Weibull analyse aan klanten retouren van de eerste generatie ***Produkt X***

bepaling van de “failure rate in time”

Boudewijn Jacobs CRE

PLOT WG Reliability 27 Juni 2019

$$\text{Failure Rate} = \frac{\text{Number of failures in time interval } (t \rightarrow t + \Delta t)}{\text{Time interval} * \text{Number of operational systems at time } t}$$

We have monitored the time to failure (hours) of 50 products in the field. Failures are not repaired

Time to Failure [h]	# of failures
1 - 40	8
41 – 80	11
81 – 120	14
121 – 160	10
161 – 200	4
201 – 240	2
241 - 280	1

Question:

Calculate the Failure Rate (/hr) for every time period

FHI PLATFORM OMGEVINGSTECHNOLOGIE

Oplossing

$$\text{Failure Rate} = \frac{\text{Number of failures in time interval } (t \rightarrow t + \Delta t)}{\text{Time interval} * \text{Number of operational systems at time } t}$$

$$\lambda(t) = \frac{1}{\Delta t} \cdot \frac{n_{systems}(t) - n_{systems}(t+\Delta t)}{n_{systems}(t)}$$

Time period (hours)	Number of failures	Failure rate
1 - 40	8	
41 - 80	11	
81 - 120	8	
121 - 160	4	
161 - 200	2	
201 - 240	1	
241 - 280	2	

$\frac{1}{40} \cdot \frac{8}{50}$

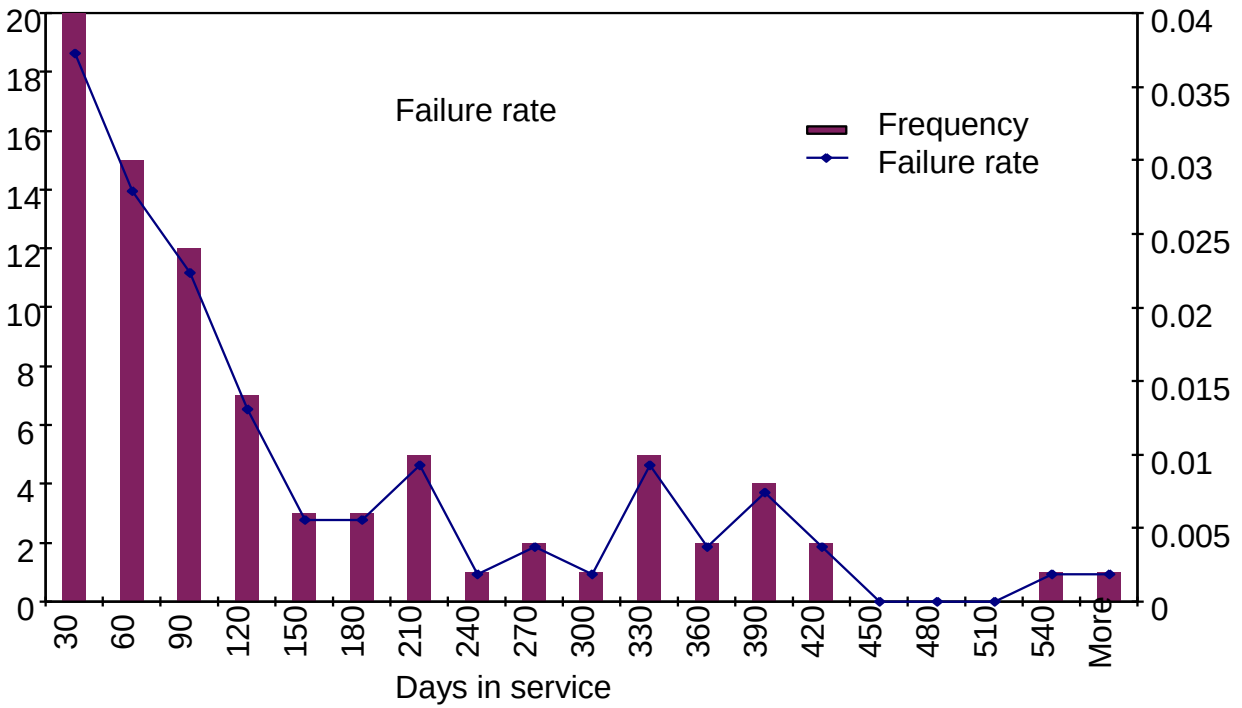
$\frac{1}{40} \cdot \frac{11}{42}$

$\frac{1}{40} \cdot \frac{8}{31}$

$\frac{1}{40} \cdot \frac{4}{23}$

Etcetera

.....



FHI PLATFORM OMGEVINGSTECHNOLOGIE

Constant failure rate

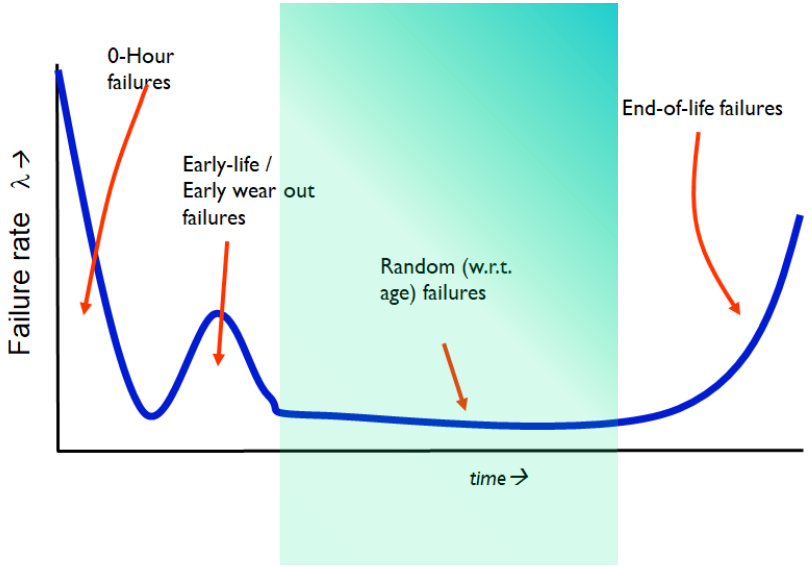
Failure Rate $\lambda(t) = \lambda_c = \text{constant}$

by definition: $\frac{dR(t)}{d(t)} = -\lambda_c R(t)$, so:

Reliability $R(t) = e^{-\lambda_c t}$

Failure Probability $F(t) = 1 - e^{-\lambda_c t}$

Mean Time Between Failures $MTBF = \frac{1}{\lambda_c}$



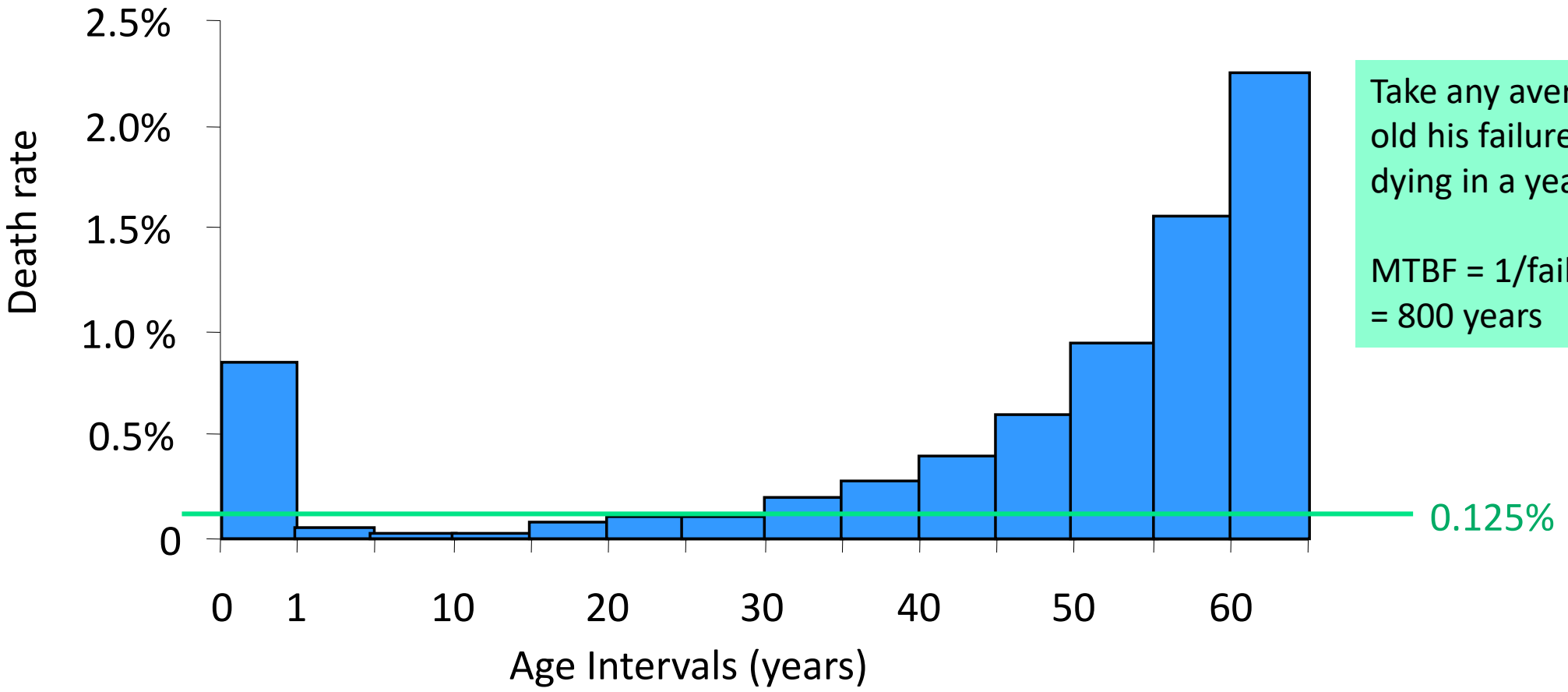
The term MTBF is only used

in the case of Constant Failure Rate !

Note that MTBF ≠ Life time

signify

The Bathtub Curve; USA 1990 Death Rate



Take any average 25 year human old his failure rate (likelihood of dying in a year) is about 0.125%.

MTBF = 1/failure rate = 1/0.125% = 800 years

Evaluate field return rate of ***product X***

Estimate probability of failure

Case number	SBJ Handling Category	SBJ Handlir	SBJ Creation D	Amou	CAG Code	Company n	Country		PL Handling	Production Date	Report Date	Week	Week_Re
PHL-161011-0346 /3	Queues afwerken	1	24/01/2017	1	845515	-	Netherland	-	Other	-	11-10-16	41	1641
PHL-161011-0346 /4	Product Handling (w/o test)	1	24/01/2017	1	845515	-	Netherland	Hum / Nois	Other	-	11-10-16	41	1641
PHL-161011-0346 /5	Queues afwerken	1	14/02/2017	1	845515	-	Netherland	-	Other	-	11-10-16	41	1641
PHL-161011-0346 /6	Product Handling (w/o test)	1	14/04/2017	1	845515	-	Netherland	Hum / Nois	Other	-	11-10-16	41	1641
PHL-161011-0346 /7	Queues afwerken	1	04/05/2017	1	845515	-	Netherland	-	Other	-	11-10-16	41	1641
PHL-161011-0346 /8	Product Handling (w/o test)	1	17/05/2017	1	845515	-	Netherland	Hum / Nois	Other	-	11-10-16	41	1641
PHL-161018-0478	Product Handling (w/o test)	1	17/02/2017	1	845515	-	Great Brita	Collected fa	Research	-	18-10-16	42	1642
PHL-161018-0478 /10	Queues afwerken	1	03/05/2017	1	845515	-	Great Brita	-	Research	-	18-10-16	42	1642
PHL-161018-0478 /11	Product Handling (w/o test)	1	04/05/2017	1	845515	-	Great Brita	Collected fa	Research	-	18-10-16	42	1642
PHL-161018-0478 /12	Queues afwerken	1	16/05/2017	1	845515	-	Great Brita	-	Research	-	18-10-16	42	1642
PHL-161018-0478 /4	Product Handling (w/o test)	1	17/01/2017	1	845515	-	Great Brita	Collected fa	Research	-	18-10-16	42	1642
PHL-161018-0478 /5	Queues afwerken	1	24/01/2017	1	845515	-	Great Brita	-	Research	-	18-10-16	42	1642
PHL-161018-0478 /6	Queues afwerken	1	06/03/2017	1	845515	-	Great Brita	-	Research	-	18-10-16	42	1642
PHL-161018-0478 /7	Product Handling (w/o test)	1	07/03/2017	1	845515	-	Great Brita	Collected fa	Research	-	18-10-16	42	1642
PHL-161018-0478 /8	Queues afwerken	1	10/03/2017	1	845515	-	Great Brita	-	Research	-	18-10-16	42	1642
PHL-161018-0478 /9	Product Handling (w/o test)	1	14/04/2017	1	845515	-	Great Brita	Collected fa	Research	-	18-10-16	42	1642
PHL-161019-0527	Queues afwerken	1	13/04/2017	1	845515	Mullenlow	Great Brita	-	Dispatch	16032/1/1	19-10-16	42	1642
PHL-161019-0527 /2	Product Handling (w/o test)	1	26/04/2017	1	845515	Mullenlow	Great Brita	Electrical va	Dispatch	16032/1/1	19-10-16	42	1642
PHL-161021-0179 /10	Queues afwerken	1	17/01/2017	2	845515	-	Great Brita	-	Other	16345/2/1	21-10-16	42	1642
PHL-161021-0179 /7	Queues afwerken	1	04/01/2017	2	845515	-	Great Brita	-	Other	16345/2/1	21-10-16	42	1642
PHL-161021-0179 /8	Product Handling (w/o test)	1	06/01/2017	2	845515	-	Great Brita	Functionali	Other	16345/2/1	21-10-16	42	1642
PHL-161021-0179 /9	Product Handling (w/o test)	1	19/01/2017	2	845515	-	Great Brita	Functionali	Other	16345/2/1	21-10-16	42	1642

FHI PLATFORM OMGEVINGSTECHNOLOGIE

Observations:

Field return data are for EMEA region only

There is no information on the exact moment of installation, therefore:

Time To Failure = Report date – Production date

Note: In a 3p-Weibull distribution, the “failure free period ɣ ” will probably give information on the average time between production and installation of the product at the customer

FHI PLATFORM OMGEVINGSTECHNOLOGIE

$$\text{Failure Rate} = \frac{\text{Number of failures in time interval } (t \rightarrow t + \Delta t)}{\text{Time interval} * \text{Number of operational systems at time } t}$$

In order to estimate the failure rate distribution for ***product X***, the following information is needed:

- Total production / sales numbers to determine the number of surviving products in the field (“suspensions” or “right censored datapoints”)

- Distribution of sales of EMEA towards global sales in order to be able to project the failure rate to the total population of products in the field

FHI PLATFORM OMGEVINGSTECHNOLOGIE

Production / sales numbers per production date:

wk12	3.14	EU/UK	2M	F3-031-00086C01	915005106701	840	8120
		EU/UK	1M	F3-031-00085C01	915005108901	900	
	3.15	EU/UK	2M	F3-031-00086C01	915005106701	420	
		US	2M	F3-031-00089C01	915005109101	400	
		EU/UK	1M	F3-031-00085C01	915005108901	900	
	3.16	US	2M	F3-031-00089C01	915005109101	940	
		EU/UK	1M	F3-031-00085C01	915005108901	750	
	3.17	US	2M	F3-031-00089C01	915005109101	1020	
		EU/UK	1M	F3-031-00085C01	915005108901	750	
	3.18	US	2M	F3-031-00089C01	915005109101	1200	
wk13	3.21	US	2M	F3-031-00089C01	915005109101	1320	8076
		EU/UK	1M	F3-031-00085C01	915005108901	420	
	3.22	US	2M	F3-031-00089C01	915005109101	948	
		EU/UK	2M	F3-031-00086C01	915005106701	450	
	3.23	EU/UK	2M	F3-031-00086C01	915005106701	1200	
		EU/UK	1M	F3-031-00085C01	915005108901	1020	
	3.24	EU/UK	2M	F3-031-00086C01	915005106701	1050	
		EU/UK	1M	F3-031-00085C01	915005108901	1668	

Production numbers are globally.

For EU/UK we need to know the percentage

to correct the failure rate.

Production numbers for ***product X*** for EU/UK = **33.6%** for total production numbers for Hue Strip globally.

EU/UK	2M	149065	33.6%
EU/UK	1M	107898	24.3%
US	2M	90807	20.5%
US	1M	51587	11.6%
several		44353	10.0%

We concentrate on the useful information in the field return file.

From the 3066 records only 1482 contain production date information. It seems that only data after ”reported” 2016 production date are trustful. 159 records are filed with production dates before 2016, even to 2013 for ***product X*** which were not being produced at that time. These will not be taken into account for the Weibull analysis.

In this investigation by taking only the light strips with mention of production date information, the total failures for ***product X*** are assumed to be (3066) / 1482 = approximately **2 times** higher.

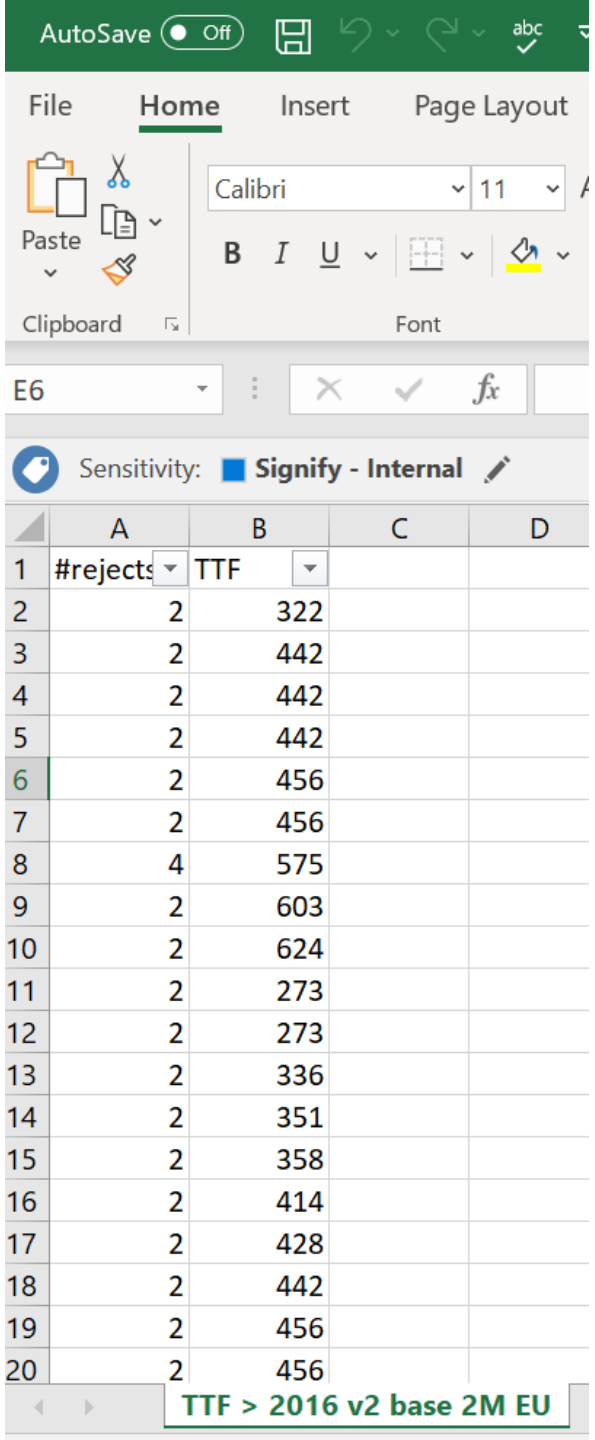
Preparation of input file

For Minitab or Reliasoft to determine the Weibull distribution the following information should be prepared:

1. # failures including Time To Failure
2. # suspension including Time of Operation

Ad 1: # failures can be derived from the field return info. Since we only take ***product X*** > 2016 for EU/UK into account which contain production date codes, we need the correct the # failures by multiplying them with a factor of 2. Refer to sheet 8. The time to failure is determined by decoding the production date code and determining the numbers of days until the failure(s) have been reported.

Ad 2: # suspensions have been determined by taking the total production numbers divided by 3, representing the number of produced ***product X*** for EU/UK.



AutoSave Off

File Home Insert Page Layout

Paste Calibri 11 B I U

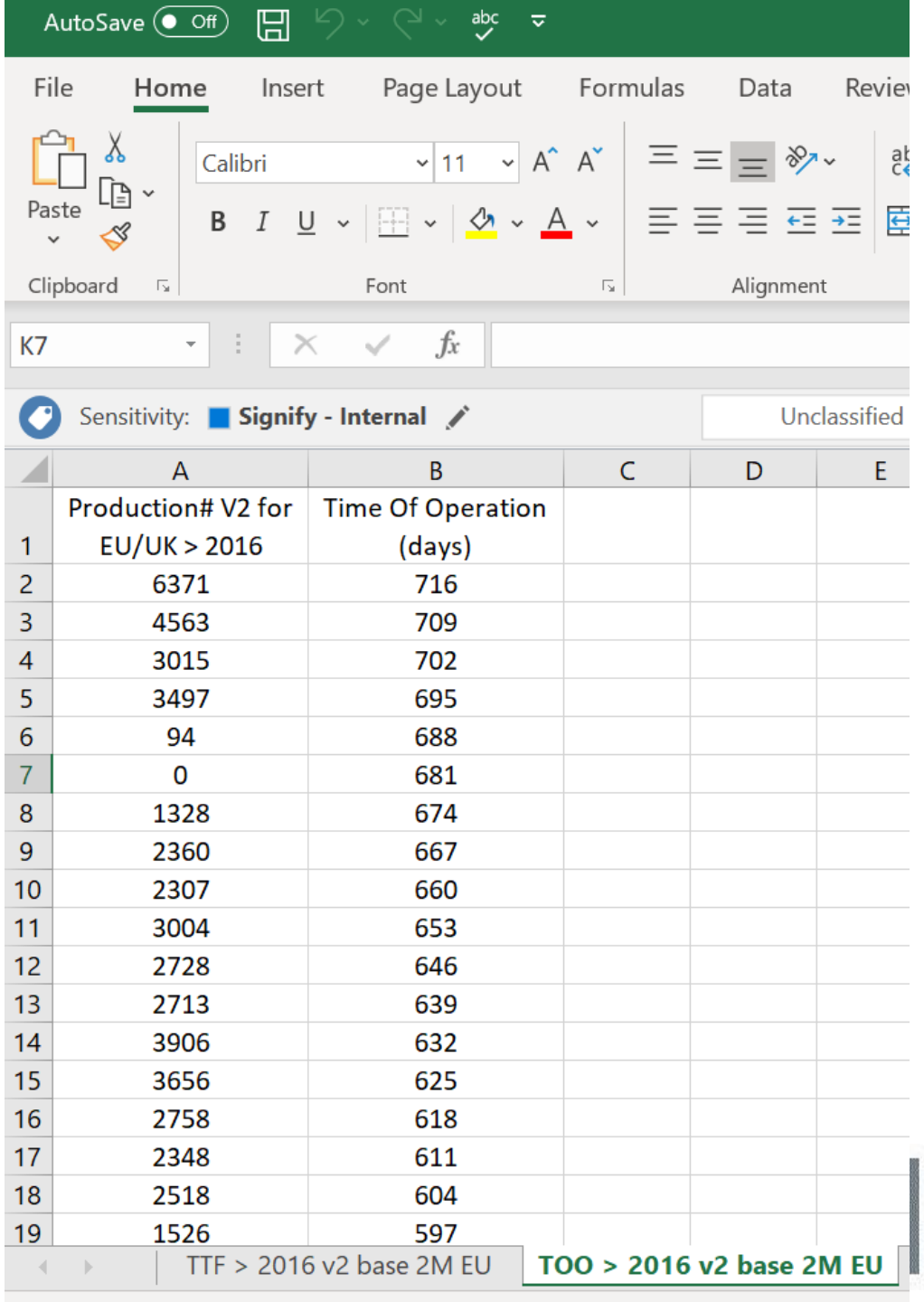
Clipboard Font

E6

Sensitivity: Signify - Internal

	A	B	C	D
1	#rejects	TTF		
2	2	322		
3	2	442		
4	2	442		
5	2	442		
6	2	456		
7	2	456		
8	4	575		
9	2	603		
10	2	624		
11	2	273		
12	2	273		
13	2	336		
14	2	351		
15	2	358		
16	2	414		
17	2	428		
18	2	442		
19	2	456		
20	2	456		

TTF > 2016 v2 base 2M EU



AutoSave Off

File Home Insert Page Layout Formulas Data Revie

Paste Calibri 11 B I U A

Clipboard Font Alignment

K7

Sensitivity: Signify - Internal Unclassified

	A	B	C	D	E
1	Production# V2 for EU/UK > 2016	Time Of Operation (days)			
2	6371	716			
3	4563	709			
4	3015	702			
5	3497	695			
6	94	688			
7	0	681			
8	1328	674			
9	2360	667			
10	2307	660			
11	3004	653			
12	2728	646			
13	2713	639			
14	3906	632			
15	3656	625			
16	2758	618			
17	2348	611			
18	2518	604			
19	1526	597			

TTF > 2016 v2 base 2M EU TOO > 2016 v2 base 2M EU

PLATFORM OMGEVINGSTECHNOLOGIE

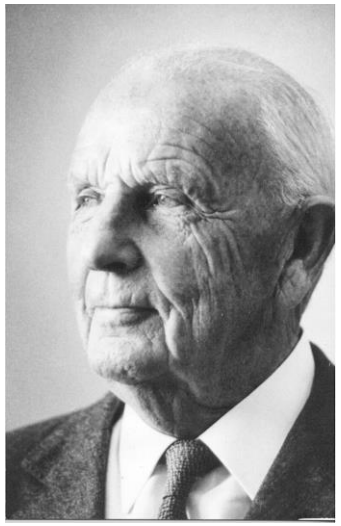
Weibull distribution

Weibull probability density function

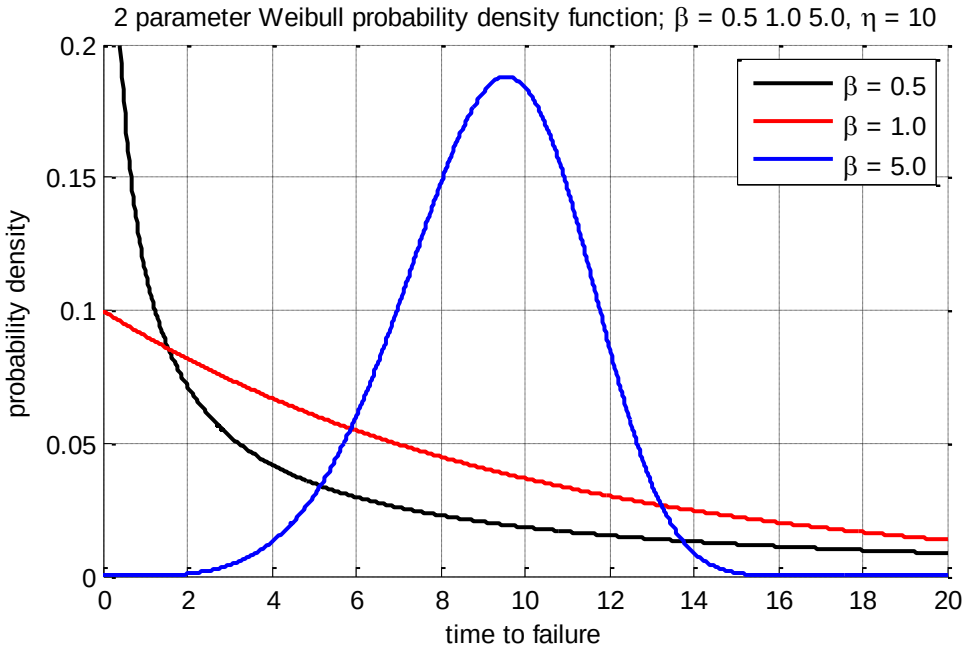
$$F(t) = 1 - e^{-(t/\lambda)^{\beta}}$$

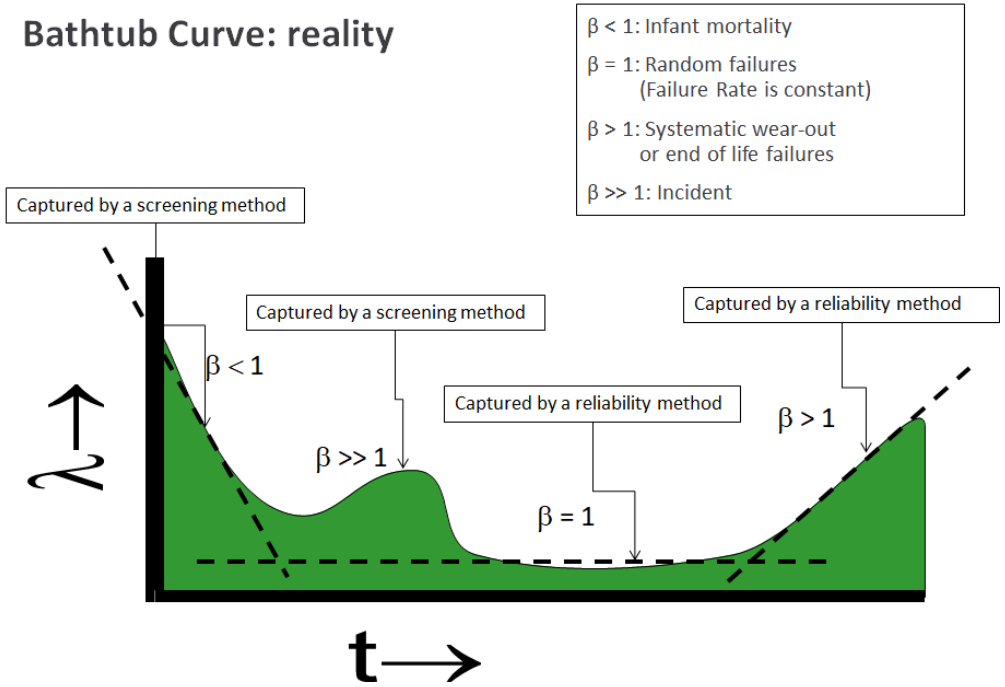
In 1937 Waloddi Weibull invented the Weibull distribution. He claimed that his distribution applied to a wide range of problems and could sometimes render good service. His idea was to allow the data to select the distribution and fit the parameters of that distribution.

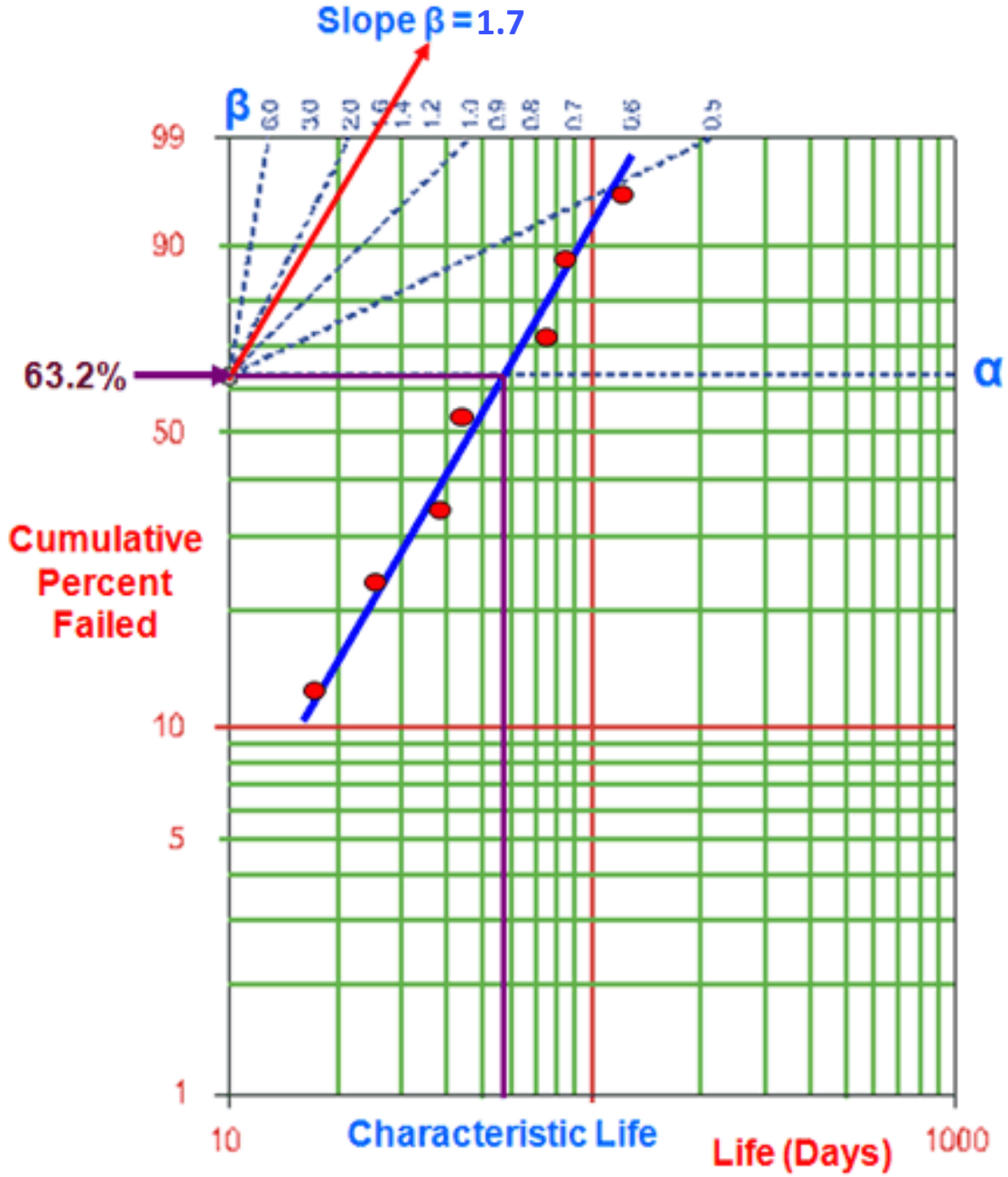
Waloddi Weibull defined the very flexible (2- or 3 parameter) Weibull probability density function (PDF)

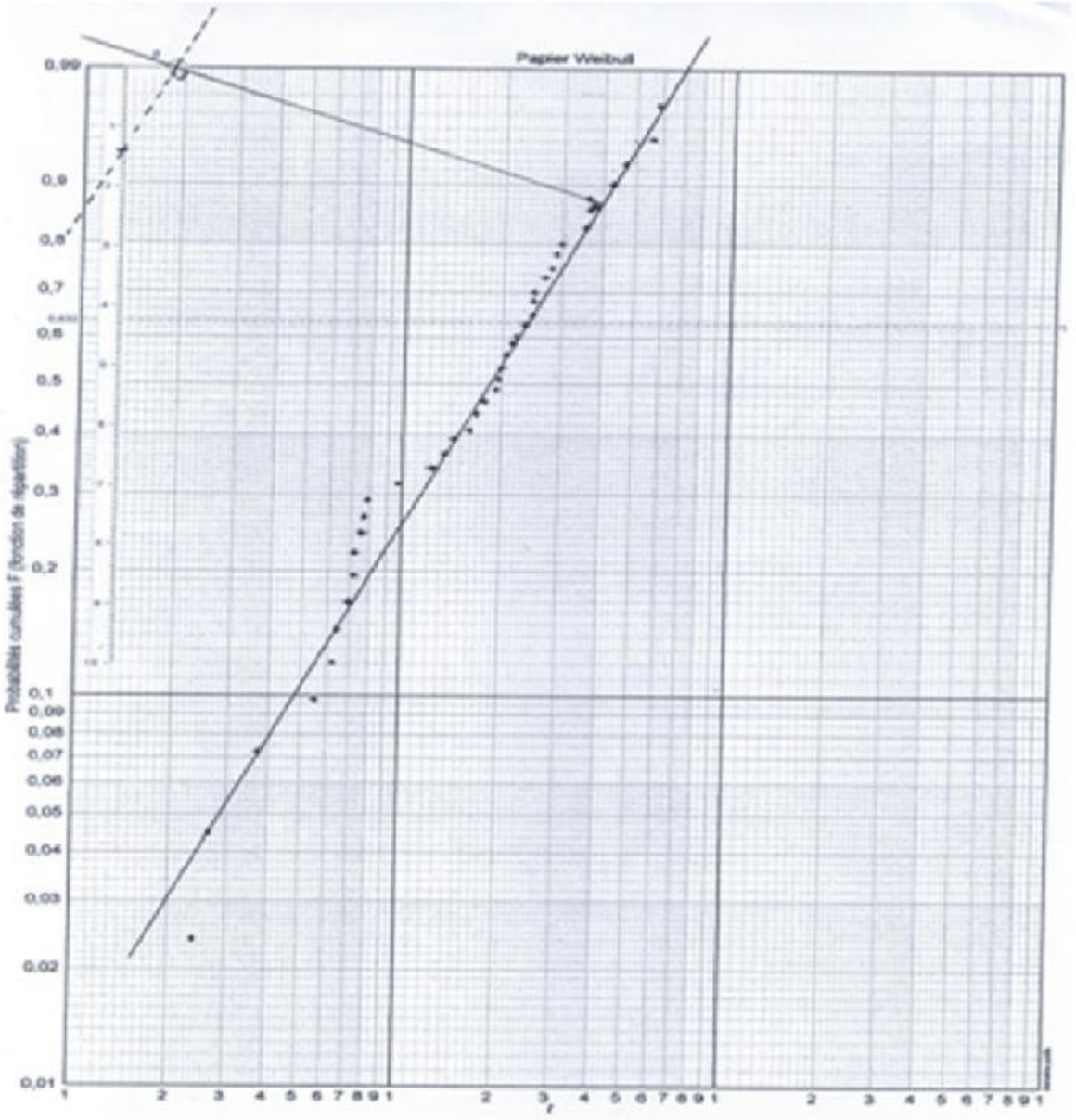


Waloddi Weibull 1887 - 1979









$$\widehat{F} = \frac{i - 0.3}{n + 0.4}$$

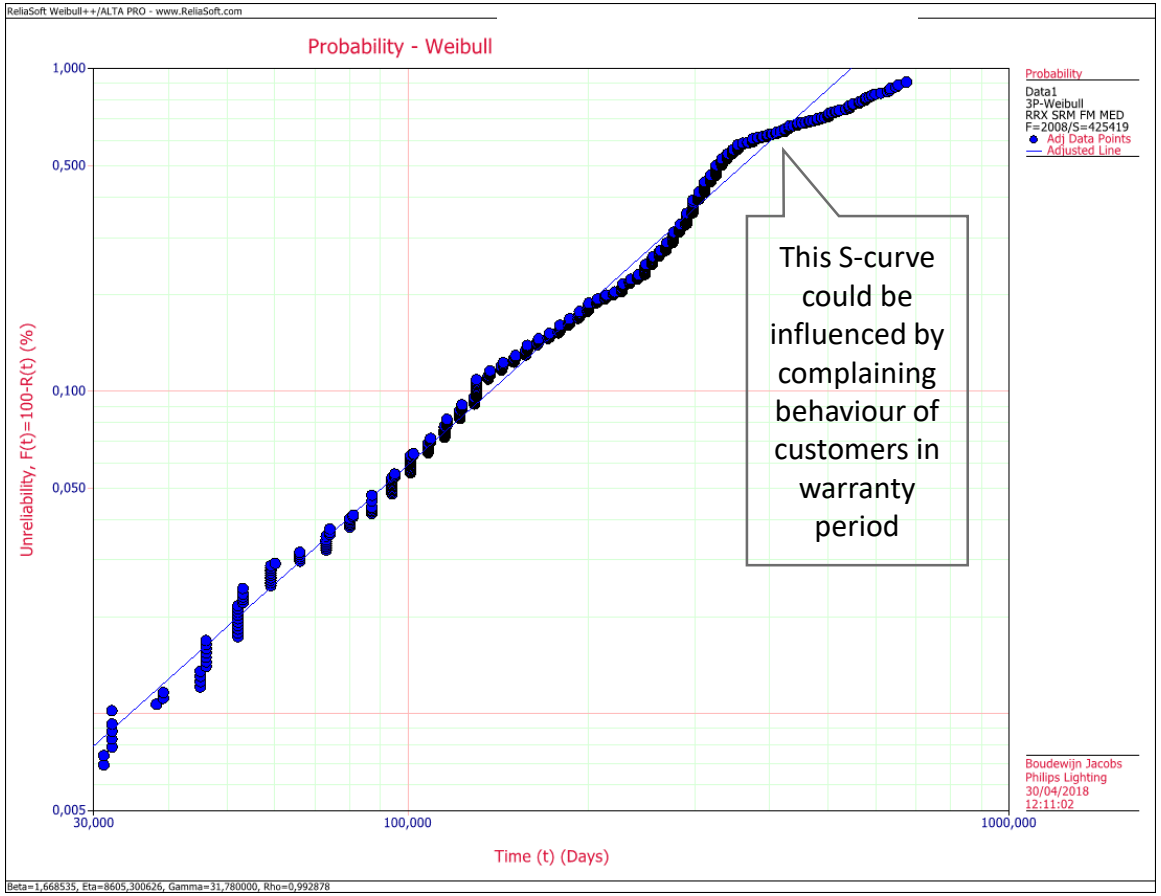
Signify

Product X
statistical failure analysis

signify

Statistical distribution analysis

3P Weibull is recommended by Reliasoft Weibull ++ as best fit.



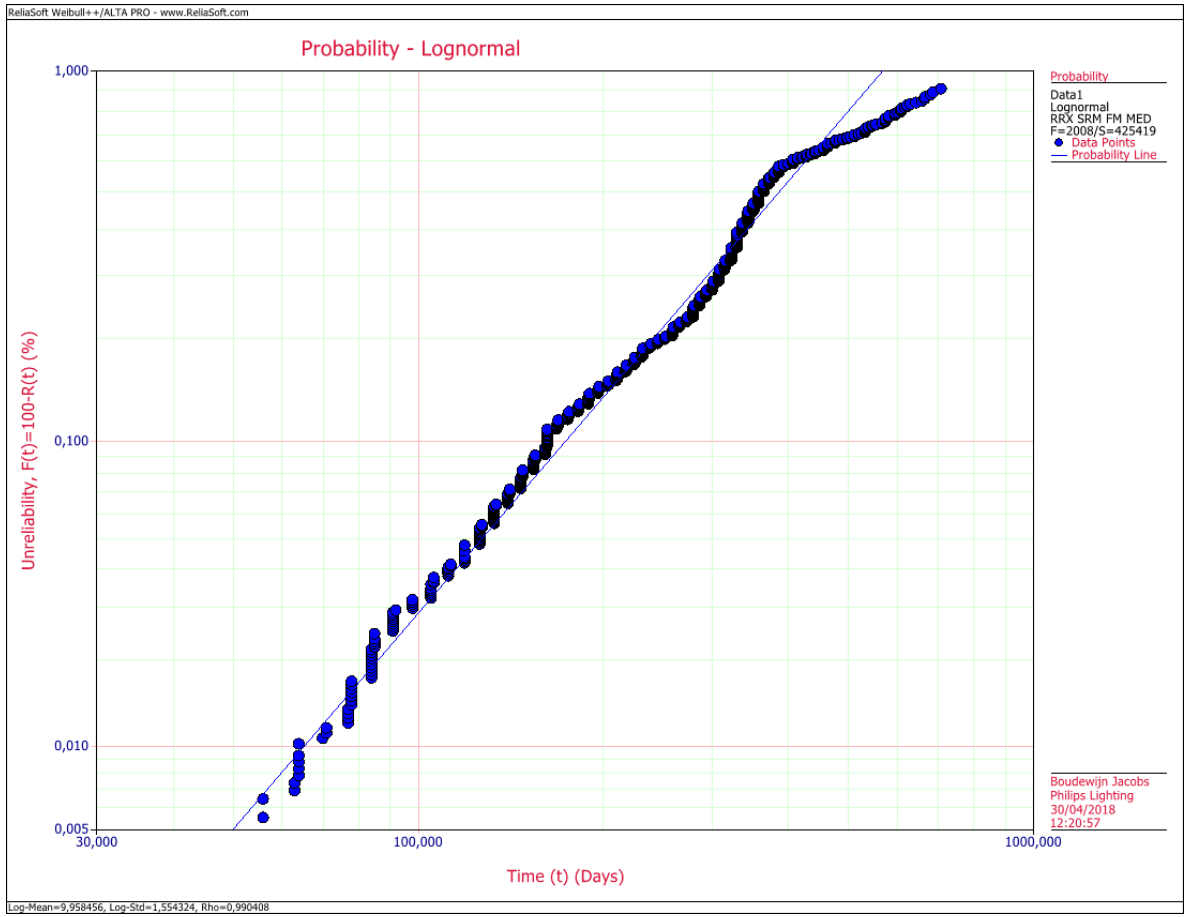
Quick Results Report	
Report Type	Plot Results
User Info	
Name:	Boudewijn Jacobs
Company:	Philips Lighting
Date:	30/04/2018

Parameters		
Distribution:	Weibull-3P	
Analysis:	NLRR	
CB Method:	FM	
Ranking:	MED	
Beta	1.7	Increasing failure rate
Eta (Days)	8605.3	63.2 % of population failing
Gamma (Days)	31.78	Failure free period
Rho	0.992878	
Fail \ Susp	2008 \ 425419	

Prob. of Failure within 1 year = 0.44 %
Prob. of Failure within 2 years = 1.5 %
Prob. of Failure within 3 years = 3.0 %

Statistical distribution analysis

CQM advice: with large number of suspension Lognormal distribution is recommended.



Quick Results Report		
Report Type	Plot Results	
User Info		
Name:	Boudewijn Jacobs	
Company:	Philips Lighting	
Date:	30/04/2018	
Parameters		
Distribution:	Lognormal-2P	
Analysis:	RRX	
CB Method:	FM	
Ranking:	MED	
Log-Mean (Days)	9.958456	
Log-Std	1.554324	
LK Value	-24391.69258	
Rho	0.990408	
Fail \ Susp	2008 \ 425419	

Prob. of Failure within 1 year = 0.45 %
Prob. of Failure within 2 years = 1.5 %
Prob. of Failure within 3 years = 2.8 %


signify