Spare Parts Optimization — how many spares to stock for a planning window

Menu: System ▸ Spare Parts Optimization...

Part 1 — What the function does

What it calculates. You run a fleet of identical machines, each carrying one component of the same type - a mechanical seal, a bearing, a relay. You are about to start a planning window in which you cannot buy more spares: a campaign at a remote site, a shutdown season, a voyage. Spare Parts Optimization tells you how many spares of that component to put on the shelf before the window starts. For every stock level s from 0 upwards ReliaEn calculates:

Result	How ReliaEn sets it
Expected demand μ	The expected number of component failures in the window: m × λ × H exactly for an exponential component; m × M(H), the renewal function, for the other distributions
Service P(N ≤ s)	The chance that the stock covers every failure in the window, with the demand N Poisson-distributed with mean μ
E[shortage]	The expected number of failures the stock cannot cover, μ·P(N ≥ s) − s·P(N ≥ s + 1)

It then recommends the stock s* by one of two objectives:

Objective	What ReliaEn recommends
Minimum stock for a target service level	The smallest stock whose service level reaches your target, for example 90%
Cost-optimal stock	The stock with the lowest total of holding cost and expected shortage cost over the window

The report gives the recommended stock, the service level it achieves, the expected shortage at that stock, the rule that decided it, a table of every stock level, a plot of service level against stock, and the checks ReliaEn made on the run.

From which data. No worksheet: everything is typed into the form - the component's life distribution (exponential, two-parameter Weibull, gamma, lognormal or three-parameter Weibull, typed or taken from a fit made earlier in the session), the number of machines, the length of the window, and the target or the two costs.

When an engineer uses it. Before a window without resupply, when the stock is bought once and must protect the whole window.

When not to use it.

Situation	Use instead
You reorder during the window, with a reorder point or a lead time	Not covered in version 1.0.0; the report states this in its scope card
You do not yet know the component's life distribution	Fit it first, for example Life Data ▸ Time Dependence ▸ Weibull (2P) distribution...; the fit then appears in this form under From analysis
The cost of owning and maintaining the fleet over a horizon	System ▸ Life-Cycle Cost... (chapter 5.4)

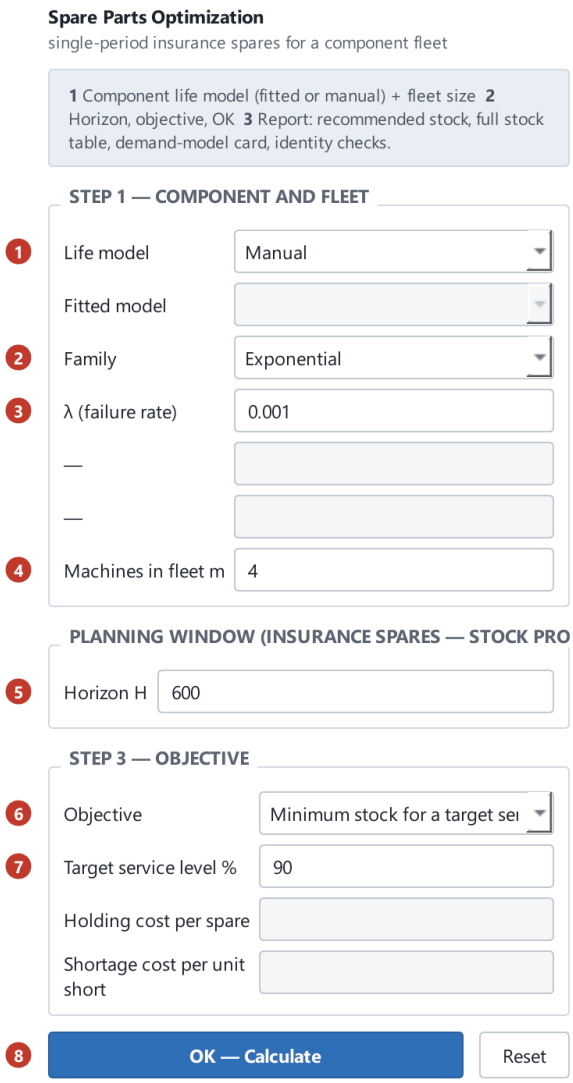
Part 2 — The example's input data

Setting. A plant runs four pumps, each with one mechanical seal, through a 600-hour campaign at a remote site with no delivery of spares. The seal has a constant failure rate of 0.001 per hour. The plant wants at least a 90% chance that the seal stock lasts the whole campaign. Ages and the horizon are in operating hours.

Input	Value
Life model	Manual
Family	Exponential, λ (failure rate) 0.001
Machines in fleet m	4
Horizon H	600
Objective	Minimum stock for a target service level, Target service level % 90

No worksheet and no file: every value is typed into the form as Part 3 shows.

The form set for this example, as Part 3's steps 2 to 8 set it:

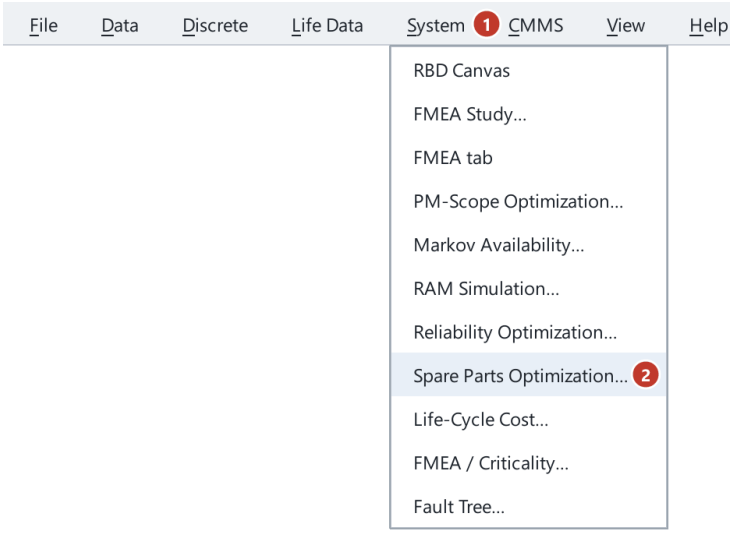


The example's values in the form

- ① to ③ Life model Manual, Family Exponential, λ (failure rate) 0.001.
- ④ and ⑤ Machines in fleet m 4, Horizon H 600.
- ⑥ and ⑦ Objective Minimum stock for a target service level, Target service level % 90.

Part 3 — How to use it, step by step

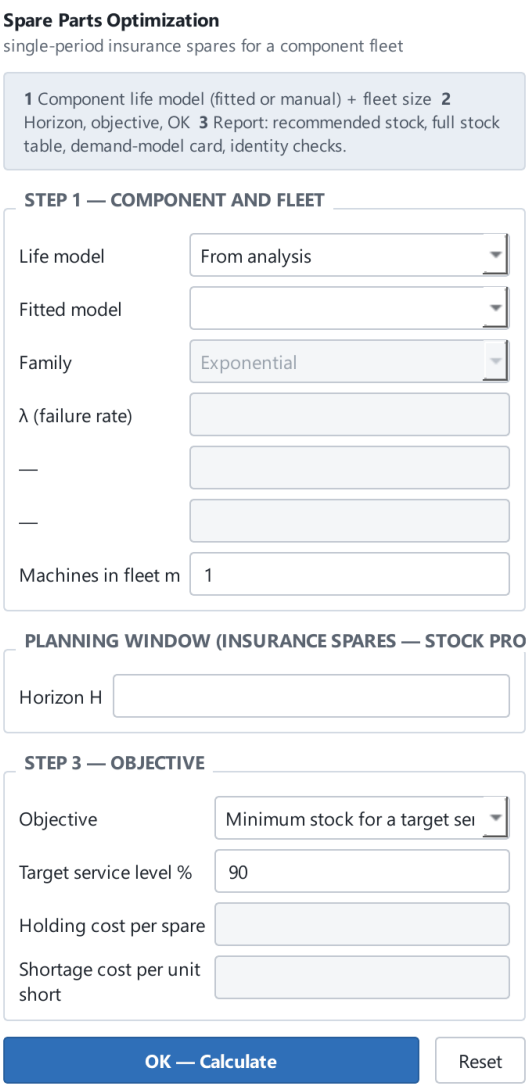
1. **Choose System ▸ Spare Parts Optimization…** in the menu bar. The form Spare Parts Optimization opens in the left panel.



Step 1 — the menu path

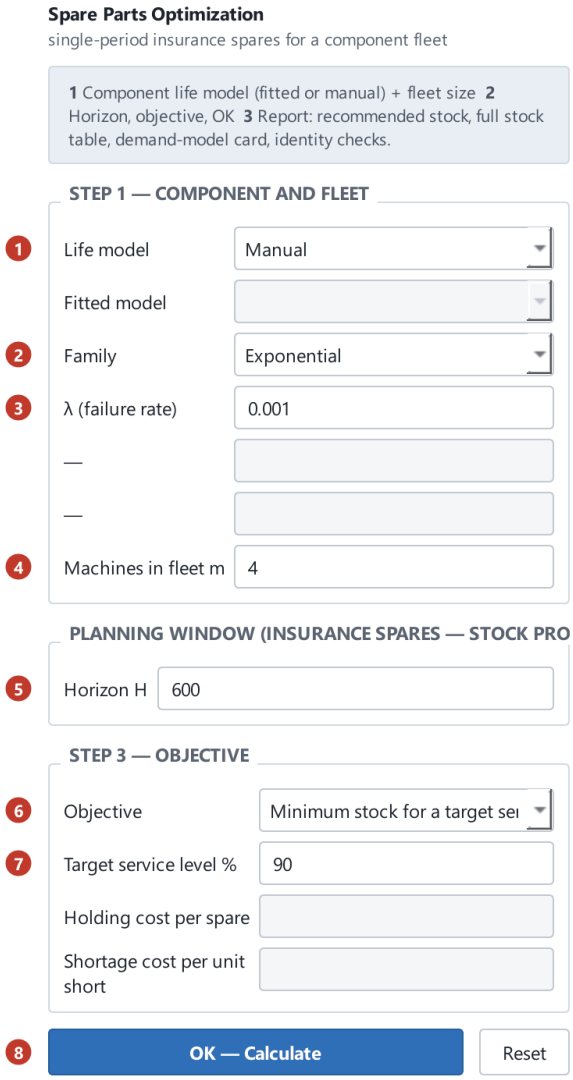
- ① System: the menu.
- ② Spare Parts Optimization…: the entry to click.

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



Step 1 — the form as it opens

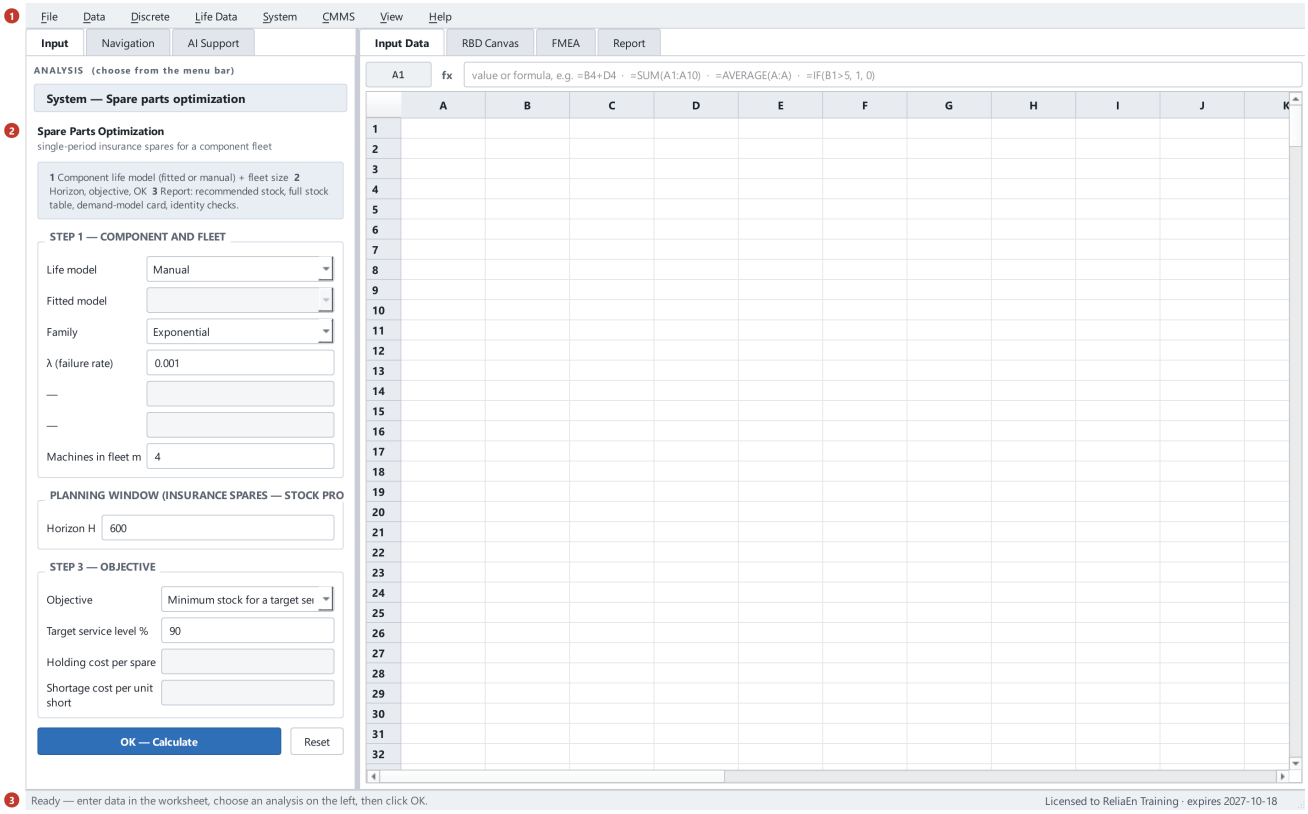
Steps 2 to 8 set the form's boxes, marked ① to ⑦ in the picture; ⑧ is the button of step 9:



Steps 2 to 8 — the form set for this example

2. ① **In Life model, choose Manual.** From analysis would take a life distribution fitted earlier in this session, chosen in Fitted model.
3. ② **Check that Family reads Exponential.** The parameter boxes follow the family.
4. ③ **In λ (failure rate), type 0.001.**
5. ④ **In Machines in fleet m, type 4.** A whole number, 1 or more.
6. ⑤ **In Horizon H, type 600.** The window, in the time unit of the life distribution: hours here.
7. ⑥ **Check that Objective reads Minimum stock for a target service level.**
8. ⑦ **Check that Target service level % reads 90.**

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



Step 9 — the window just before OK

- ① The menu bar: File, Data, Discrete, Life Data, System, CMMS, View, Help.
- ② The form, set as in steps 2 to 8; OK — Calculate at its foot.
- ③ The status bar: Ready — enter data in the worksheet, choose an analysis on the left, then click OK. and Licensed to ReliaEn Training · expires 2027-10-18.

Part 4 — The report, card by card

INPUT DATA

1	Component	`Exponential(λ = 0.001)`
2	Machines in fleet m	`4`
3	Horizon H	`600`
4	Objective	`Minimum stock for a target service level`
5	Target service level %	`90`

Input data

- ① Component Exponential(λ = 0.001): the seal's life model, a constant failure rate of 0.001 per hour.
- ② Machines in fleet m 4: the four pumps that draw on the one seal stock.
- ③ Horizon H 600: the campaign the stock must cover, in hours, with no resupply.
- ④ Objective Minimum stock for a target service level: ReliaEn looks for the smallest stock that meets the target.
- ⑤ Target service level % 90.

These are your entries as ReliaEn read them.

RESULTS

1	Recommended stock s*	4
2	Achieved service level	90.41%
3	E[shortage] at s*	0.1475907
4	Binding	target (90.41% ≥ 90%)

Results

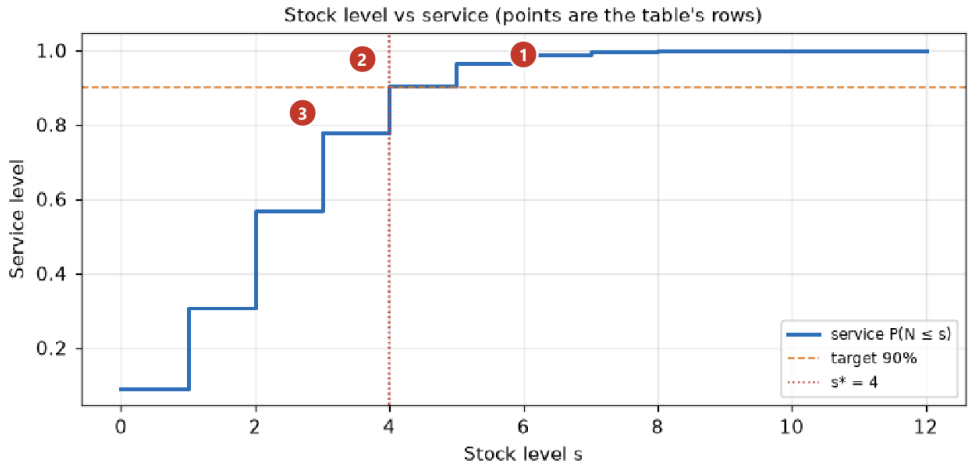
- ① Recommended stock s* 4: hold four seals.
- ② Achieved service level 90.41%: four seals cover every failure of the campaign with this probability.
- ③ E[shortage] at s* 0.1475907: failures in the campaign that, on average, find no seal on the shelf.
- ④ Binding target (90.41% ≥ 90%): the 90% target decided the stock; four is the first stock that reaches it.

INTERPRETATION

1 Single-period insurance-spares question: an initial stock protects the fleet over [0, H] with no resupply. Every stock level was enumerated with the closed-form Poisson loss identity — the recommendation is computed, not searched, and the identity card below states what was verified on this run.

Interpretation

- ① Single-period insurance-spares question: an initial stock protects the fleet over [0, H] with no resupply. Every stock level was enumerated with the closed-form Poisson loss identity — the recommendation is computed, not searched, and the identity card below states what was verified on this run.



Interactive Plot

Service level against stock

- ① The points: one per stock level, 0 to 12 spares, each at its service level - the rows of the stock table.
- ② The point at 4 spares: 0.9041314, the first at or above 0.9.
- ③ The point at 3 spares: 0.7787229, below the target.

DEMAND MODEL

1 Expected demand μ = 2.4000000 (route: m·λ·H, exact)
2 exact — Poisson superposition of exponential components (μ = m·λ·H)

Demand model

- ① Expected demand μ = 2.4000000 (route: m·λ·H, exact): 4 pumps × 0.001 per hour × 600 hours.
- ② exact — Poisson superposition of exponential components (μ = m·λ·H): for a constant failure rate the Poisson demand is exact, not an approximation.

STOCK TABLE — S = 0..12 (FULL ENUMERATION)

1 The plot's points ARE these rows — same numbers, stated.

2 s	3 Service P(N ≤ s)	4 E[shortage]
0	0.0907180	2.4000000
1	0.3084410	1.4907180
2	0.5697087	0.7991590
5 3	0.7787229	0.3688677
6 4	0.9041314	0.1475907
5	0.9643275	0.0517221
6	0.9884059	0.0160496
7	0.9966614	0.0044555
8	0.9991380	0.0011169
9	0.9997985	0.0002549
10	0.9999570	0.0000533
11	0.9999915	0.0000103
12	0.9999985	0.0000018

Stock table — s = 0..12 (full enumeration)

- ① The plot's points ARE these rows — same numbers, stated.
- ② s: the number of spares held, 0 to 12.
- ③ Service P(N ≤ s): the probability that the campaign's failures do not exceed the stock.
- ④ E[shortage]: the expected number of failures that find no spare.
- ⑤ The row for 3 spares: 0.7787229 and 0.3688677.
- ⑥ The row for 4 spares: 0.9041314 and 0.1475907, the recommended stock.

IDENTITY CHECKS — ENGINE-ASSERTED ON THIS RUN

K3 (oracle cells) and K6 (D44b cross-module value route) are pytest-resident. The only non-exact element in this module is the named demand approximation itself — never an identity.

Id	Check	Status
1 K1	minimal stock: service(3) = 0.7787229 < 0.9 ≤ 0.9041314 = service(4)	holds
2 K2	demand mean by two routes — m·λ·H equals the renewal closed form, bitwise	holds
K4	service nondecreasing and E[shortage] strictly decreasing while positive, over the whole enumeration	holds
K5	loss-function telescope E[shortage](s) − E[shortage](s+1) = P(N > s) at every s (mechanism bound κ×ULP, κ = 8)	holds

Identity checks — engine-asserted on this run

- ① K1 minimal stock: service(3) = 0.7787229 < 0.9 ≤ 0.9041314 = service(4): three spares miss the target, four meet it.
- ② K2, K4, K5: the demand mean by two routes, the order of the table and the shortage arithmetic; each reads holds.

SPARE PARTS OPTIMIZATION — V1 SCOPE

1 Reorder points, continuous review, lead-time demand and multi-echelon stocking are named v2 — this run answers the single-period insurance-spares question.

Spare Parts Optimization — v1 scope

- ① Reorder points, continuous review, lead-time demand and multi-echelon stocking are named v2 — this run answers the single-period insurance-spares question.

Part 5 — How to interpret the results

How many seals to stock. Four. The fleet expects 2.4000000 seal failures in the campaign (4 pumps × 0.001 per hour × 600 hours), and four seals cover all of them with probability 0.9041314 - 90.41%, the first stock that reaches the 90% target. Three seals would cover them with probability 0.7787229 only.

What the fourth seal leaves open. On average 0.1475907 failures in the campaign still find no seal on the shelf. A fifth seal lowers that to 0.0517221 and raises the service level to 0.9643275: past the fourth seal each spare buys less. Read the stock table at the stock you can afford.

Why the number is exact here. For a constant failure rate the Poisson demand model is exact, not an approximation, so the demand card carries no small-fleet caution. For a component that wears out (Weibull, gamma, lognormal) the demand comes from the renewal function and the Poisson spread is an approximation: on a fleet of fewer than 10 machines, treat the stock one either side of s* as a judgement call.

When the price of a shortage matters more than a target. Run the Cost-optimal stock objective with the holding cost of a spare for the whole window and the cost of each failure without one, and compare its service level with what the plant accepts.

What the result is not. It is the opening stock for one window with no resupply. Reorder points, lead times and stocking across several stores are not calculated in version 1.0.0.