Non-constant failure rate — a mean life from a survivor table, without assuming a constant rate

Menu: Life Data ▸ Estimate Failure Function ▸ Non-constant rate (survivor regression)…

Part 1 — What the function does

What it calculates. A group of like units starts service together, and you count how many are still running at a series of times: a survivor table, time against the survivors Ns(t). ReliaEn fits one quadratic $Ns(t) = a \cdot t^2 + b \cdot t + c$ to the table by least squares and turns it into a mean life (the MTBF of one unit of the group) and a reliability, without assuming that the failure rate is constant. It takes two routes through the same curve: Methods 1/2 integrate the fitted reliability $R(t) = Ns(t) / N_0$; Method 3 derives the failure rate $\lambda(t) = Nf'(t) / Ns(t)$ and integrates $e^{-\int \lambda}$.

What ReliaEn prints	What it tells you
Ns(t) quadratic and **Regression R^2**	The fitted curve, and how closely it follows the table (1 is a perfect fit; below 0.6 a caution card)
MTBF — Methods 1/2 and **MTBF — Method 3**	The mean life by the two routes; on a good fit they are close
R at the target time by both routes (when asked for)	The share of units still running at a planning time
Integration range	The time up to which the quadratic is used: where the fitted survivor count reaches zero
The reliability plot and the failure-rate plot	The data against both curves, and whether λ(t) rises (wear-out) or falls

From which data. Two worksheet columns: the times, starting at 0, and the number of units still running at each, never negative and never rising. At least four rows. The group size N_0 is the largest count unless you type it.

When an engineer uses it. When only counts of survivors are kept - a batch fitted in one shutdown, counted at each inspection - and the failure rate may change with age, so a constant-rate MTBF would mislead.

When not to use it.

Situation	Use instead
The failure time of each unit is known	Life Data ▸ Time Dependence ▸ Exponential distribution… (it builds the survivor table from the times) or Weibull (2P) distribution… (chapter 2.6)
A fitted life distribution with confidence bounds is wanted	Life Data ▸ Time Dependence ▸ Weibull (2P) distribution… (chapter 2.6)
One machine is repaired again and again	Life Data ▸ Estimate Failure Function ▸ Repairable unit data… (chapter 3.1)

Part 2 — The example's input data

Setting. Forty conveyor idlers were fitted in one shutdown and counted every 100 hours. The planner wants their mean life and the reliability at 350 hours, the next planned stop.

Time, hours	0	100	200	300	400	500	600	700
Ns, idlers running	40	39	36	31	24	16	8	1

Input	Value
Integration step Δt	2
R at target time (optional)	350
N0 (blank = max Ns)	blank: the largest count, 40
File in the worked-example zip	3-Non-Constant-Rate/Example-2.csv — columns Time and Ns, 8 rows

	① A	② B	C
1	0	40	
2	100	39	
3	200	36	
4	300	31	
5	400	24	
6	500	16	
7	600	8	
8	700	1	
9			

The example data in the worksheet

- ① Column A: the 8 count times, 0 to 700 hours.
- ② Column B: the idlers still running at each, 40 down to 1.

Part 3 — How to use it, step by step

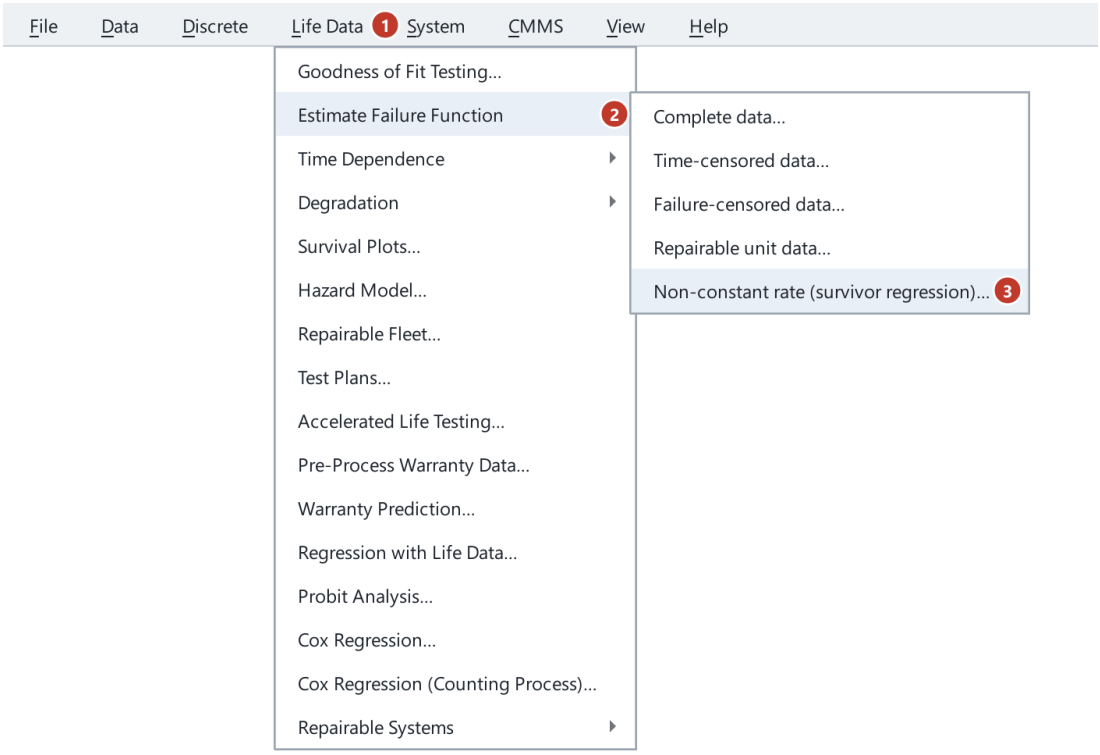
1. **Put the survivor table in columns A and B.** Copy the 8 rows of Example-2.csv - its columns Time and Ns - into columns A and B of the worksheet, starting at row 1.

	① A	② B	C
1	0	40	
2	100	39	
3	200	36	
4	300	31	
5	400	24	
6	500	16	
7	600	8	
8	700	1	
9			

Step 1 — the survivor table in columns A and B

- ① Column A: the count times, 0 to 700 hours.
- ② Column B: the idlers still running, 40 down to 1.

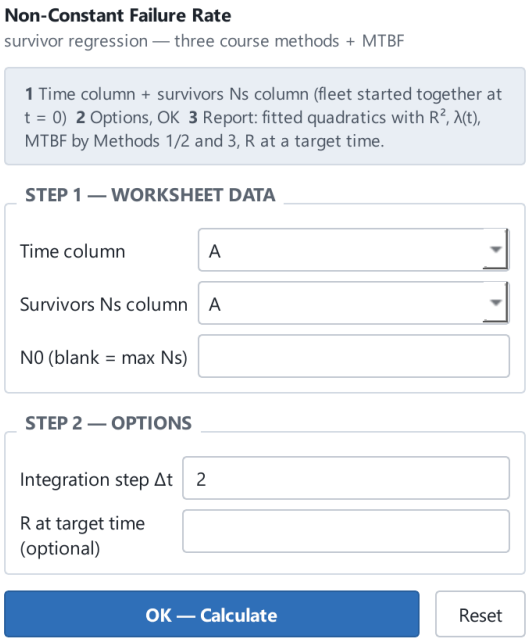
2. **Choose Life Data ▸ Estimate Failure Function ▸ Non-constant rate (survivor regression)...** in the menu bar. The form Non-Constant Failure Rate opens in the left panel.



Step 2 — the menu path

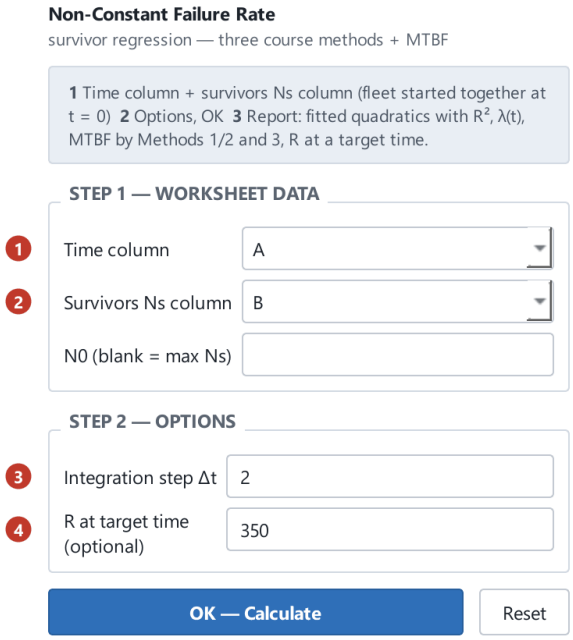
- ① Life Data: the menu.
- ② Estimate Failure Function: the submenu.
- ③ Non-constant rate (survivor regression)...: the entry to click.

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



Step 2 — the form as it opens

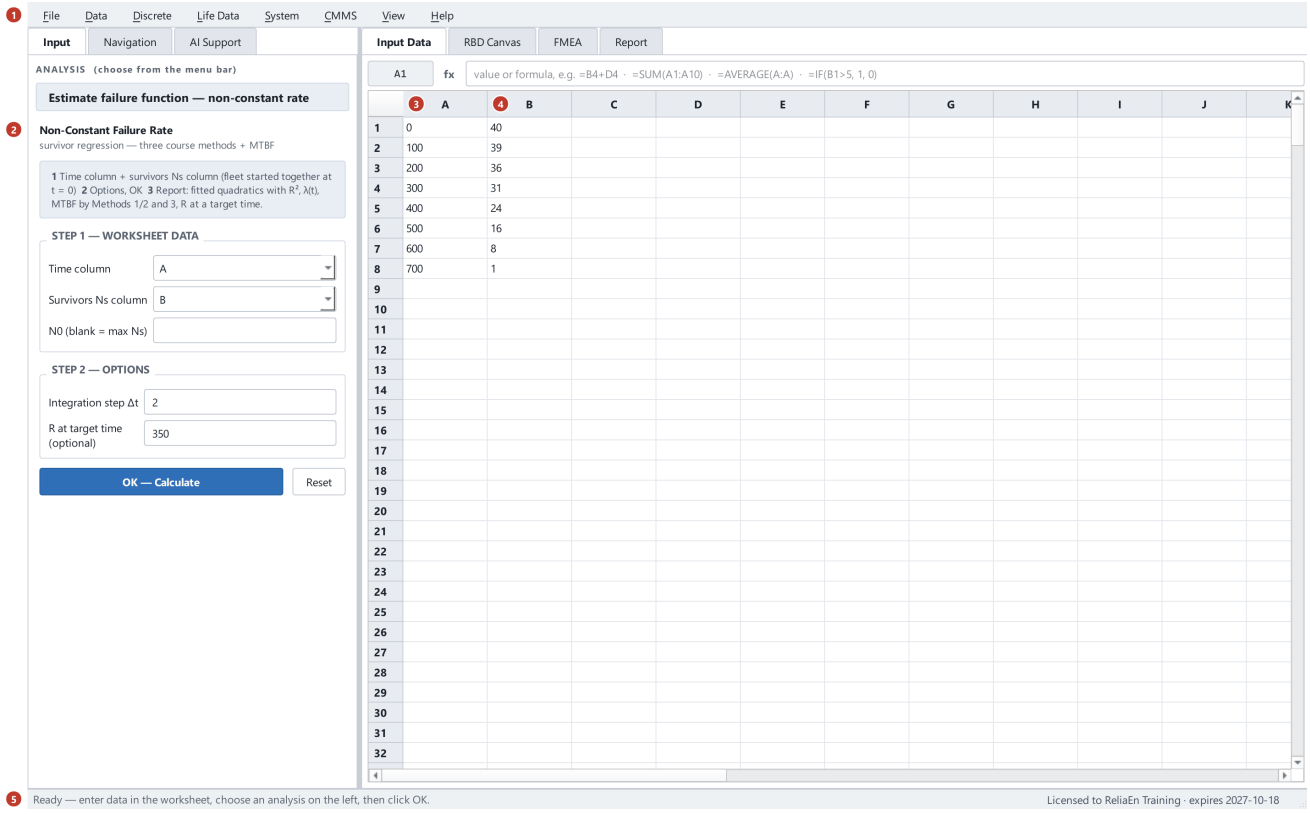
Steps 3 to 6 set or check the form's four boxes, marked ① to ④ in the picture:



Steps 3 to 6 — the form set for this example

3. ① **Check that Time column reads A.**
4. ② **In Survivors Ns column, choose B.**
5. ③ **Check that Integration step Δt reads 2.**
6. ④ **In R at target time (optional), type 350.** The next planned stop. N0 (blank = max Ns) stays blank: the largest count, 40, is the group size.

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



Step 7 — 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 6; OK — Calculate at its foot.
- ③ Column A: the count times.
- ④ Column B: the survivor counts.
- ⑤ 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 — Non-Constant Failure Rate (Survivor Regression)

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$R(t) = Ns(t)/N_0$; $\lambda(t) = Nf'(t)/Ns(t)$; Method 3 uses the general model $R(t) = e^{-\int\lambda(u)du}$; MTBF = $\int_0 R(t)\,dt$

The report's head

- The title Life Data — Non-Constant Failure Rate (Survivor Regression), the date and time of the run, and the model in one line: R(t) = Ns(t)/N₀; λ(t) = Nf′(t)/Ns(t); Method 3 uses the general model R(t) = e^(−∫λ(u)du); MTBF = ∫₀ R(t) dt.

INPUT DATA

1	Data rows	8
2	N_0 — fleet size	40
3	Integration step Δt	2
4	Integration range	0 – 696 (fitted Ns → 0)

Input data

- ① Data rows 8.
- ② N_0 — fleet size 40: the forty idlers.
- ③ Integration step Δt 2.
- ④ Integration range 0 – 696 (fitted Ns → 0).

RESULTS

1	Ns(t) quadratic	-0.0000577·t² -0.018512·t +40.958333
2	Regression R^2	0.99515
3	MTBF — Methods 1/2 (∫R dt)	437.79
4	MTBF — Method 3 (∫e^(−∫λ) dt)	428.10
5	R(350) — Methods 1/2 (survivor regression)	0.6852
6	R(350) — Method 3 (hazard path)	0.6691

Results

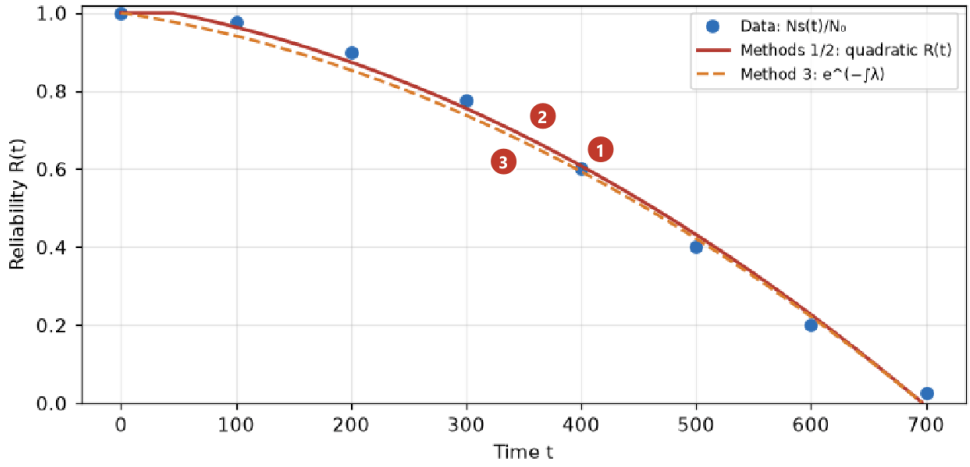
- ① Ns(t) quadratic -0.0000577·t² -0.018512·t +40.958333.
- ② Regression R^2 0.99515.
- ③ MTBF — Methods 1/2 (∫R dt) 437.79.
- ④ MTBF — Method 3 (∫e^(−∫λ) dt) 428.10.
- ⑤ R(350) — Methods 1/2 (survivor regression) 0.6852.
- ⑥ R(350) — Method 3 (hazard path) 0.6691: the more cautious of the two.

INTERPRETATION

1 The survivor table is regressed quadratically (course Methods 1/2 integrate the fitted R(t); Method 3 derives λ(t) = Nf′/Ns and integrates e^(−∫λ)). A rising λ(t) means Zone C wear-out — the constant-rate MTBF would be misleading. The three methods agree at MTBF ≈ 437.8–428.1; quadratic extrapolation is only valid up to t = 696 where the fitted survivor curve reaches zero.

Interpretation

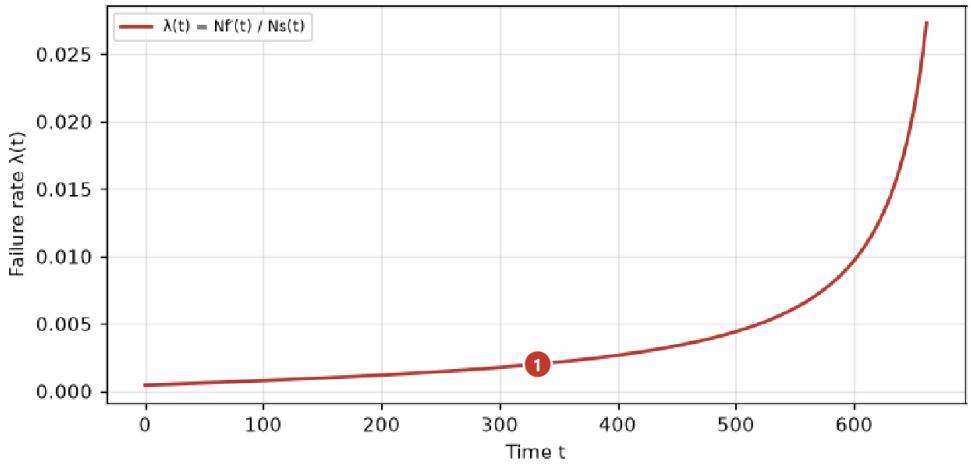
- ① ReliaEn's reading: The survivor table is regressed quadratically (course Methods 1/2 integrate the fitted R(t); Method 3 derives λ(t) = Nf′/Ns and integrates e^(−∫λ)). A rising λ(t) means Zone C wear-out — the constant-rate MTBF would be misleading. The three methods agree at MTBF ≈ 437.8–428.1; quadratic extrapolation is only valid up to t = 696 where the fitted survivor curve reaches zero.



Interactive Plot

Reliability R(t) against time

- ① Data: Ns(t)/N_0: the eight counts as fractions of 40.
- ② Methods 1/2: quadratic R(t): flat at 1 for about the first 45 hours - the fitted count starts at 40.96, above N_0, and R is capped at 1 - then falling to 0 at 696.
- ③ Method 3: e^(− ∫λ): just below it.



Interactive Plot

Failure rate λ(t) against time

- ① λ(t) = Nf'(t) / Ns(t): rising slowly, then steeply as the fitted count nears zero - wear-out.

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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

The fit. The quadratic is $Ns(t) = -0.0000577 \cdot t^2 - 0.018512 \cdot t + 40.958333$ with $R^2 = 0.99515$: it follows the counts closely. The negative t^2 term means the count falls faster and faster - the idlers wear out, and the failure-rate plot rises. The fitted count reaches zero at 696 hours, so the quadratic is used from 0 to 696 and not beyond.

The mean life. Methods 1/2 give an MTBF of 437.79 hours, Method 3 gives 428.10. The two routes agree within about 2 %, which is what a good fit looks like; a large gap would mean the quadratic describes the tail poorly.

The planned stop. At 350 hours the reliability is 0.6852 by Methods 1/2 and 0.6691 by Method 3: about two idlers in three still run. Plan the stop with the more cautious 0.6691 and stock replacements for the other third, about 13 of the 40.

How far to trust it. The answer rests on one quadratic through eight counts. Read Regression R^2 first, and look for a caution card: a curve that never reaches zero, or a target time beyond the integration range, gets one, and then the caution card is the one to believe.