Reliability block diagram canvas — the reliability of a system drawn from its components

Menu: System ▸ RBD Canvas

Part 1 — What the function does

What it calculates. A reliability block diagram (RBD) shows how the failure of parts of a system stops the system. Each block is one component with its own life distribution. Blocks in a chain are in series: every one must survive. Blocks side by side are in parallel: one survivor is enough. A k-out-of-n group needs at least k of its n identical units, and a standby group switches to the next unit when the running unit fails. On the RBD Canvas tab you draw the diagram from START to END, give each block a life distribution, and click Evaluate…. For the mission time you give, ReliaEn calculates:

Result	What it is
R_sys(mission)	The chance that the system runs the whole mission without a system failure
MTBF_sys = ∫R_sys dt	The system's mean time between failures (MTBF): the area under its reliability curve
System B10, System median	The operating times by which one system in ten, and half of the systems, have failed
Minimal cut sets	The smallest groups of blocks whose joint failure stops the system; a set of one block is a single point of failure
Importance measures	For each block: Birnbaum importance (how much the system reliability moves per unit of the block's reliability), risk achievement worth RAW and risk reduction worth RRW
Service intervals	The operating time at which the system falls to each target reliability
Cross-check	A seeded simulation of the same diagram, and whether it agrees with the analytic answer

ReliaEn reduces the diagram to series, parallel, k-out-of-n and standby groups and multiplies out the block reliabilities: series $R = \Pi R_i$, parallel $R = 1 - \Pi(1 - R_i)$, k-out-of-n $R = \Sigma\, C(n,x)R^x(1-R)^{n-x}$ for x from k to n. A diagram that does not reduce that way (a bridge) is evaluated through its structure function.

From which data. No worksheet: the diagram itself is the input. Each block takes either a distribution and parameters you type in its Block properties (Manual parameters), or a life distribution fitted earlier in the same project (a Source entry that names the fit, for example From analysis — Weibull(β = 2.182, η = 169.394)).

The diagram is part of the project. File ▸ Save Project… writes it into the project file with the worksheet, the reports and the fitted results; File ▸ Open Project… restores it as drawn, and the same Evaluate… gives the same report.

When an engineer uses it. When each component's life distribution is known or fitted, and the question is the reliability of the system at a mission time, without repair.

When not to use it.

Situation	Use instead
Components are repaired during the mission and you want availability, downtime or repair-crew effects	System ▸ RAM Simulation… (chapter 4.5) - it simulates the diagram drawn on this canvas
You want the cheapest redundancy that reaches a reliability target	System ▸ Reliability Optimization… (chapter 4.6) - it works on this canvas's diagram

A component is repaired and you want its long-run availability from failure and repair rates	System ▸ Markov Availability… (chapter 4.3)
You think in failure events rather than success paths	System ▸ Fault Tree… (chapter 4.8)
You do not yet know a component's life distribution	Fit it first, for example Life Data ▸ Time Dependence ▸ Weibull (2P) distribution…; the fit then appears in the block's Source list

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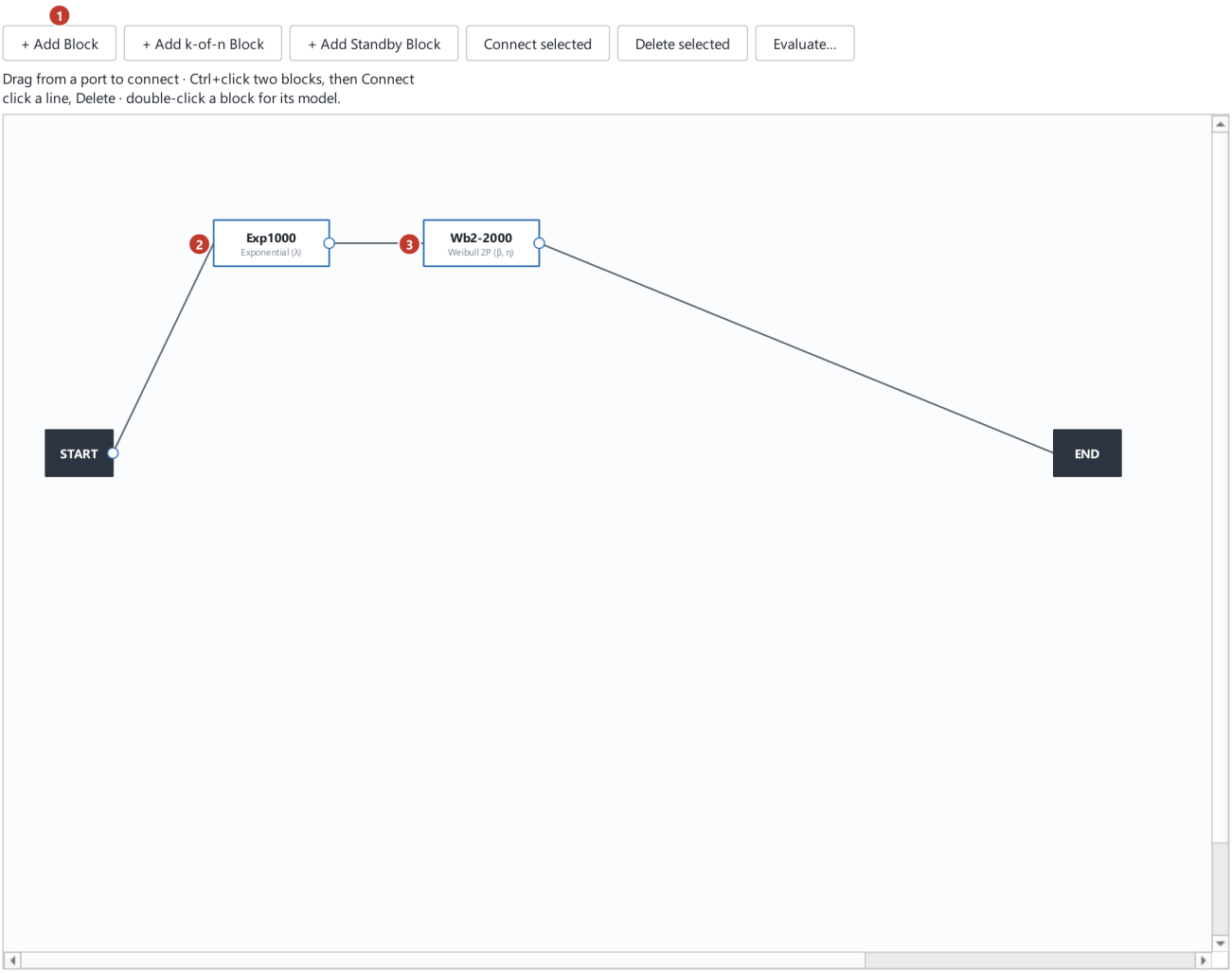
Part 2 — The example's input data

Setting. A conveyor drive has a motor with a constant failure rate and a gearbox that wears out. The drive stops if either fails. The planner wants the chance that the drive runs a 500-hour campaign, and which of the two parts to improve first. Times are in operating hours.

Block	Source	Distribution and parameters
Exp1000 (the motor)	Manual parameters	Exponential (λ), λ — failure rate 0.001
Wb2-2000 (the gearbox)	Manual parameters	Weibull 2P (β, η), β — shape 2, η — scale 2000

Input	Value
The lines	START → Exp1000 → Wb2-2000 → END: the two blocks in series
Evaluate system ▸ Mission time t	500
File in the worked-example zip	none - the diagram is drawn on the canvas as Part 3 shows; the saved project of Part 4 is the file

The diagram on the canvas, as Part 3 draws it:

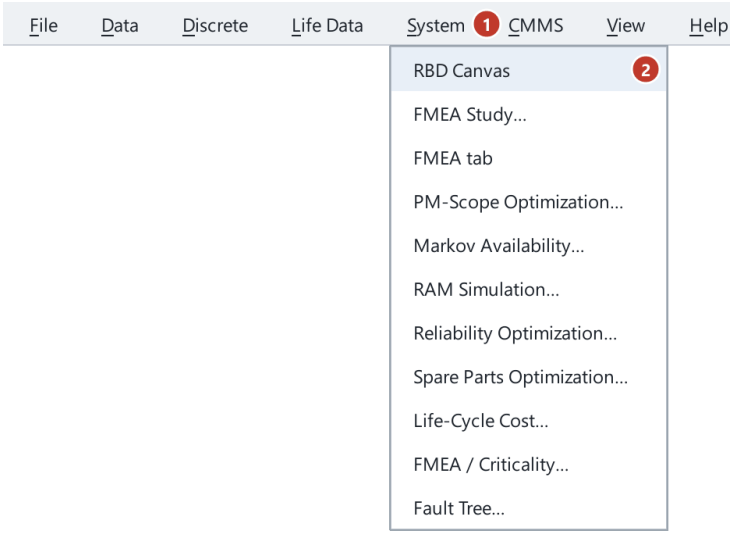


The example's diagram on the canvas

- ① + Add Block: adds one block, after asking for its name.
- ② Exp1000, the motor, with its model Exponential (λ) under the name.
- ③ Wb2-2000, the gearbox, with Weibull 2P (β, η).

Part 3 — How to use it, step by step

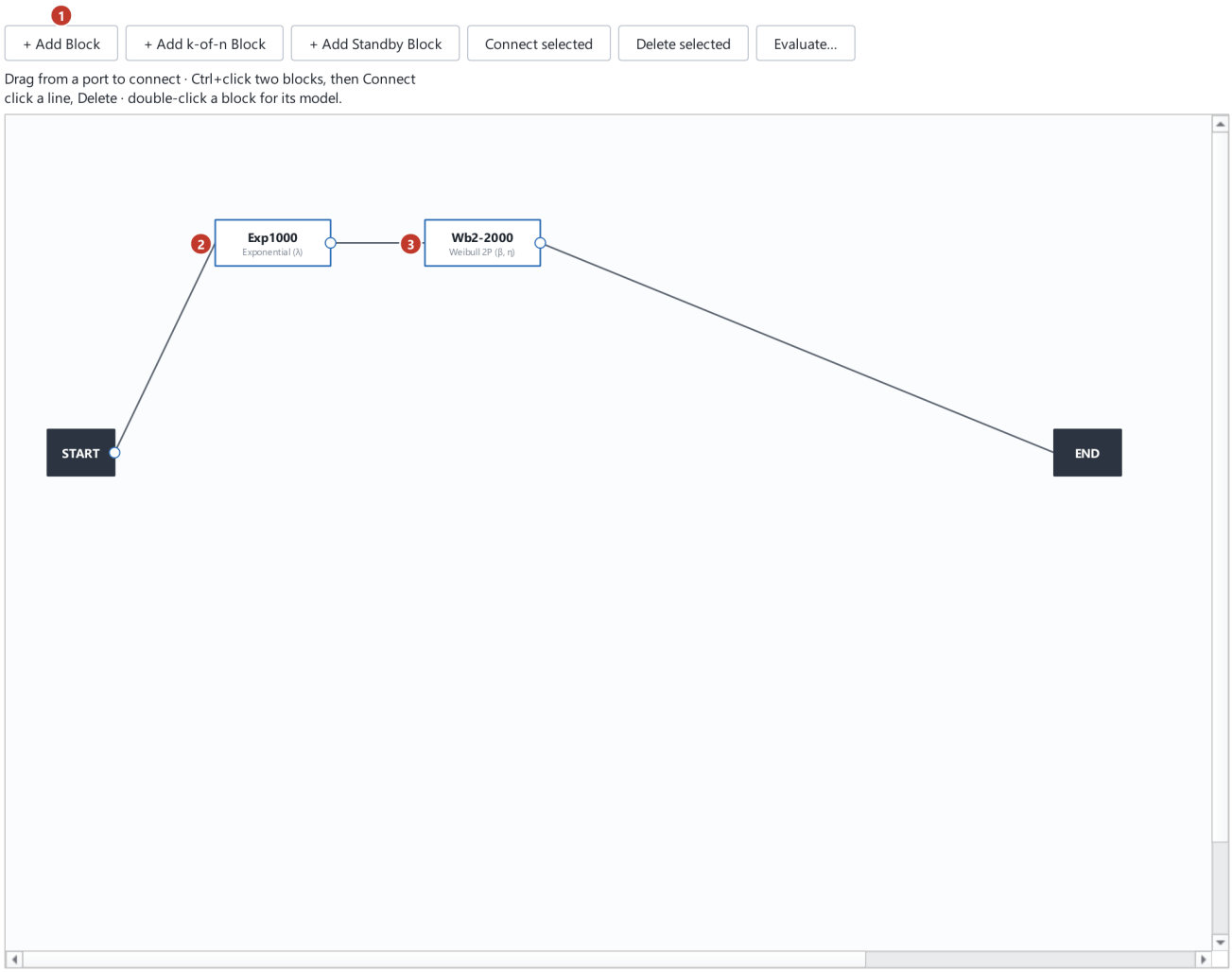
1. **Choose System ▸ RBD Canvas** in the menu bar. The main area switches to the RBD Canvas tab, with START on the left and END on the right.



Step 1 — the menu path

- ① System: the menu.
- ② RBD Canvas: the entry to click.

The canvas with the drive drawn, as steps 2 to 5 leave it:

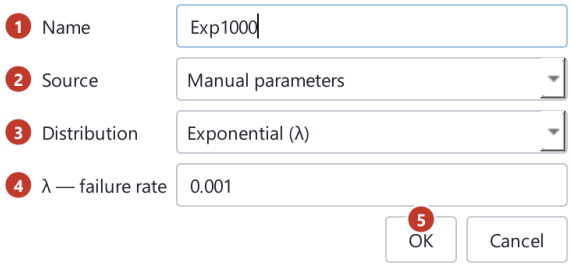


Steps 2 to 5 — the drive on the canvas

- ① + Add Block: adds one block, after asking for its name.
- ② Exp1000, the motor, with its model Exponential (λ) under the name.
- ③ Wb2-2000, the gearbox, with Weibull 2P (β, η).

2. ① **Click + Add Block, type Exp1000 as the name and click OK; then click + Add Block again for Wb2-2000.** Drag each block by its body to where you want it, Wb2-2000 to the right of Exp1000. A new block shows double-click… under its name until it has a model.

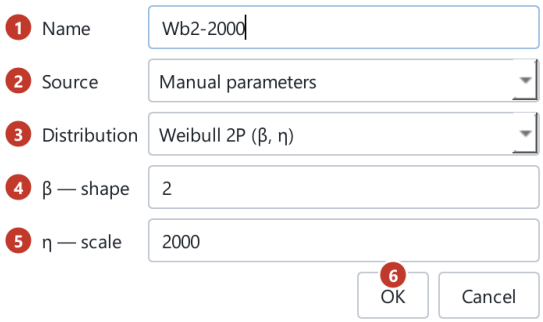
3. **Double-click the block Exp1000.** Block properties opens; set it as the picture shows.



Step 3 — Block properties for the motor

- ① Name: Exp1000.
- ② Source: Manual parameters.
- ③ Distribution: Exponential (λ).
- ④ λ — failure rate: 0.001.
- ⑤ OK: click it.

4. **Double-click the block Wb2-2000** and set Block properties as the picture shows.

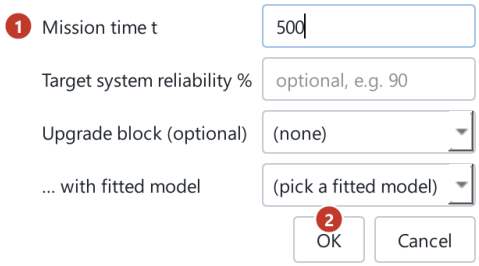


Step 4 — Block properties for the gearbox

- ① Name: Wb2-2000.
- ② Source: Manual parameters.
- ③ Distribution: Weibull 2P (β, η).
- ④ β — shape: 2.
- ⑤ η — scale: 2000.
- ⑥ OK: click it.

5. **Draw the three lines** from left to right: press on the small round port at the right edge of START, drag to ② Exp1000 and release; then from the port of Exp1000 to ③ Wb2-2000, and from the port of Wb2-2000 to END. The two blocks are now in series.

6. **Click Evaluate...** at the end of the toolbar. Evaluate system opens.

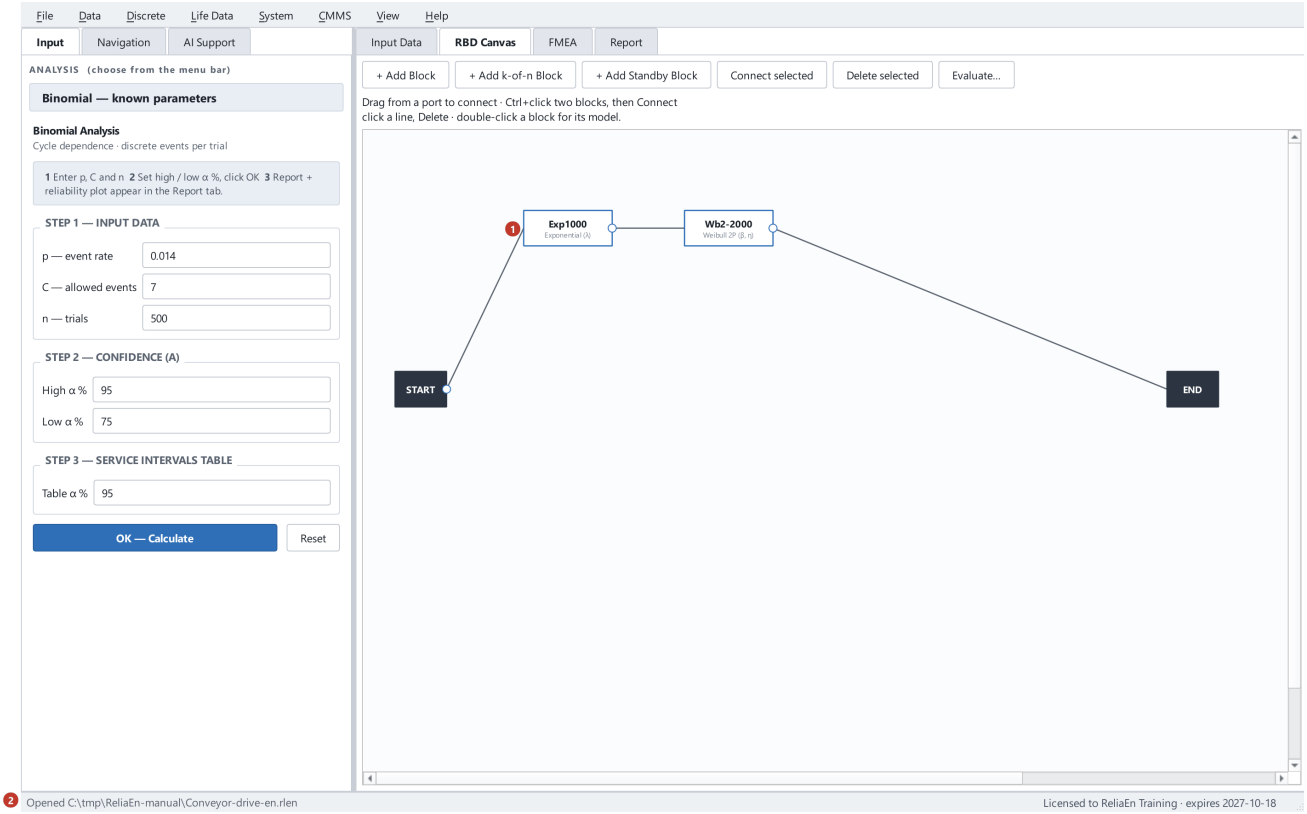


Step 6 — Evaluate system

- ① Mission time t: type 500.
- ② OK: click it. ReliaEn calculates, and the report opens on the Report tab.

Part 4 — The report, card by card

Before reading the report, keep the diagram: save the project with File ▸ Save Project..., start an empty one with File ▸ New Project - the canvas empties - and open the file again with File ▸ Open Project.... The canvas shows the drive as it was drawn:



The saved diagram, reopened

- ① The diagram as saved: Exp1000 and Wb2-2000 in series between START and END, each block with its model.
- ② The status bar: Opened and the path of the file - here C:\tmp\ReliaEn-manual\Conveyor-drive-en.rlen - and Licensed to ReliaEn Training · expires 2027-10-18.

The left panel keeps the form opened last; the canvas does not use it. Evaluate... with 500 on the reopened diagram prints the report below again, card for card.

INPUT DATA

1	Blocks in the diagram	2
2	Mission time	500
3	Evaluation	analytic (series-parallel reduction, exact)

Input data

- ① Blocks in the diagram 2. The diagram holds two blocks: Exp1000 and Wb2-2000.
- ② Mission time 500. ReliaEn reports the system at 500 hours.
- ③ Evaluation analytic (series-parallel reduction, exact). The diagram reduces to series and parallel groups, so the answer is exact.

RESULTS

1	R_sys(mission)	0.5698
2	MTBF_sys = ∫R_sys dt	757.87
3	System B10	102.72
4	System median	602.42

Results

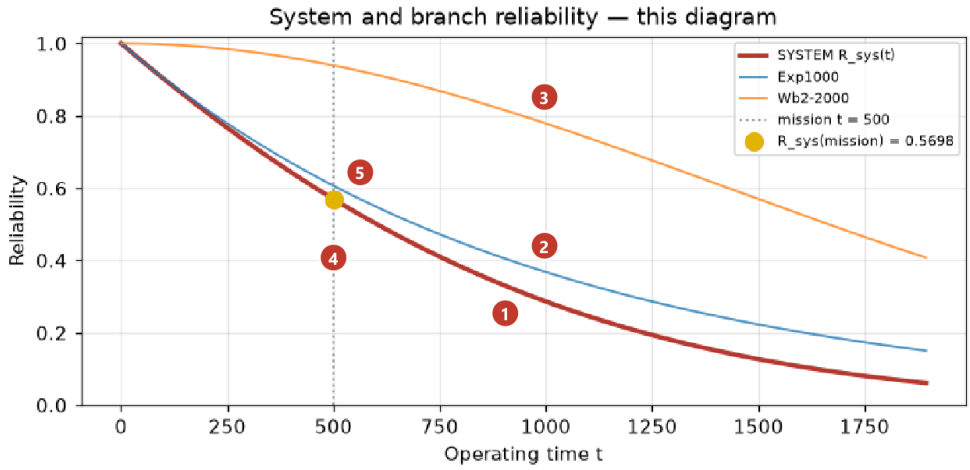
- ① R_sys(mission) 0.5698. The chance that the drive runs the whole 500 hours without a system failure.
- ② MTBF_sys = ∫R_sys dt 757.87. The system's mean time between failures (MTBF), in hours.
- ③ System B10 102.72. One system in ten has failed by 102.72 hours.
- ④ System median 602.42. Half of the systems have failed by 602.42 hours.

INTERPRETATION

1. The system survives its mission of 500 with probability 0.5698. MTBF_sys = 757.87 — note it is SHORTER than most individual blocks' lives: a chain is weaker than its links, and redundant groups only partly buy that back. Block-level answers (which one to improve) come from the importance measures in the next RBD cycle.

Interpretation

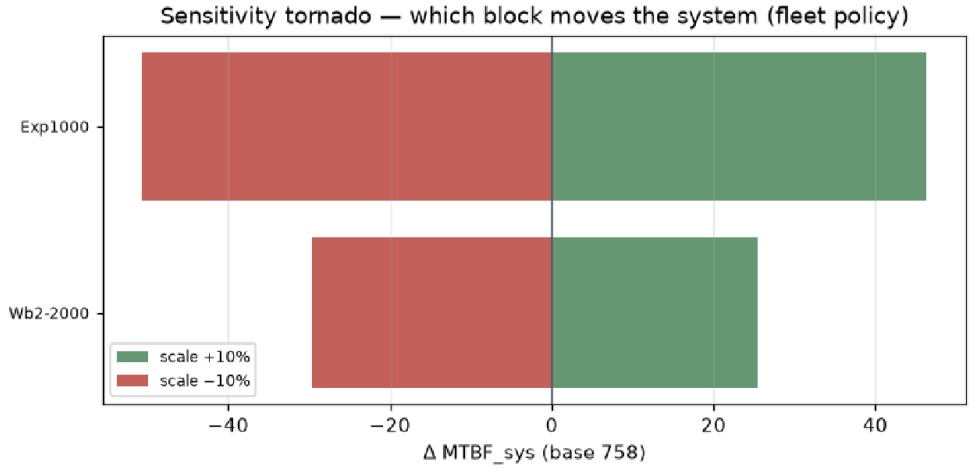
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Interactive Plot

Plot

- ① The line: SYSTEM R_sys(t).
- ② The line: Exp1000.
- ③ The line: Wb2-2000.
- ④ The vertical line: mission t = 500.
- ⑤ The points: R_sys(mission) = 0.5698.



Interactive Plot

Plot

- One bar per block, in the plot Sensitivity tornado — which block moves the system (fleet policy): the change of the system MTBF when that block's scale moves by 10%.

STRUCTURE — AS DRAWN (REDUCED TREE)

1 SERIES = all must survive; PARALLEL = any one suffices; k-of-n = at least k of the n units.

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2 SERIES
3   • Exp1000  [manual — Exponential(λ = 0.001)]
4   • Wb2-2000  [manual — Weibull(β = 2, η = 2000)]
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Structure — as drawn (reduced tree)

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- ② SERIES
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- ④ • Wb2-2000 [manual — Weibull(β = 2, η = 2000)]

BLOCKS — MODELS AND SOURCES (THIS DIAGRAM)

1 Every block names where its numbers came from — fitted analyses carry their full model; manual blocks show their parameters.

2 Block	3 Model source	4 R(mission)
5 Exp1000	manual — Exponential(λ = 0.001)	0.6065
6 Wb2-2000	manual — Weibull(β = 2, η = 2000)	0.9394

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- ⑤ Exp1000 · manual — Exponential(λ = 0.001) · 0.6065
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SYSTEM CONFIDENCE — PROPAGATED FROM THE FITTED BLOCKS

1 All blocks are manual — no parameter uncertainty is available to propagate; R_sys is a point statement. Use 'From analysis…' sources to carry the fits' confidence into the system.

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MINIMAL CUT SETS — HOW THIS SYSTEM CAN FAIL (THIS DIAGRAM)

1. 2 distinct minimal failure combinations. Single-name rows are SINGLE POINTS OF FAILURE.

#	The system fails when...
1	Exp1000 fails
2	Wb2-2000 fails

4. Exact, from the structure function — the same minimal cuts the Fault Tree module computes for a worksheet tree; carrying an RBD's sets into a tree is a named v2.

Minimal cut sets — how this system can fail (this diagram)

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- ② 1 · Exp1000 fails
- ③ 2 · Wb2-2000 fails
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CROSS-CHECK — INDEPENDENT SIMULATION OF THIS DIAGRAM

1. Analytic R_sys(mission) = 0.5698 · seeded simulation = 0.5607 ± 0.0069 (95 %, N = 20,000, seed 20260810) · |Δ| = 0.0090 against 3σ = 0.0105: agree

Cross-check — independent simulation of this diagram

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IMPORTANCE MEASURES — WHICH BLOCK DRIVES SYSTEM RISK (AT THE MISSION TIME)

1. 'Exp1000' carries the highest Birnbaum importance (0.9394) — improving its reliability moves the system most. RAW = how much worse if it were failed; RRW = how much better if it were perfect.

2 Block	3 Birnbaum $\partial R/\partial R_i$	4 RAW	5 RRW
6 Exp1000	0.9394	2.324	7.101
7 Wb2-2000	0.6065	2.324	1.093

8. k-of-n and standby templates are ranked as ONE design (the group's unit model), not per physical item.

Importance measures — which block drives system risk (at the mission time)

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- ⑦ Wb2-2000 · 0.6065 · 2.324 · 1.093
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SERVICE INTERVALS — THE SYSTEM STAYS ABOVE TARGET RELIABILITY UNTIL

① System-level ladder — plan outages against the SYSTEM's reliability, not a single block's.

② Target R_sys	③ Operating time t
95%	50.7
④ 90%	102.7
80%	211.9
70%	329.5
50%	602.4
25%	1,089.5
10%	1,634.6

SERVICE INTERVALS — the SYSTEM stays above target reliability until

- ① System-level ladder — plan outages against the SYSTEM's reliability, not a single block's.
- ② Target R_sys
- ③ Operating time t
- ④ 90% · 102.7

Part 5 — How to interpret the results

Will the drive run the campaign? With probability 0.5698. At 500 hours the motor alone survives with probability 0.6065 (e^(−0.001 × 500)) and the gearbox with 0.9394 (e^(−(500/2000)²)); in series the drive needs both, so 0.6065 × 0.9394 = 0.5698. Each part on its own looks better than the drive does: a chain is weaker than its links.

How long the drive lasts on average. MTBF_sys 757.87 hours, the area under the system's reliability curve - shorter than either part's own mean life. One drive in ten has stopped by 102.72 hours (System B10), half by 602.42 hours (System median).

Where the drive can fail. The cut-set card lists two rows of one block each: the motor and the gearbox are both single points of failure, and nothing in the diagram protects either.

Which part to improve first. The motor. Its Birnbaum importance is 0.9394 - the gearbox's reliability, because the drive survives only when the gearbox does too - against the gearbox's 0.6065. A perfect motor would cut the drive's failure probability 7.101 times (RRW); a perfect gearbox only 1.093 times. A failed part fails the drive in either case, so both carry the same RAW, 2.324.

When to service. For the drive to stay at 90% reliability or more, plan its outage before 102.7 hours of running - the system's ladder, not a single part's life.

Why to trust the number. The diagram reduces to one series group, so the answer is exact; the seeded simulation of 20,000 drives agrees within three standard errors.

What the result is not. It is the reliability without repair. For a drive that is repaired during the campaign, simulate the same diagram with System ▸ RAM Simulation….