx Site:** 45% **Single Tx Site:** 100%	2 hrs
T3	10.71%	17,472 hrs

Qty Tx

Probability of Coincident Fault

Value of Customer Reliability

Customer CoF

Comments

ZSS Specific (**Dynamic**)

- The 45% load at risk for T2 is the weighted average as the load at risk non-linearly reduces from 100% to 40% by the end of the T2 period.
- The 10.71% load at risk for T3 is the weighted average of 40% (untested) for 12 weeks (first Tx replacement) and 1.92% for remainder of the year whilst a 2nd Tx is on order and replaced.
  - The 1.92% reflects the typical 1 wk p.a. of extreme hot weather.

(Static)

ZSS Specific (**Dynamic**)

Single-Tx: 1.92%
(i.e., 1 of 52 weeks where an alternate ZSS may be unable to support)
Multi-Tx: 0.674%
[= 23% (12 weeks replacement period) x 2.93% (average Tx PoF for EDPR period)]
(**Static**)

ZSS Specific, converted to $/MWh (x1000). (**Dynamic**)

Calculation Example

Equipment ID: 3XXXXXXX

ZSS WGL
From '2024 station output.xlsx',
37.74285552 MW

×

$$\left[\begin{pmatrix}0.45\\ \times\\ 2\ hrs\end{pmatrix}+\begin{pmatrix}0.1071\\ \times\\ 17{,}472\ hrs\end{pmatrix}\right]$$

×

WGL has **3 Tx banks**, ∴ the probability of a coincident fault is:
0.674%

×

The VCR for WGL is:
$38,370.48/MWh

=

$18,273,966

CoF = ZSS Avg Demand Output x ($T2_{load\ at\ risk}$ x $T2_{duration}$ + $T3_{load\ at\ risk}$ x $T3_{duration}$) x (Probability_of_coincident_fault) x VCR x 1,000

Power Transformers - Safety

AusNet

Key Concepts

Key hazards resulting from a PT failure identified by CIGRE are fire and explosions.

The levers to change CoF are:
- Exposure levels to public, dictated by location.
- Exposure levels to staff, dictated by age.

Units

LoC

%

%

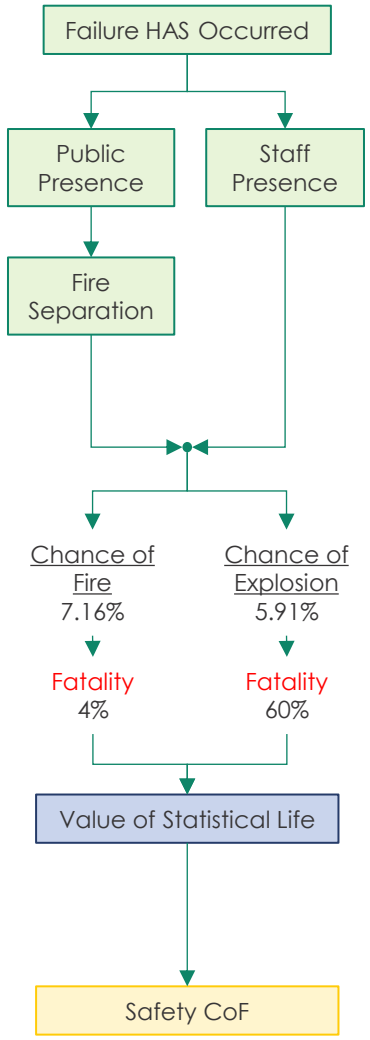
%

CoC

$

CoF

Events



Comments

Public Presence
Applies a multiplier for the type of area over the person per m^2 value. Refer to table in Key Notes. **(Dynamic)**

Staff Presence
Applies a bathtub curve to visits value and reflects the age of the asset. **(Dynamic)**

Fire Separation
- **Insufficient Clearance =** 0.9%
- **Sufficient Clearance =** 0.3%
- **Fire Wall =** 0.1%
- **Sound Enclosure =** 0.05%
- **No Fire Barrier =** 0.9%
- **Unspecified =** 0.2%

(Dynamic)

References CIGRE industry data from the Transformer Reliability Survey (2015). (**Static**)

Assumed likelihood of most severe outcome – Fatality. (**Static**)

*Refer to AMS 01-09 for Value of Statistical Life. (**Static**)*

DF = 6

Calculation Example

Equipment ID: **3XXXXXXX**

The presence of the public, being in a ***commercial*** area (0.42 multiplier) having population of ***13*** in a ***137,000 m²*** area, with an ***unspecified fire separation*** is

+

The staff exposure, with asset being a ***mid-life*** asset, is

$$\left[\begin{pmatrix}0.000040\\ \times\\ 0.002\end{pmatrix} + .003038\right]$$

×

$$\left[\begin{pmatrix}7.16\%\\ \times\\ 4\%\end{pmatrix} + \begin{pmatrix}5.9\%\\ \times\\ 60\%\end{pmatrix}\right]$$

×

Value of Statistical Life is: **$5,700,000**

×

6

= **$3,696.72**

CoF = (Public_Exposure x Fire_separation + Staff_Exposure) x ($\%_{Fire}$ x Rate_of_Fire_Fatality + $\%_{Explosion}$ x Rate_of_Explosion_Fatality) x Value_of_Life x DF

Power Transformers - Environment (Bushfire)

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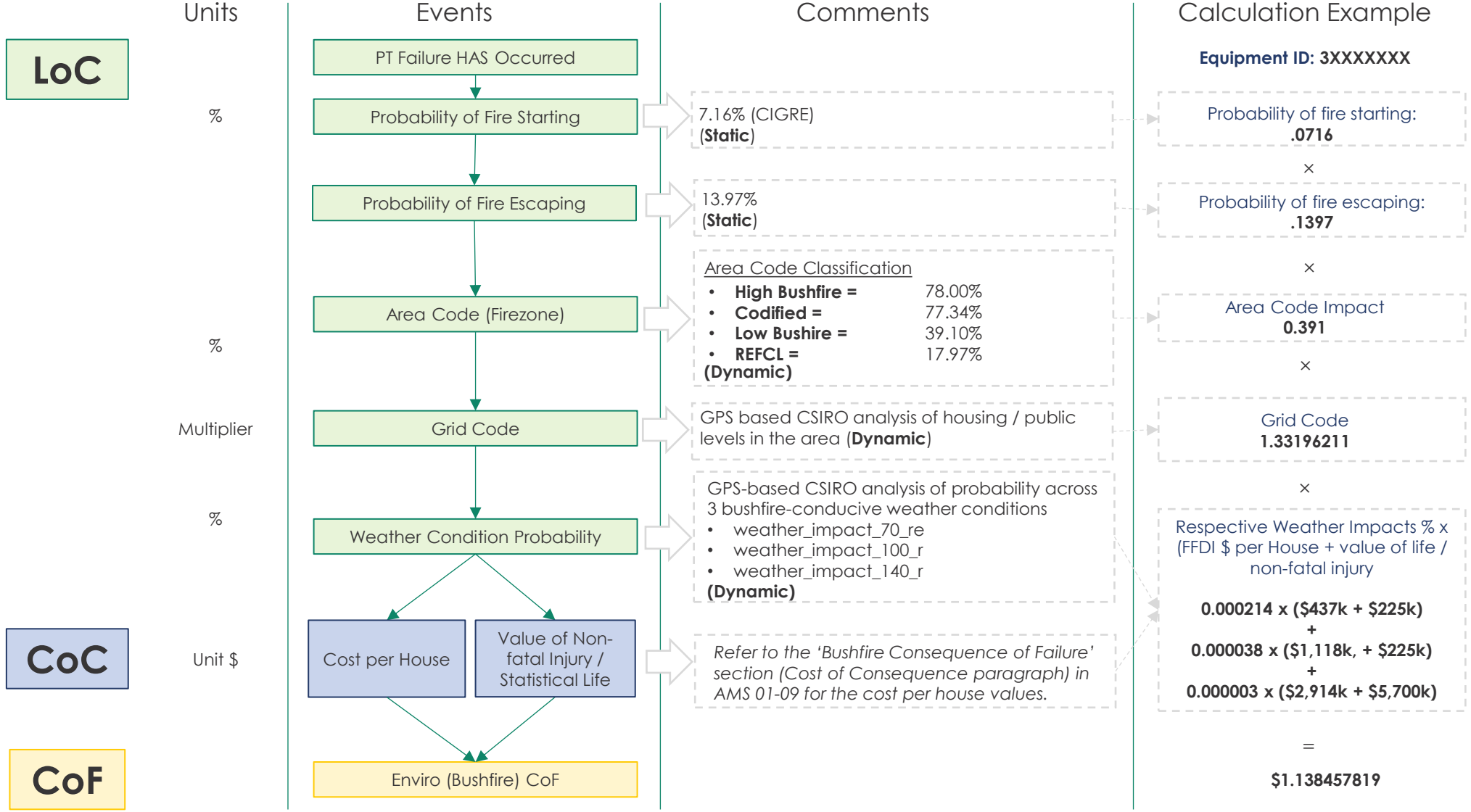
Key Concepts

A bushfire hazard can lead to loss of housing and human injury / fatality.

The scale of consequences is contextualised to the GPS location, allowing for:

- The type of land
- The density of housing/public in an area
- Likelihood of various weather conditions conducive to bushfire
- Likely housing damage from weather conditions
- Likely injury/fatality from weather conditions



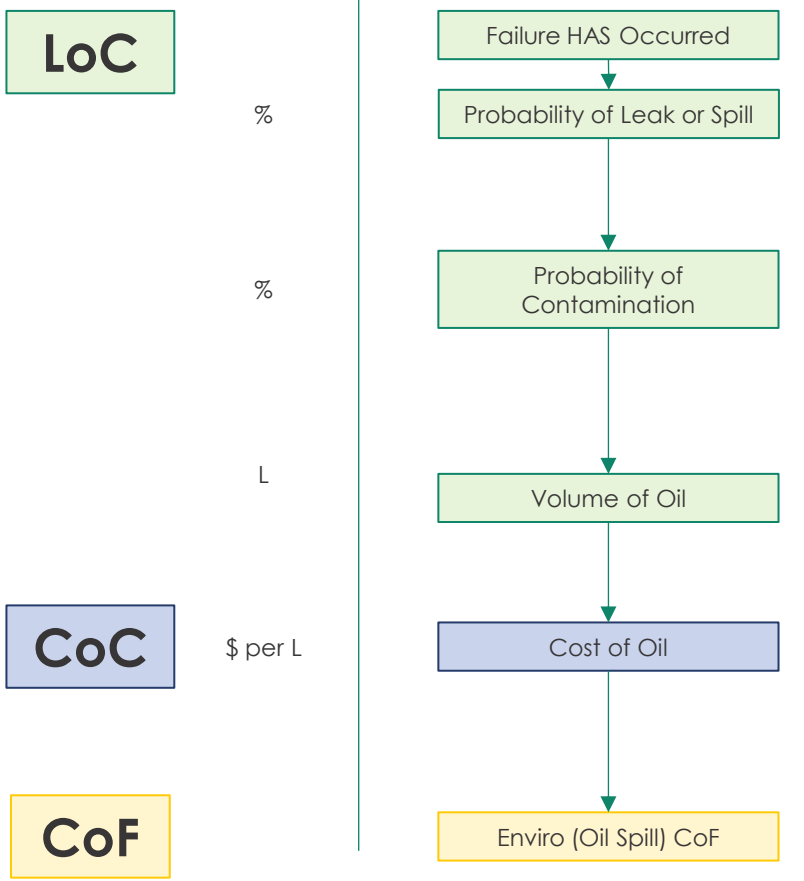
CoF = Potential Bushfire Risk × Area Code Impact × Grid Code × (Respective_Weather_Impacts x (FFDI_Per_House_Impacts + Value_of_Life_or_Non-fatal_Injury))

Power Transformers - Environment (Oil Spill)

AusNet

Key Concepts

Risk of oil spill is influenced by the volume of oil in the transformer, and the type of protection available (i.e., bunding and flooring).



CoF = (Probability_of_leak_or_spill) x (Probability_of_contamination) x (Oil_volume) x (Cost_of_oil)

PT Bushings

PT Bushings - Customer

AusNet

Key Concepts

The core event tree for PT Bushings is similar to Power Transformers. The only difference is that this event tree considers the type of bushing, which then dictates the T3 duration.

The inclusion of probability of coincident PT fault (from PT event tree) remains as it is the consideration for redundancy (whether it be another PT in the same station, or another station altogether.

LoC

CoC

CoF

Events	Units
Failure HAS Occurred	
ZSS Avg Demand Output	MW
Load at Risk / Duration	%, Hrs
Qty Tx	Count
Probability of Coincident PT Fault	%
Value of Customer Reliability	$/MWh
Customer CoF	

Comments

ZSS Avg Demand Output: ZSS Specific (**Dynamic**)

Phase	Load at Risk (%)	Duration
T2	**Multiple Tx Site:** 45% **Single Tx Site:** 100%	2 hrs
T3	**OIP/SRBP:** 10.71% **Other:** 6.31%	**OIP/SRBP:** 17,472 hrs **Other:** 6 wks/1,008 hrs

(**Dynamic**)
SRBP – Replace, due to higher failure rate (poor dielectric performance)/catastrophic failure
OIP – Replace, due to poor oil containment.
Others – Replace 6 wks.

Qty Tx	Probability (%)	Logic
Single Tx	1.92%	1 of 52 wks where an alternate ZSS may be unable to support
Multiple Tx	**OIP/SRBP:** 0.674%	= 23% (12 wks replacement period) x 2.93% (avg Tx PoF for EDPR period)
	Other: 0.33695%	=11.5% (6 wks replacement period) x 2.93% (avg Tx PoF for EDPR period)

(**Static**)

ZSS specific (**Dynamic**)
Multiply by 1000 to convert to $/MWh.

Calculation Example

Equipment ID: 3XXXXXXX

ZSS SLE
From '2024 station output.xlsx', the average demand is:
14.74 MW

×

This asset is OIP, ∴ the T3 duration is:
17,472 hrs

$$\left[\begin{pmatrix}\mathbf{0.45}\\ \times\\ \mathbf{2\ hrs}\end{pmatrix}+\begin{pmatrix}\mathbf{0.1071}\\ \times\\ \mathbf{17,472}\end{pmatrix}\right]$$

×

SLE has 3 Tx banks, ∴ the prob_coinc_fault is:
0.00674

×

SLE's VCR is
38.97 $/kWh
×1000

=

$7,248,176

$$\mathbf{CoF = ZSS_{Avg\ Demand\ Output} \times (T2_{load\ at\ risk} \times T2_{duration} + T3_{load\ at\ risk} \times T3_{duration}) \times Prob\_coinc\_fault \times VCR \times 1{,}000}$$

PT Bushings - Safety

AusNet

Key Concepts

The core event tree for PT Bushings is similar to Power Transformers. The only difference is that this event tree considers the type of bushing, which then dictates the T3 duration.

The inclusion of probability of coincident PT fault (from PT event tree) remains as it is the consideration for redundancy (whether it be another PT in the same station, or another station altogether).

Units

LoC

%

%

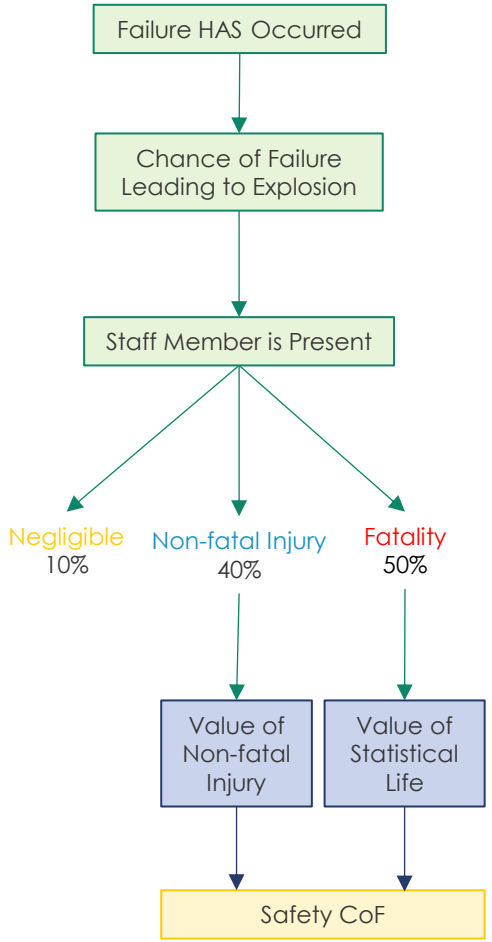
%

CoC

$

CoF

Events



Comments

The likelihood of explosion depends on the asset type.
RIP / RIS – 0%
OIP / SRBP – 90%
(**Dynamic**)

0.29%
Based on 8 visits by 2 staff for average 1.6 hrs duration per annum. (**Static**)

Assumed spread of likelihood, allowing for varying degrees of impact depending on where in the switchyard the person is located at the time. (**Static**)

Refer to AMS 01-09 for the Value of Non-fatal Injury and Value of Statistical Life. **(Static)**

DF (Worker) = 3 (**Static**)

Calculation Example

Equipment ID: **3XXXXXXX**

Bushing type is **Synthetic Resin Bonded Paper (SRBP)**, therefore chance of failure leading to explosion is:
0.9

×

0.0029

×

$$\left[\left(\begin{matrix}40\%\\\times\\\$225k\end{matrix}\right)+\left(\begin{matrix}50\%\\\times\\\$5.7M\end{matrix}\right)\right]$$

×

3

=

$ 23,020.20

$$\text{CoF} = \%_{explosion} \times \%_{staff\_present} (\%_{fatal} \times \$_{fatal} + \%_{non\text{-}fatal} \times \$_{non\text{-}fatal}) \times DF$$

PT Bushings - Environment (Oil Spill)

AusNet

Key Concepts

The risk of oil spill from PT bushings is solely driven by the bushing type and its subsequent containment of oil.

The tiers of oil spill volume to inform the penalty sizes is based on the EPA penalty tiers for dangerous litter and waste.

Units

LoC

%

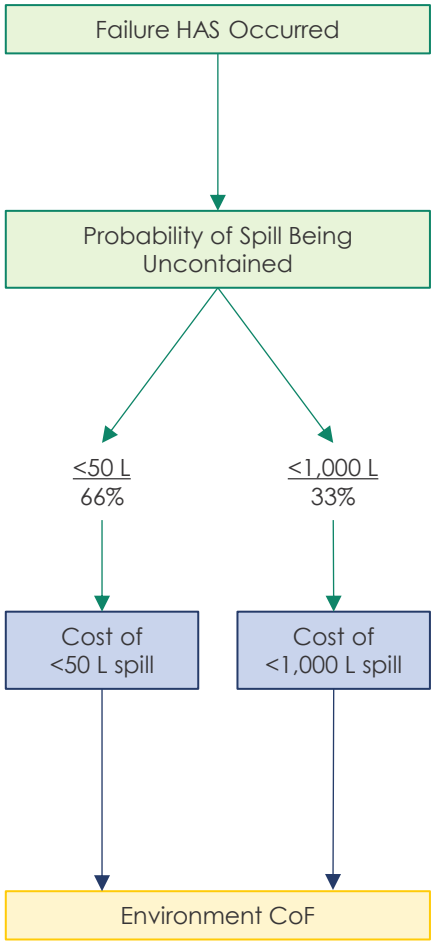
%

CoC

$

CoF

Events



Comments

Type	Probability of Uncontained Spill (%)
RIP / RIS	-
OIP	5%
SRBP	90%

(Dynamic)

Assume spread of spill sizes, noting transformers may have a containment bund in place. (**Static**)

Cost of Oil Remediation
- <50 L: $4k x2 = $8k
- <1,000L: $6k x2 = $12k

x2 multiplier assumed for clean-up, and restoration costs.
(Static)

Calculation Example

Equipment ID: 3XXXXXXX

Type is **Oil Impregnated Paper**. Therefore, probability of spill being uncontained is **0.05**

×

$$\left[\left(\begin{matrix}66\% \\ \times \\ \$8{,}000\end{matrix}\right)+\left(\begin{matrix}33\% \\ \times \\ \$12{,}000\end{matrix}\right)\right]$$

=

$462

$$\text{CoF} = \%_{\text{spill\_being uncontained}} \times \left(\%_{<50\ \text{L}} \times \$_{<50\ \text{L}} + \%_{<1{,}000\ \text{L}} \times \$_{<1{,}000\ \text{L}} \right)$$

Conductors

Conductors – Customer

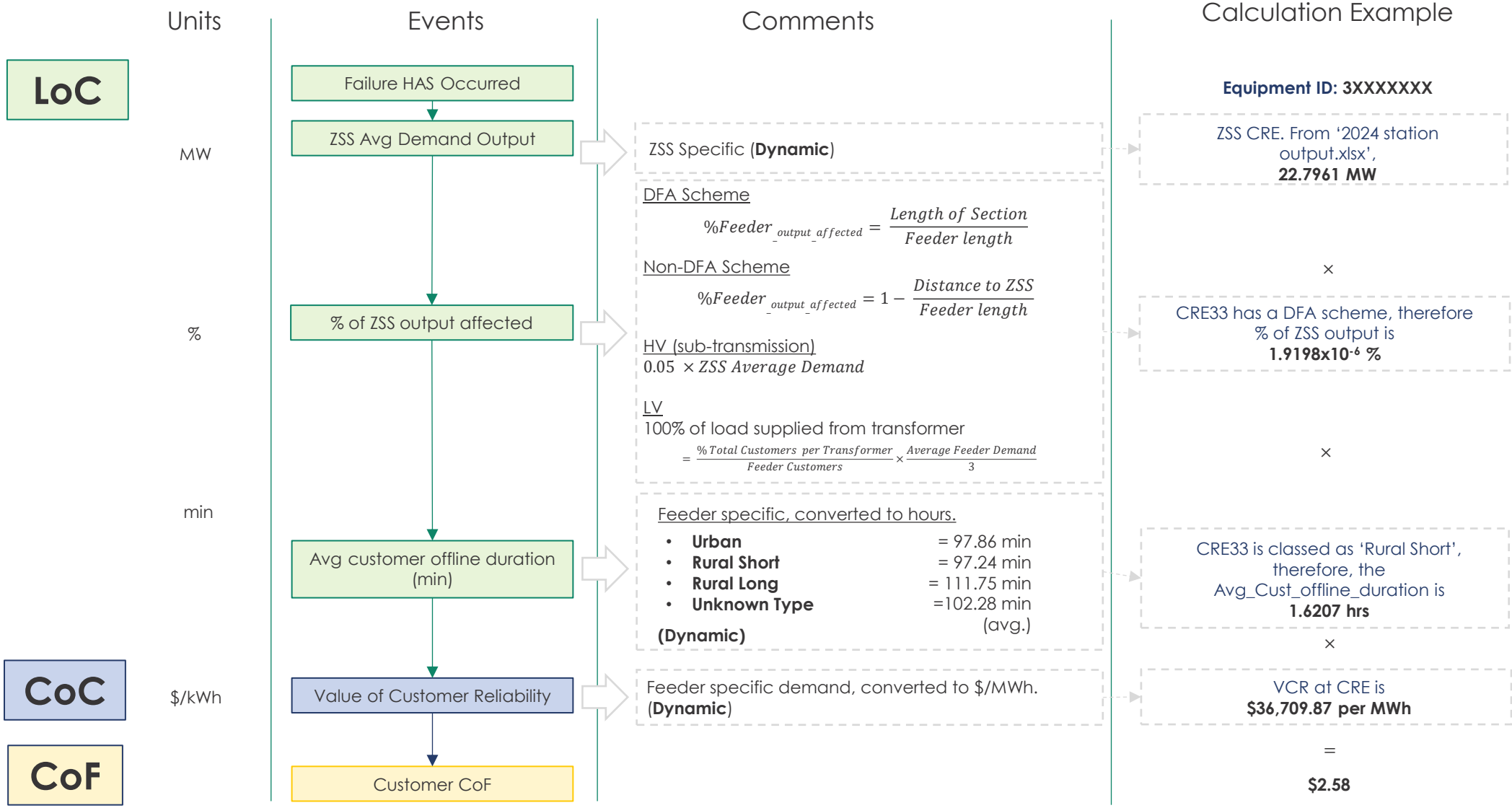
AusNet

Key Concepts

The amount of station output affected is equivalent to the ratio of total conductor lengths offline-to-total ZSS conductor lengths.

In a DFA arrangement, the total conductor length is considered to be 1 isolatable section.

In a non-DFA scheme, the total conductor length is considered to be all lengths downstream of the fault to the end of the feeder, as the crow flies. This analysis was provided by AusNet, based on GPS locations.

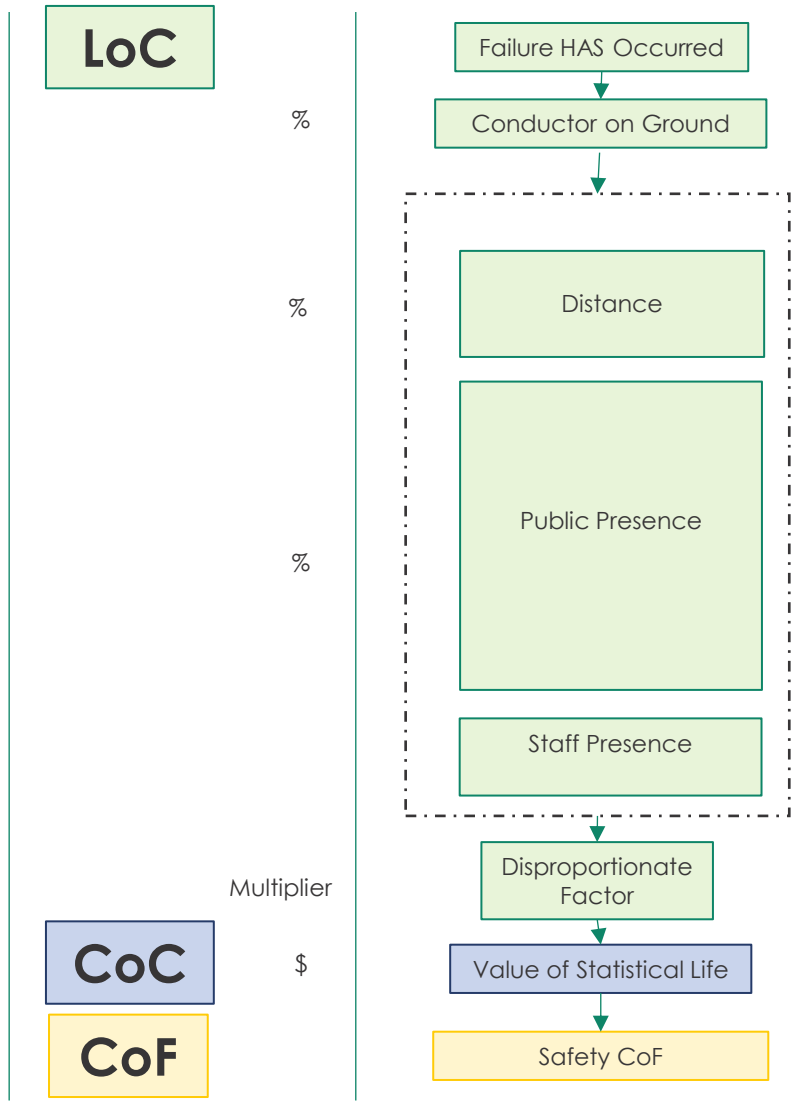


CoF = ZSS Avg Demand Output x $\%_{ZSS\_output\_affected}$ x (Avg_Cust_offline_durations / 60) x (VCR x 1,000)

Conductors - Safety

Key Concepts

This event tree considers the proximity of a conductor on the ground to the nearest road, and the probably voltage levels.



Comments

0.3% (**static**) assumed based on observations in ZK notifications

Distance Probability Function:
- **<5m** = 0.06
- **5-10m** = 0.03
- **10-20m** = 0.015
- **20-50m** = 0.0007
- **50-100m** = 0.00004
- **>100m** = 0.000002
- **Default (if no category matches)** = 0.04999

(Dynamic)

Public presence applies a multiplier for the type of area over the person per m^2 value. (**Dynamic**)

Population per area comes from Mesh Blocks defined by the Australian Bureau of Statistics https://www.abs.gov.au/census/guide-census-data/mesh-block-counts/latest-release

Staff presence applies a bathtub curve visits value and reflects the age of the asset. (**Static**)

DF = 3 for Staff, 3 for public (**static**)

Refer to AMS 01-09 for the Value of Statistical Life. (**Static**)

Calculation Example

Equipment ID: **3XXXXXXX**

Conductor Probability (on ground)
0.003

×

Being in a ***residential*** area having population of **67** in a ***0.0181 km²*** area, public exposure is (**dynamic**)
0.00154

+

Distance to road is <5m, so distance probability is (**dynamic**)
0.06

+

Staff exposure with 1 visit every 5 years for 2 staff at 30m long expressed as a portion of the year, is (**static**)
0.002%

$$0.003 \times [(0.00154 \times 6) + 0.06 \times 6 + (0.070 \times 3)]$$

×

Value of life is
$5,700,000
=
$9,217

CoF = Prob_conductor_on_grd x (Worker_Exposure x DF + Public_Exposure x DF + Dist_to_road x DF)

Conductors - Environment (Bushfire)

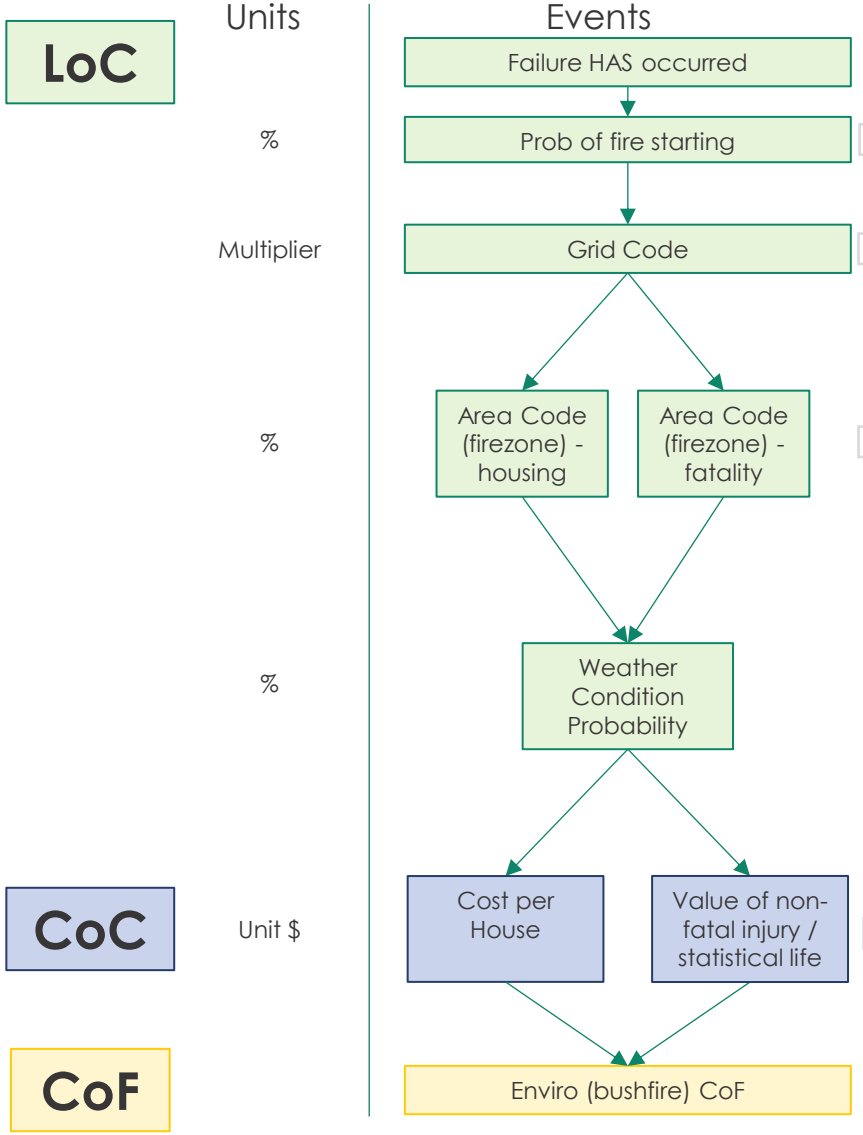
Key Concepts

This event tree is similar to the Environment (Bushfire) event tree for PT.

A bushfire hazard can lead to loss of housing and human injury / fatality.

The scale of consequences is contextualised to the GPS location, allowing for:

- Typical weather conducive to bushfire
- The type of land
- The density of housing
- The density of the public



Comments

Fire Category	Pr. Fire Start
LBRA	0.46%
HBRA	0.55%
REFCL	0.46%
Codified	0.06%

GPS based CSIRO analysis of housing / public levels in the area (**Dynamic**)

Area Code multipliers per Ausnet AMS 01-09

Category	Housing	Fatality
LBRA	0.2	1
HBRA	1	3
REFCL	4.6	6
Codified	19.8	10

GPS based CSIRO analysis of probability across 3 bushfire-conducive weather conditions (**dynamic**)

- weather_impact_70_re
- weather_impact_100_r
- weather_impact_140_r

CSIRO assessment (**static**)

Weather condition	FFDI $ per house	Value of life / injury
70_re	$367k	$225k
100_r	$940k	$225k
1400_r	$2,450k	$5.7m

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Calculation Example

Equipment ID: **3XXXXXXX**

Potential Bushfire Risk
0.0046

×

Grid Code
3.677176

×

Area is categorised as LBRA, therefore:
Housing Area code - 0.2
Fatality Area code - 1

$$\left[0.2 \times \begin{pmatrix} 0.000577 \times \$367k + 0.000146 \times \$940k + 0.000021 \times \$2{,}450k \end{pmatrix} + 1 \times \begin{pmatrix} 0.000577 \times \$225k + 0.000146 \times \$225k + 0.000021 \times \$5{,}700k \end{pmatrix}\right]$$

=

$11.43

$$CoF = Potential\_Bushfire\_Risk \times Grid\_Code \times \sum (Area\_Code_{house,fatality} \times (Weather\_Condition\_Prob_{70,100,1400} \times Unit\_Cost_{70,100,1400}))$$

Circuit Breakers

Circuit Breakers - Customer

Key Concepts

The type of CB will determine how much of the station output is affected.

Each Tx is assumed to support equal portion of the station output.

For B/T, TR and Feeder CBs, once any manual switching is completed, the item can be repaired/replaced without any risk of supply interruption.

For 66kV CB, they will need repair / replacing before risk to supply interruption is confidently mitigated.

For 66kV CB in a multi-CB config, the most common CB/Tx configs were analysed for their output impacts, with either 1 or 2 CB's offline, and what it means for Tx going offline.

LoC

CoC

CoF

Units	Events	Comments
	Failure HAS occurred	
MW	ZSS Avg Demand Output	ZSS Specific (**Dynamic**)
Count	Qty Tx and CB	ZSS Specific (**Dynamic**)
MW	MW affected	

CB Type	MW Affected
BT, TR	(ZSS_Output / Tx_count) x 2
Feeder	(ZSS_Output / Tx_count) x 1
66kV	ZSS_Output

	Load at Risk / Duration	

CB Type	ZSS type	T2	T3
BT / TR / Feeder	-	45%	-
66kV	Ring / Double Bus	60%	30%
66kV	Simple (single-Tx)	100%	50%
66kV	Simple (multi-Tx)	89%	44%
66kV	Simple, No B/T	75%	75%
66kV	Simple T	70%	37%
Durations		**T2**	**T3**
Durations		2 hrs	96 hrs

- The above values were determined through an analysis of the more common configs for 66kV CBs and the average impact of either 1 or 2 x 66kV CB failing.

	Prob of coincident CB failure *(Only for 66kV CB in a multi-CB config)*	**Chance of 2nd failed CB being concurrent =** 0.05%
$/kWh	Value of Customer Reliability	ZSS Specific, converted to $/MWh. (**Dynamic**)
$	Customer CoF	

Calculation Example

Equipment ID: 3XXXXXXX

Item is located at BN, therefore ZSS Avg Demand Output is **19.04 MW**

×

Qty of Tx is 3

CB type is 66kV,
ZSS type is 66kV Double Bus
Therefore, T2 is 60%, T3 is 30%

×

As a Double Bus config,
T2 = 60% and **T3 = 30%** load at risk.

$$\left[\begin{pmatrix}60\% \\ \times \\ 2\ hrs\end{pmatrix} + \begin{pmatrix}30\% \\ \times \\ 96\ hrs\end{pmatrix}\right]$$

×

Given Qty Tx >1, use
Pr coincidental CB fault =
0.0005

×

At BN, VCR is
$37.31 per MWh x 1000

=

$10,661.75

B/T, TR, Fdr CBs
66kV CBs in single CB stns

Eqn 1. CoF = MW affected x ($T2_{\%}$ x $T2_{hrs}$ + $T3_{\%}$ x $T3_{hrs}$) x VCR x 1000

66kV CBs in multi-CB stn

CoF = Eqn 1 x 0.05%

Circuit Breakers - Safety

AusNet

Key Concepts

The CB type will determine the possible consequence, as shown on the next page.

Units

LoC

%

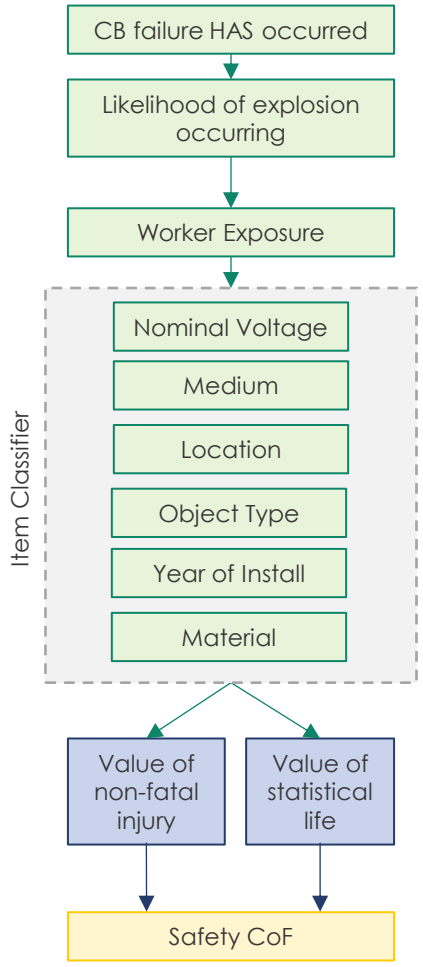
%

CoC

$

CoF

Events



Comments

5.91%
(Assumed same as the chance of a Tx exploding)
(**Static**)

0.44%
(Yearly average of 8 visits by 2 staff for 2.4 hrs per visit) (**Static**)

The hazard classification of CB is outlined in the next slide.

Value of statistical life = $5.7M
Value of non-fatal injury = $219k
(**Static**)

DF = 3, for staff

Calculation Example

Equipment ID: **3XXXXXXX**

5.91%

×

0.44%

×

This asset is CBBO-based 66kV Oil, Porcelain, The consequence of failure is a:
Fatal explosion.

×

$5,700,000

×

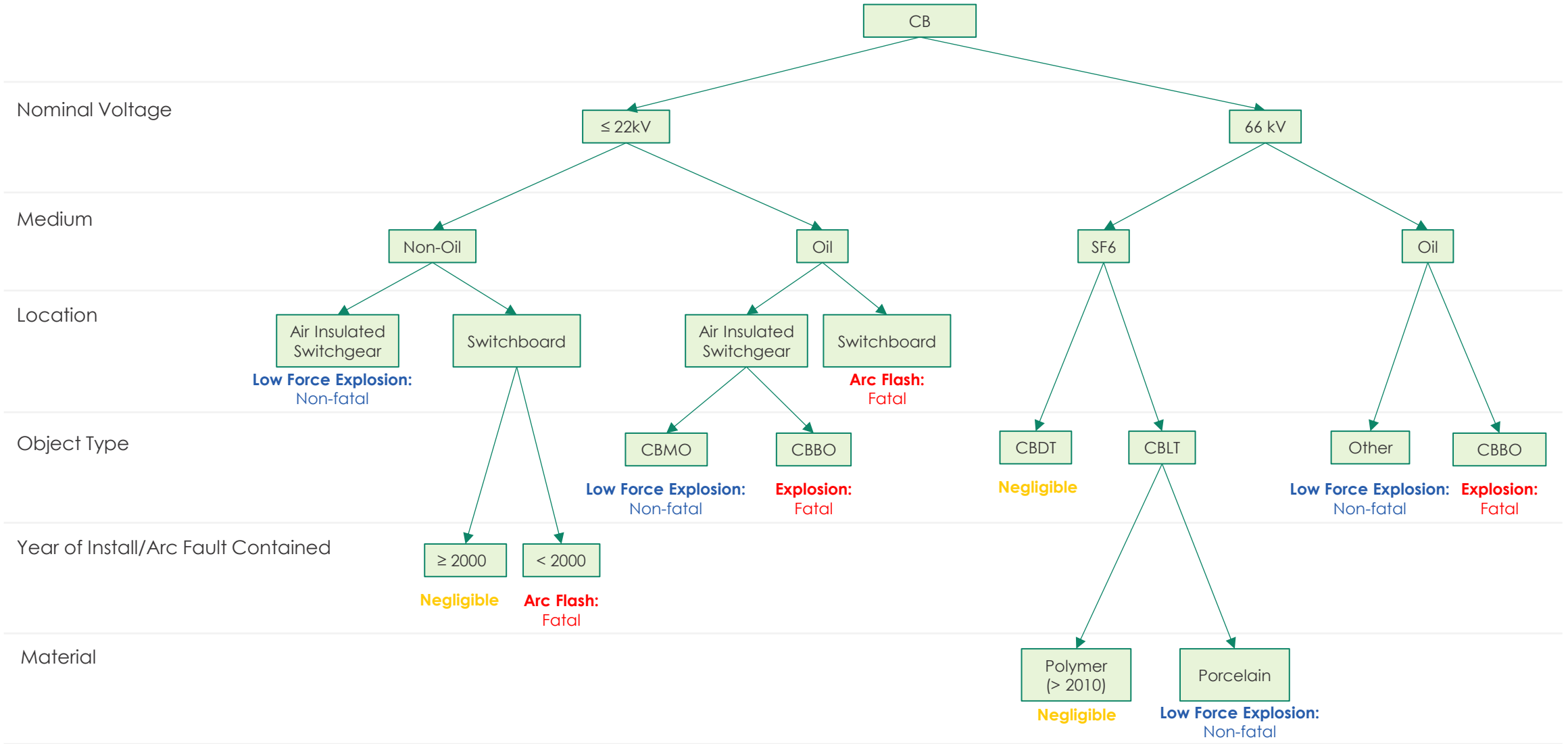
3

= **$4,447**

CoF = $\%_{\text{failure leading to explosion}}$ x $\%_{\text{worker exposure}}$ x [*Value_of_life* or *non-fatal_injury*] x DF

Circuit Breakers – Item Classifier for Consequence Scenarios

This CB item classifier indicates the ultimate consequences associated with each item. The characteristics used to classify each CB are indicated in the below diagram.



ACR / Sectionalisers

ACR / Sectionalisers, Ctrl Box, Switches, 4G Comms - Customer

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Key Concepts

This event tree covers the following assets:

- ACR / Sectionalisers
- Control Boxes
- Switches
- 4G comms

A failed asset in isolation will not impact the customer. An impact will only be realised if another fault in the line has occurred at the same time, which then required these assets to 'activate'. This event tree assumes conductor and cable failures to be representative of those line faults.

Each isolatable section is assumed to represent an equal portion of the station output.

Units

LoC

%

MW

Counts

MW, %

CoC

$ / MWh

CoF

Events

Failure HAS occurred

Probability of Coincident Line Fault

ZSS Avg Demand Output

Section count against Feeder and Station

Phase	Load at risk	Duration
T2	Entire Feeder (feeder section count)	4 hrs
T3	2 isolatable section	24 hrs

Value of Customer Reliability

Customer CoF

Comments

The chance of a line fault is 1.52%. (**Static**)

ZSS Specific (**Dynamic**)
MW Per Section = $\frac{ZSS\ output}{ZSS\ section\ count}$

Each section is assumed to have an equal portion of the ZSS output. This then informs the MW affected for the Feeder, and 2 isolatable sections (**Dynamic**)

The entire Feeder comes offline whilst the location of the asset failure is found. Once found, only the relevant 2 isolatable sections remain offline whilst the item is reaplced. (**dynamic**)

ZSS Specific (in $/kWh) (**Dynamic**)
Multiply by 1000 to convert to $/MWh

Calculation Example

Equipment ID: 3XXXXXXX

Probability of Coincidental Line Fault
0.0152

×

ZSS output:
7.45 MW
Feeder Section count:
192
Therefore, MW Per Section:
$\frac{7.45}{192}$ = **0.0252**

×

Calculate T2 and T3 hours:
$\left[\begin{pmatrix}192\\ \times\\ 4\ hrs\end{pmatrix}+\begin{pmatrix}2\\ \times\\ 24\ hrs\end{pmatrix}\right]$

×

KMS's VCR is
$36.13833 per kWh
× 1000

=

$11.3k

$$CoF = \%_{coinc\ line\ fault} \times \frac{ZSS\ output}{ZSS\ section\ count} \times (Feeder\_section\_count \times T2_{duration} + 2 \times T3_{duration}) \times VCR \times 1000$$

ACR / Sectionalisers - Safety

AusNet

Key Concepts

This event tree analyses the possibility of a low-force explosion and pressure release for an item commonly located at a pole top.

Due to the nature of the location, any member of the public walking underneath would have an extremely low chance of being affected by the explosion / pressure release.

Units

LoC

Type

%

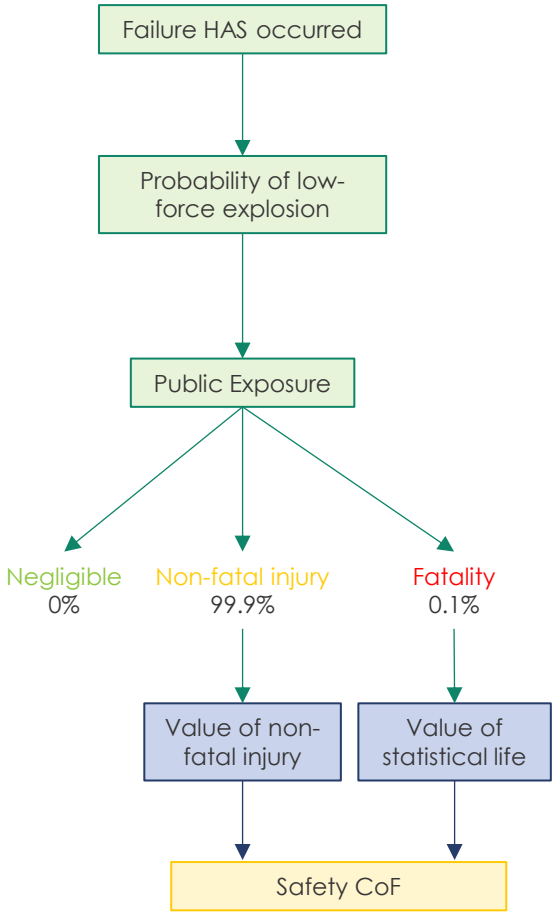
%

CoC

$

CoF

Events



Comments

Only **Oil** or **Gas** insulated items pose a safety risk, at 0.1% chance **(Dynamic).**

Public presence applies a multiplier for the type of area over the person per m² value. (**Dynamic**)

Balance of outcomes (**Static**)

Value of statistical life = $5.7M
Value of non-fatal injury = $225k
(**Static**)

DF = 6 (public) (**static**)

Calculation Example

Equipment ID: 3XXXXXXX

This asset is a gas-insulated item, therefore the probability is applicable.
0.01

×

The public exposure factor is
0.001

×

$$\left[\begin{pmatrix}0.999\\ \times\\ \$225K\end{pmatrix}+\begin{pmatrix}0.001\\ \times\\ \$5.7M\end{pmatrix}\right]$$

×

DF
6

=

$0.31

CoF = $\%_{explosion}$ x $\%_{exposure}$ x ($\%_{non\text{-}fatal\ injury}$ x $225k + $\%_{fatality}$ x $5.7m) x DF

ACR / Sectionalisers - Environment (Bushfire)

AusNet

Key Concepts

This event tree is similar to the Enviro (bushfire) event tree for Tx.

A bushfire hazard can lead to loss of housing and human injury / fatality.

The scale of consequences is contextualised to the GPS location, allowing for:

- Typical weather conducive to bushfire
- The type of land
- The density of housing
- The density of the public

LoC

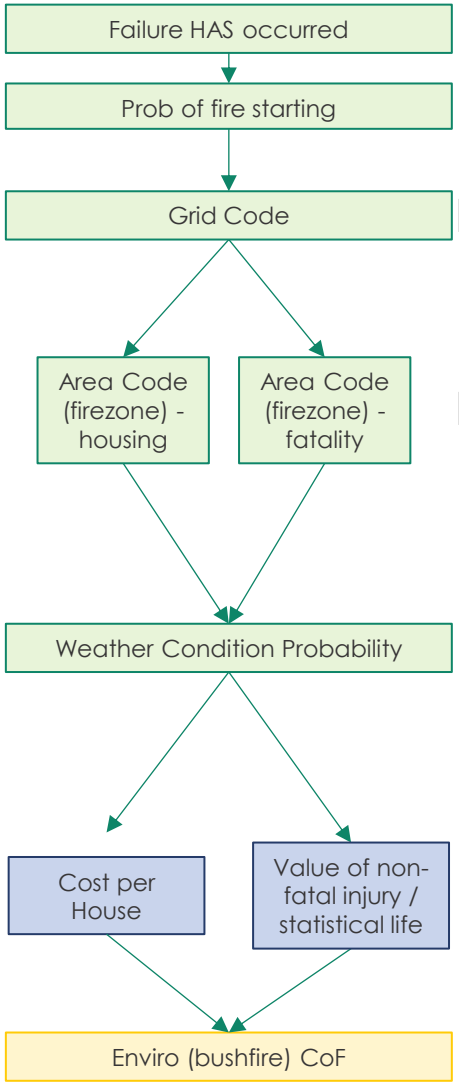
CoC

CoF

Units

- %
- Multiplier
- %
- %
- Unit $

Events



Comments

Only Oil-based assets have a chance of starting a fire, at 0.1%. For Gas or Air assets, the chance is negligible (**Static**)

GPS based CSIRO analysis of housing / public levels in the area (**Dynamic**)

Area Code multipliers per Ausnet AMS 01-09

Category	Housing	Fatality
LBRA	0.2	1
HBRA	1	3
REFCL	4.6	6
Codified	19.8	10

GPS based CSIRO analysis of probability across 3 bushfire-conducive weather conditions (**Dynamic**)

- weather_impact_70_re
- weather_impact_100_r
- weather_impact_1400_r

CSIRO assessment (**Static**)

Weather condition	FFDI $ per house	Value of life / injury
70_re	$367k	$219k
100_r	$940k	$219k
1400_r	$2,450k	$5.3m

Calculation Example

Equipment ID: 3XXXXXXX

Potential Bushfire Risk
.001

×

Grid Code
1.52383

×

Area is categorised as HBRA, therefore:
Housing Area code - 1
Fatality Area code - 3

$$\left[1 \times \begin{pmatrix} 0.000568 \\ \times \\ \$367k \\ + \\ 0.000144 \\ \times \\ \$940k \\ + \\ 0.000021 \\ \times \\ \$2{,}450k \end{pmatrix} + 3 \times \begin{pmatrix} 0.000568 \\ \times \\ \$219k \\ + \\ 0.000144 \\ \times \\ \$219k \\ + \\ 0.000021 \\ \times \\ \$5{,}300k \end{pmatrix}\right]$$

=

$1.82

$$\text{CoF} = \text{Prob\_of\_fire} \times \text{Grid\_Code} \times \sum(\text{Area\_Code}_{\text{house,fatality}} \times (\text{Weather\_Condition\_Prob}_{70,100,1400} \times \text{Unit\_Cost}_{70,100,1400}))$$

Switches - Safety

Safety Consequence was not considered material, and no event tree was produced.

Fuses

Fuses - Customer

Key Concepts

Only a small proportion of the station output will be affected by a fuse failure, given that fuses are located near the end of lines (i.e. each fuse only services a handful of customers). It is assumed that only 10% of the station output can be affected by all the fuses connected to a ZSS.

The duration of time that a customer will be offline following a fuse failure is calculated from historic outage data (previous 5 years). This is given by feeder.

This tree requires that individual equipment IDs can be mapped back to a Feeder and ZSS.

	Units	Events	Comments	Calculation Example
LoC		Fuse failure has occurred		**Equipment ID: 3XXXXXXX**
	MW	ZSS Avg Demand Output	ZSS Specific (**Dynamic**)	ZSS MFA. From '2023 station output.xlsx', **12.074 MW**
				×
	%	% of customers affected	Only a small proportion of this output will be affected by an individual fuse. Assume that a maximum of 5% of customers are downstream of fuses in the network. Assume that the MW affected is equally distributed across all the fuses connected to a single ZSS. (**Dynamic**)	**0.05**
			% of customers affected $= 0.05 \times \frac{1}{\text{No. of fuses linked to ZSS}}$	×
				$\frac{1}{5167}$ (inverse of count of fuses in 'Fuses.csv' connected to ZSS BDL)
				×
	Hrs	Average customer offline durations	Times taken 'Average Customer Offline by feeder.csv' (in minutes) specific to the feeder (**Dynamic**) Divide by 60 to convert to hours.	Feeder BDL31. From 'Average Customer Offline by feeder.csv', **87.33 mins ÷ 60**
				×
CoC	$/MWh	Value of Customer Reliability	ZSS Specific (in $/kWh) (**Dynamic**) Multiply by 1000 to convert to $/MWh.	ZSS BDL. From 'Customer Energy at Risk (AER VCR).xlsx', **40.44 $/kWh × 1000**
				=
CoF		Customer CoF		**$7.16**

CoF = ZSS_output x $\%_{\text{customers affected}}$ x $\frac{Avg\_customer\_offline\_duration}{60}$ x VCR x 1000

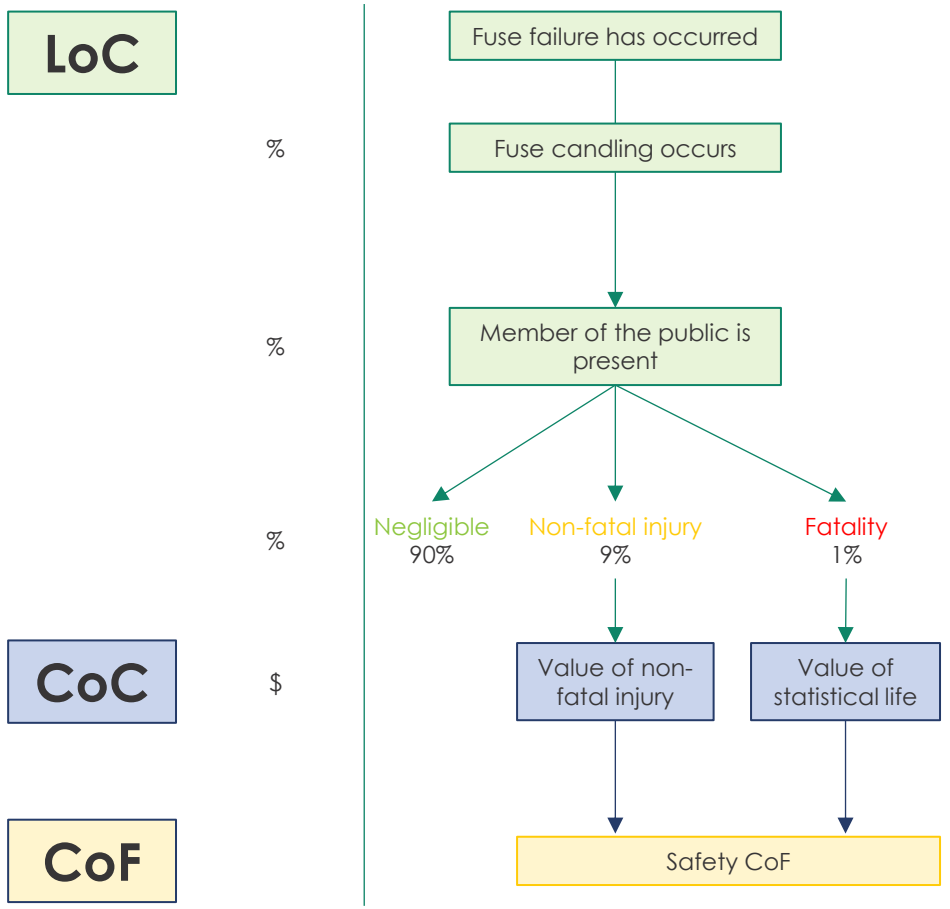
Fuses - Safety

Key Concepts

Fuse candling will occur when a fuse fails. This can cause harm to the public (due to the molten products falling on to them) or can spark a bushfire.

For a failed fuse to cause harm, a member of the public must be in the near vicinity. This likelihood is calculated using census data.

Fuse candling is a slow process, so people would likely move out of the way before serious injury occurs. There have been no historic fatalities from fuse failures, so the likelihood of fatality has been set very low.



$$CoF = \%_{\text{fuse candling occurence}} \times \%_{\text{public exposure}} \times (\%_{\text{non-fatal injury}} \times \$_{\text{non-fatal injury}} + \%_{\text{fatality}} \times \$_{\text{fatality}}) \times DF$$

Fuses - Environment (Bushfire)

AusNet

Key Concepts

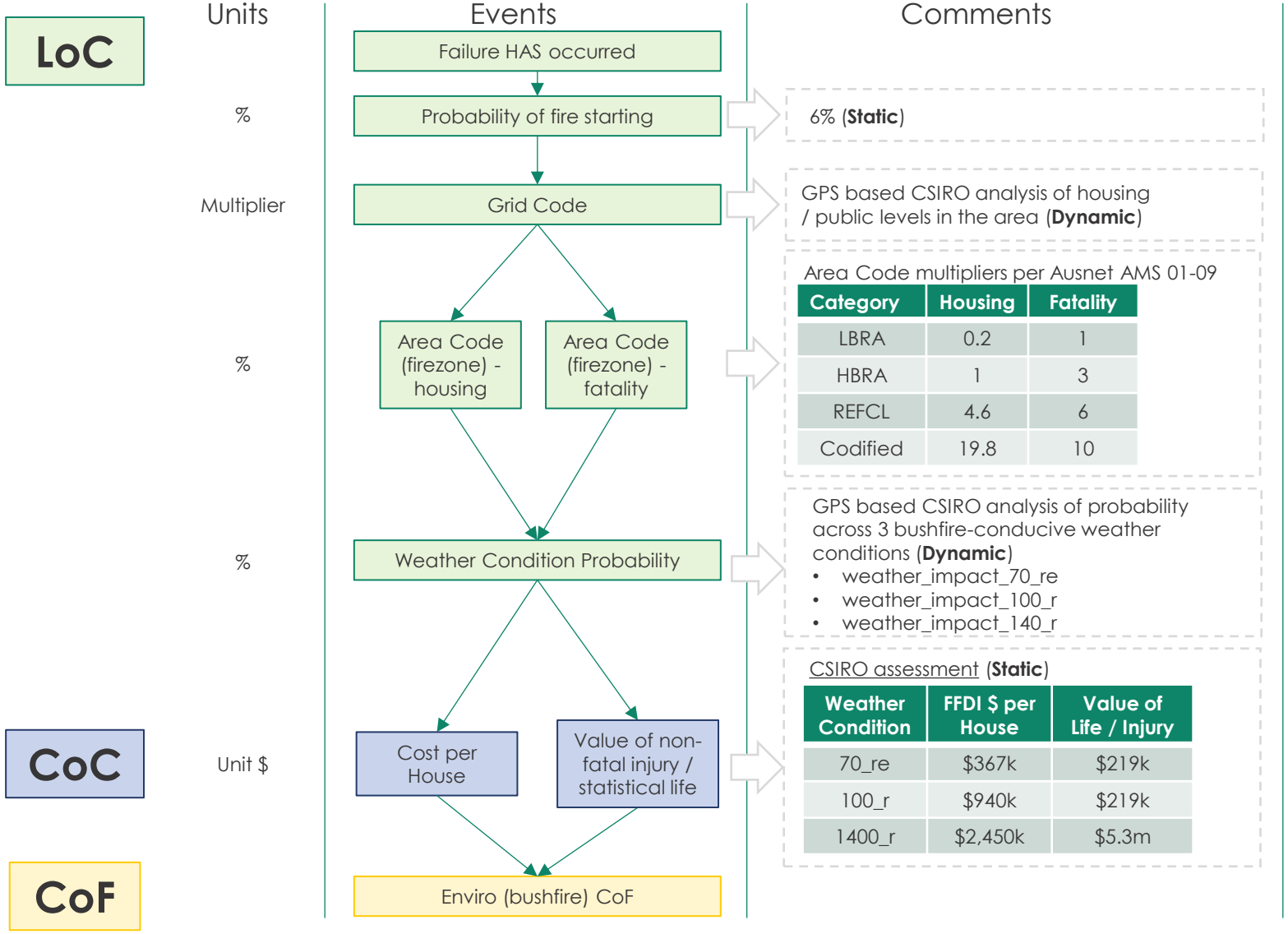
Fuse candling will occur when a fuse fails. This can cause harm to the public (due to the molten products falling on to them) or can spark a bushfire.

This event tree is similar to the Enviro (bushfire) event tree for Tx and Conductors.

A bushfire hazard can lead to loss of housing and human injury / fatality.

The scale of consequences is contextualised to the GPS location, allowing for:

- Typical weather conducive to bushfire
- The type of land
- The density of housing
- The density of the public



Category	Housing	Fatality
LBRA	0.2	1
HBRA	1	3
REFCL	4.6	6
Codified	19.8	10

Weather Condition	FFDI $ per House	Value of Life / Injury
70_re	$367k	$219k
100_r	$940k	$219k
1400_r	$2,450k	$5.3m

See Conductor Bushfire Example

CoF = Potential Bushfire Risk × Area Code Impact × Grid Code × (FFDI Per House Impacts × Respective Weather Impacts)

Communications Systems

Communication ZSS - Customer

AusNet

Key Concepts

Only SDH/PDH & DIC assets are considered for comms trees

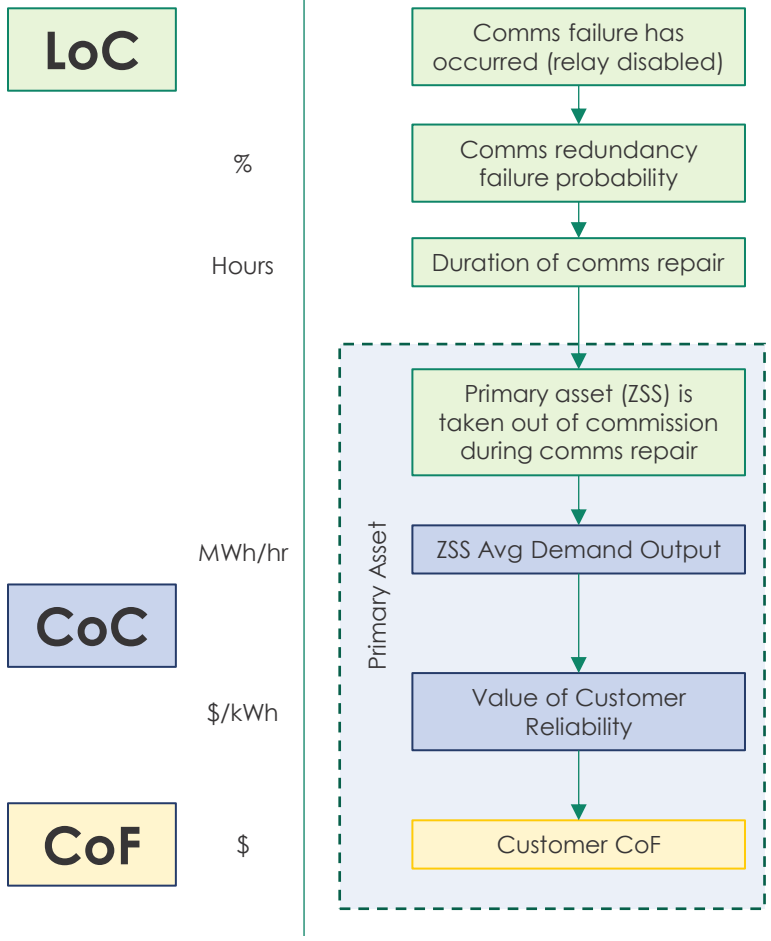
Assumed 25% of ZSS protection requires comms to function

All SDH/PDH & DIC assets are assumed to support the protection functions at a ZSS

Assumed that all comms assets have one level of redundancy with identical PoF to the main comms unit.

The failure consequence assumes that the primary asset (ZSS) will be taken out of commission for the period until the comms can be repaired.

Assumed that all comms assets have one level of redundancy with identical PoF to the main comms unit. It is assumed that this is built into the primary asset CoF already.



Comments

Assumed same PoF for the parallel comms circuit **(Dynamic)**

Average repair duration 6hrs factored based on T Phases below from PT event tree **(Static)**

Phase	Load at Risk	Duration
T2	45%	2hr
T3	6.17%	4hr

ZSS Specific **(Dynamic)**

ZSS specific based on customer and geographic split **(Dynamic)**

Calculation Example

Equipment ID: 3XXXXXXX

25%
(Additional factor to allow for the fact that not all ZSS protection includes comms)
NA 20240624

×

Average repair duration 6 hrs = (2hr x 0.45)+(4hr x 0.0617) = **1.148hr**

×

Station FTR, (Customer Energy at Risk (AER VCR)), (Assume Station Black Energy at Risk (MW) = **8.74 MW**

×

Station FTR (Customer Energy at Risk (AER VCR)) = **$39.35 x 1000**

=

$98,705

$$CoF = (T2_{load\ at\ risk} \times T2_{duration} + T3_{load\ at\ risk} \times T3_{duration}) \times ZSS\ Avg\ Demand\ Output \times 0.25 \times VCR \times 1{,}000$$

Communication DFA - Customer

AusNet

Key Concepts

Only SDH/PDH & DIC assets are considered for comms trees

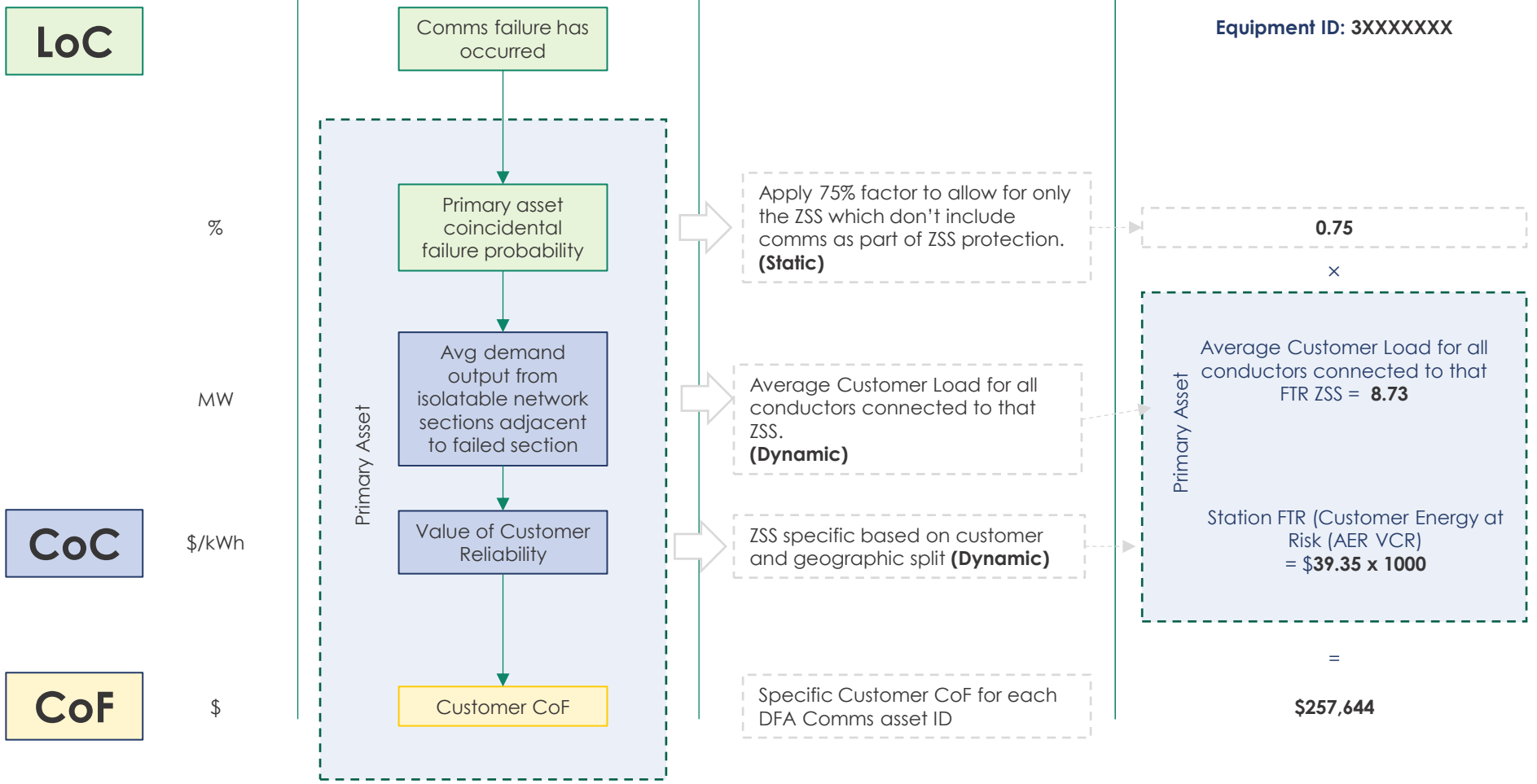
Assumed that all comms assets have one level of redundancy with identical PoF to the main comms unit. It is assumed that this is built into the primary asset CoF already.

Assumed that DFA consequence is only applicable to DFA feeders from ZSS protected by relays operate without comms. Assumed 75% of ZSS's have relays which operate without comms.

Consequence is based on load at risk from an additional isolatable section being taken off-line in the event of a conductor failure on a DFA Feeder.

Conductors are considered as the primary asset for coincidental failure with the comms asset.

Where the DFA connects to a terminal station, the primary asset PoF and CoF are taken as averages across the network.



CoF = 0.75 x Average ZSS conductor PoF x Average ZSS conductor customer CoC

Communication Total - Customer

Key Concepts

The total Customer CoF for communication is the sum of the DFA and ZSS component of the communication equipment.

Calculation

Total Communication = CoF (DFA) + CoF(ZSS)

=

0.75 x Average ZSS conductor PoF x Average ZSS conductor customer CoC

+

($T2_{load\ at\ risk}$ x $T2_{duration}$ + $T3_{load\ at\ risk}$ x $T3_{duration}$) x ZSS Avg Demand Output x 0.25 x VCR x 1,000

Calculation Example

Equipment ID: 3XXXXXXX

CoF = 98.7k + 257.6k
= $356k

Communication Protection - Safety

AusNet

Key Concepts

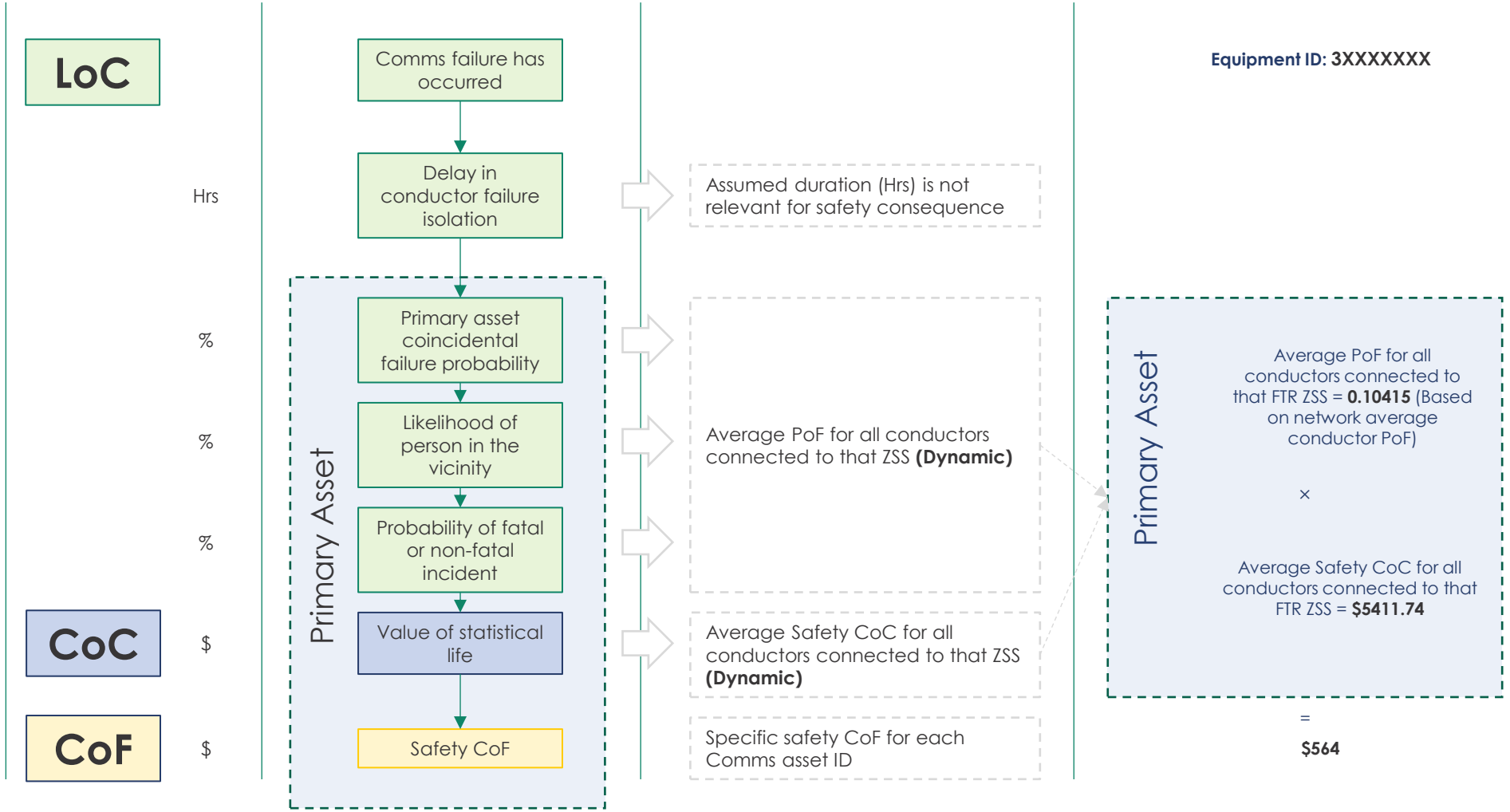
Only SDH/PDH & DIC assets are considered for comms trees

Assumed that all comms assets have one level of redundancy with identical PoF to the main comms unit. It is assumed that this is built into the primary asset CoF already.

Assumed that Safety consequence is related to the unprotected safety hazard associated with a conductor failure in parallel with a comms failure.

Conductors are considered as the primary asset for coincidental failure with the comms asset.

Where the comms are associated with a terminal station, the primary asset PoF and CoF are taken as averages across the network.



Example Calculation

Equipment ID: 3XXXXXXX

Primary Asset

Average PoF for all conductors connected to that FTR ZSS = **0.10415** (Based on network average conductor PoF)

×

Average Safety CoC for all conductors connected to that FTR ZSS = **$5411.74**

=

$564

CoF = Average ZSS conductor PoF x Average ZSS conductor safety CoC

Communication Protection - Environment (Bushfire)

AusNet

Key Concepts

Only SDH/PDH & DIC assets are considered for comms trees

Assumed that all comms assets have one level of redundancy with identical PoF to the main comms unit. It is assumed that this is built into the primary asset CoF already.

Assumed that Bushfire consequence is related to the unprotected bushfire hazard associated with a conductor failure in parallel with a comms failure.

Conductors are considered as the primary asset for coincidental failure with the comms asset.

Where the comms are associated with a terminal station, the primary asset PoF and CoF are taken as averages across the network.

Units

LoC

Hrs

%

%

%

House Count

CoC

$/house

CoF

$

Events

Primary Asset

- Comms failure has occurred
- Delay in conductor failure isolation
- Primary asset coincidental failure probability
- Probability of fire start
- Weather condition probability
- Damage probability (fire region)
- Housing density
- Cost per house
- Bushfire CoF

Comments

- Assumed duration (Hrs) is not relevant for safety consequence
- Average PoF for all conductors connected to that ZSS **(Dynamic)**
- Average Bushfire CoC for all conductors connected to that ZSS **(Dynamic)**
- Specific bushfire CoF for each Comms Asset ID

Example Calculation

Equipment ID: 3XXXXXXX

Primary Asset

Average PoF for all conductors connected to that BDL ZSS = **0.02** (Based on network average conductor PoF))

×

Average Bushfire CoC for all conductors connected to that BDL ZSS = **$700**

=

$14

CoF = Average ZSS conductor PoF x Average ZSS conductor bushfire CoC

Protection Systems

Protection RTU DFA - Customer

Key Concepts

Assumed consequence of RTU failure is that DFA system won't work.

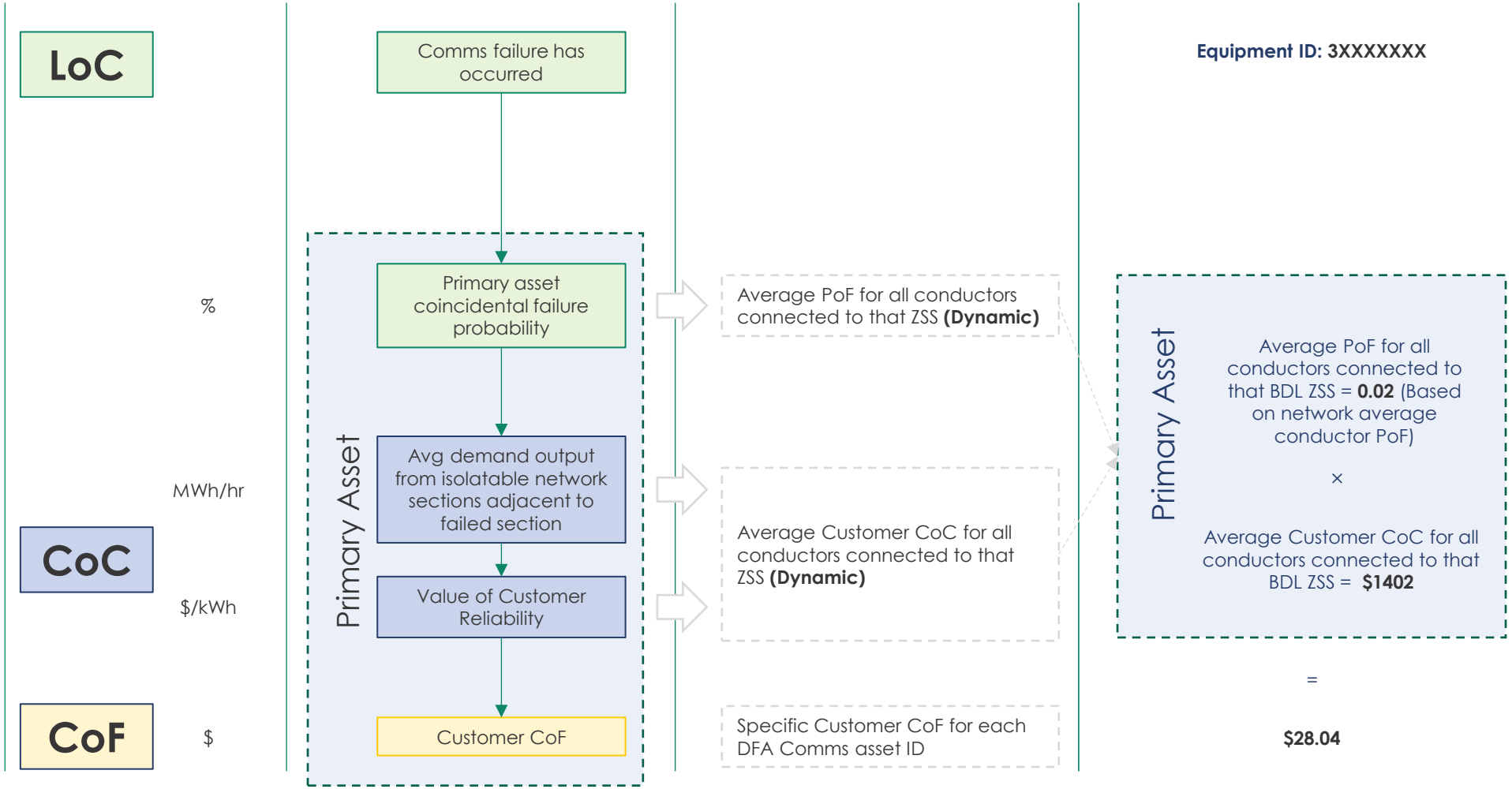
Assumed that there is no redundancy for an RTU failure.

Assumed that DFA consequence is applicable to all RTU assets.

Consequence is based on load at risk from an additional isolatable section being taken off-line in the event of a conductor failure on a DFA Feeder.

Conductors are considered as the primary asset for coincidental failure with the RTU asset.

Where the RTU is associated with a terminal station, the primary asset PoF and CoF are taken as averages across the network.



CoF = Average ZSS conductor PoF x Average ZSS conductor customer CoC

Protection ZSS - Customer

AusNet

Key Concepts

Only Relay assets are considered for protection trees

All Relay assets are assumed to support the protection functions at a ZSS

The failure consequence assumes that the primary asset (ZSS) will be taken out of commission for the period until the relay can be repaired.

Assumed that all protection assets have one level of redundancy with identical PoF to the main comms unit. It is assumed that this is built into the primary asset CoF already.

At T3, assume 25% of the customers have been brought back online.

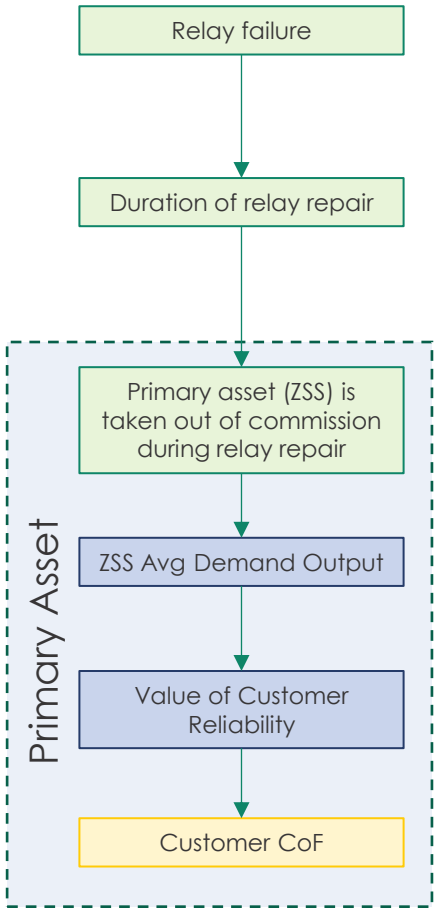
Units

LoC — Hours

CoC — MW, $/kWh

CoF — $

Events



Comments

Average 2 CAPBANKS 5 CBs per ZSS
Asset Class = TX, LN, FDR, BUS

Phase	Load at Risk %			MTTR hrs	
	CBs	CAPBANK	OTHERS	IED	Non-IED
T2	0.2	0.5	$\frac{1}{No.\,Assets\,class}$	3.6	3.6
T3*	0.2* 0.75	0.5*0.75	$\frac{0.75}{No.\,Assets\,class}$	12	84

ZSS Specific **(Dynamic)**

ZSS specific based on customer and geographic split **(Dynamic)**

Specific Customer CoF for each ZSS Comms asset ID

Example Calculation

Equipment ID: 3XXXXXXX

Average repair duration MTTR hrs

$$\left[\begin{pmatrix} LaR \\ \times \\ 3.6\ hr \end{pmatrix} + \begin{pmatrix} LaR \\ \times \\ 12/84\ hr \end{pmatrix}\right]$$

×

Station MSD, (station output), (Assume Station Black Energy at Risk = **6.5 MW**

×

Station MSD (Customer Energy at Risk (AER VCR) = $**35.89 per kWh**

=

$234,915.00

$$CoF = (T2_{load\ at\ risk} \times T2_{duration} + T3_{load\ at\ risk} \times T3_{duration}) \times ZSS\ Avg\ Demand\ Output \times VCR \times 1{,}000$$

Protection - Safety

AusNet

Key Concepts

Only Relay assets are considered for protection trees

Assumed that all relay assets have one level of redundancy with identical PoF to the main comms unit. It is assumed that this is built into the primary asset CoF already.

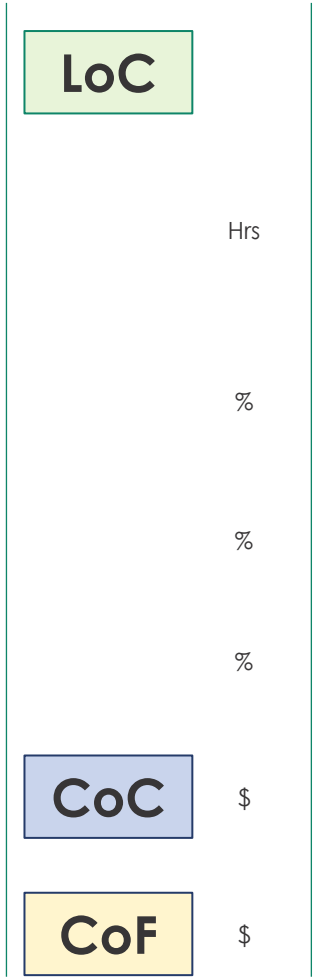
Assumed that safety consequence is related to the unprotected safety hazard associated with a coincidental failure of a relay and a conductor.

Conductors are considered as the primary asset for coincidental failure with the relay asset.

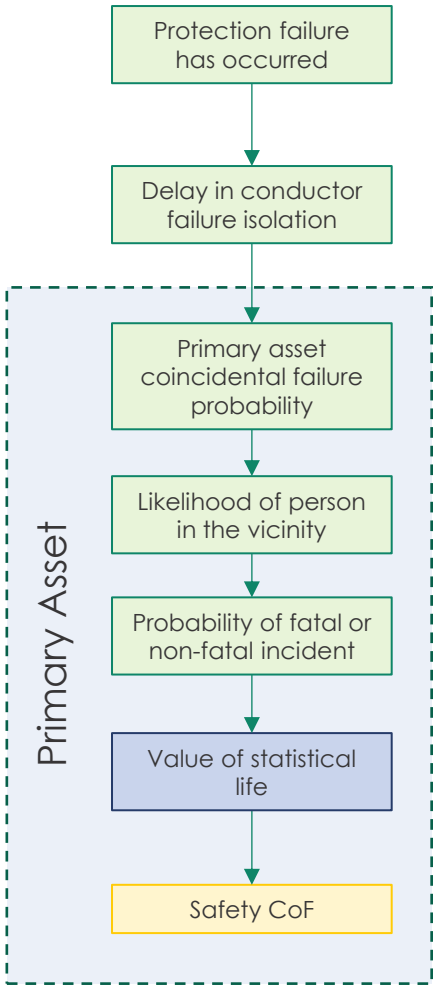
Coincidental failure probability is based on the product of the primary and secondary asset PoF's

Average values have been used for primary asset CoF and PoF at ZSS level. This approach is adopted due to the complexity of filtering relay data based on function and feeder.

Units



Events



Comments

Assumed duration (Hrs) is not relevant for safety consequence,

Average PoF for all conductors connected to ZSS **(Dynamic)**

Average Safety CoC for all conductors on that ZSS **(Dynamic)**

Specific safety CoF for each Comms asset ID

Calculation Example

Equipment ID: 3XXXXXXX

Primary Asset

Average PoF for all conductors connected to ZSS = **0.0827** (Based on network average conductor PoF)

×

Average Safety CoC for all conductors on that ZSS. = **$17,686.83**

=

$125.50

CoF = Average ZSS conductor PoF x Average ZSS conductor safety CoC

Protection - Environment (Bushfire)

AusNet

Key Concepts

Only Relay assets are considered for protection trees

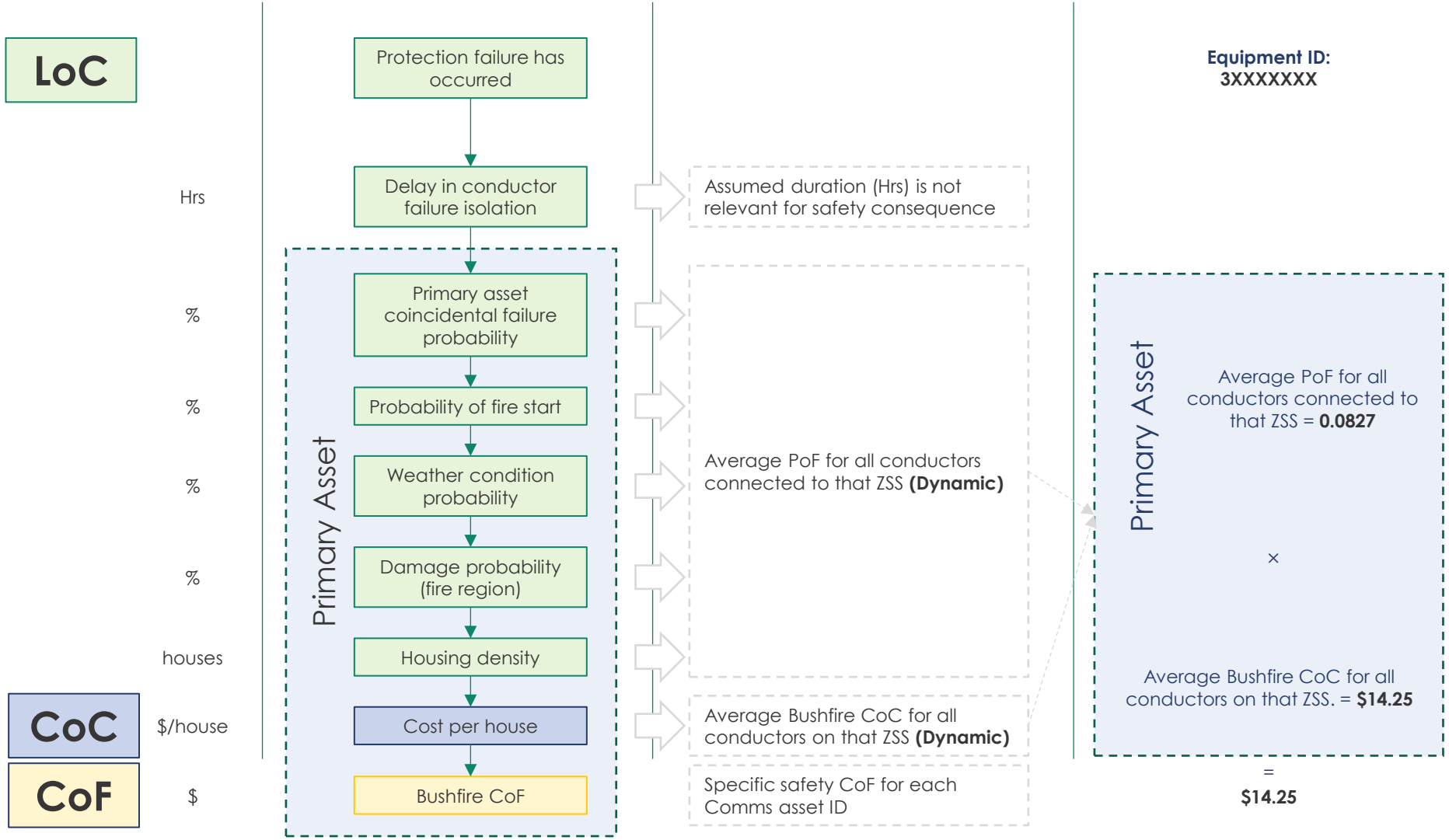
Assumed that all relay assets have one level of redundancy with identical PoF to the main comms unit. It is assumed that this is built into the primary asset CoF already.

Assumed that Bushfire consequence is related to the unprotected bushfire hazard associated with a conductor failure in parallel with a relay failure.

Conductors are considered as the primary asset for coincidental failure with the relay asset.

Coincidental failure probability is based on the product of the primary and secondary asset PoF's

Average values have been used for primary asset CoF and PoF at ZSS level. This approach is adopted due to the complexity of filtering relay data based on function and feeder.



CoF = Average ZSS conductor PoF x Average ZSS conductor bushfire CoC

Protection DC System (Aux Power) - Customer

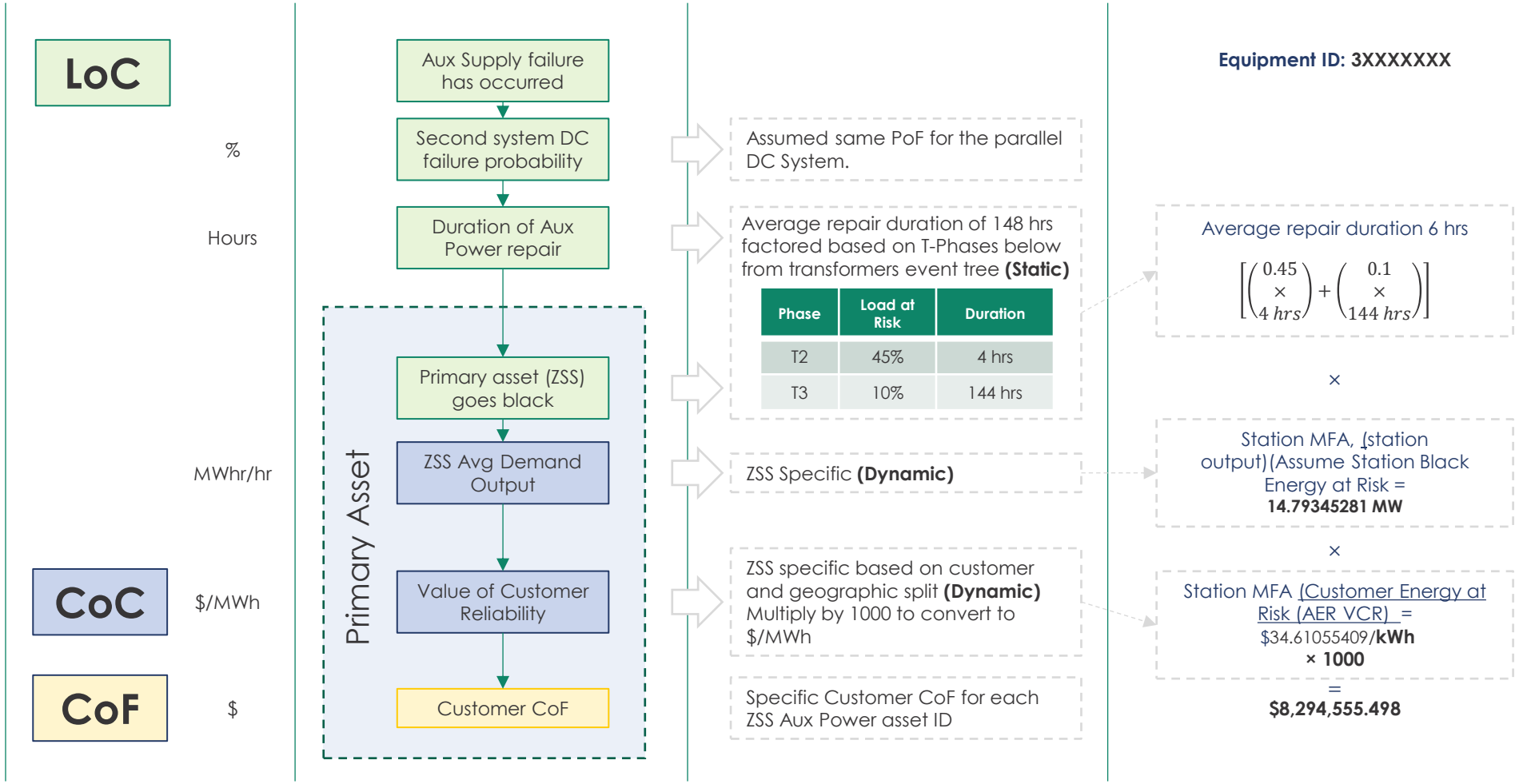
AusNet

Key Concepts

Assumed that the secondary system DC provides one level of redundancy with identical PoF to the main Aux supply.

Assumed that all Aux power assets are supporting the functionality of a ZSS

The failure consequence assumes that the ZSS associated with each Aux power asset will be have a 'station black' event for the period until Aux supply can be repaired.



$$CoF = (T2_{load\ at\ risk} \times T2_{duration} + T3_{load\ at\ risk} \times T3_{duration}) \times ZSS_{Avg\ Demand\ Output} \times VCR \times 1{,}000$$

Additional Information

Key Notes

- **Safety Event Trees**
  - Public Presence – Likelihood multiplier. This multiplier reflects the portion of weekday and weekend hours in during which people are likely to be present. The portions and final multiplier values are in the table below. As an example, a hospital is considered to have people present 24/7, therefore the multiplier is 1.0.

Category	Residential	Education	Commercial	Parkland	Pri Prod	Industrial	Hospital	Transport
Weekday hours	16	8	10	2	5	10	24	12
Weekend hours	24	0	10	2	5	0	24	10
Portion (multiplier)	0.76	0.24	0.42	0.08	0.21	0.30	1.00	0.48

  - Worker Presence. Zone substations are considered to have numerous work visits per year for varying reasons. This means, the frequency and duration of visits vary. Following SME discussions, substations are simplistically assumed to have 6 visits of 2 hrs each, and 2 visit of 30min each. This averages to 8 visits of 1.6 hrs duration each. At 2 staff per visit, this equates to 0.29% exposure per annum.

- **Environment Event Trees**
  - Fatality-related Bushfire Outcomes. For bushfire related fatality outcomes, the DF element is accounted for in the Area Code multipliers, taken from AMS 01-09 Tables 12 and 13.
- **Handling Missing Data**
  - For assets where the Consequence of Failure(CoF) could not be calculated due to missing or invalid data (e.g., missing age), CoF will be calculated using either the mean values of the missing data field or, in some cases, the adjusted mean values. For example, when calculating the age of cables, the data is skewed towards cables aged less than 20 years because these are the only recorded ages we have. Therefore, an adjusted age was created to move the mean of the cable age beyond 20 years. This adjustment will be determined on a case-by-case basis.

Typical Duration of the Three Stages of Outage

		< 66KV			66KV-132KV			220KV-500KV		
		T1 (hrs)	T2 (hrs)	T3 (hrs)	T1 (hrs)	T2 (hrs)	T3 (hrs)	T1 (hrs)	T2 (hrs)	T3 (hrs)
Bare Conductors	Conductor									
	Groundwire									
Insulators	Insulator									
Insulated Cables	Cable									
	Sheath									
Poles	Pole									
Towers	Structure									
X-Arms	Crossarm									
Transformers	Power Transformer									
	Distribution Transformer									
Regulators	Voltage Regulator									
Reactors	Reactor									
Capacitors	Capacitor Bank									

		< 66KV			66KV-132KV			220KV-500KV		
		T1 (hrs)	T2 (hrs)	T3 (hrs)	T1 (hrs)	T2 (hrs)	T3 (hrs)	T1 (hrs)	T2 (hrs)	T3 (hrs)
Circuit Breakers	Circuit Breaker									
Switchboards	Switchboard									
Isolators	Disconnector									
Switches	Automatic Switch									
	Earthing Switch									
	Manual Switch									
Surge Arrestors	Surge Diverter									
BESS	Battery Energy Storage System									
Station Batteries	Battery									
Protection Relays	Protection Relays									
Meters	Meters									
Control Box	Control Box									
Comms Equipment	Comms Equipment									

Location Factors

Group	Location	Score
Road and Rail	Freeway and/or Rail	5
Road and Rail	Highway and/or Rail	5
Road and Rail	Arterial and/or Rail	4
Road and Rail	Sub-arterial and/or Rail	4
Urban score	Residential built-up Easement	3
Urban score	Residential clear Easement	3
Road and Rail	Collector road and/or Rail	2
Urban score	Rural	2
	Other	1

Asset Characteristics - Consequence Modification (1 of 2)

AusNet

			< 66KV					66KV-132KV					220KV-500KV				
	Obj Type	Description	Safety	SF6	Oil	Fire	Waste	Safety	SF6	Oil	Fire	Waste	Safety	SF6	Oil	Fire	Waste
Bare Conductors	CTRABC	Conductor ABC		0	0				0	0				0	0		
	CTRACCR	Conductor ACCR		0	0				0	0				0	0		
	CTRACSR	Conductor ACSR		0	0				0	0				0	0		
	CTRAL	Conductor Aluminium		0	0				0	0				0	0		
	CTRCU	Conductor Copper		0	0				0	0				0	0		
	CTRCVR	Conductor Covered		0	0				0	0				0	0		
	CTRSTEEL	Conductor Steel		0	0				0	0				0	0		
	GWACSR	Groundwire ACSR		0	0				0	0				0	0		
	GWOPGW	Groundwire OPGW		0	0				0	0				0	0		
	GWSTEEL	Groundwire SteeL		0	0				0	0				0	0		
Insulators	INSCYCL	Insulator CycloA															
	INSGLAS	Insulator Glass															
	INSMIXD	Insulator Mixed															
	INSPOLY	Insulator Polymeric															
	INSPORC	Insulator Porcelain															
Insulated Cables	CABLE	Cable															
	CABLEOHSER	Cable OH Service		0	0				0	0				0	0		
	SHTHCU	Sheath Copper		0	0				0	0				0	0		
	SHTHOFC	Sheath OFC		0	0				0	0				0	0		
Poles	POLECOM	Pole Comms		0	0				0	0				0	0		
	POLECONC	Pole Concrete		0	0				0	0				0	0		
	POLEGRC	Pole Glass-Rein Conc		0	0				0	0				0	0		
	POLEGRP	Pole Glass Reinforced Plastic		0	0				0	0				0	0		
	POLELGT	Lighting Pole		0	0			0	0	0	0	0	0	0	0	0	0
	POLESTEEL	Pole Steel		0	0				0	0			0	0	0	0	0
	POLEWD	Pole Wood		0	0				0	0			0	0	0	0	0
Towers	EARTHMAST	Earth Mast		0	0				0	0				0	0		
	RACK	Rack Structure		0	0				0	0				0	0		
	TWRCOM	Tower Communications		0	0				0	0				0	0		
	TWRMCCT	Tower Multi Circuit		0	0				0	0				0	0		
	TWRSCCT	Tower Single Circuit		0	0				0	0				0	0		
X-Arms	XARMGRP	Crossarm Glass Reinforced Plastic		0	0				0	0				0	0		
	XARMSTEEL	Crossarm Steel		0	0				0	0				0	0		
	XARMWOOD	Crossarm Wood		0	0				0	0				0	0		

			< 66KV					66KV-132KV					220KV-500KV				
	Obj Type	Description	Safety	SF6	Oil	Fire	Waste	Safety	SF6	Oil	Fire	Waste	Safety	SF6	Oil	Fire	Waste
Transformers	PT	Power Transformer		0					0					0			
	DT	Dist Transformer		0				0	0	0	0	0	0	0	0	0	0
Regulators	VOLTREG	Voltge Regulator															
Reactors	REACASC	Reac Arc Supp Coil															
	REACCAPBNK	Reac Capacitor Bank															
	REACCAPSER	Reac Capcitr Bnk Ser															
	REACHFILTR	Reac Harmonic Filtr															
	REACLNETRP	Reactor Line Trap															
	REACNEUT	Reactor Neutral															
	REACSHNT	Reactor Shunt															
	REACSVCOMP	Reac Static Var Comp															
	REACSYNCON	Reac Synchro Comp															
Capacitors	CAPBANK	Capacitor Bank															
Circuit Breakers	CBAB	Circ Brkr Air Blast															
	CBBO	Circ Brkr Bulk Oil															
	CBDT	Circ Brkr GasDeadTnk															
	CBGIN	Circ Brkr Gas Ins															
	CBLT	Circ Brkr GasLiveTnk															
	CBMO	Circ Brkr Min Oil															
	CBVU	Circ Brkr Vac															
Switchboards	SWCHBDIND	Indoor Switchboard															
Isolators	DISCGIN	Disconnector Gas Ins															
	ISOL	Isolator															
	ISOLGNGD	Isolator Ganged															
	ISOLROTARY	Isolator Rotary															
	SWCHFLTW	Switch Fault Throw															
	SWCHPPLV	Parallelg Pillar LV															

Asset Characteristics - Consequence Modification (2 of 2)

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			< 66KV					66KV-132KV					220KV-500KV				
	Obj Type	Description	Safety	SF6	Oil	Fire	Waste	Safety	SF6	Oil	Fire	Waste	Safety	SF6	Oil	Fire	
Switches	FUSESAVER	Fusesaver															
	LINCAPSWCH	Line Capacitr Switch															
	RECLGAS	Recloser Gas															
	RECLOIL	Recloser Oil															
	RECLVU	Recloser Vacuum															
	SECLGAS	Sectionaliser Gas															
	SWCHEARTH	Switch Earthing															
	SWEARTHGIN	SW Earthing Gas Ins															
	SWCHABIND	Switch Air Break Ind															
	SWCHABPOLE	Switch Air Break Pol															
	SWCHGASIND	Switch Gas Indoor															
	SWCHGASPOL	Switch Gas Pole															
	SWCHOILIND	Switch Oil Indoor															
Surge Arrestors	SDIV	Surge Diverter															
	SDIVGIN	Surge Div Gas Ins															
BESS	BESS	Batt Energy System		0	0				0	0				0	0		
Station Batteries	BATT	Battery		0	0				0	0				0	0		
Protection Relays				0	0				0	0				0	0		
Meters				0	0				0	0				0	0		
Control Box				0	0				0	0				0	0		
Comms Equipment				0	0				0	0				0	0		

02 Transmission

Coverage (1 of 2)

Event trees have been developed for Customer & Market, Safety, Environmental, and Bushfire consequence categories to provide a structured approach for assessing the likelihood of consequence (LoC). The trees illustrate how a sequences of events interact to determine LoC of an asset class or technical object type.
Development of event trees for Financial consequences is under review.

Asset Classes – Hyperlinked (If Applicable)	LoC				
	Customer & Market	Safety	Environmental	Financial/Collateral	Bushfire
Power Transformers	No Event Tree Refer to AMS 01-09			Under Review	
Circuit Breakers				Under Review	
Bushings	No Event Tree Refer to AMS 01-09	Refer to 'Bushings, CTs, and VTs - Safety' section	Under Review	Under Review	
Current Transformers (CTs)	No Event Tree Refer to AMS 01-09	Refer to 'Bushings, CTs, and VTs - Safety' section	No Event Tree Refer to AMS 01-09	Under Review	
Voltage Transformers (VTs)	No Event Tree Refer to AMS 01-09	Refer to 'Bushings, CTs, and VTs - Safety' section	No Event Tree Refer to AMS 01-09	Under Review	
Disconnectors (Isolators and Earth Switches)	No Event Tree Refer to AMS 01-09			Under Review	
Transmission Line Structures (Towers and T Poles)	No Event Tree Refer to AMS 01-09		Under Review		
Transmission Line Insulators	No Event Tree Refer to AMS 01-09		Under Review		
Transmission Line Conductors & Groundwires	No Event Tree Refer to AMS 01-09	Conductors Groundwires	Under Review		

Legend:

- Not Considered
- Completed

Each event tree is paired with a table, defining likelihood probabilities based on specific asset characteristics such as nominal voltage (kV), capacity, and technical object type.

The probabilities presented in this document are derived from either the DNO CNAIM methodology or have been developed and reviewed internally by AusNet subject matter experts (SMEs). Further clarification please refer to AMS 01-09.

Coverage (2 of 2)

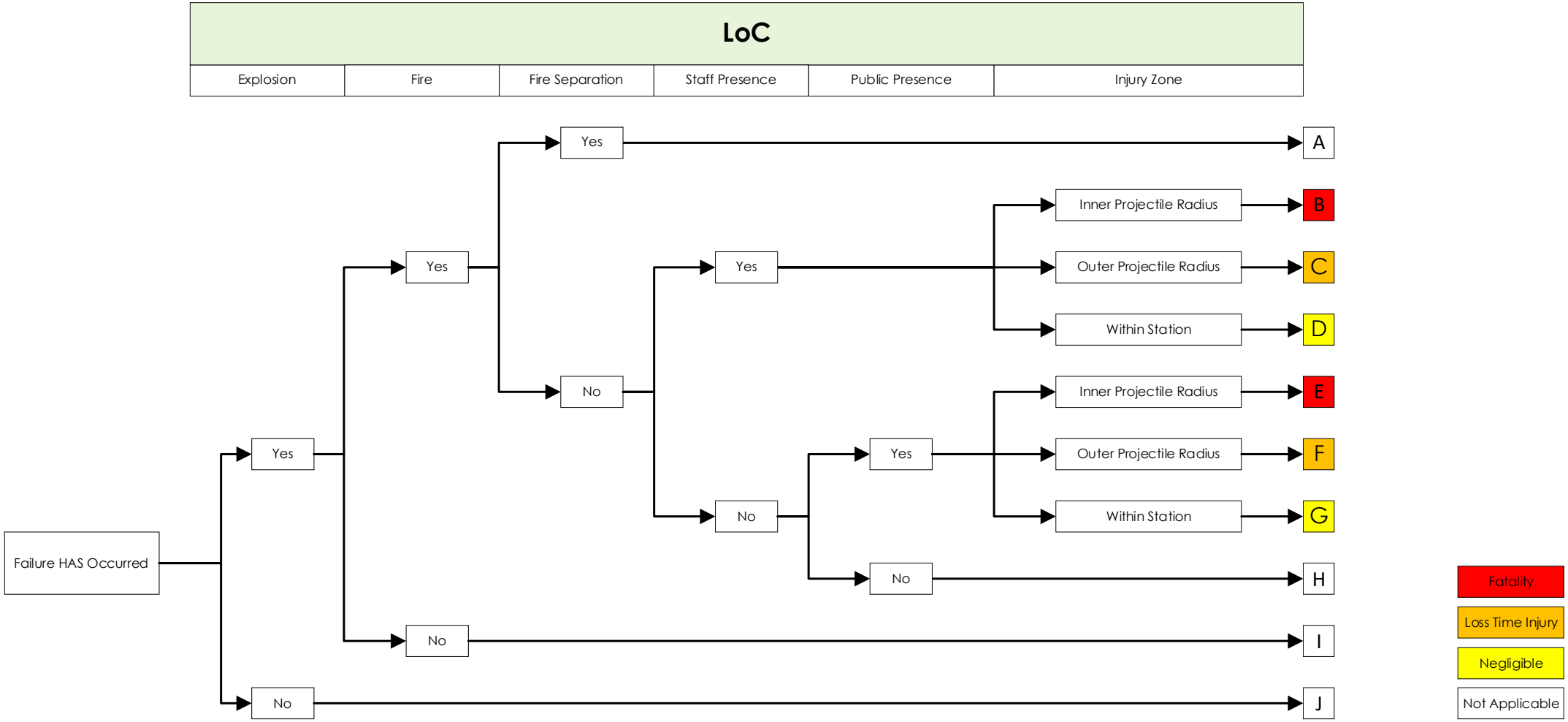
Asset Classes – Hyperlinked (If Applicable)	LoC				
	Customer & Market	Safety	Environmental	Financial/Collateral	Bushfire
Surge Diverters	No Event Tree Refer to AMS 01-09			Under Review	
Civil Infrastructure	No Event Tree Refer to AMS 01-09		Under Review	Under Review	
Communication Systems	No Event Tree Refer to AMS 01-09	Under Review		Under Review	Under Review
Secondary Systems	No Event Tree Refer to AMS 01-09	Under Review		Under Review	Under Review
Auxiliary Power Supplies	No Event Tree Refer to AMS 01-09	Under Review		Under Review	Under Review
Power Cables	Under Review	Under Review		Under Review	

Legend:

- Not Considered
- Completed

Power Transformers

Power Transformers – Safety (1 of 2)



Power Transformers – Safety (2 of 2)

Power Transformer Safety LoC Combination Classifier.

Classifier ID	Asset Type	Nominal Voltage (KV)	Source	Fatality (B,E)	LTI (C,F)
1	Power Transformers	66kV ≤ V < 220kV	DNO	0.003134	0.000416
2		≥ 220kV	DNO	0.003134	0.000416

Power Transformers – Environmental

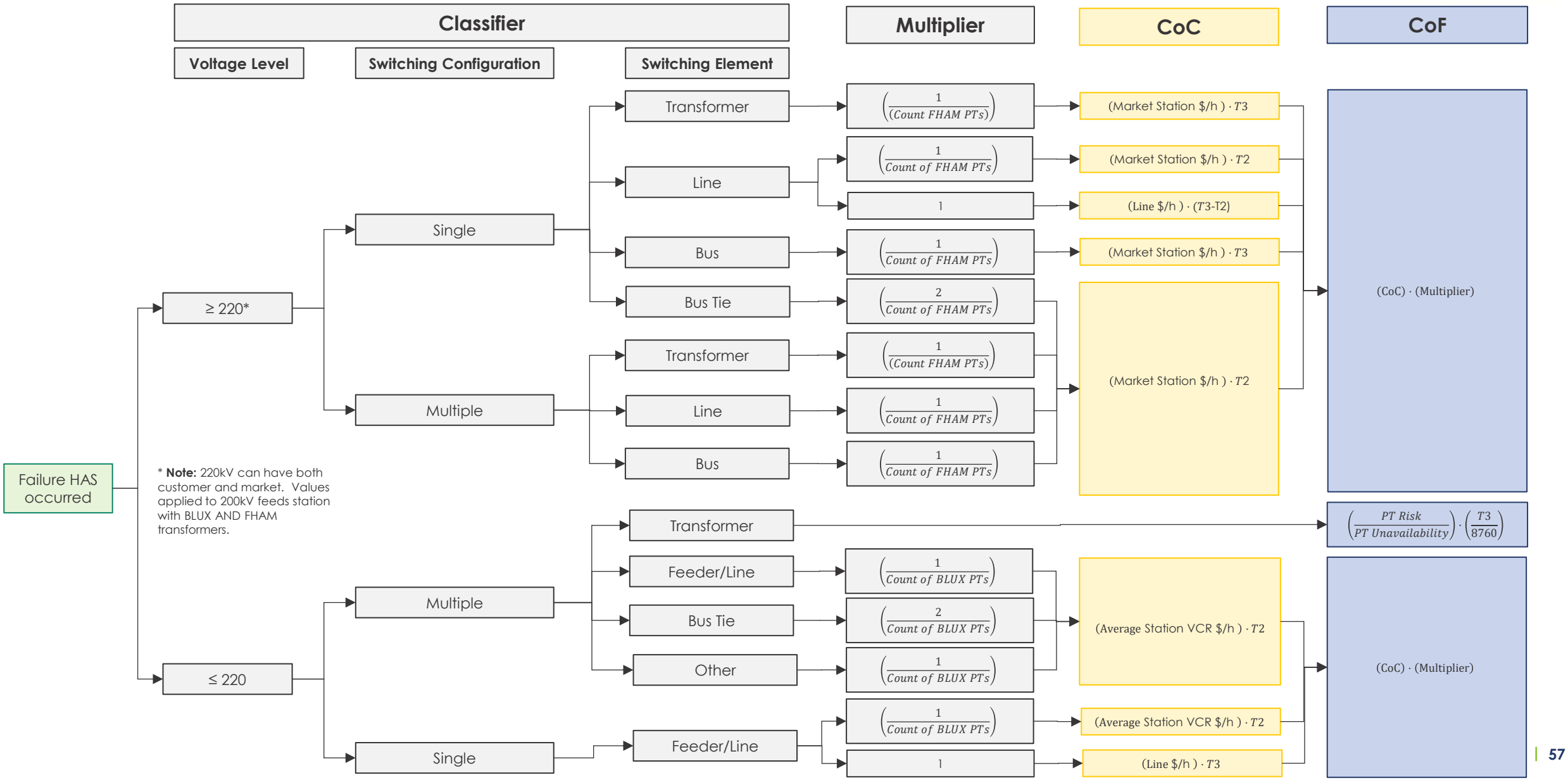
Power Transformer Environmental LoC Combination Classifier

Classifier ID	Asset Type	Nominal Voltage (kV)	Object Type	Oil Containment System	Source	LoC
1	Power Transformer	66kV ≤ , < 220kV	PT	Compliant (C) Bund & Treatment	Internal Review	0.000375
2				(C) Bund only & Part Oil Treat	Internal Review	0.00075
3				Part (C) Bund & Porous Floor	Internal Review	0.00375
4				Part (C) with Trench Through Floor	Internal Review	0.00525
5				No Bunding	Internal Review	0.0075
6		≥ 220kV	PT	Compliant (C) Bund & Treatment	Internal Review	0.0005
7				(C) Bund only & Part Oil Treat	Internal Review	0.001
8				Part (C) Bund & Porous Floor	Internal Review	0.005
9				Part (C) with Trench Through Floor	Internal Review	0.007
10				No Bunding	Internal Review	0.01

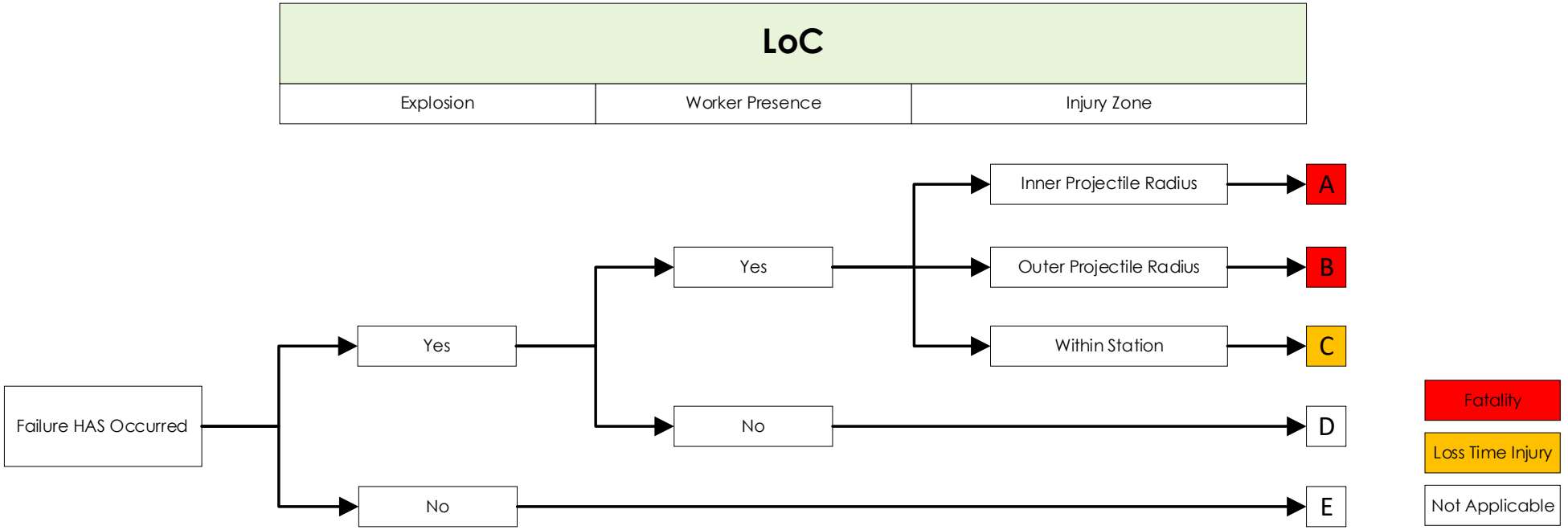
Note: This table provides LoCs for oil spills only.

Circuit Breakers

Circuit Breakers - Customer & Market



Circuit Breakers – Safety (1 of 2)



Circuit Breakers – Safety (2 of 2)

Circuit Breaker Safety LoC Combination Classifier.

Classifier ID	Asset Type	Nominal Voltage (kV)	Object Type	Source	Fatality (A, B)	LTI (C)
1	Circuit Breaker	66kV ≤ , < 220kV	CBBO	DNO	0.003134	0.000416
2			CBDT	DNO	0.003134	0.000416
3			CBGIN	DNO	0.003134	0.000416
4			CBLT	DNO	0.003134	0.000416
5			CBMO	DNO	0.003134	0.000416
6			CBVU	DNO	0.003134	0.000416
7		220kV	CBBO	DNO	0.005722	0.00076
8			CBDT	DNO	0.005722	0.00076
9			CBGIN	DNO	0.005722	0.00076
10			CBLT	DNO	0.005722	0.00076
11			CBMO	DNO	0.005722	0.00076
12			CBVU	DNO	0.005722	0.00076
13		330kV	CBBO	DNO	0.007008	0.00093
14			CBDT	DNO	0.007008	0.00093
15			CBGIN	DNO	0.007008	0.00093
16			CBLT	DNO	0.007008	0.00093
17			CBMO	DNO	0.007008	0.00093
18			CBVU	DNO	0.007008	0.00093
19		500kV	CBBO	DNO	0.008626	0.001145
20			CBDT	DNO	0.008626	0.001145
21			CBGIN	DNO	0.008626	0.001145
22			CBLT	DNO	0.008626	0.001145
23			CBMO	DNO	0.008626	0.001145
24			CBVU	DNO	0.008626	0.001145

Circuit Breakers – Environmental

Circuit Breaker Environmental LoC Combination Classifier.

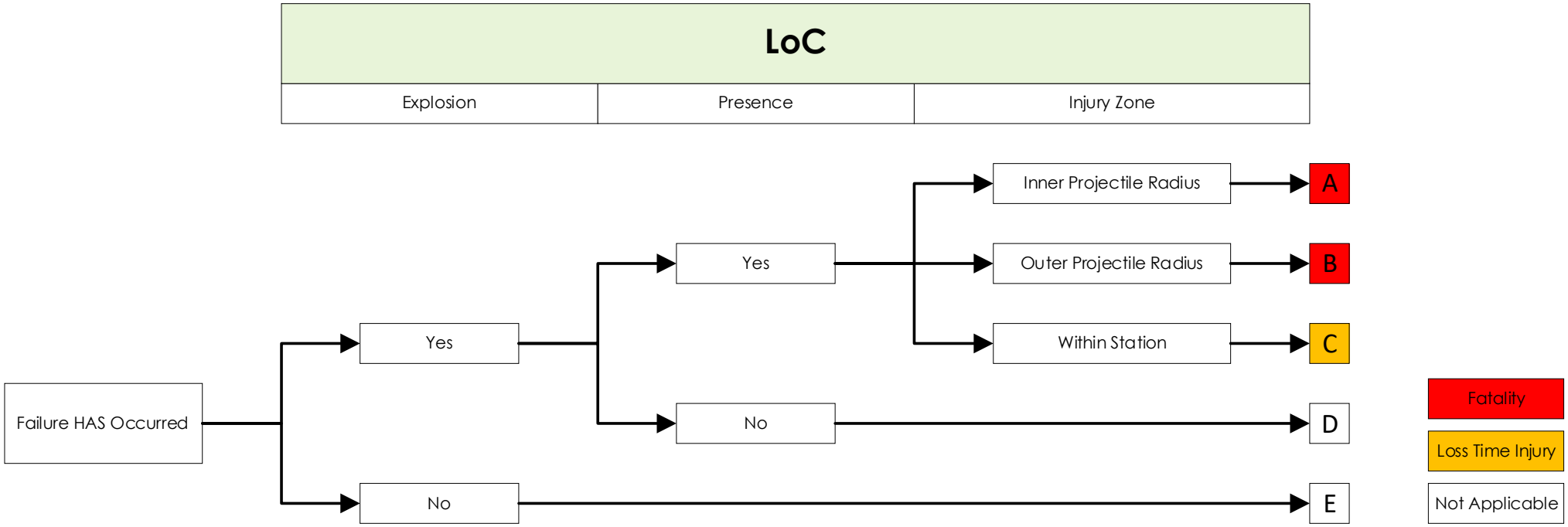
Classifier ID	Asset Type	Nominal Voltage (kV)	Object Type	Construction Type	Source	LoC
1	Circuit Breaker	66kV ≤ , < 220kV	CBBO	Polymeric	Internal Review	0.02
2				Porcelain	Internal Review	0.05
3			CBDT	Polymeric	Internal Review	0.01
4				Porcelain	Internal Review	0.01
5			CBGIN	Polymeric	Internal Review	0.01
6				Porcelain	Internal Review	0.01
7			CBLT	Polymeric	Internal Review	0.01
8				Porcelain	Internal Review	0.01
9			CBMO	Polymeric	Internal Review	0.01
10				Porcelain	Internal Review	0.01
11			CBVU	Polymeric	Internal Review	0.01
12				Porcelain	Internal Review	0.01
13		≥ 220kV	CBBO	Polymeric	Internal Review	0.01
14				Porcelain	Internal Review	0.01
15			CBDT	Polymeric	Internal Review	0.01
16				Porcelain	Internal Review	0.01
17			CBGIN	Polymeric	Internal Review	0.01
18				Porcelain	Internal Review	0.01
19			CBLT	Polymeric	Internal Review	0.01
20				Porcelain	Internal Review	0.01

Classifier ID	Asset Type	Nominal Voltage (kV)	Object Type	Construction Type	Source	LoC
21	Circuit Breaker	≥ 220kV	CBMO	Polymeric	Internal Review	0.02
22				Porcelain	Internal Review	0.02
23			CBVU	Polymeric	Internal Review	0.01
24				Porcelain	Internal Review	0.01

Note: This table provides LoCs for oil spills only.

Bushings, CTs, and VTs

Bushings, CTs, and VTs – Safety (1 of 2)



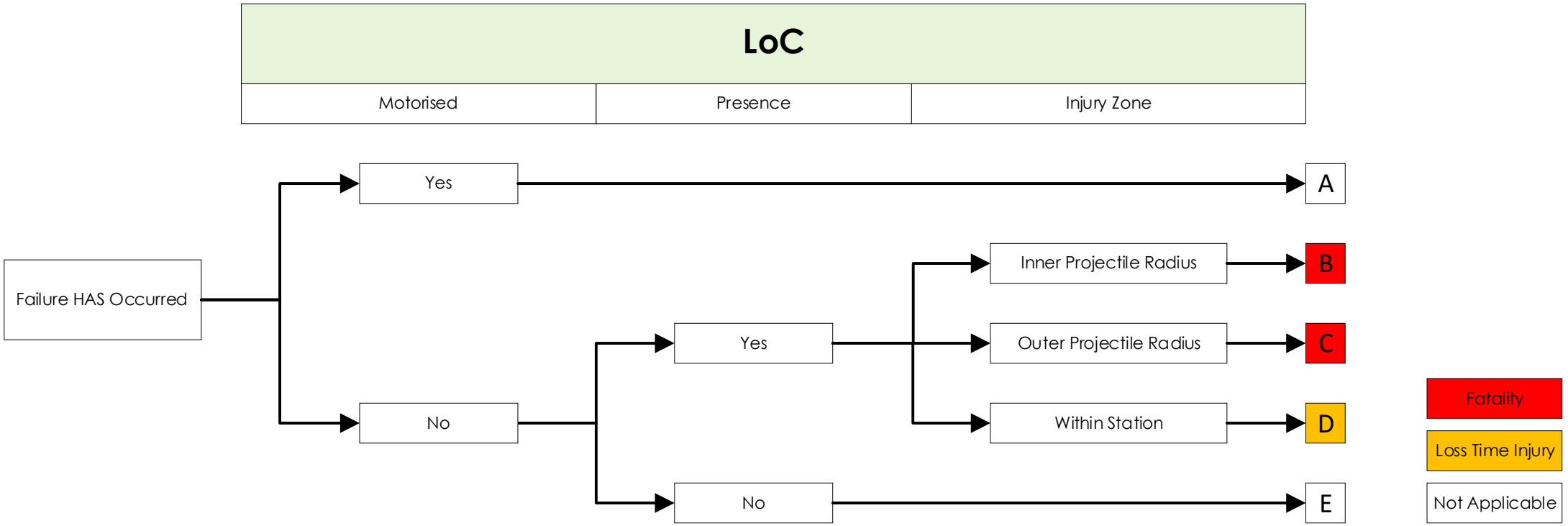
Bushings, CTs, and VTs – Safety (2 of 2)

Combination Classifier by Nominal Voltage and Construction Type for CB Bushings, PT Bushings, CTs, and VTs.

Classifier ID	Asset Type	Nominal Voltage (kV)	Construction Type	Source	Fatality (A, B)	LTI (C)
1	PT Bushing	66kV ≤ , < 220kV	RIP	DNO	0	0
2			OIP	DNO	0.00313	0.00042
3			SRBP	DNO	0.00313	0.00042
4		220kV	RIP	DNO	0	0
5			OIP	DNO	0.00405	0.00054
6			SRBP	DNO	0.00405	0.00054
7		330kV	RIP	DNO	0	0
8			OIP	DNO	0.00496	0.00066
9			SRBP	DNO	0.00496	0.00066
10		500kV	RIP	DNO	0	0
11			OIP	DNO	0.00610	0.00081
12			SRBP	DNO	0.00610	0.00081
13	CB Bushing	66kV ≤ , < 220kV	CBBO	DNO	0.0019	0.00026
14			CBLT	DNO	0.0019	0.00026
15		≥ 220kV	All	DNO	0.00313	0.00042
16			Other	DNO	0.00313	0.00042
17	Current Transformer	66kV ≤ , < 220kV	Hairpin	DNO	0.0019	0.00026
18			Other	DNO	0.0019	0.00026
19		≥ 220kV	Hairpin	DNO	0.00313	0.00042
20			Other	DNO	0.00313	0.00042
21	Voltage Transformer	66kV ≤ , < 220kV	CVT	DNO	0.0019	0.00026
22			MVT	DNO	0.0019	0.00026
23		≥ 220kV				

Disconnectors (Isolators and Earth Switches)

Disconnectors (Isolators and Earth Switches) – Safety (1 of 2)



Disconnectors (Isolators and Earth Switches) – Safety (2 of 2)

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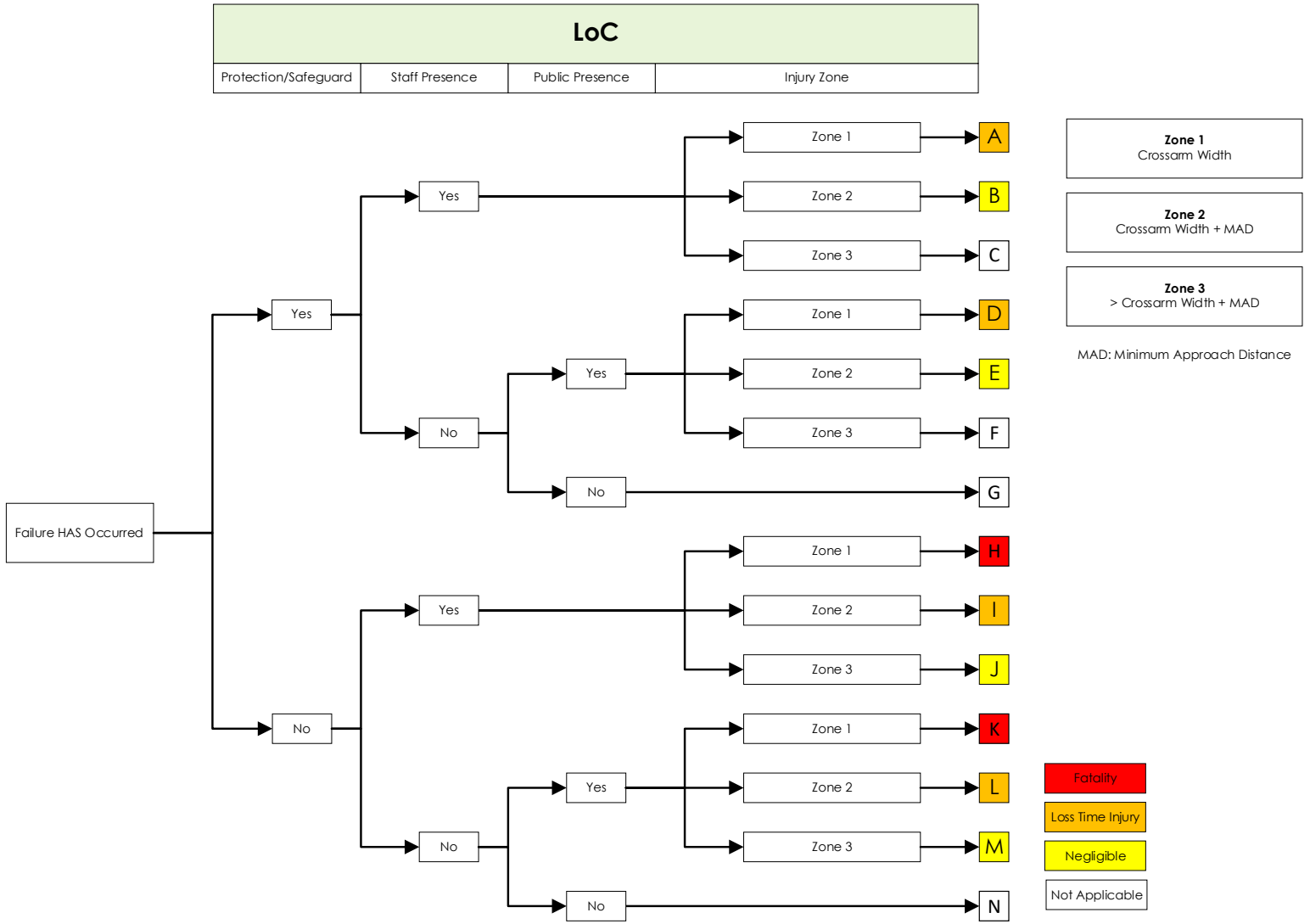
Disconnector Safety LoC Combination Classifier

Classifier ID	Asset Type	Nominal Voltage (V)	Object Type	Source	Fatality (B, C)	LTI (D)
1	Disconnectors	66kV ≤ V < 220kV	DISCGIN	DNO	0.00589	0.000713
2			ISOLGNGD	DNO	0.00589	0.000713
3			SWCHEARTH	DNO	0.00589	0.000713
4			SWEARTHGIN	DNO	0.00589	0.000713
5			ISOLROTARY	DNO	0.00589	0.000713
6			ISOL	DNO	0.00190	0.000260
7		≥ 220kV	DISCGIN	DNO	0.00589	0.000713
8			ISOLGNGD	DNO	0.00589	0.000713
9			SWCHEARTH	DNO	0.00589	0.000713
10			SWEARTHGIN	DNO	0.00589	0.000713
11			ISOLROTARY	DNO	0.00589	0.000713
12			ISOL	DNO	0.00190	0.000260

Transmission Line Structures (Towers and T-Poles)

Transmission Line Structures (Towers and T-Poles) – Safety (1 of 2)



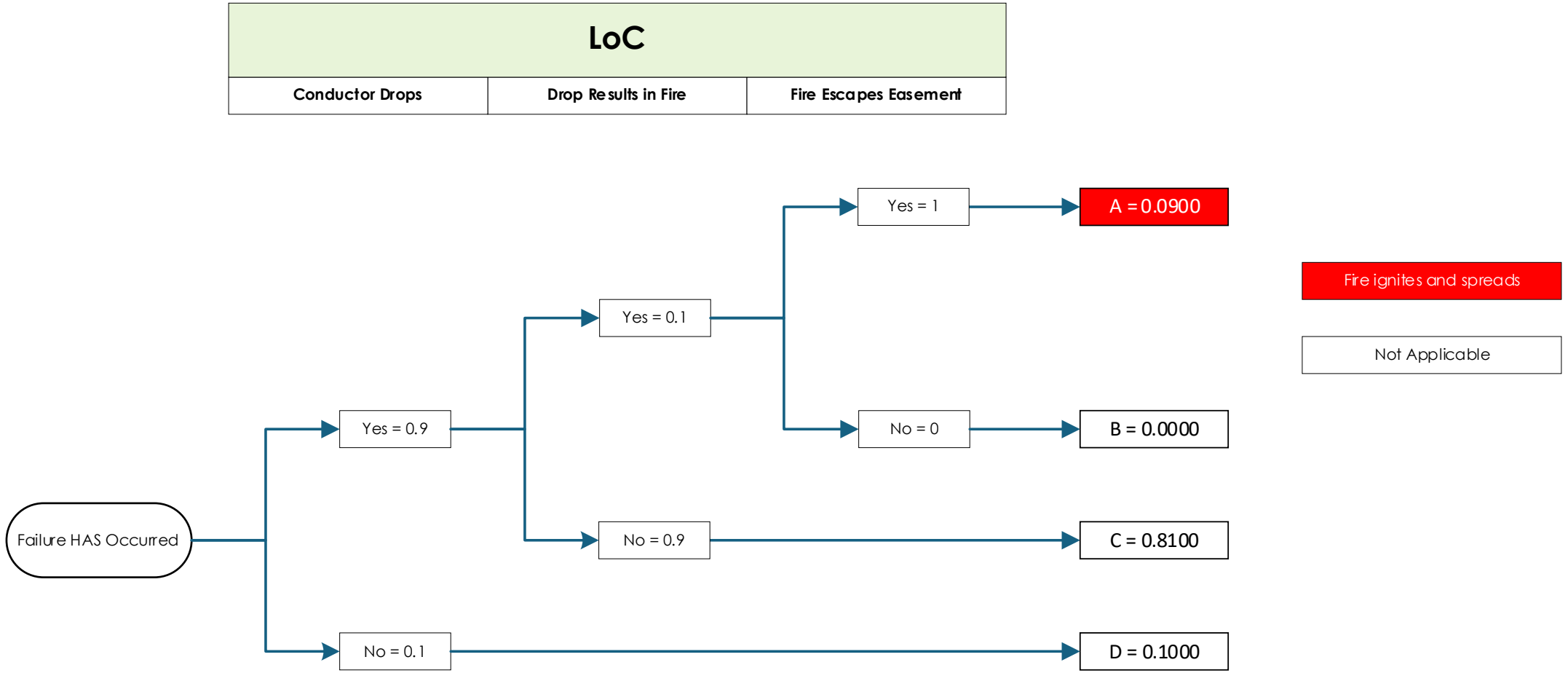
Transmission Line Structures (Towers and T-Poles) – Safety (2 of 2)

AusNet

Structures Safety LoC Combination Classifier.

			Source	LTI (A, I)	Staff Fatality (H)	Public Fatality (K)	
						V/Multi	Single/Twin
Urban Score	0	Rural area	DNO	0.0001360	0.0000272		
	1	Residential area with clear easement	DNO	0.0001360	0.0000272		
	2	Residential area with built up easement	DNO	0.0001360	0.0000272		
	0	Rural area	Internal Review			0.0000750	0.0000750
	1	Residential area with clear easement	Internal Review			0.0075000	0.0075000
	2	Residential area with built up easement	Internal Review			0.0150000	0.0150000
Road Crossing Code	0	No Road Crossing	Internal Review			0.0001034	0.0001034
	1	Collector	Internal Review			0.0148392	0.0148392
	2	Sub-Arterial	Internal Review			0.0844415	0.0844415
	3	Arterial	Internal Review			0.1614056	0.1614056
	4	Highway	Internal Review			0.1202589	0.1202589
	5	Freeway	Internal Review			0.2654290	0.2654290

Transmission Line Towers – Bushfire



Transmission Line Towers – Collateral Damage

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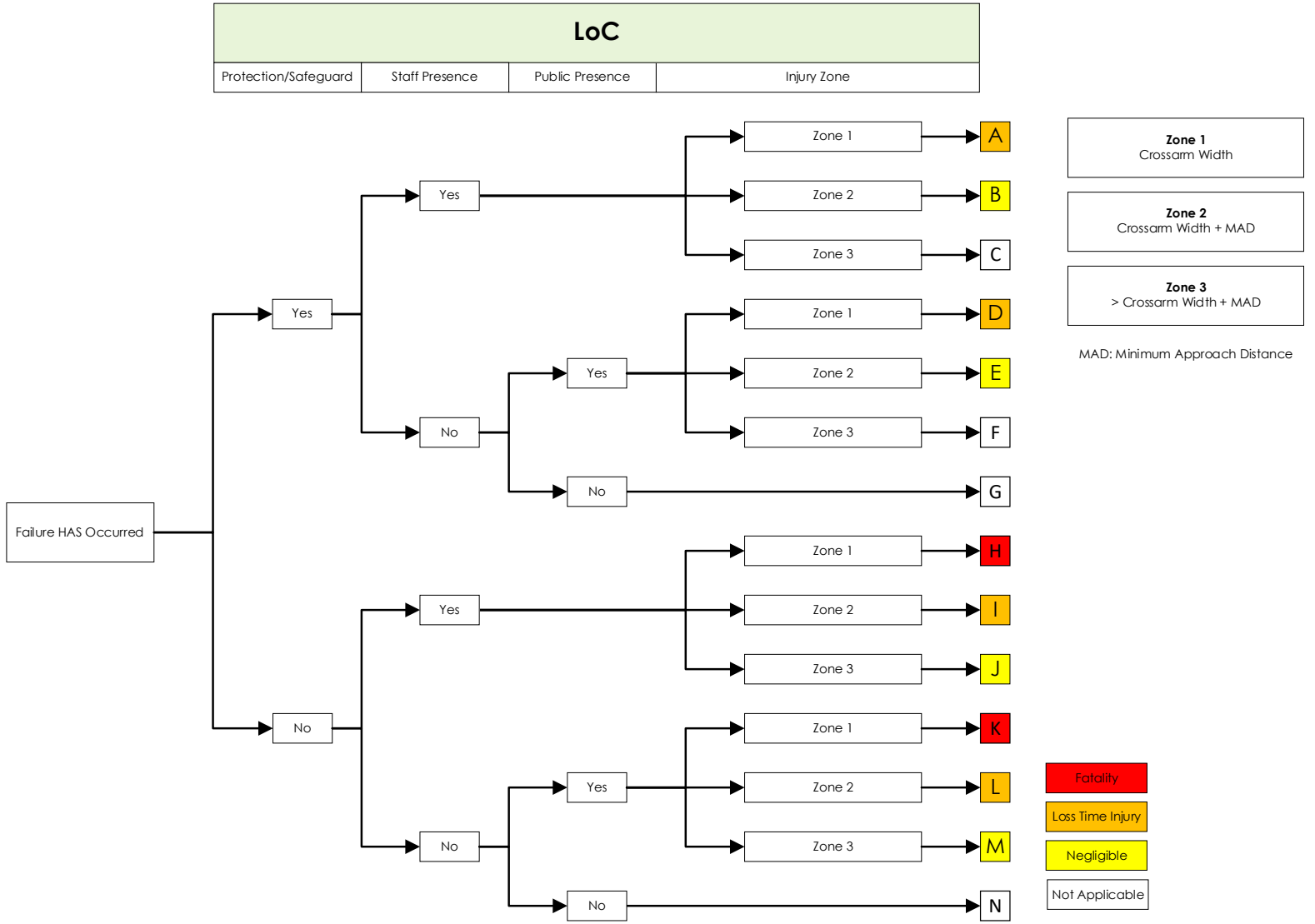
Towers Collateral Damage LoC

			Source	LoC
House Damage	0	Rural area	Internal Review	0.00
	1	Residential area with clear easement	Internal Review	0.00
	2	Residential area with built up easement	Internal Review	0.80
Property Disturbance	0	Rural area	Internal Review	1.00
	1	Residential area with clear easement	Internal Review	0.80
	2	Residential area with built up easement	Internal Review	1.00

Transmission Line Insulators

Transmission Line Insulators – Safety (1 of 2)



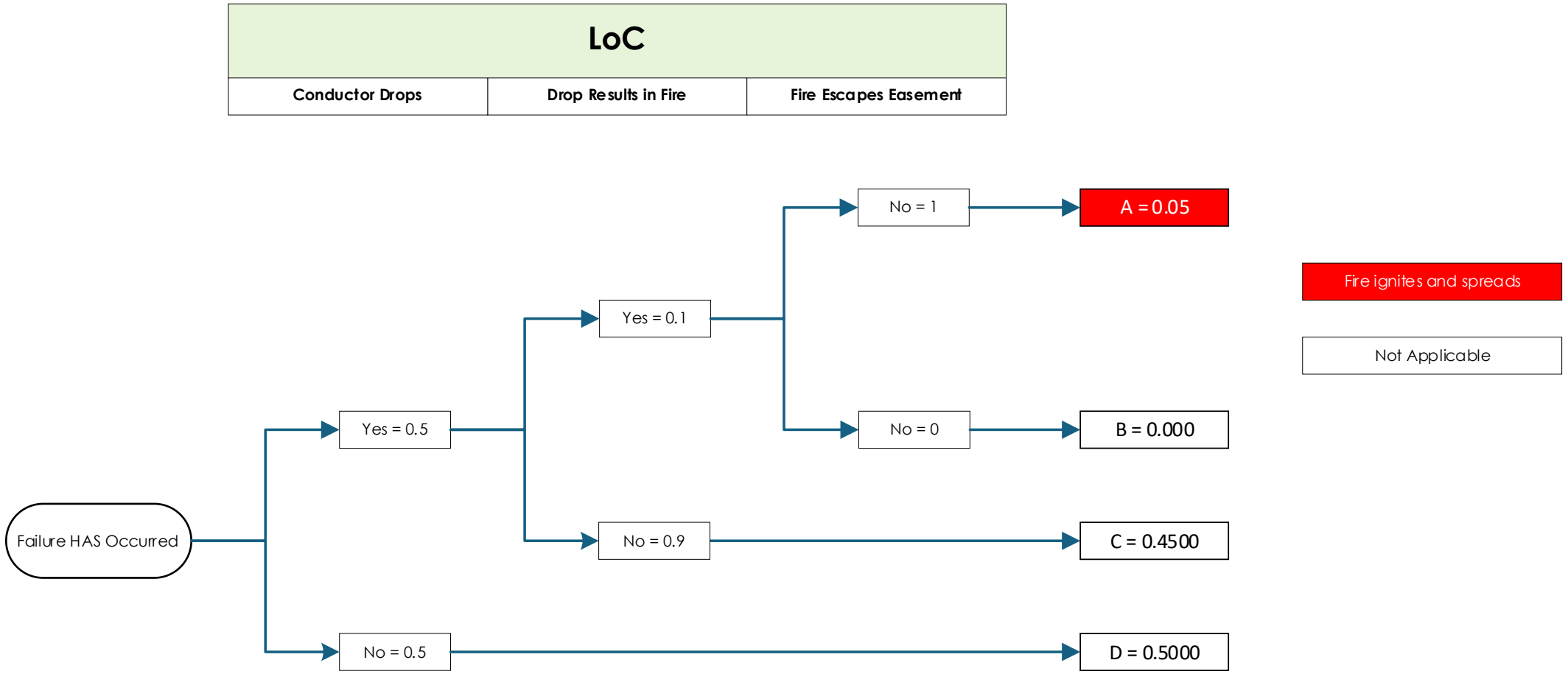
Transmission Line Insulators – Safety (2 of 2)

AusNet

Line Insulators Safety LoC Combination Classifier

			Source	LTI (A, I)	Staff Fatality (H)	Public Fatality (K)	
						V/Multi	Single/Twin
Urban Score	0	Rural area	DNO	0.0001360	0.0000272		
	1	Residential area with clear easement	DNO	0.0001360	0.0000272		
	2	Residential area with built up easement	DNO	0.0001360	0.0000272		
	0	Rural area	Internal Review			0.0000800	0.0000800
	1	Residential area with clear easement	Internal Review			0.0037500	0.0037500
	2	Residential area with built up easement	Internal Review			0.0075000	0.0075000
Road Crossing Code	0	No Road Crossing	Internal Review			0.0000207	0.0001034
	1	Collector	Internal Review			0.0029678	0.0148392
	2	Sub-Arterial	Internal Review			0.0168883	0.0844415
	3	Arterial	Internal Review			0.0322811	0.1614056
	4	Highway	Internal Review			0.0240518	0.1202589
	5	Freeway	Internal Review			0.0530858	0.2654290

Transmission Line Insulators – Bushfire



Transmission Line Insulators – Collateral Damage

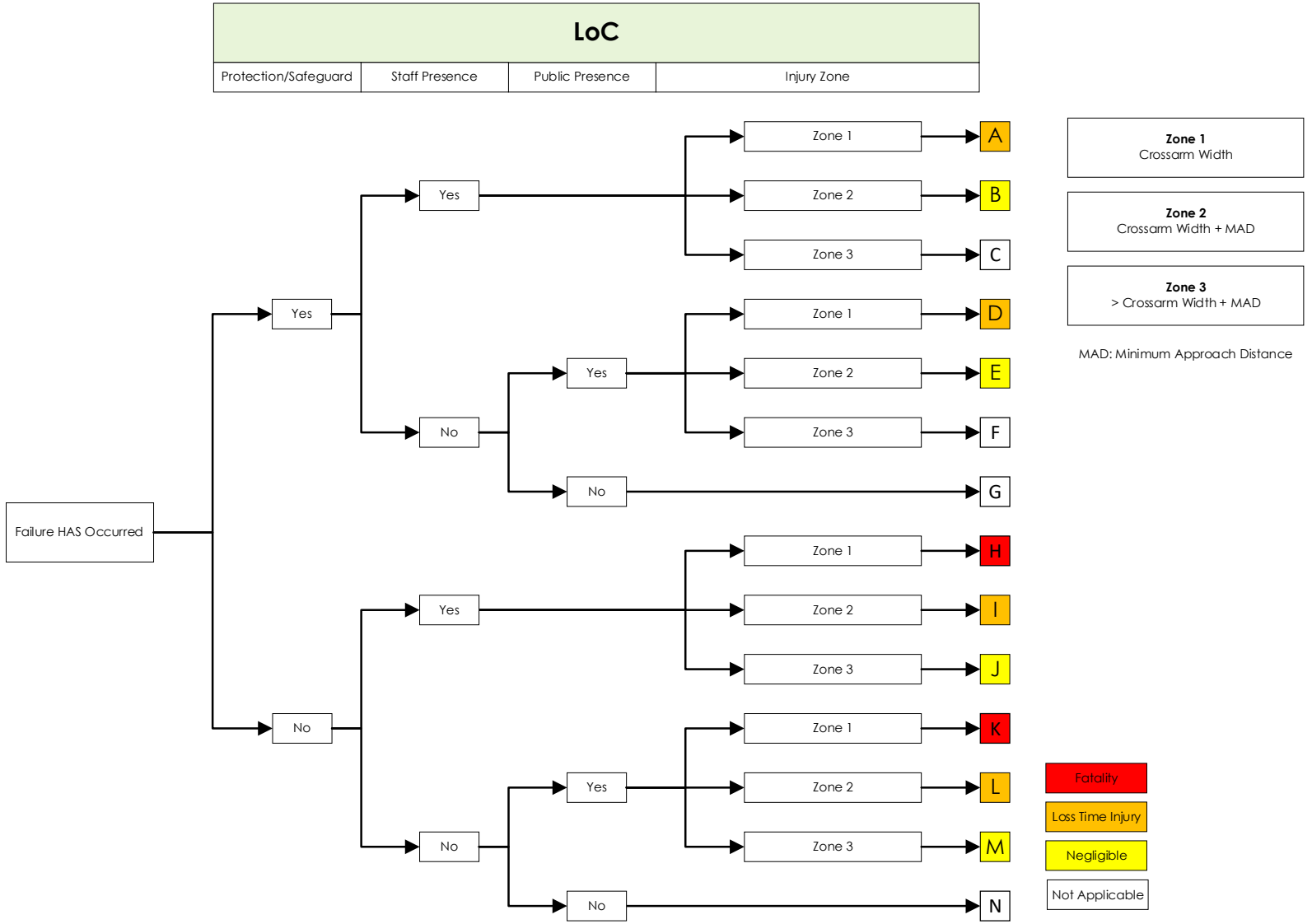
AusNet

Insulators Collateral Damage LoC

			Source	LoC
House Damage	0	Rural area	Internal Review	0.00
	1	Residential area with clear easement	Internal Review	0.00
	2	Residential area with built up easement	Internal Review	0.50
Property Disturbance	0	Rural area	Internal Review	0.50
	1	Residential area with clear easement	Internal Review	0.75
	2	Residential area with built up easement	Internal Review	1.00

Transmission Line Conductors & Groundwires

Transmission Line Conductors and Ground wires – Safety (1 of 3)



Transmission Line Conductors – Safety (2 of 3)

AusNet

Conductors Safety LoC Combination Classifier

			Source	LTI (A, I)	Staff Fatality (H)	Public Fatality (K)	
						V/Multi	Single/Twin
Urban Score	0	Rural area	DNO	0.0001360	0.0000272		
	1	Residential area with clear easement	DNO	0.0001360	0.0000272		
	2	Residential area with built up easement	DNO	0.0001360	0.0000272		
	0	Rural area	Internal Review			0.0000800	0.0000800
	1	Residential area with clear easement	Internal Review			0.0037500	0.0037500
	2	Residential area with built up easement	Internal Review			0.0075000	0.0075000
Road Crossing Code	0	No Road Crossing	Internal Review			0.0001034	0.0001034
	1	Collector	Internal Review			0.0148392	0.0148392
	2	Sub-Arterial	Internal Review			0.0844415	0.0844415
	3	Arterial	Internal Review			0.1614056	0.1614056
	4	Highway	Internal Review			0.1202589	0.1202589
	5	Freeway	Internal Review			0.2654290	0.2654290

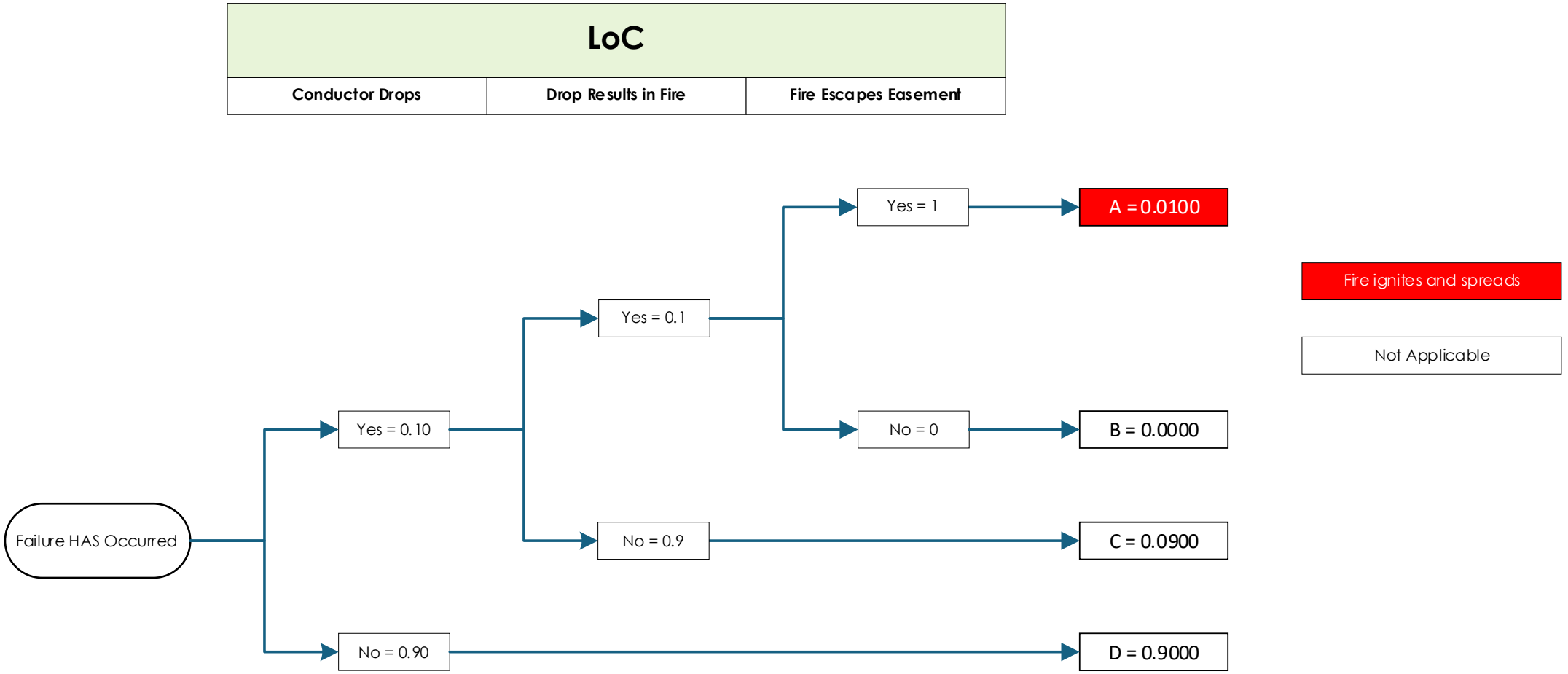
Transmission Line Ground wires – Safety (3 of 3)

AusNet

Groundwires Safety LoC Combination Classifier

			Source	LTI (A, I)	Staff Fatality (H)	Public Fatality (K)	
						V/Multi	Single/Twin
Urban Score	0	Rural area	DNO	0.0001360	0.0000272		
	1	Residential area with clear easement	DNO	0.0001360	0.0000272		
	2	Residential area with built up easement	DNO	0.0001360	0.0000272		
	0	Rural area	Internal Review			0.0000075	0.0000075
	1	Residential area with clear easement	Internal Review			0.0004000	0.0004000
	2	Residential area with built up easement	Internal Review			0.0045000	0.0045000
Road Crossing Code	0	No Road Crossing	Internal Review			0.0001034	0.0001034
	1	Collector	Internal Review			0.0148392	0.0148392
	2	Sub-Arterial	Internal Review			0.0844415	0.0844415
	3	Arterial	Internal Review			0.1614056	0.1614056
	4	Highway	Internal Review			0.1202589	0.1202589
	5	Freeway	Internal Review			0.2654290	0.2654290

Transmission Line Conductors – Bushfire



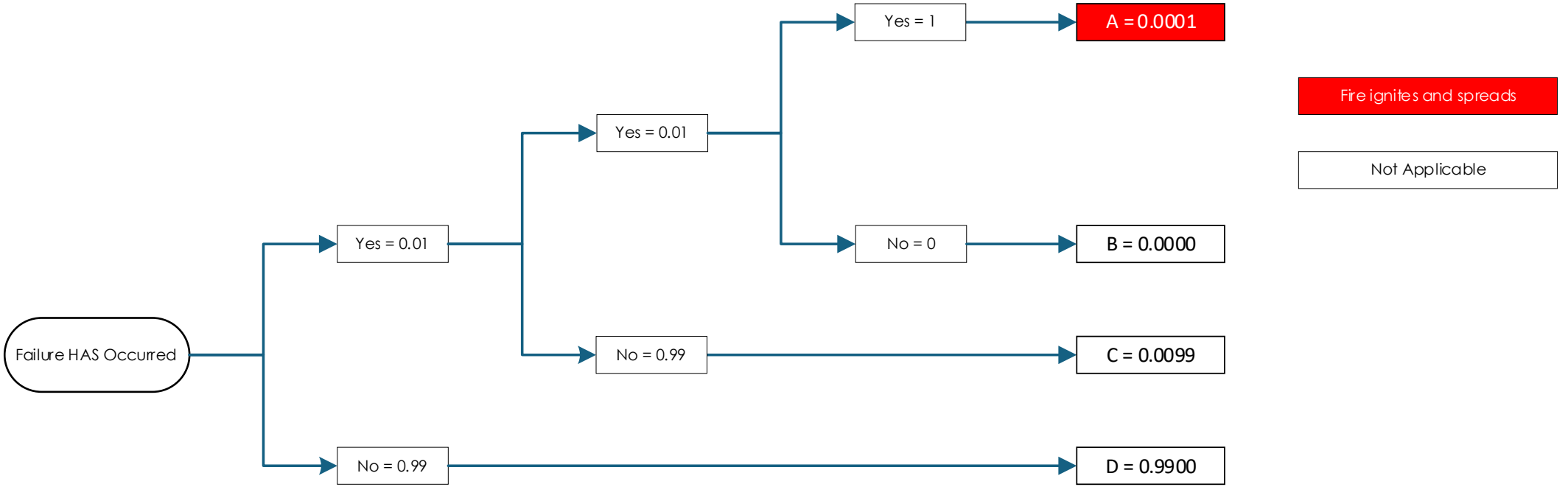
Transmission Line Conductors – Collateral Damage

Conductors Collateral Damage LoC

			Source	LoC
House Damage	0	Rural area	Internal Review	0.00
	1	Residential area with clear easement	Internal Review	0.00
	2	Residential area with built up easement	Internal Review	0.50
Property Disturbance	0	Rural area	Internal Review	0.50
	1	Residential area with clear easement	Internal Review	0.75
	2	Residential area with built up easement	Internal Review	1.00

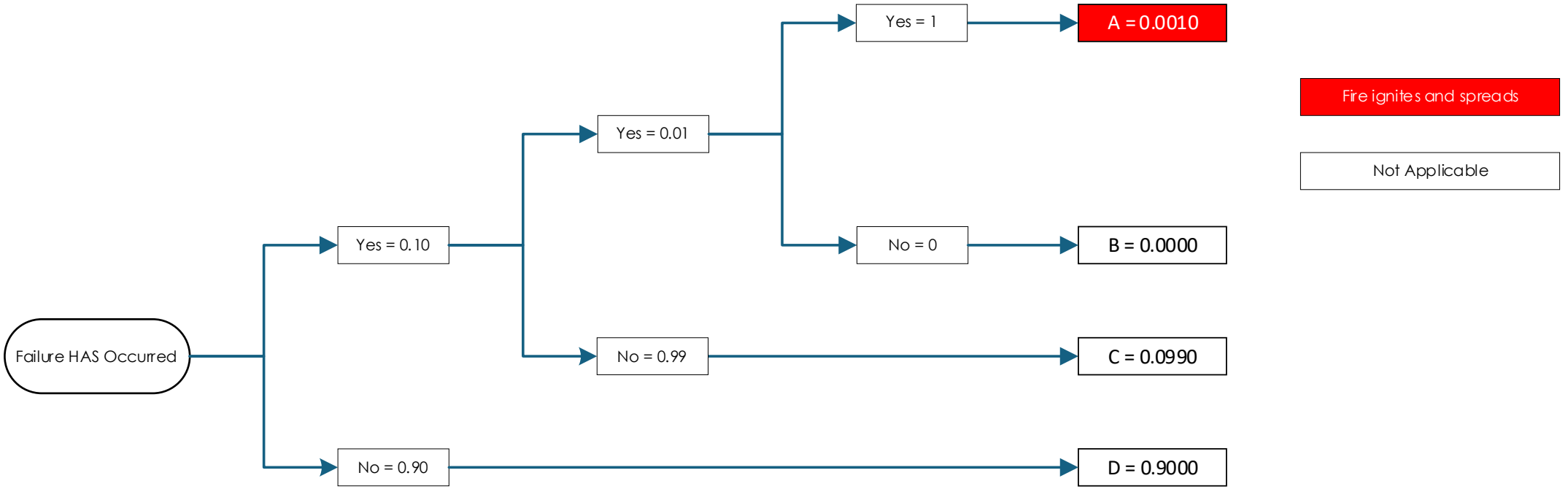
Transmission Line Ground wires – Condition Based Failure Bushfire

LoC		
Earthwire Drops	Drop Results in Fire	Fire Escapes Easement



Transmission Line Ground wires – Rating Based Failure Bushfire

LoC		
Earthwire Drops	Drop Results in Fire	Fire Escapes Easement



Transmission Line Ground wires – Collateral Damage

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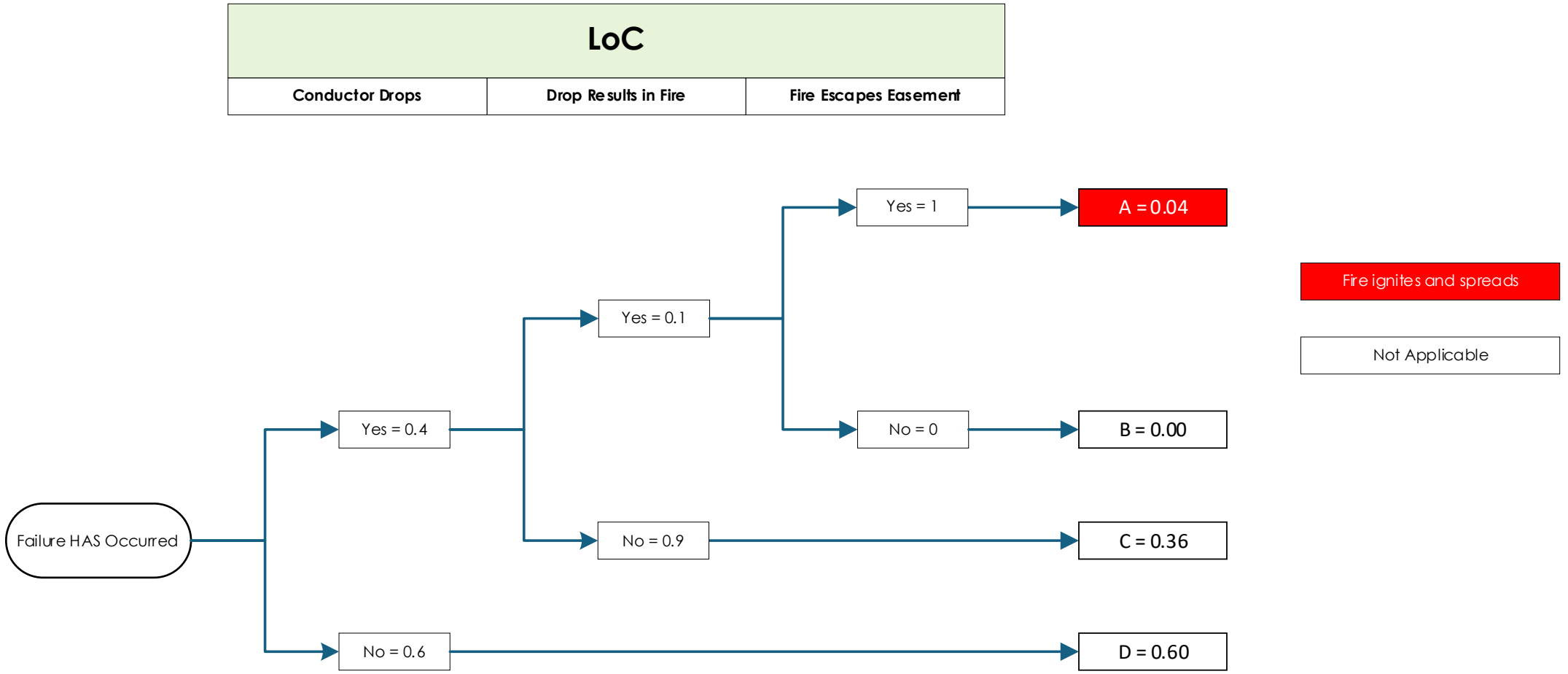
Ground-wires Collateral Damage LoC

			Source	LoC
House Damage	0	Rural area	Internal Review	0.00
	1	Residential area with clear easement	Internal Review	0.00
	2	Residential area with built up easement	Internal Review	0.25
Property Disturbance	0	Rural area	Internal Review	0.25
	1	Residential area with clear easement	Internal Review	0.37
	2	Residential area with built up easement	Internal Review	0.50

Transmission Line Conductors – Low Span Vehicle to Ground Arc



Surge Diverters

Surge Diverters - Safety

Surge Diverters Safety LoC Combination Classifier

Classifier ID	Asset Type	Nominal Voltage (kV)	Source	LoC
1	Surge Diverters	66kV	Internal Review	0.000466
2		≥ 220kV	Internal Review	0.00071

Civil Infrastructure

Civil Infrastructure – Safety

Civil Infrastructure Safety LoC Combination Classifier.

Classifier ID	Asset Type	Source	Probability of Fatality	Probability of Injury
1	Fire	Internal Review	0.0100	0.5000
2	Building	Internal Review	0.0050	0.4000
3	SSC	Internal Review	0.0060	0.4500
4	Roads	Internal Review	0.0040	0.5000
5	Switchyards	Internal Review	0.0040	0.5000

AusNet

Thank You

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