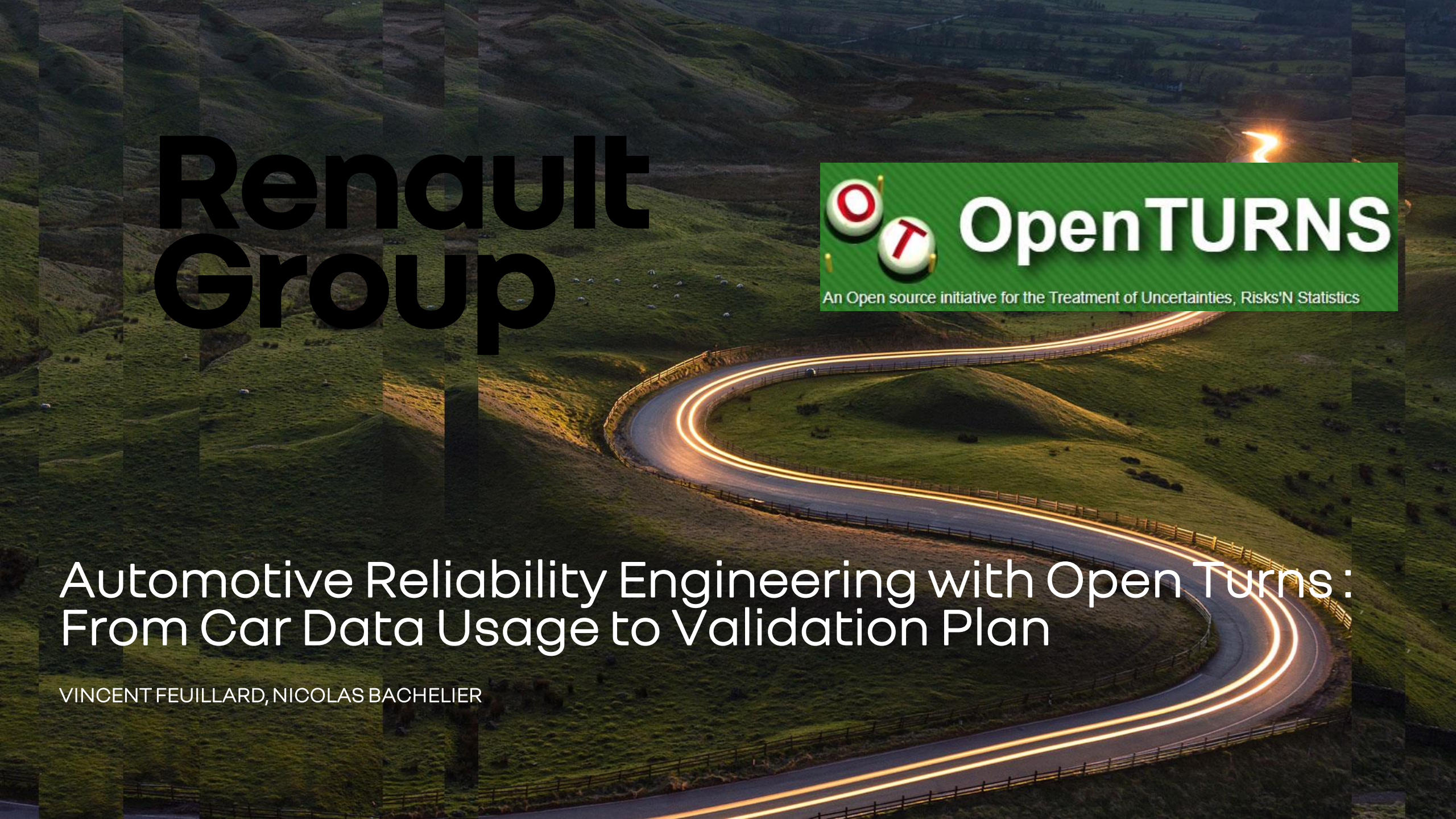


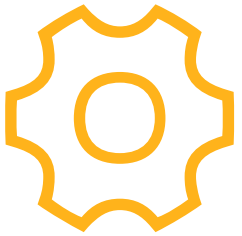
Automotive Reliability Engineering with Open Turns : From Car Data Usage to Validation Plan

VINCENT FEUILLARD, NICOLAS BACHELIER

Executive summary

- **Context :**
  - Reliability Stress-Strength computations and Validation Plans are done with various methods & tools within Renault Group.
- **Key points :**
  - Deploy the best practices making computations as realistic as possible regarding customer usage thanks to car data.
  - Save internal costs thanks to a capitalised reliability tool
  - Validation plan Right Sizing :
    - Avoid useless oversized tests
    - Increase reliability then increase Customer Satisfaction and residual value

- **Conclusion :**
  - Reliability Stress-Strength computation tool with Python / Openturns.
  - 2022 : Proof Of Concept achieved by INSA Rouen Intern
  - 2023 : Renault Group Reference tool with PHIMECA



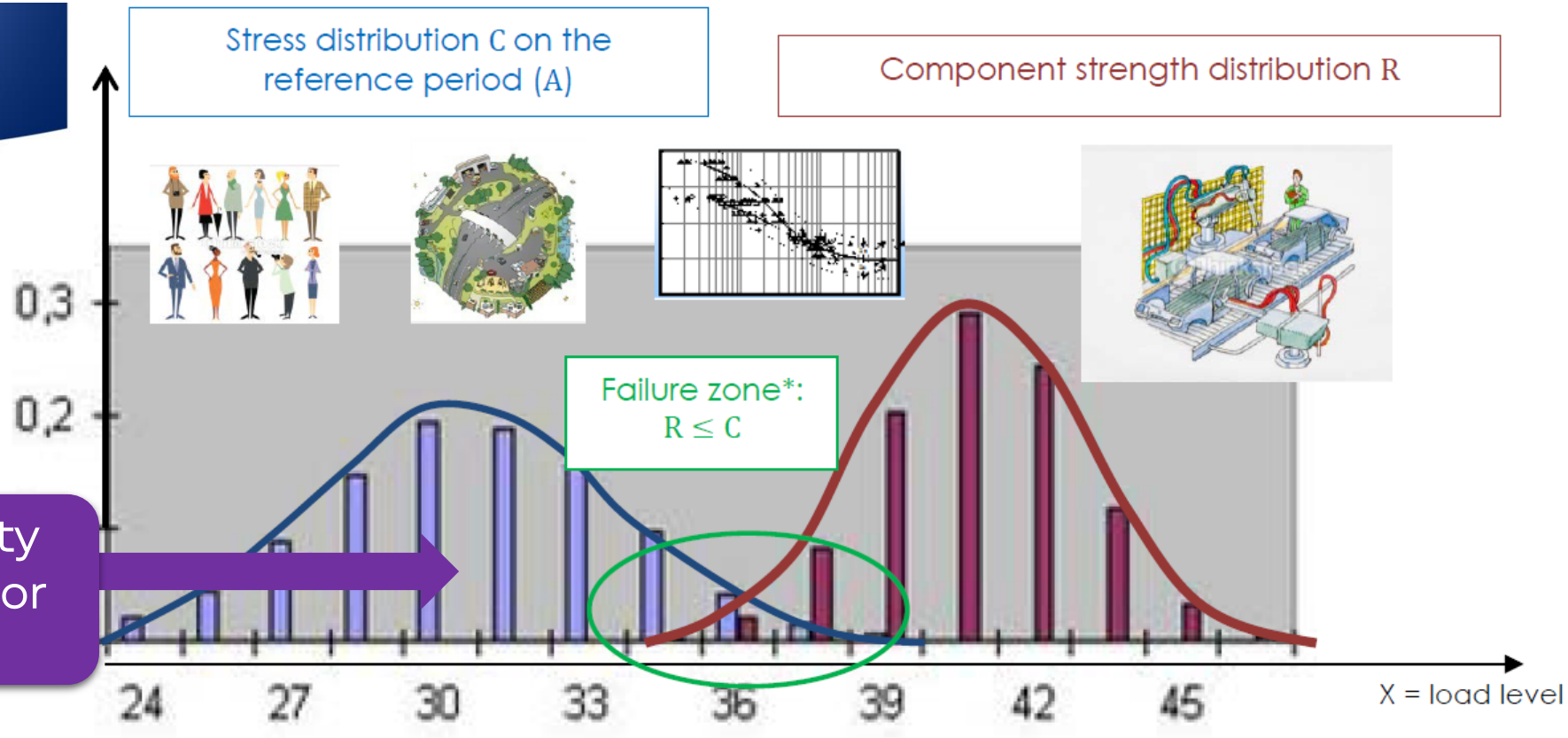
00 – Automotive Reliability using Stress – Strenght method

F% : Cumulated failure ratio

Handbook for Automotive Reliability – assessment and Validation.

The failure probability P_f (=Prob (R≤C)) is estimated using a statistical approach.

The Stress-Strength method depicted in ***Figure 12*** is a simple approach that can be used in many cases.



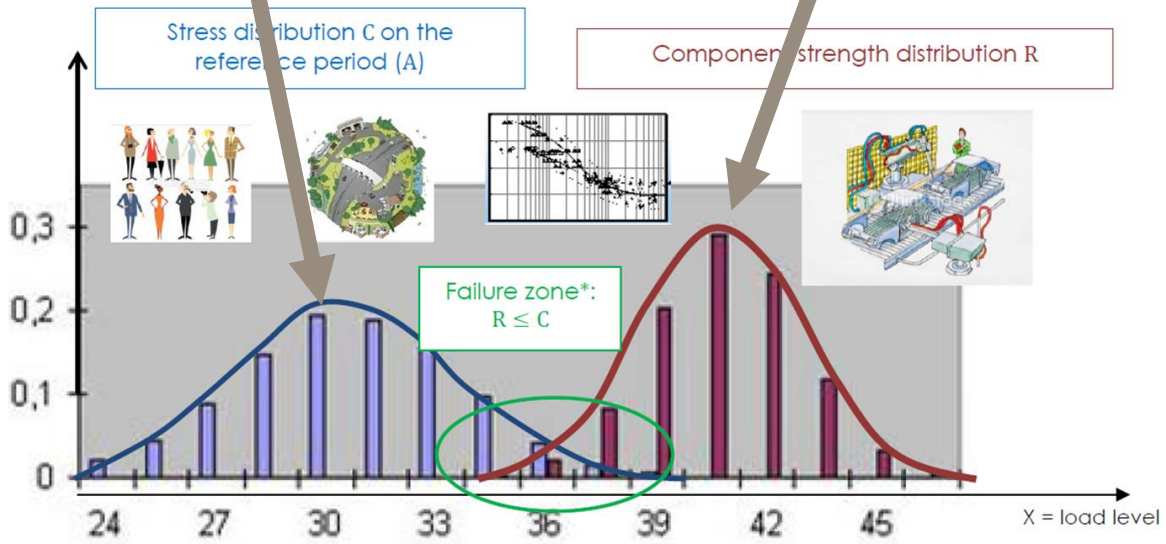
Stress at reliability horizon (mileage or year in service)

*The failure probability does not correspond to the area under the curve.

Figure 12: Stress-Strength method.

01 – Reliability pipeline in Renault Group

Customer Usage modeling → Stress Prediction → Strength Specification → Validation Plan Specification

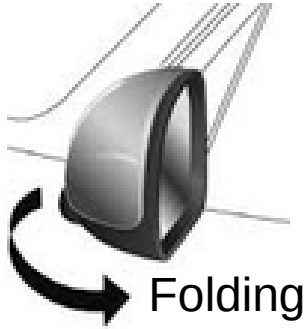


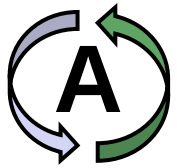
*The failure probability does not correspond to the area under the curve.

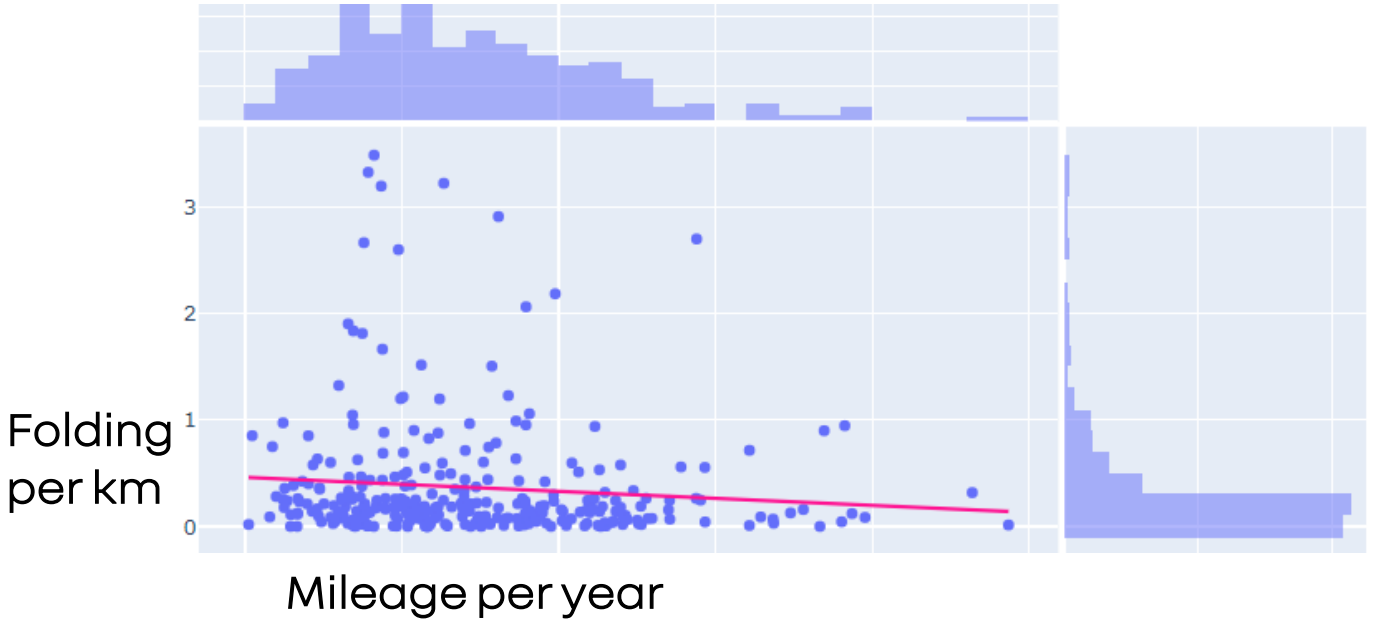
Figure 12: Stress-Strength method.

DURABILITY

01 – From CAN Network Data of connected cars to usage description



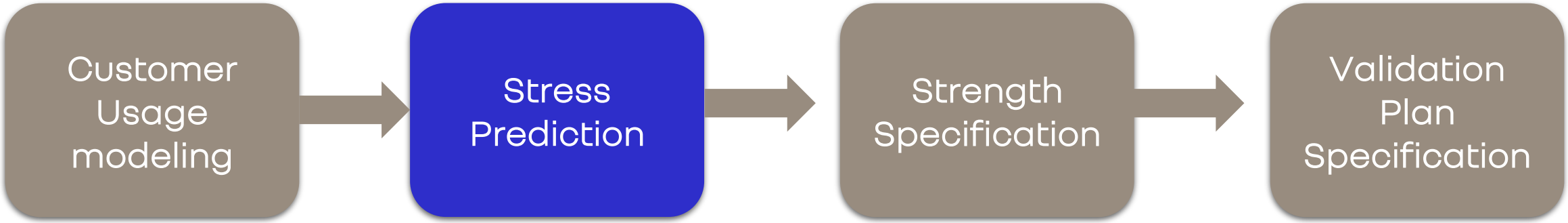




From CAN parameter triggering outside mirror folding, sample is extracted : folding / km
km / year
Correlation coefficient (folding / km , km / year)

Usage & mileage Distribution fittings :
Parametric,
Truncated parametric (usage ≥ 0)
MLE ajustment / BIC Criteria
Non parametric (Kernel smoothing)

02 – Reliability pipeline in Renault Group



DURABILITY

02 – Reliability specification in Renault Group

RENAULT

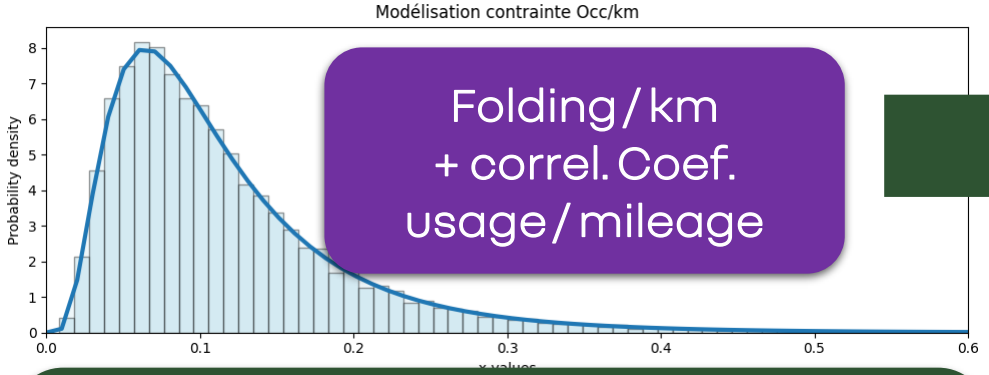
Vehicle and Powertrain Parts

Reliability Assurance Standard

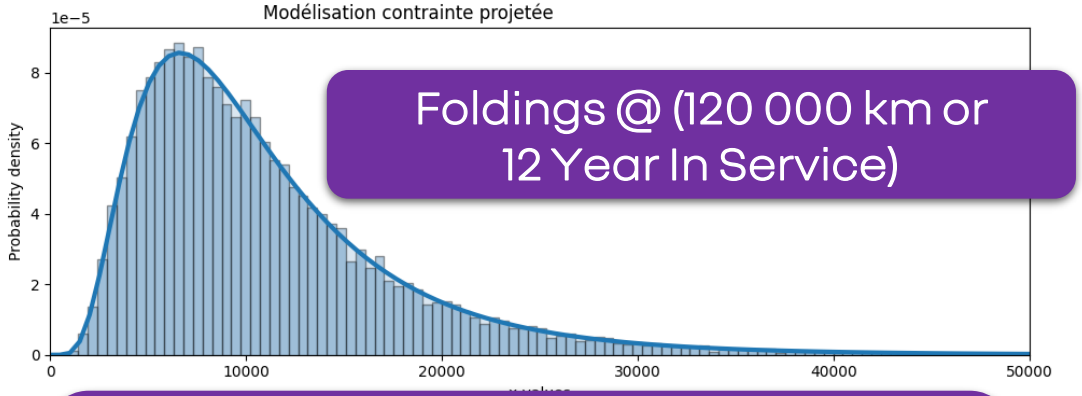
Reliability specification :
Outside Mirror
Phenomenon : Folding not functionning :
F% = 0,1% @ 12 Years In Service or 120 000 km

Grade	D	C	B	A
Gravity	Failure without impact on driving	Failure with impact on driving	Vehicle immobilizing breakdown	Potentially safety issue

02 – From Usage to Stress @ (120 000 km or 12 years in service) :



Folding / km
+ correl. Coef.
usage / mileage

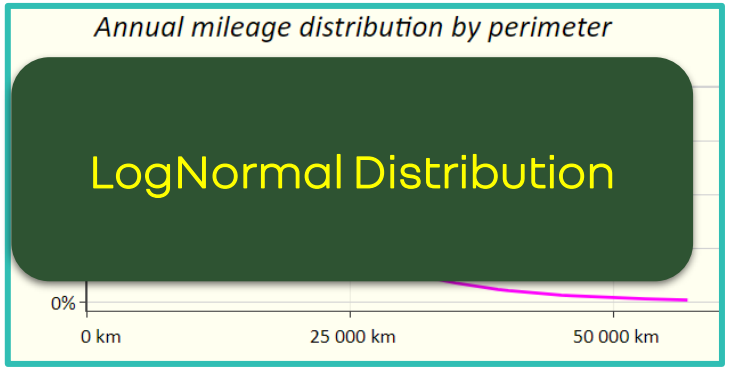


Foldings @ (120 000 km or
12 Year In Service)

Monte Carlo Sample using composed
Distribution of Mileage distribution,
Usage distribution (NormalCopula)

Sample projection :
Month in service incremental loop

Mileage distribution

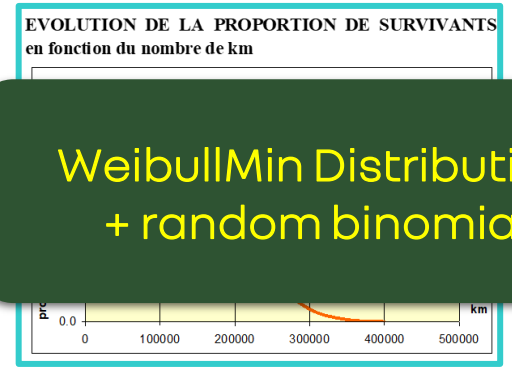


LogNormal Distribution

Resale
distribution

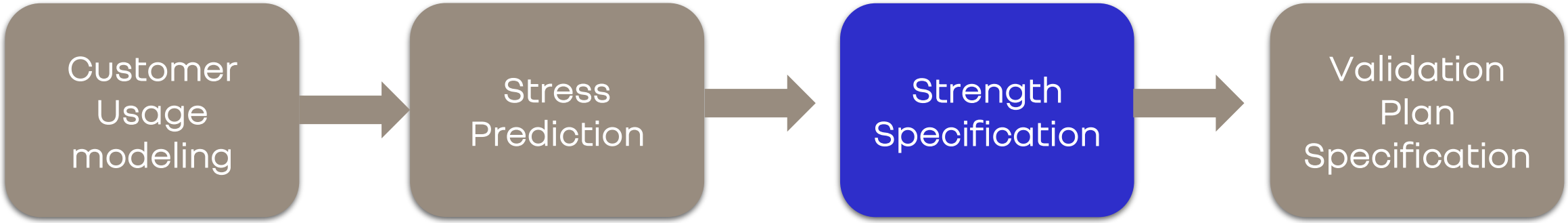
WeibullMin Distribution
+ random binomial

Out of run
distribution



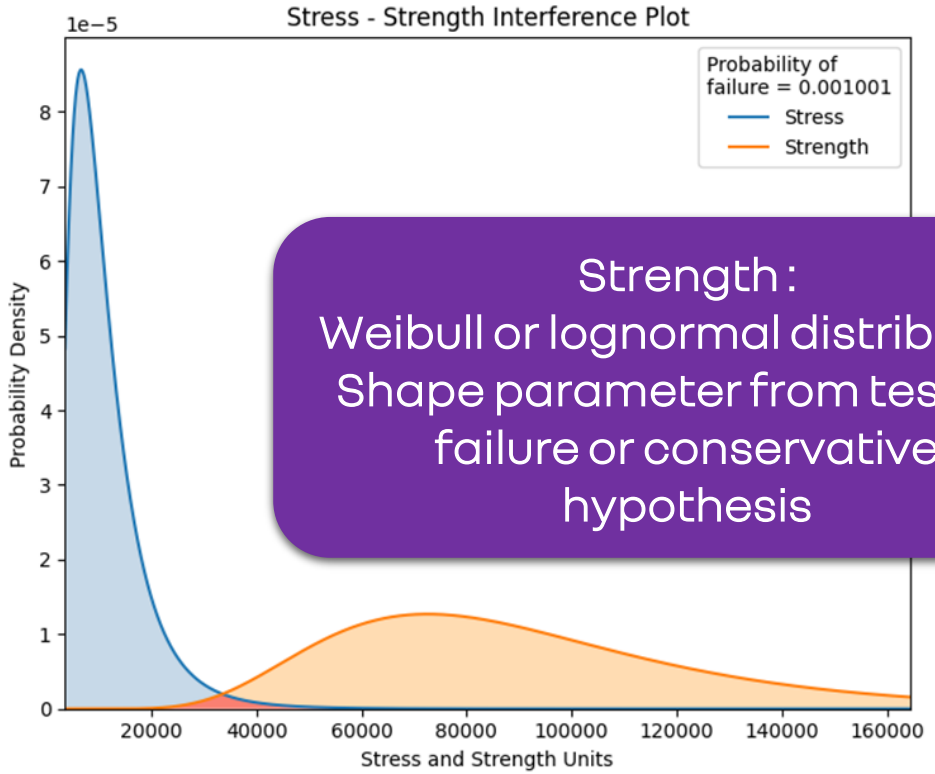
WeibullMin Distribution
+ random binomial

03 – Reliability pipeline in Renault Group



DURABILITY

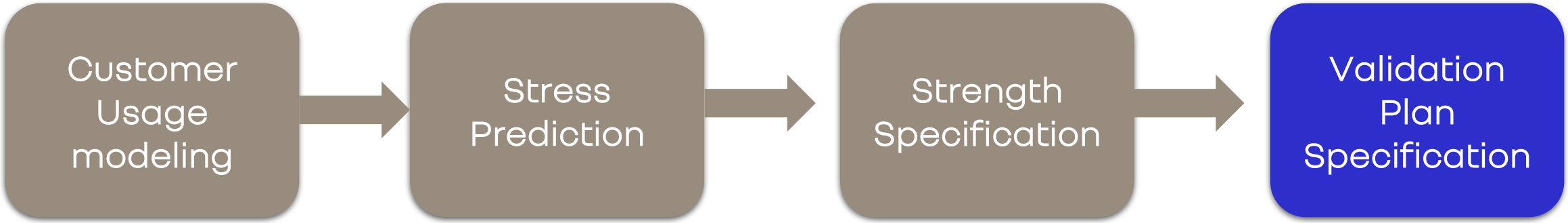
03 - Stress – Strength computation : Strength specification



Strength :
Weibull or lognormal distribution,
Shape parameter from tests to failure or conservative hypothesis

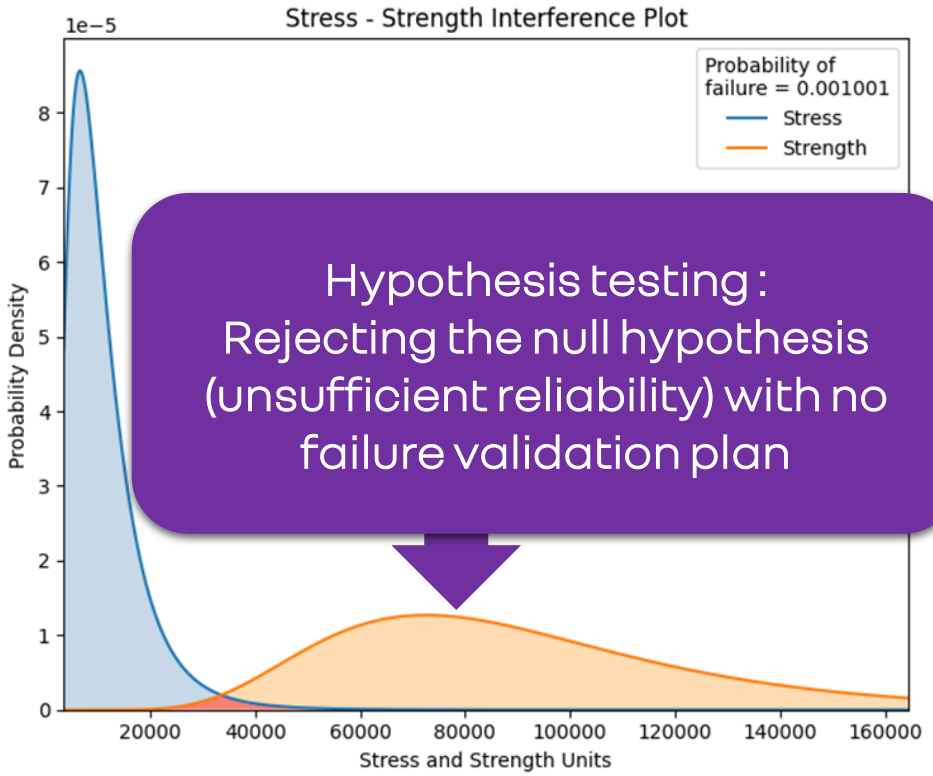
Thanks to distribution arithmetic,
Z distribution = Strength dist. – Stress dist.
F% = Proba(Z < 0)
Scipy.optimize gives Strength scale parameter targetting F%

04 – Reliability pipeline in Renault Group

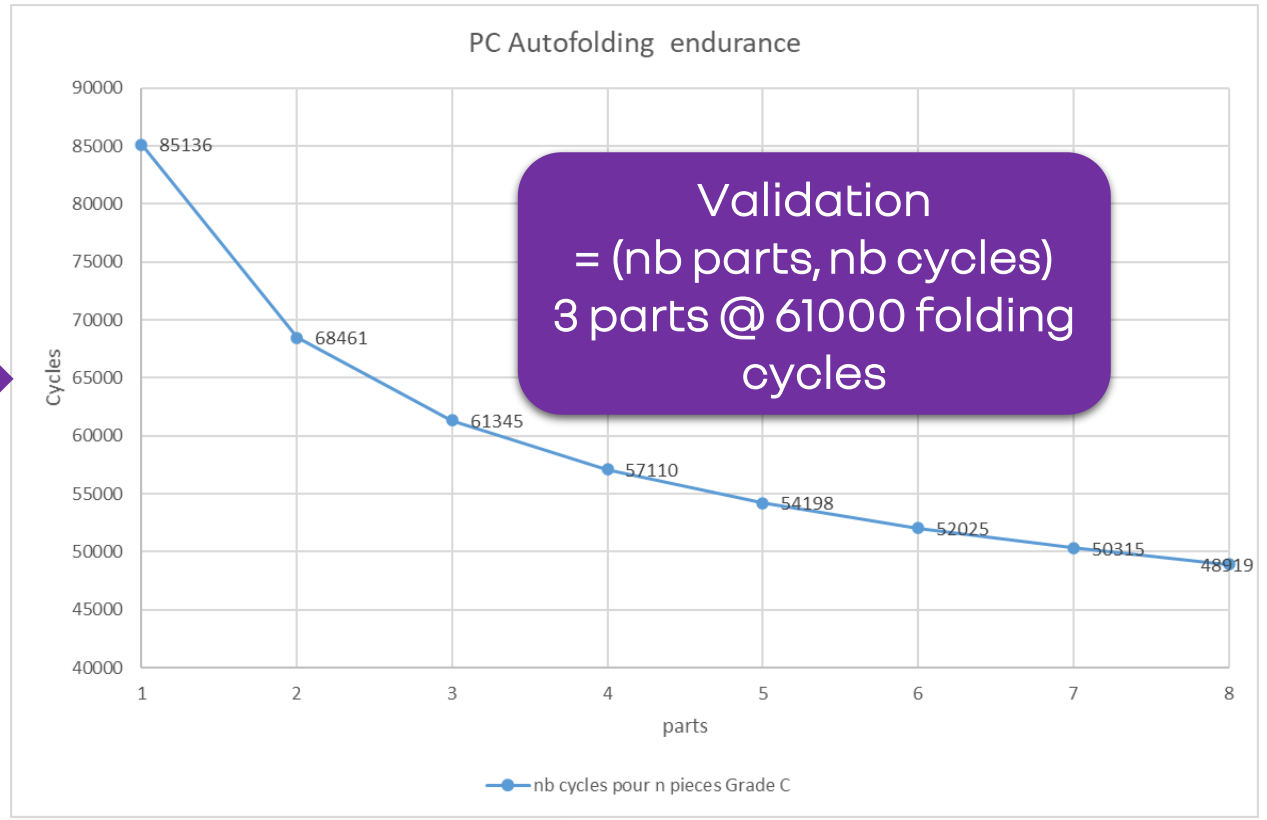


DURABILITY

04 - Stress – Strength computation : From Strength to validation plan



Hypothesis testing :
Rejecting the null hypothesis (unsufficient reliability) with no failure validation plan

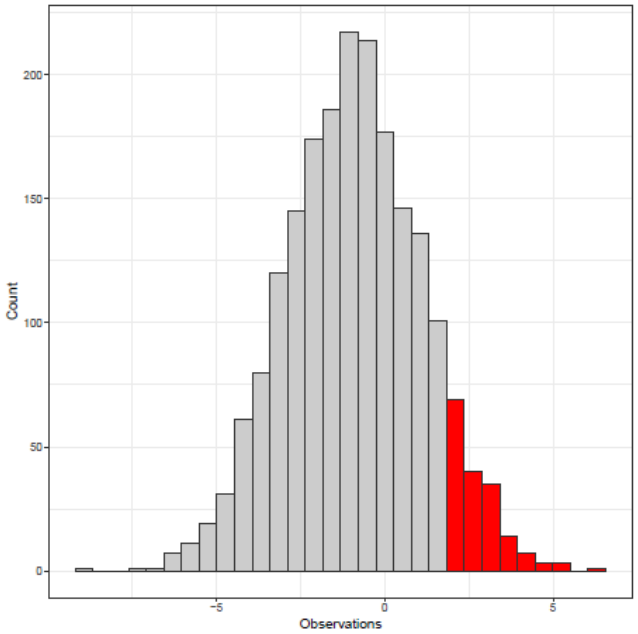


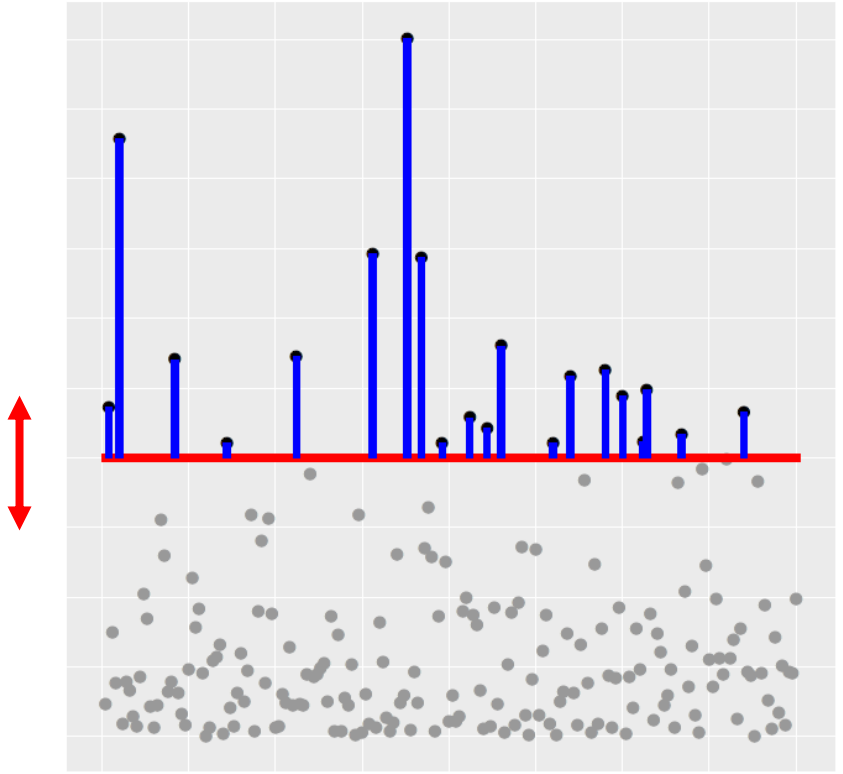
Validation
= (nb parts, nb cycles)
3 parts @ 61000 folding cycles

Confidence Level in test = Probability of one or more failure among n parts in test given reliability is unsufficient

05 – Next step : Stress modeling using extreme value theory

Focus on the upper tail of the distribution





Over Threshold Approach, using Generalized Pareto Distribution.
Threshold :
Big enough for asymptotical distribution
Small enough for accuracy


RG
Thank you