FMEA / Criticality — failure modes ranked by RPN and by MIL-STD criticality

Menu: System ▸ FMEA / Criticality...

Part 1 — What the function does

What it calculates. FMEA stands for failure mode and effects analysis. You list the ways an item can fail - one worksheet row per failure mode - and score each mode from 1 to 10 for severity (S), occurrence (O) and detection (D). FMEA / Criticality ranks the modes:

Ranking	What ReliaEn calculates	What you need
By RPN (risk priority number)	RPN = S × O × D for each mode, the rank, and each mode's share of the total RPN	The five columns item, mode, S, O, D
By MIL-STD criticality (the military standard method)	Cm = β × α × λp × t for each mode: the expected number of times the mode causes its end effect in one mission; Cr, the item total	Three more columns: the part failure rate λp, the mode ratio α and the loss probability β; and the mission time t
By money (optional)	The expected loss per year of each mode, in a priced Pareto card	One more column, the mean downtime (MDT) per event, and the production loss per hour

Equal RPNs are ordered by severity first, then occurrence (the S-first rule). The report gives the top-ranked mode, the modes marked ★ (Top-N to highlight), a Pareto plot, the ranked table and, with the criticality columns, the criticality table.

From which data. The worksheet, one row per failure mode, chosen column by column in the form.

When an engineer uses it. For a quick, worksheet-based ranking of failure modes, scored by a team or taken from an existing FMEA sheet, and - when the rates are known - for the expected number of end effects per mission.

When not to use it.

Situation	Use instead
You want a full FMEA study document with functions, effects, causes, actions and revisions	System ▸ FMEA Study... (chapter 4.2)
You want to see how failure modes combine through the system structure	System ▸ Fault Tree... (chapter 4.8)
You want the failure rate from failure data first	Fit it, for example Life Data ▸ Time Dependence ▸ Exponential distribution...; a λp cell may then name the fit (exp, weibull or fleet) instead of a number

Part 2 — The example's input data

Setting. A pump with a part failure rate λp of 40e-6 per hour fails in three modes. The team scored them and estimated, for each, the share of the pump's failures (α) and the chance that the mode causes the end effect - the loss of the pumping duty (β). The mission is one year, 8760 hours.

Item	Mode	S	O	D	λp (/h)	α	β
PUMP	bearing	7	5	4	4e-05	0.45	1.0
PUMP	seal	5	5	4	4e-05	0.30	0.3
PUMP	impeller	4	4	4	4e-05	0.25	0.2

Input	Value
Mission time t	8760
Top-N to highlight	5 (all three modes are marked)
File in the worked-example zip	4-FMEA-Criticality/Example-3.csv - the three rows in columns A to H

The data in the worksheet, as the pictures of Part 3 show it:

	① A	② B	③ C	④ D	⑤ E	⑥ F	⑦ G	⑧ H	I
1	PUMP	bearing	7	5	4	40e-6	0.45	1.0	
2	PUMP	seal	5	5	4	40e-6	0.30	0.3	
3	PUMP	impeller	4	4	4	40e-6	0.25	0.2	
4									

The example data in the worksheet

- ① Column A: Item column (3 values)
- ② Column B: Mode column (3 values)
- ③ Column C: S column (3 values)
- ④ Column D: O column (3 values)
- ⑤ Column E: D column (3 values)
- ⑥ Column F: λp column (/h) (3 values)
- ⑦ Column G: α column (mode ratio) (3 values)
- ⑧ Column H: β column (loss prob.) (3 values)

Part 3 — How to use it, step by step

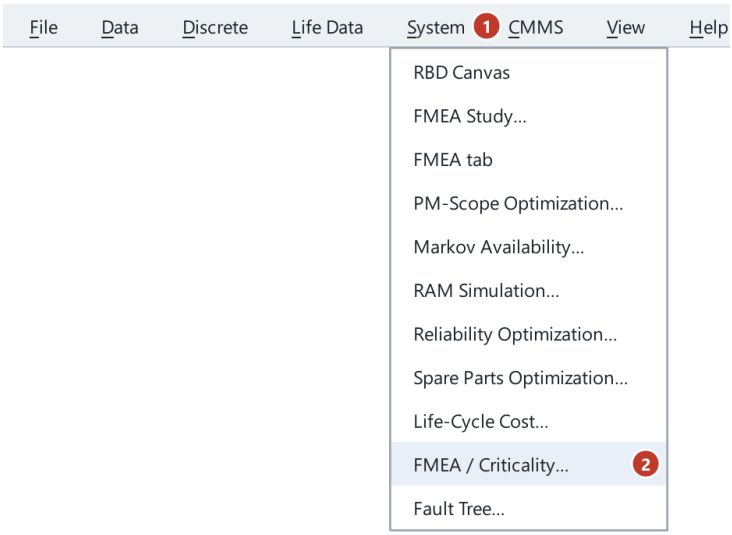
1. **Put the three modes into the worksheet.** Import 4-FMEA-Criticality/Example-3.csv with File ▸ Import Data (Excel / CSV / JSON)..., or type the rows into columns A to H.

	① A	② B	③ C	④ D	⑤ E	⑥ F	⑦ G	⑧ H	I
1	PUMP	bearing	7	5	4	40e-6	0.45	1.0	
2	PUMP	seal	5	5	4	40e-6	0.30	0.3	
3	PUMP	impeller	4	4	4	40e-6	0.25	0.2	
4									

Step 1 — the data in the worksheet

- ① Column A: Item column (3 values)
- ② Column B: Mode column (3 values)
- ③ Column C: S column (3 values)
- ④ Column D: O column (3 values)
- ⑤ Column E: D column (3 values)
- ⑥ Column F: λp column (/h) (3 values)
- ⑦ Column G: α column (mode ratio) (3 values)
- ⑧ Column H: β column (loss prob.) (3 values)

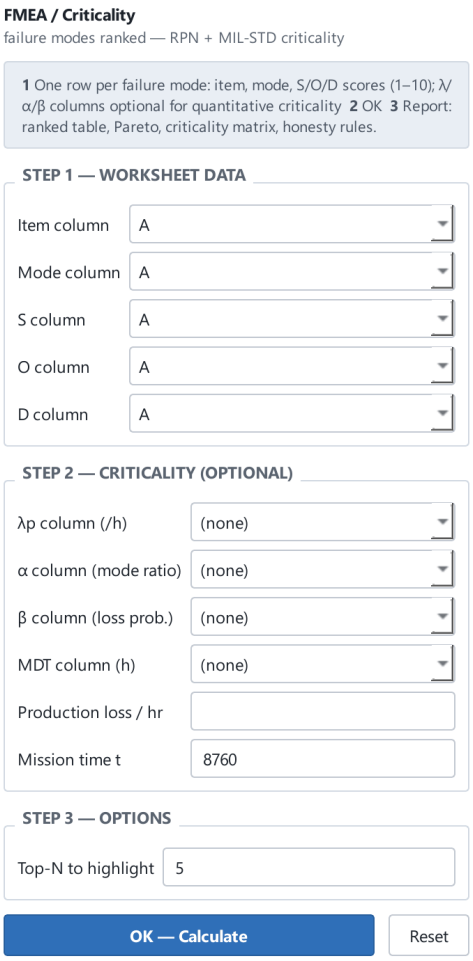
2. **Choose System ▸ FMEA / Criticality...** in the menu bar. The form FMEA / Criticality opens in the left panel.



Step 2 — the menu path

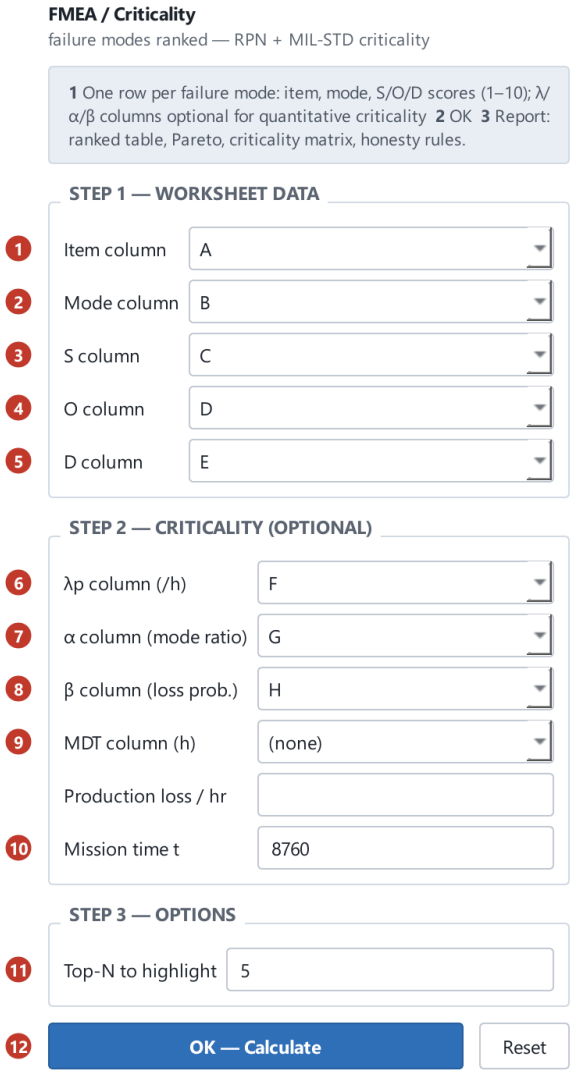
- ① System: the menu.
- ② FMEA / Criticality...: the entry to click.

The form as it opens, before any box is set:



Step 2 — the form as it opens

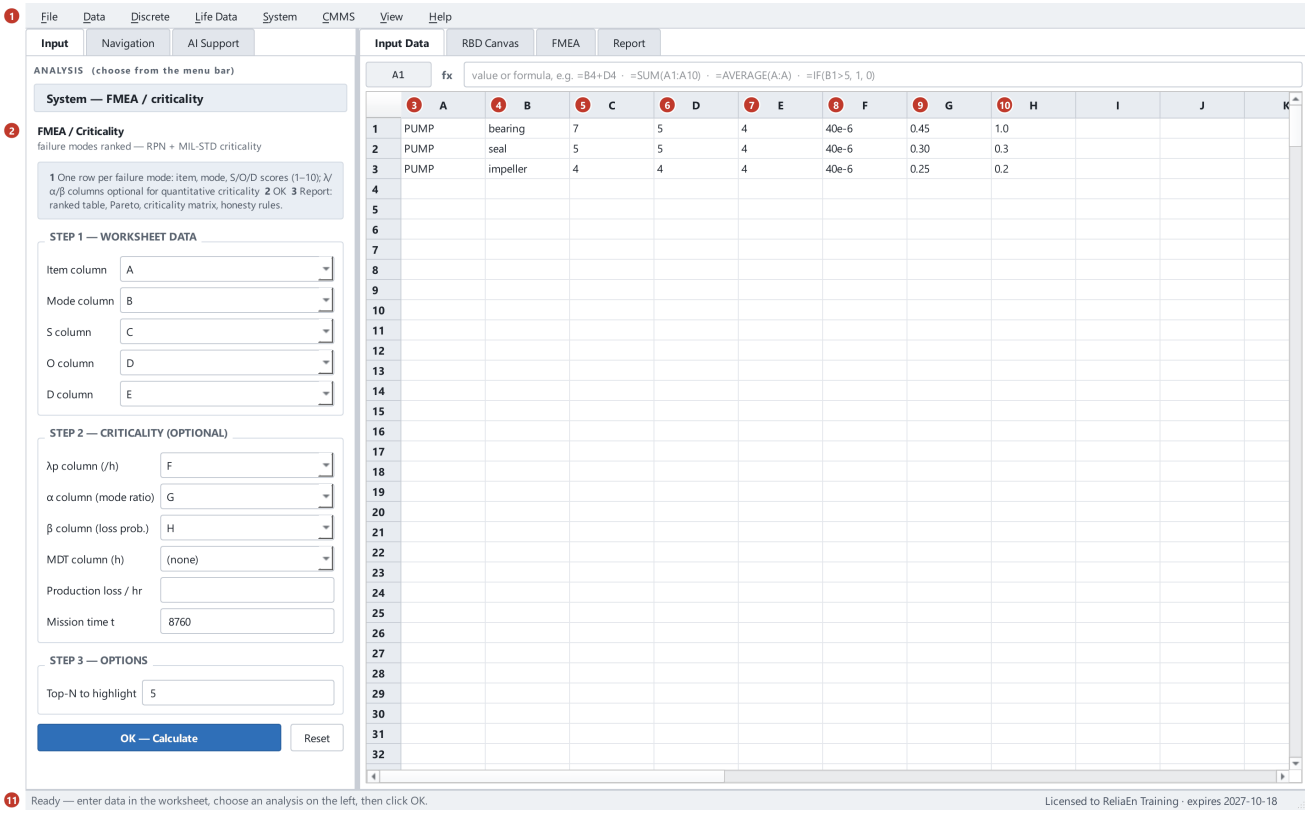
Steps 3 to 13 set the form, marked ① to ⑪; ⑫ is the button of step 14:



Steps 3 to 13 — the form set for this example

3. ① **In Item column, choose A.** The five columns of step 3 to 7 must all differ.
4. ② **In Mode column, choose B.**
5. ③ **In S column, choose C.**
6. ④ **In O column, choose D.**
7. ⑤ **In D column, choose E.**
8. ⑥ **In λp column (/h), choose F.** λp, α and β are given together or not at all.
9. ⑦ **In α column (mode ratio), choose G.**
10. ⑧ **In β column (loss prob.), choose H.**
11. ⑨ **Leave MDT column (h) at (none).** No money ranking in this example.
12. ⑩ **Check that Mission time t reads 8760.**
13. ⑪ **Check that Top-N to highlight reads 5.**

14. **Click OK — Calculate** at the foot of the form (② in the picture below). ReliaEn ranks the modes and shows the report.



Step 14 — the window just before OK

- ① The menu bar: File, Data, Discrete, Life Data, System, CMMS, View, Help.
- ② The analysis form, set as in steps 3 to 13; OK — Calculate at its foot.
- ③ Column A: Item column (3 values)
- ④ Column B: Mode column (3 values)
- ⑤ Column C: S column (3 values)
- ⑥ Column D: O column (3 values)
- ⑦ Column E: D column (3 values)
- ⑧ Column F: λp column (/h) (3 values)
- ⑨ Column G: α column (mode ratio) (3 values)
- ⑩ Column H: β column (loss prob.) (3 values)
- ⑪ The status bar: Ready — enter data in the worksheet, choose an analysis on the left, then click OK., Licensed to ReliaEn Training · expires 2027-10-18.

Part 4 — The report, card by card

INPUT DATA

1	Data	`this worksheet — 3 failure modes`
2	Mission time (criticality)	**8760**

Input data

- ① Data this worksheet — 3 failure modes. How many failure modes ReliaEn read from the worksheet.
- ② Mission time (criticality) 8760. The mission time t of the criticality numbers.

RESULTS

1	Top-ranked mode	PUMP: bearing (RPN 140, 46.1% of total)
2	Modes in the top set	PUMP: bearing, PUMP: seal, PUMP: impeller
3	Highest item criticality Cr	PUMP = 0.2067 expected events/mission

Results

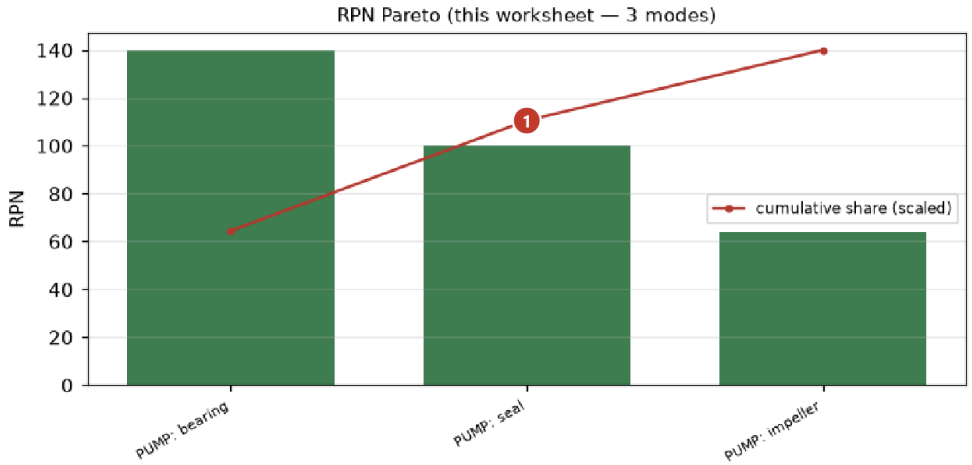
- ① Top-ranked mode PUMP: bearing (RPN 140, 46.1% of total). The mode with the highest RPN and its share of the total RPN.
- ② Modes in the top set PUMP: bearing, PUMP: seal, PUMP: impeller. The modes marked ★, in rank order.
- ③ Highest item criticality Cr PUMP = 0.2067 expected events/mission. The item with the highest criticality Cr: its expected number of end effects per mission.

INTERPRETATION

1 The ranking sorts by RPN with the S-FIRST tie rule: equal products with higher severity rank first — S9·O3·D3 (lethal, rare, detectable) is not the same risk as S3·O3·D9. Fix actions move different axes: design changes move S, prevention moves O, monitoring moves D.

Interpretation

- ① The ranking sorts by RPN with the S-FIRST tie rule: equal products with higher severity rank first — S9·O3·D3 (lethal, rare, detectable) is not the same risk as S3·O3·D9. Fix actions move different axes: design changes move S, prevention moves O, monitoring moves D.



Interactive Plot

Plot

- ① The line: cumulative share (scaled).

RANKED FAILURE MODES (THIS WORKSHEET — 3 FAILURE MODES)

1 HONESTY RULES (the guide's traps): RPN multiplies ORDINAL scales — 200 is not "twice" 100, and ties within ~±20% are ties. No single threshold decides action: the table ranks, the owner draws the line. Rows tied on RPN, S and O keep their worksheet order.

2 Rank	3 Item	4 Mode	5 S	6 O	7 D	8 RPN	9 Share
10 1 ★	PUMP	bearing	7	5	4	140	46.1%
11 2 ★	PUMP	seal	5	5	4	100	32.9%
12 3 ★	PUMP	impeller	4	4	4	64	21.1%

Ranked failure modes (this worksheet — 3 failure modes)

- ① HONESTY RULES (the guide's traps): RPN multiplies ORDINAL scales — 200 is not "twice" 100, and ties within ~±20% are ties. No single threshold decides action: the table ranks, the owner draws the line. Rows tied on RPN, S and O keep their worksheet order.
- ② Rank
- ③ Item
- ④ Mode
- ⑤ S
- ⑥ O
- ⑦ D
- ⑧ RPN
- ⑨ Share
- ⑩ 1 ★ · PUMP · bearing · 7 · 5 · 4 · 140 · 46.1%
- ⑪ 2 ★ · PUMP · seal · 5 · 5 · 4 · 100 · 32.9%
- ⑫ 3 ★ · PUMP · impeller · 4 · 4 · 4 · 64 · 21.1%

MIL-STD CRITICALITY — CM = B·A·ΛP·T (THIS WORKSHEET — 3 FAILURE MODES)

1 Cm = expected occurrences of this mode CAUSING that end effect per mission — continuous, additive across modes and items (unlike RPN). Item totals: PUMP = 0.2067.

2 Item	3 Mode	4 λp /h	5 λ source	6 α	7 β	8 Cm
9 PUMP	bearing	4e-05	manual	0.45	1	0.1577
10 PUMP	seal	4e-05	manual	0.3	0.3	0.03154
11 PUMP	impeller	4e-05	manual	0.25	0.2	0.01752

MIL-STD criticality — Cm = β·α·λp·t (this worksheet — 3 failure modes)

- ① Cm = expected occurrences of this mode CAUSING that end effect per mission — continuous, additive across modes and items (unlike RPN). Item totals: PUMP = 0.2067.
- ② Item
- ③ Mode
- ④ λp /h
- ⑤ λ source
- ⑥ α
- ⑦ β
- ⑧ Cm
- ⑨ PUMP · bearing · 4e-05 · manual · 0.45 · 1 · 0.1577
- ⑩ PUMP · seal · 4e-05 · manual · 0.3 · 0.3 · 0.03154
- ⑪ PUMP · impeller · 4e-05 · manual · 0.25 · 0.2 · 0.01752

Part 5 — How to interpret the results

Which mode to act on first. The bearing, by both rankings. Its RPN is 140 (7 × 5 × 4), 46.1% of the total 304, and the next mode, the seal, has 100 - more than 20% below, so the bearing stands clear of the honesty rule's tie band. Its criticality Cm is 0.1577 of the pump's 0.2067.

What the criticality number means. Cm = β × α × λp × t is the expected number of times the mode causes the end effect in one mission. For the bearing: 1.0 × 0.45 × 4e-05 × 8760 = 0.1577. The seal adds 0.3 × 0.3 × 4e-05 × 8760 = 0.03154 and the impeller 0.2 × 0.25 × 4e-05 × 8760 = 0.01752; the pump's total Cr = 0.2067 end effects a year. Unlike RPN, these numbers add up across modes and items.

Why the two rankings can differ. RPN multiplies ordinal scores: 200 is not "twice" 100, and a team's scores rank perception. Cm is built from rates and probabilities. Here they agree; when they do not, trust the criticality ranking for how often the end effect happens and use RPN for what the team fears.

Where to draw the action line. The report ranks; it never says where to stop. All three modes are marked ★ because Top-N to highlight is 5 and there are three modes.

What a fix moves. A design change moves S, prevention moves O, monitoring moves D; in criticality terms, prevention lowers α × λp and a safeguard lowers β.