Warranty prediction — returns ahead, the reserve, bad batches and the warranty length

Menu: Life Data ▸ Warranty Prediction…

Part 1 — What the function does

What it calculates. A product ships every month and customers return failed units under warranty. Each month's production is a cohort, and its returns by month of service form one row of a shipment/return triangle. ReliaEn fits one life distribution to the whole triangle by interval-censored maximum likelihood, then forecasts each cohort's returns from its units still in the field: the fitted chance of failing in the next period, given survival to its current age.

What ReliaEn prints	What it tells you
Fitted life model with SE	The distribution the returns follow, here the Weibull β and η
Forecast next month with band, and the forecast table	How many returns to expect in each period ahead, and next month's split by cohort
Warranty reserve	The forecast times the cost per claim, with a cumulative column
Batch check	Whether any production month returns more than its band allows
Warranty length with bounds	How long a warranty can be for a target claim rate
Maturity and the **trust check**	How much of the fleet has failed so far, and whether 50 re-simulated triangles agree

From which data. The triangle on the worksheet: a shipments column, oldest cohort first, and the returns of the first service period in the next column, the later periods to its right. At least two cohorts and three returns in all.

When an engineer uses it. When a product is in the field under warranty, and the questions are how many returns to plan for, how much money to hold, whether a production month is bad, and how long a warranty can be offered.

When not to use it.

Situation	Use instead
Other distributions are to be fitted to the same triangle in a grouped analysis	Life Data ▸ Pre-Process Warranty Data… (chapter 2.19)
The exact age at failure of every returned unit is known	A Life Data ▸ Time Dependence analysis with exact times
Units are repaired and fail again many times	Life Data ▸ Repairable Fleet…

Part 2 — The example's input data

Setting. A household appliance has shipped for four months. A claim costs 250, and the product team wants claims held below 10 % of units sold. The reliability engineer wants next month's returns, the reserve for four months, and the warranty length that keeps the target.

Cohort	Shipped (column A)	Returns, months of service 1 to 4 (B to E)
1	1000	12, 18, 25, 30
2	1200	15, 22, 28
3	900	10, 17
4	1100	14

Input	Value
Return periods k / Life distribution	4 / Weibull
Periods ahead / Confidence %	4 / 95
Cost per claim / Target claim rate %	250 / 10
File in the worked-example zip	2-Warranty-Prediction/Example-1.csv — the triangle in columns A to E

	① A	② B	③ C	④ D	⑤ E	F
1	1000	12	18	25	30	
2	1200	15	22	28		
3	900	10	17			
4	1100	14				
5						

The example data in the worksheet

- ① Column A: the units shipped of each cohort, oldest first.
- ② Column B: the returns in the first month of service.
- ③ Column C: the second month; the newest cohort has none yet.
- ④ Column D: the third month.
- ⑤ Column E: the fourth month, the oldest cohort only.

Part 3 — How to use it, step by step

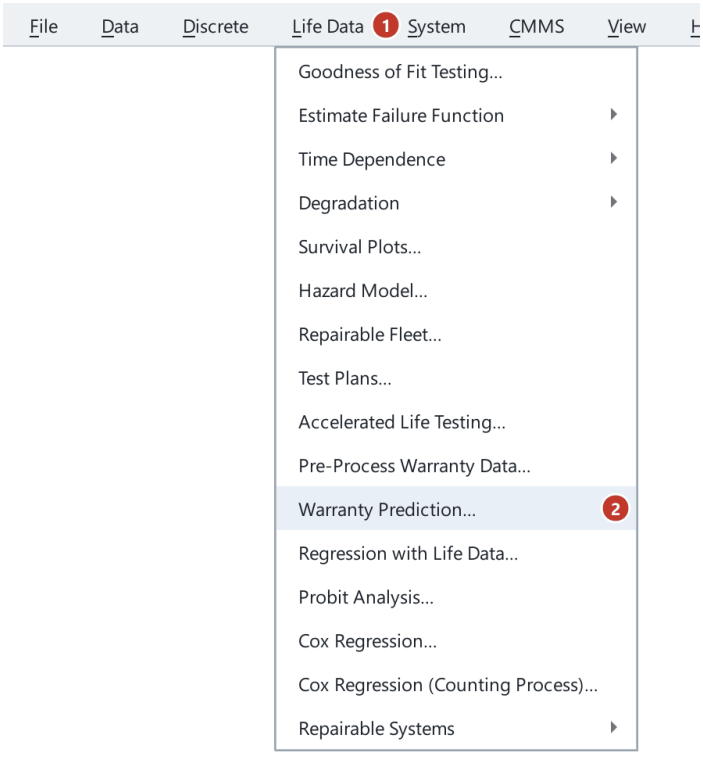
1. **Put the triangle in columns A to E.** Copy the 4 rows of Example-1.csv into columns A to E of the worksheet, starting at row 1: the shipments in column A, the returns of each month of service to their right.

	① A	② B	③ C	④ D	⑤ E	F
1	1000	12	18	25	30	
2	1200	15	22	28		
3	900	10	17			
4	1100	14				
5						

Step 1 — the triangle in columns A to E

- ① Column A: the units shipped of each cohort, oldest first - 1000, 1200, 900, 1100.
- ② Column B: the returns in the first month of service - 12, 15, 10, 14.
- ③ Column C: the second month - 18, 22, 17; the youngest cohort has no second month yet.
- ④ Column D: the third month - 25, 28.
- ⑤ Column E: the fourth month - 30, the oldest cohort only.

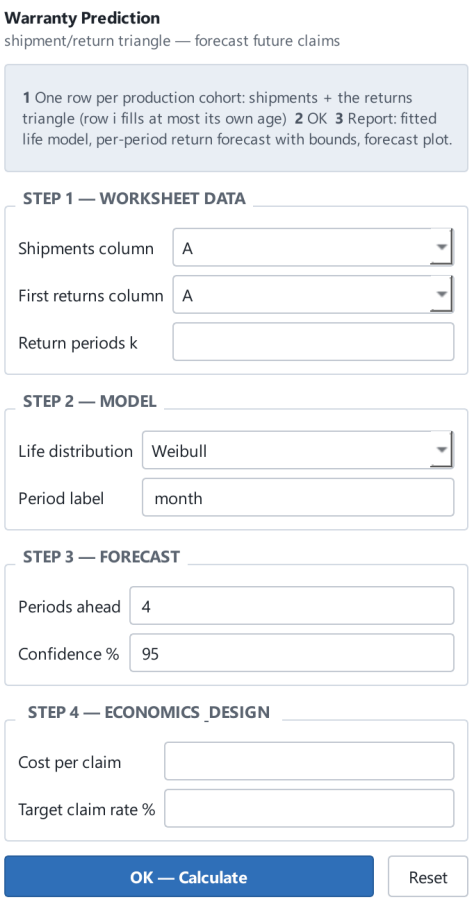
2. **Choose Life Data ▸ Warranty Prediction...** in the menu bar. The form Warranty Prediction opens in the left panel.



Step 2 — the menu path

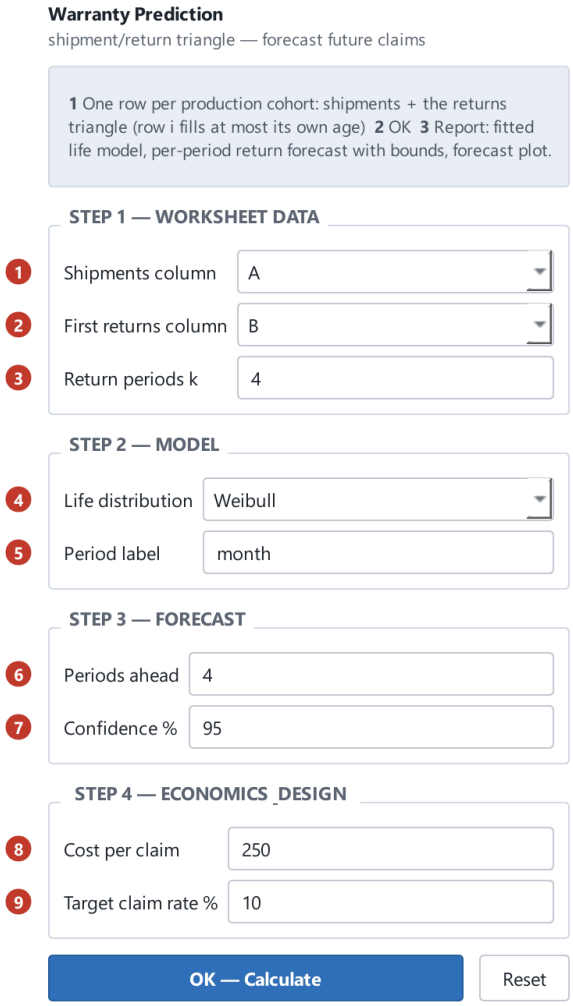
- ① Life Data: the menu.
- ② Warranty Prediction...: the entry to click.

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



Step 2 — the form as it opens

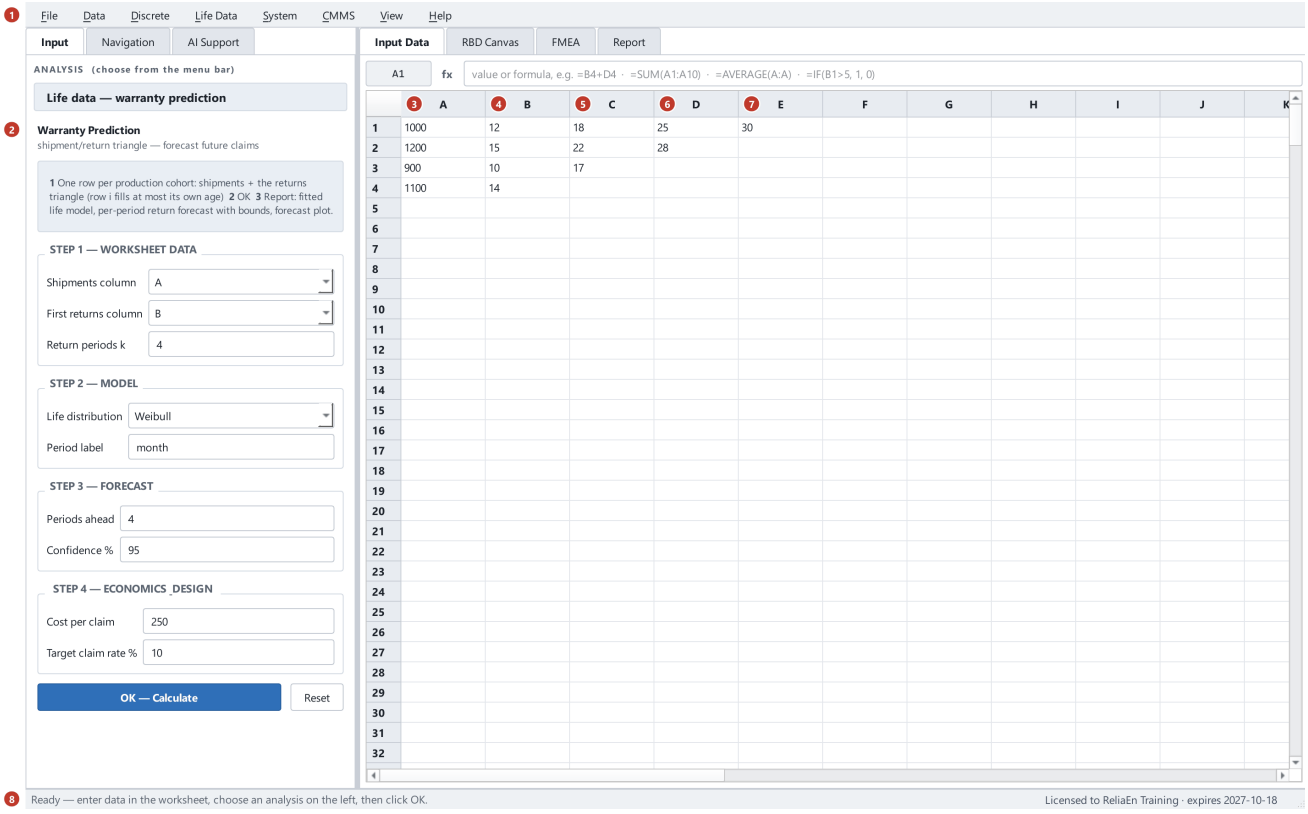
Steps 3 to 11 set or check the form's nine boxes, marked ① to ⑨ in the picture:



Steps 3 to 11 — the form set for this example

3. ① **Check that Shipments column reads A.**
4. ② **In First returns column, choose B.** The later months are read from the columns to its right.
5. ③ **In Return periods k, type 4.** The triangle has four months of service.
6. ④ **Check that Life distribution reads Weibull.**
7. ⑤ **Check that Period label reads month.** The report uses this word for every period.
8. ⑥ **Check that Periods ahead reads 4.**
9. ⑦ **Check that Confidence % reads 95.**
10. ⑧ **In Cost per claim, type 250.** It turns the forecast into the reserve.
11. ⑨ **In Target claim rate %, type 10.** It sets the warranty-length designer.

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



Step 12 — 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 3 to 11; OK — Calculate at its foot.
- ③ Column A: the shipments.
- ④ to ⑦ Columns B to E: the returns of months 1 to 4.
- ⑧ 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

Life Data — Warranty Prediction

```
2026-11-04 07:19:41
cohort forecast = N_field · [F(a+j) − F(a+j−1)] / R(a) ; interval-censored MLE
```

The report's head

- The title Life Data — Warranty Prediction, the date and time of the run, and the method in one line: cohort forecast = N_field · [F(a+j) − F(a+j−1)] / R(a); interval-censored MLE.

INPUT DATA

	Data	this worksheet — 4 cohorts, 191 returns, 4009 still in field
2	Life distribution	weibull
3	Forecast horizon	4 months ahead
4	Confidence	95%
5	Return periods	4

Input data

- ① Data this worksheet — 4 cohorts, 191 returns, 4009 still in field.
- ② Life distribution weibull.
- ③ Forecast horizon 4 months ahead.
- ④ Confidence 95%.
- ⑤ Return periods 4.

RESULTS

1	Fitted life model	Weibull β = 1.4405 (SE 0.1042), η = 21.85 months (SE 3.35)
2	Forecast next month	106.0 [85.0, 126.9]

Results

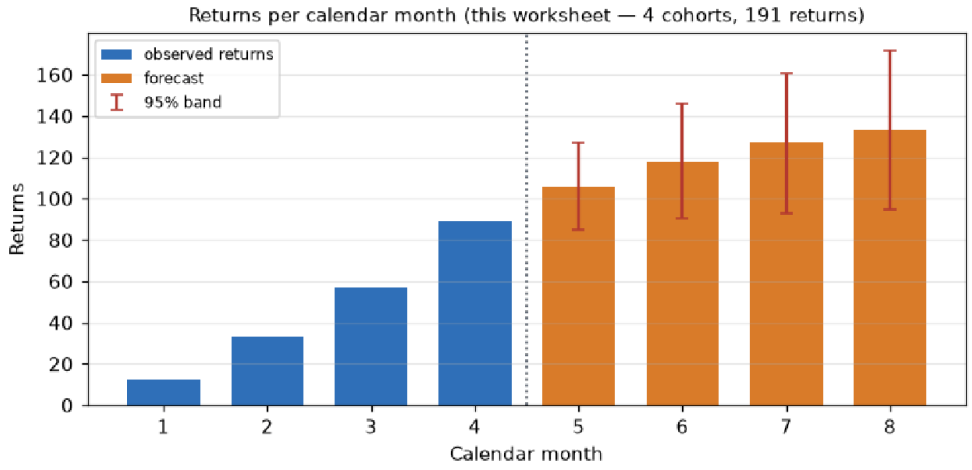
- ① Fitted life model Weibull β = 1.4405 (SE 0.1042), η = 21.85 months (SE 3.35).
- ② Forecast next month 106.0 [85.0, 126.9].

INTERPRETATION

1 Each production cohort ages one month per calendar month; its future returns are the fitted model's failure probability for its NEXT age slice, applied to the units it still has in the field. The triangle's youngest cohorts carry the least information — watch the young-triangle note when it appears.

Interpretation

- ① ReliaEn's reading: Each production cohort ages one month per calendar month; its future returns are the fitted model's failure probability for its NEXT age slice, applied to the units it still has in the field. The triangle's youngest cohorts carry the least information — watch the young-triangle note when it appears.



Interactive Plot

Returns per calendar month (this worksheet — 4 cohorts, 191 returns)

- Blue bars: the returns observed in calendar months 1 to 4 - 12, 33, 57 and 89, the triangle's diagonals. Orange bars with red whiskers: the forecast for months 5 to 8 with its 95% band.

TRIANGLE AS READ (THIS WORKSHEET — 4 COHORTS, 191 RETURNS, 4009 STILL IN FIELD)

1 Row i may fill at most its own age — the engine validated the triangle shape and the returns-vs-shipments budget before fitting.

2 Cohort	3 Shipped	4 Returns by service period	5 Age	6 Still in field
7 1	1000	12 / 18 / 25 / 30	4	915
8 2	1200	15 / 22 / 28	3	1135
9 3	900	10 / 17	2	873
10 4	1100	14	1	1086

Triangle as read (this worksheet — 4 cohorts, 191 returns, 4009 still in field)

- ① Row i may fill at most its own age — the engine validated the triangle shape and the returns-vs-shipments budget before fitting.
- ② to ⑥ The columns Cohort, Shipped, Returns by service period, Age, Still in field.
- ⑦ Cohort 1: 1000 shipped, 12 / 18 / 25 / 30, age 4, 915 still in field.
- ⑧ Cohort 2: 1200, 15 / 22 / 28, age 3, 1135.
- ⑨ Cohort 3: 900, 10 / 17, age 2, 873.
- ⑩ Cohort 4: 1100, 14, age 1, 1086.

RETURN FORECAST — NEXT 4 MONTHS (FLEET FIT)

1 Conditional on each cohort's survival to its current age; bands by the delta method on the fitted parameters.

2 Month ahead	3 Expected returns	4 95% band
5 +1	105.98	[85.03, 126.92]
6 +2	118.13	[90.15, 146.10]
7 +3	126.76	[92.90, 160.63]
8 +4	132.91	[94.40, 171.41]

Return forecast — next 4 months (fleet fit)

- ① Conditional on each cohort's survival to its current age; bands by the delta method on the fitted parameters.
- ② to ④ The columns Month ahead, Expected returns, 95% band.
- ⑤ +1: 105.98 [85.03, 126.92].
- ⑥ +2: 118.13 [90.15, 146.10].
- ⑦ +3: 126.76 [92.90, 160.63].
- ⑧ +4: 132.91 [94.40, 171.41].

NEXT-MONTH DETAIL BY COHORT (FLEET FIT)

1 The forecast's first row, split by cohort.

Cohort	Expected returns
2 1	29.57
3 2	32.89
4 3	21.84
5 4	21.68

Next-month detail by cohort (fleet fit)

- ① The forecast's first row, split by cohort.
- ② to ⑤ Cohorts 1 to 4: 29.57, 32.89, 21.84, 21.68 - together the 105.98 of month +1.

WARRANTY RESERVE — CURRENCY TO HOLD (FLEET FIT + COST PER CLAIM)

1 Forecast × cost per claim, band included — the number finance actually needs.

2 Month ahead	3 Expected cost	4 95% band	5 Cumulative reserve
6 +1	26,494	[21,259, 31,729]	26,494
7 +2	29,531	[22,538, 36,525]	56,025
8 +3	31,691	[23,224, 40,158]	87,716
9 +4	33,227	[23,600, 42,853]	120,943

Warranty reserve — currency to hold (fleet fit + cost per claim)

- ① Forecast × cost per claim, band included — the number finance actually needs.
- ② to ⑤ The columns Month ahead, Expected cost, 95% band, Cumulative reserve.
- ⑥ +1: 26,494 [21,259, 31,729], cumulative 26,494.
- ⑦ +2: 29,531 [22,538, 36,525], cumulative 56,025.
- ⑧ +3: 31,691 [23,224, 40,158], cumulative 87,716.
- ⑨ +4: 33,227 [23,600, 42,853], cumulative 120,943 - the reserve for the four months.

BATCH CHECK — DOES ANY PRODUCTION PERIOD MISBEHAVE? (THIS WORKSHEET)

1 Every cohort sits inside its band — no production period stands out.

2 Cohort	3 Observed	4 Expected	5 95% band	6 Ratio	7 Verdict
8 1	85	83.01	[66, 100]	1.02×	clean
9 2	65	66.78	[52, 83]	0.97×	clean
10 3	27	28.28	[19, 39]	0.95×	clean
11 4	14	12.87	[6, 20]	1.09×	clean

Batch check — does any production period misbehave? (this worksheet)

- ① Every cohort sits inside its band — no production period stands out.
- ② to ⑦ The columns Cohort, Observed, Expected, 95% band, Ratio, Verdict.
- ⑧ Cohort 1: 85 against 83.01 [66, 100], 1.02×, clean.
- ⑨ Cohort 2: 65 against 66.78 [52, 83], 0.97×, clean.
- ⑩ Cohort 3: 27 against 28.28 [19, 39], 0.95×, clean.
- ⑪ Cohort 4: 14 against 12.87 [6, 20], 1.09×, clean.

WARRANTY-LENGTH DESIGNER (FLEET FIT)

1 Claims stay under 10.0% for a warranty of 4.58 months [4.08, 5.15] — 100 claims per 1,000 units sold ≈ 25,000 per 1,000 units. Quote the LOWER bound if the warranty must hold with confidence.

Warranty-length designer (fleet fit)

- ① Claims stay under 10.0% for a warranty of 4.58 months [4.08, 5.15] — 100 claims per 1,000 units sold ≈ 25,000 per 1,000 units. Quote the LOWER bound if the warranty must hold with confidence.

HOW MATURE IS THIS TRIANGLE? (THIS WORKSHEET)

1 4.5% of the fleet has failed so far; the oldest cohort is 4 months old (model F = 8.3% there). Everything beyond that age is the fitted shape speaking, not data — expect the forecast to firm up as returns arrive.

How mature is this triangle? (this worksheet)

- ① 4.5% of the fleet has failed so far; the oldest cohort is 4 months old (model F = 8.3% there). Everything beyond that age is the fitted shape speaking, not data — expect the forecast to firm up as returns arrive.

TRUST CHECK — SEEDED SIMULATION (FLEET FIT)

1 50 re-simulated triangles put the next-month forecast between 91.7 and 128.1 (5–95%). The analytic 106.0 sits inside — the two routes agree.

Trust check — seeded simulation (fleet fit)

- ① 50 re-simulated triangles put the next-month forecast between 91.7 and 128.1 (5–95%). The analytic 106.0 sits inside — the two routes agree.

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The report's foot

- ① The licence line Licensed to ReliaEn Training · RL-2026-0017: the licence the report was made under.

Part 5 — How to interpret the results

What the returns follow. The Weibull fit gives β = 1.4405 and η = 21.85 months: the shape above 1 says the appliances wear out. So far 191 of 4,200 units have come back, 4.5 % of the fleet; the oldest cohort is 4 months old, where the model puts 8.3 % failed.

Returns ahead and the reserve. About 106 returns are expected next month (105.98, band 85.03 to 126.92), rising to 118.13, 126.76 and 132.91 in the three months after. Next month's returns split by cohort as 29.57, 32.89, 21.84 and 21.68. At 250 a claim the reserve for the four months is 120,943; use the band's upper ends if finance wants a cautious figure.

No bad batch. The cohorts returned 85, 65, 27 and 14 units against 83.01, 66.78, 28.28 and 12.87 expected; every one sits inside its band, so no production month needs investigating.

The warranty length. Claims stay under 10 % for a warranty of 4.58 months, bounds 4.08 to 5.15. To hold the target with confidence, offer no more than the lower bound, 4.08 months.

How far to trust it. With only 4.5 % failed, everything beyond four months of age is the fitted shape speaking, not data: repeat the analysis as new months arrive. Fifty re-simulated triangles put next month between 91.7 and 128.1, and the analytic 106.0 lies inside.