TOPFIELD CONSULTANCY LTD			
Calculation Title	**TECHNICAL NOTE _TN032 FMEA & FMECA CALCULATION**		
TN Number	TN032		
Project Number	TOPFIELD/P004	**Superseded by Calc.**	N/A
Calculation Number	032	**Revision**	A
Engineer	M. Harris	**Date**	6.7.19
Checker	-	**Date**	

Objective

This technical note (TN) illustrates the equations used for the FMEA & FMECA failure calculations based on the standard approach.

Section 1 describes the FMECA calculation methods and section 2 provides FMECA case examples. A typical FMECA flow diagram is also shown at the end of this section. Section 3 presents the calculation sections required to develop the new FMECA template from the existing FMEA.

The following 2 Cases have been considered in the TN for the FMECA Calculation methods:

- Case 1 – Failure Mode Criticality for a Carbon Film Resistor component
- Case 2 – Failure Item Criticality for a Carbon Film Resistor component

Assumptions

1). Failure data has been presented per hour or a per year basis.

2). All failure modes will be derived from FMD-91 data source [1].

3). Only the most likely failure modes will be considered for the cases as the least likely may increase costs and impact schedule without having a significant impact on the overall results.

Terms / Abbreviations Used

Abbrev	Term (unit)	Note
n	Number of failure modes for a component for a specific severity classification. Note J is the total number of failure modes for a component for a specific severity classification.	-

Abbrev	Term (unit)	Note
β	Failure effect probability	-
α	Failure mode ratio or modal failure mode	
λ	Part failure rate	Failures per million hours, failures per yr, failures per hr
t	Duration of the operation	Hrs, no of cycles

1). FMECA CALCULATION EXAMPLES

There are two methods of calculation:

- Failure Mode Criticality (C_m) method, and
- Failure Item Criticality (C_r) method

EQUATIONS

3.1). Calc1: Eqn1 – Failure Mode Criticality (C_m) Method1 :

$$C_m = \beta\alpha\lambda_p t$$

where:

C_m = Criticality number for each failure mode

β = Conditional probability of failure effect

α = Failure mode ratio

λ_p = Part failure rate

t = Duration of applicable mission phase usually expressed in hours or number of operating cycles.

This method expresses criticality in terms of modal node.

3.1). Calc1: Eqn2 – Failure Item Criticality Method2:

$$C_r = \sum_{n=1}^{j} (\beta\alpha\lambda_p t)_n \qquad n = 1,2,3,\ldots j \qquad \text{or} \qquad C_r = \sum_{n=1}^{j} (C_m)_n$$

where:

- C_r = Criticality number for the item being analyzed
- n = The current failure mode of the item being analyzed for a particular severity classification
- j = The number of failure modes for the item being analyzed for a particular severity classification
- C_m = Criticality number for a particular failure mode
- β = Probability of occurrence of the resulting failure effect
- α = Failure mode ratio
- λ_p = Part failure rate
- t = Duration of applicable mission phase usually expressed in hours or number of operating cycles.

Note:

Care to be taken using this method as single point failures of items can be improperly ranked

TABLE 1: TYPICAL FAILURE EFFECT PROBABILITIES (β)

FAILURE EFFECT	β VALUE
Actual Loss	1.00
Probable Loss	> 0.10 to < 1.00
Possible Loss	> 0 to 0.10
No Effect	0

Table1: Test Data for Methods 1, 2.

Term	Value	Description	Unit
n	1 … j	Number of failure modes for a component for a specific severity classification. Note J is the total number of failure modes for a component for a specific severity classification.	-

Term	Value	Description	Unit
β	1.00	Failure effect probability	-
α		Failure mode ratio or modal failure mode	
λ		Part failure rate	Failures per million hours, failures per yr, failures per hr
t		Duration of the operation	Hrs, no of cycles

CRITICALITY MATRIX

The following criticality matrix provides a means for identifying and comparing failure modes for all components within a given system or subsystem in terms of severity. Severity is classified n four categories in the table below with Level 1 being the most severe (catastrophic) and Level 4 being the least severe (minor) as follows:

DESCRIPTION	CATEGORY	MISHAP DEFINITION
Catastrophic	I	Death or system loss.
Critical	II	Severe injury, severe occupational illness, or major system damage.
Marginal	III	Minor injury, minor occupational illness, or minor system damage.
Minor	IV	Less than minor injury, occupational illness, or minor system damage.

2). FMECA CASE EXAMPLES

2.1). Case Example 1 using Calc1: Eqn1 – Failure Mode Criticality (Method1) :

Failure Mode Criticality:

Component type: Carbon Film Resistor

Part Number: R14

Failure Rate (λ_p): .25673 failures per million hours

Failure Effect Probability (α): Open (.75)
Short (.25)

Time (t): 1 hour

Failure Mode Probability (β): 1

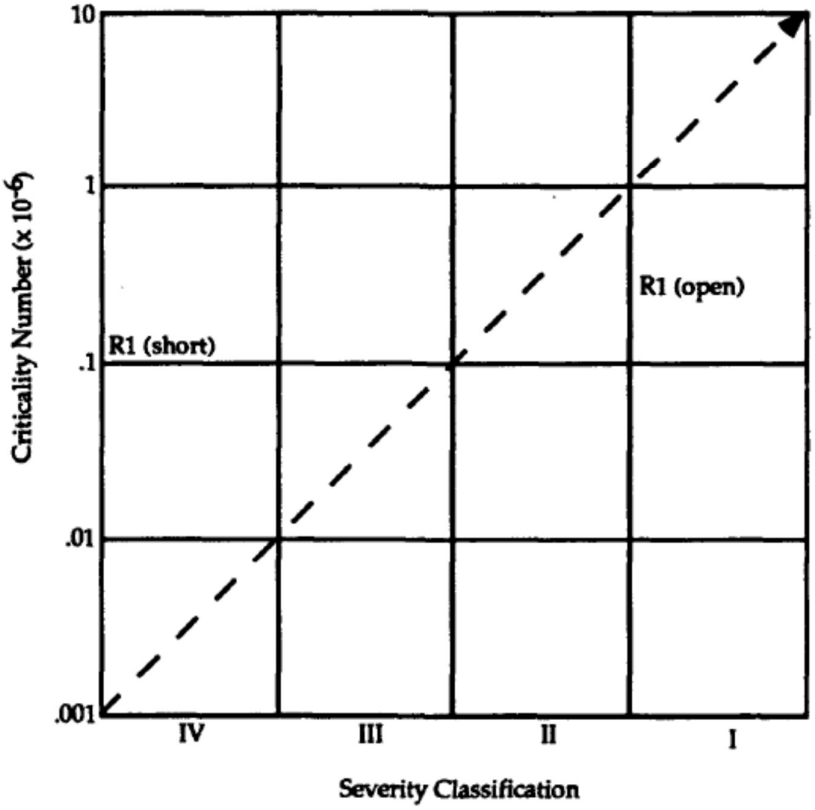
Failure Mode Criticality (C_m):

$$C_m = \beta \alpha \lambda_p t$$

$$C_m \text{ (open)} = (1 \times .75 \times .25673 \times 1)$$
$$C_m \text{ (open)} = .192548 \times 10^{-6}$$

$$C_m \text{ (short)} = (1 \times .25 \times .25673 \times 1)$$
$$C_m \text{ (short)} = .064183$$

- assume a "open" failure mode could cause a catastrophic effect
- assume a "short" failure mode could cause a minor effect



2.2). Case Example 2 using Calc1: Eqn2 – Item Criticality Number (Method2):

Item Criticality:

Component type: Carbon Film Resistor

Part Number: R14

Failure Rate (λ_p): .25673 failures per million hours

Failure Effect Probability (α): Open (.75)
Short (.25)

Time (t): 1 hour

Failure Mode Probability (β): 1

Item Criticality (Cr):

$$C_r = \sum_{n=1}^{j} (\beta\, \alpha\, \lambda_p\, t)_n \quad N = 1, 2, 3, \ldots j \text{ or } C_r = \sum_{n=1}^{j} (C_m)\, n$$

$$C_r = (1 \times .75 \times .25673 \times 1) + (1 \times .25 \times .25673 \times 1)$$

$$C_r = .25673$$

FMECA FLOWCHART

The figure below indicates the FMECA process used to estimate component failures:

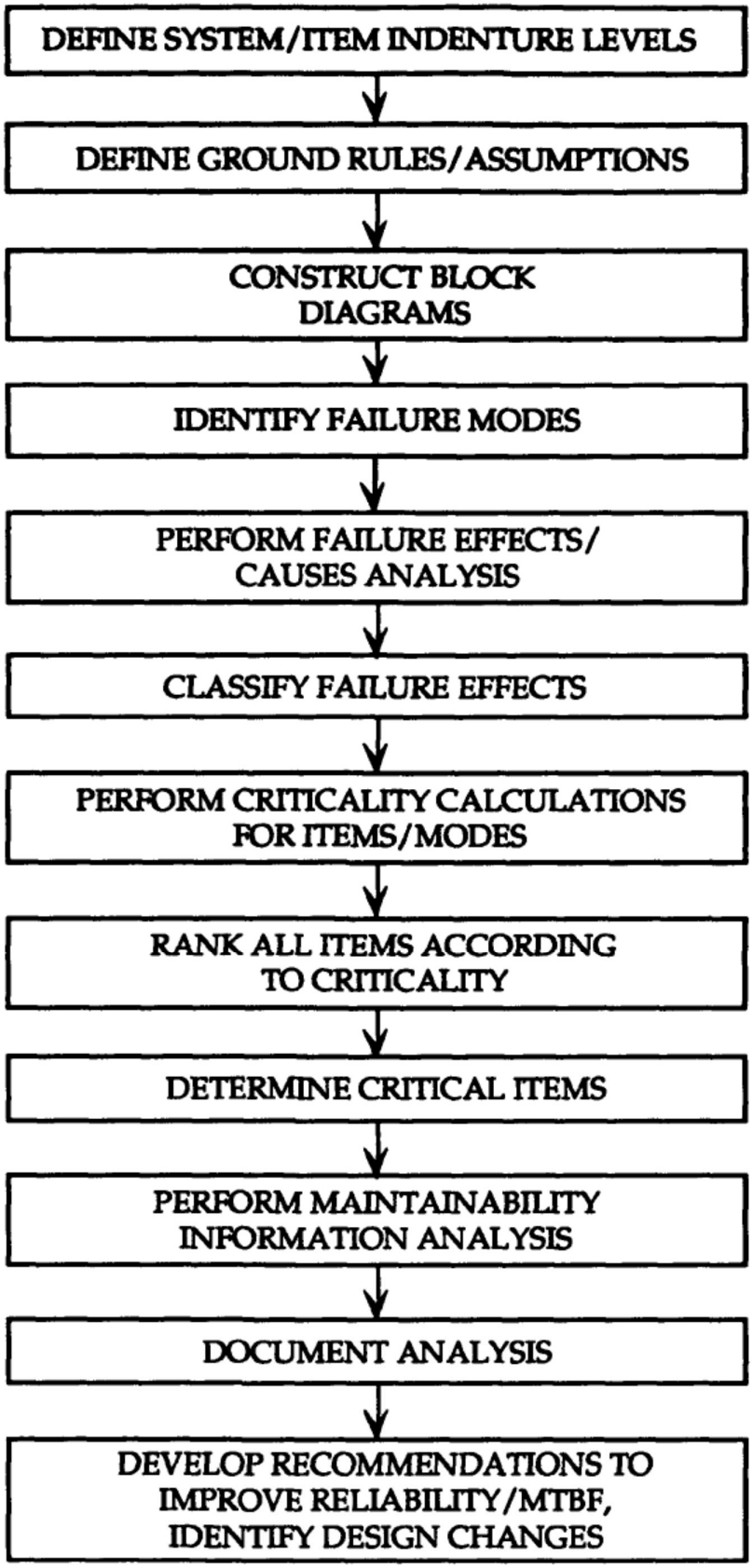

DEFINE SYSTEM/ITEM INDENTURE LEVELS
DEFINE GROUND RULES/ASSUMPTIONS
CONSTRUCT BLOCK DIAGRAMS
IDENTIFY FAILURE MODES
PERFORM FAILURE EFFECTS/ CAUSES ANALYSIS
CLASSIFY FAILURE EFFECTS
PERFORM CRITICALITY CALCULATIONS FOR ITEMS/MODES
RANK ALL ITEMS ACCORDING TO CRITICALITY
DETERMINE CRITICAL ITEMS
PERFORM MAINTAINABILITY INFORMATION ANALYSIS
DOCUMENT ANALYSIS
DEVELOP RECOMMENDATIONS TO IMPROVE RELIABILITY/MTBF, IDENTIFY DESIGN CHANGES

Table1: Test Input Data

Term	User Input/ Calculation Ref	Input Type Format	Value	Unit
Criticality number (for each failure mode), Cm	Eqn1 [1]	Number	Derived from eqn1	-
Failure mode ratio or modal failure mode, α	Input1 [2]	Number	0.75 (Open) 0.25 (Short)	-
Failure effect probability, β	Input2 [2]	Number	1	-
Part failure rate, λp	Input3 [2]	Number	0.25673	Failures per million hours, failures per yr, failures per hr
Duration of the operation, t	Input4 [2]	Number	1	Hrs or no of cycles

Notes:

[1]. In accordance with FMECA document based on the Reliability Analysis Center (RAC).

Table2: Consequence Calculation Outputs

Consequence	Equation No.	Calculation	Result
Cm (open)	Eqn1	(1 x 0.75 x 0.25673 x 1)	1.92548E-07
Cm (short)	Eqn1	(1 x 0.25 x 0.25673 x 1)	0.064183
Cr	Eqn2	(1 x 0.75 x 0.25673 x 1) + (1 x 0.25 x 0.25673 x 1)	0.2567 3

3). FMECA CALCULATION SECTION

To create the new FMECA template the following calculation section will need to be inserted into the current FMEA template:

Failure Effect Probability, β	Failure Mode Ratio, α	Failure Rate, λp	Operating Time, t	Failure Mode Criticality, Cm	Failure Item Criticality, Cr