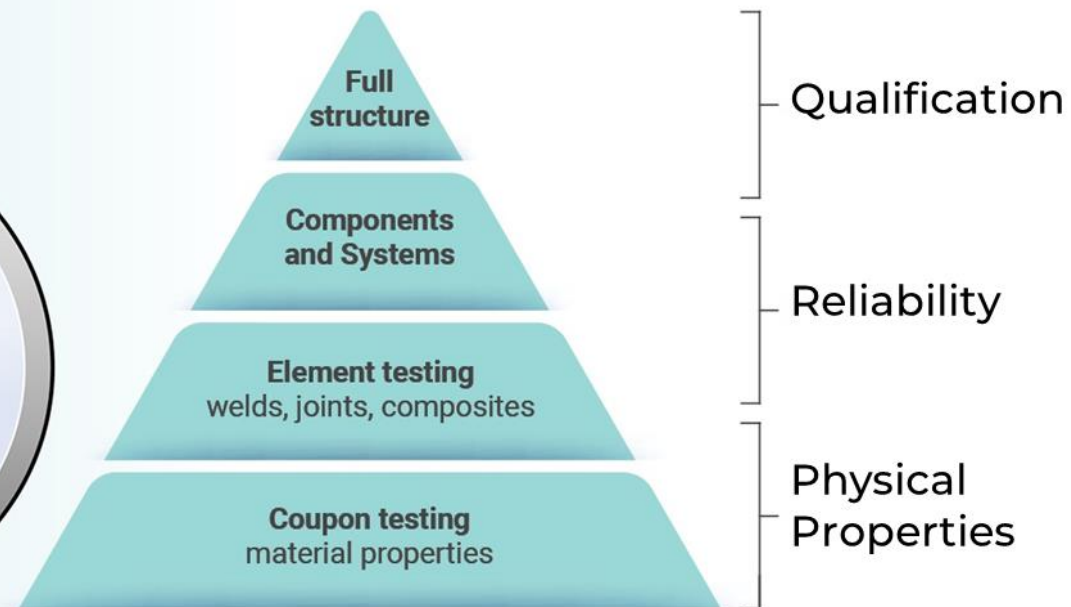
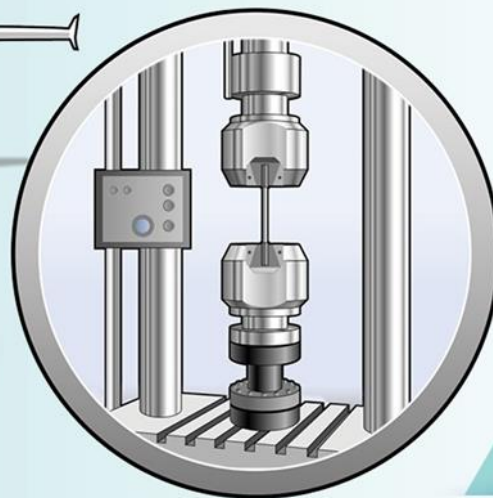
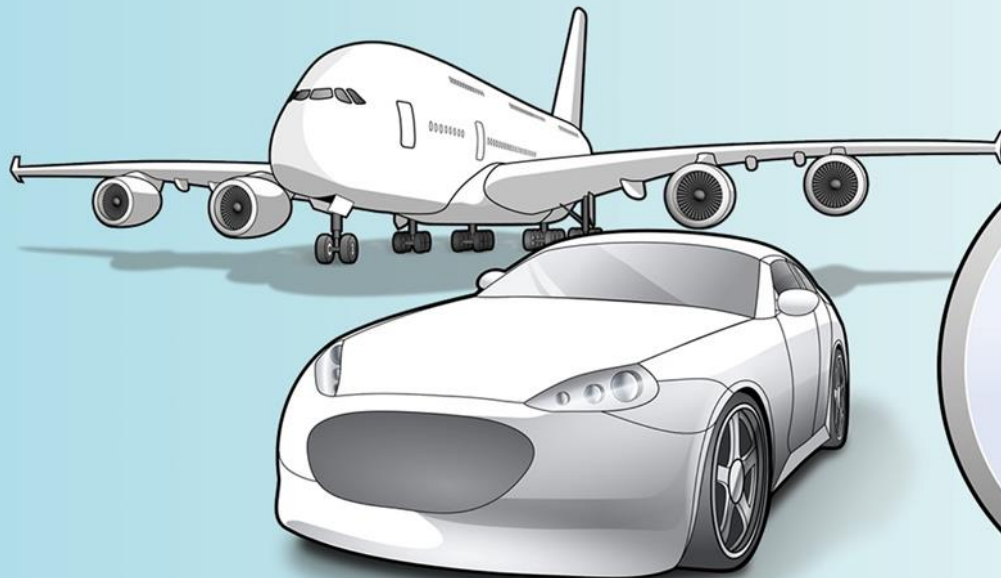




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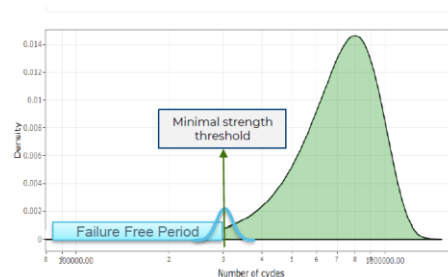
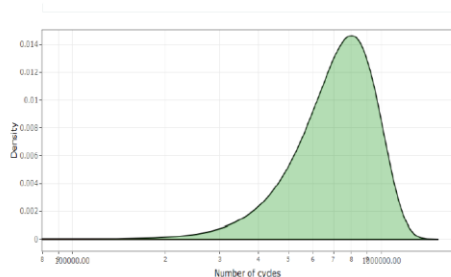
21 November 2023

« New » Stress-Strength interference Approach



New constrained approach:

- Warranty Extension
- Higher reliability ($P_f < 0,01\%$)
- Small sample size (3-10)
- New tailored approach needed



- Modern Reliability Methods and Tool for New Mobility: Valeo perspective

Dr. Marco Bonato,
Head of Reliability and Data Analytics Expert,
Valeo Thermal Systems

Modern Reliability Methods and Tool for New Mobility: Valeo perspective

Abstract

- As a major tier1 supplier, Valeo is actively involved in the fast pace changes shaping modern automotive industries. The advent of electrification, autonomous and connected driving comes with new challenges for reliability of automotive parts. This concept of “novelty” embraces many aspects related to durability: mission profiling, failure modes detections and preventions, determination of failure root causes, physical models to accelerated design validation tests, analyses of warranty field data, development and comparison of validation specifications, testing and simulations etc.
- This presentation illustrates the new methods and tools available within the reliability community that have been deployed in the recent years by Valeo. By focusing on thermal systems related components, we will emphasize the application of these so-called modern reliability tools during the whole process of product development: from concept to support phase. We will illustrate the application of the various reliability approaches grouped according to the three different branches of the discipline: experimental, predictive, and operational reliability.
- Several case studies will illustrate the deployment of the new techniques:
 - Monitoring of product failure during accelerated bench tests
 - Analysis of Big Road Load Data (vehicle measurements)
 - Reliability predictions from a small sample size
 - Fatigue simulation
 - Data Mining for faster reliability predictions
 - Data Driven Model-based Systems Engineering for automatic FMEA

Modern Reliability Methods and Tool for New Mobility: Valeo perspective

- ▲ About the presenter, Dr. Marco Bonato,
Head of Reliability and Data Analytics Expert, Valeo Thermal Systems
 - Marco Bonato is Reliability Manager and Reliability Senior Expert, in Valeo since 2012. His responsibility includes the management and expertise development of the three branches of reliability engineering: operational, experimental and predictive. Marco holds a Ph.D. in Physical Chemistry from the University of Bristol (UK). Prior to this, he obtained a Master degree in Inorganic Chemistry at the University of Padua (Italy).



Modern Reliability Methods and Tools for New Mobility: Valeo perspective

21st November 2023

Technology Days| Session #6: Improving Reliability with FMEA

Marco Bonato
Valeo Thermal Systems
La Verrière
France

SMART TECHNOLOGY FOR SMARTER MOBILITY

Valeo Worldwide Presence

North America

16,717 Employees
25 Production sites

South America

2,175 Employees
5 Production sites

Europe

(including Africa)

49,344 Employees
75 Production sites

Asia

(including the Middle East
& Oceania)

35,064 Employees
79 Production sites



103,300
employees



31
countries

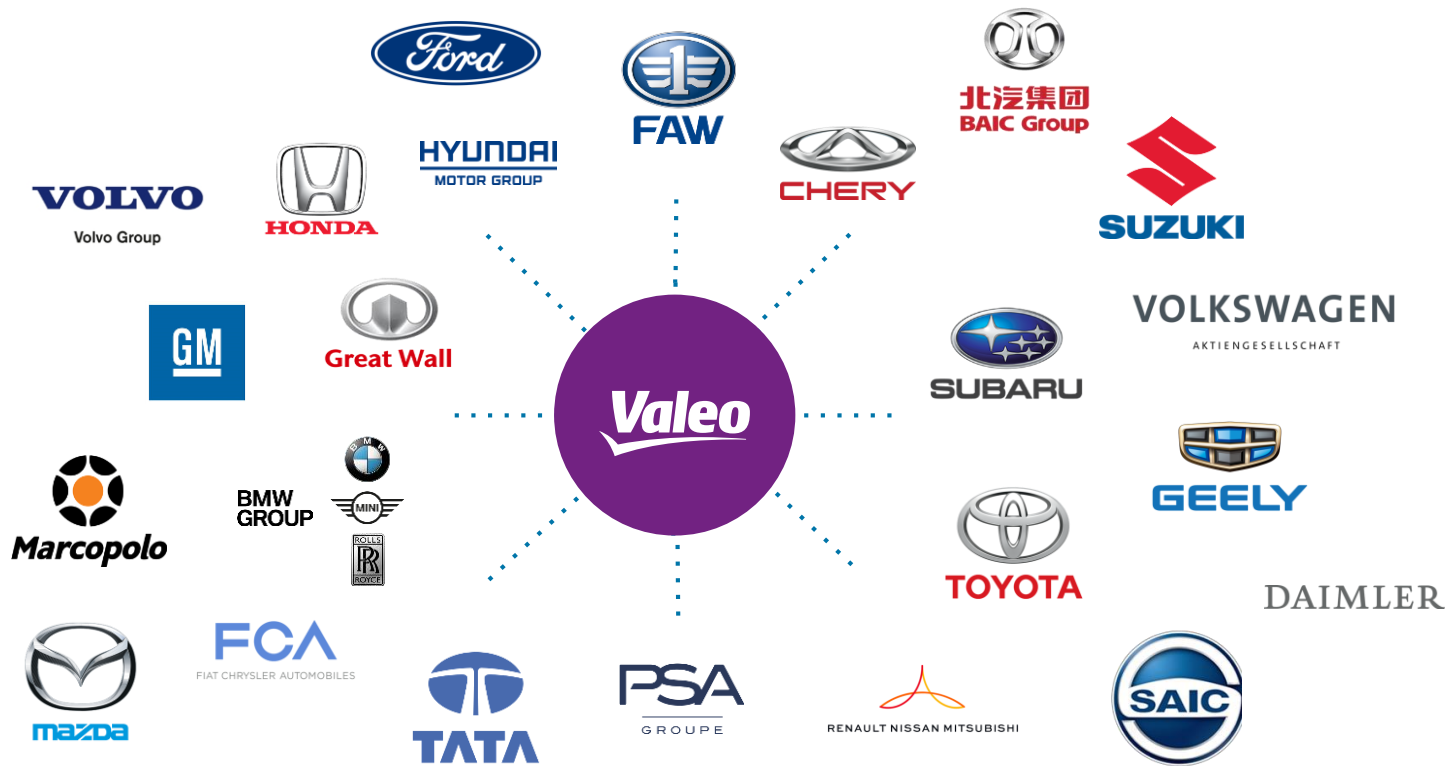


184
Production sites



64
R&D centers

Our Main Customers



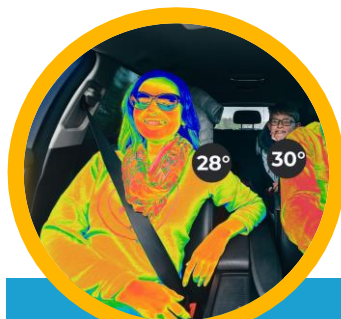
Business Groups & Aftermarket



COMFORT
& DRIVING
ASSISTANCE
SYSTEMS



POWERTRAIN
SYSTEMS



THERMAL
SYSTEMS



VISIBILITY
SYSTEMS



AFTERMARKET
ACTIVITY

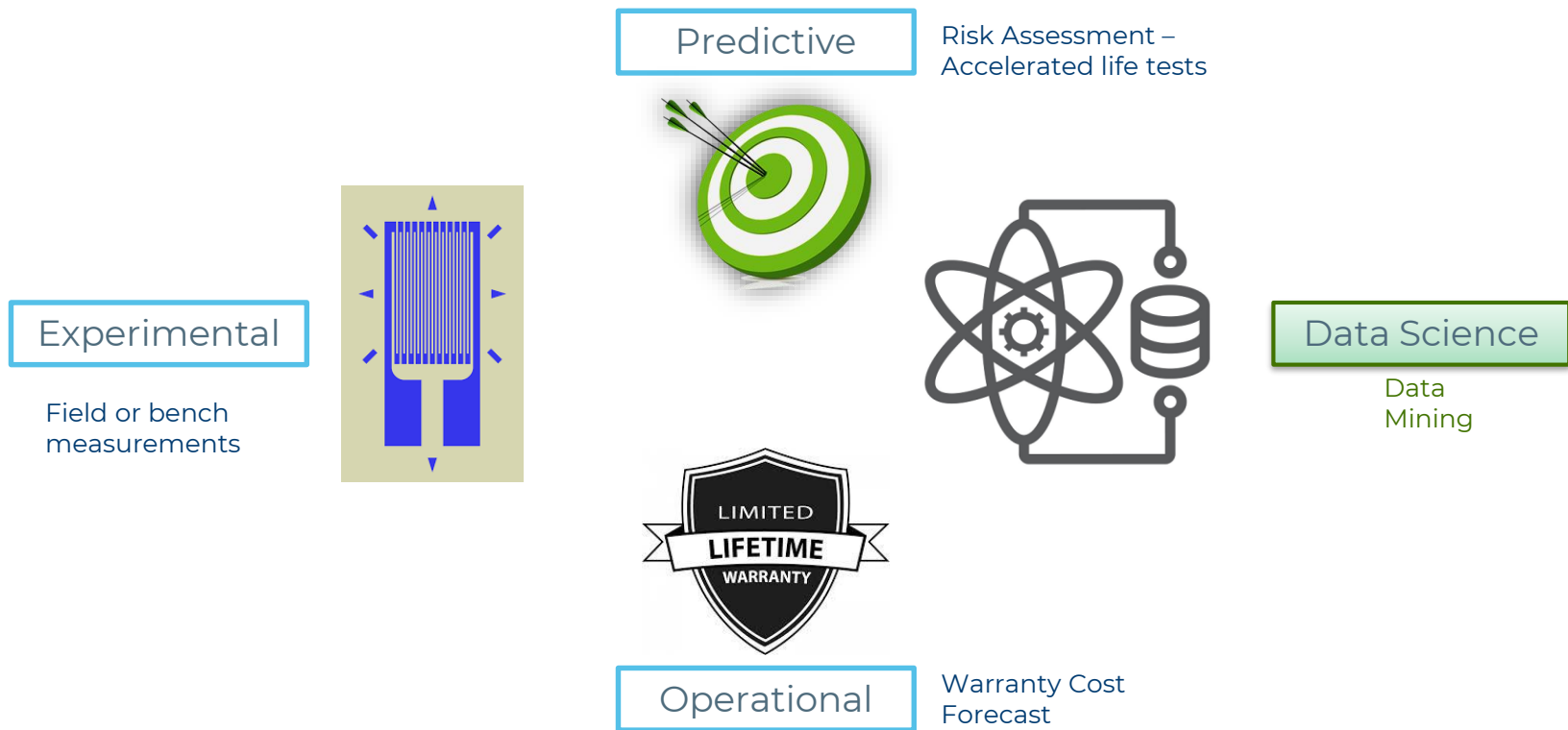
VALEO
SERVICE



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- 1 Reliability at Valeo
- 2 Reliability Trends
- 3 Modern Reliability
- 4 Q&A

Reliability in Valeo



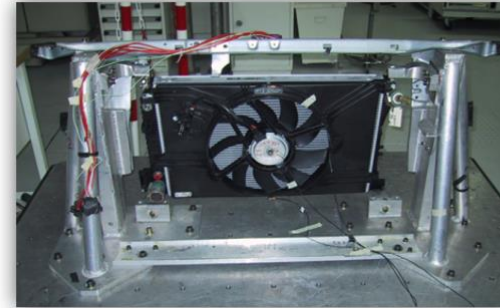
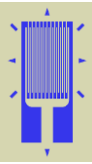
Trends in Automotive Reliability

A Supplier Perspective

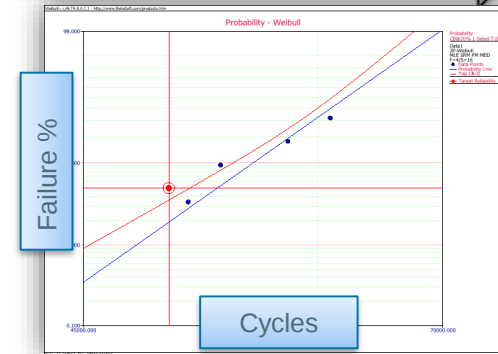
- Reliability is in high demand among final users
 - ➔ Validation tests are more and more severe, therefore **longer** and **expensive**
 - ➔ **Heat Exchangers** : very small sample size available $n \in [3-10]$
 - Carmakers and extension of the warranty period
 - ➔ Electric and Hybrid powertrain
 - ➔ from 3 years 100 000 km to 8 years 150 000
- Importance of accurate and credible Reliability Predictions !
 - **Need of tailored statistical (data driven) approaches**
 - **Focus on Modern Reliability Methods&Tools**



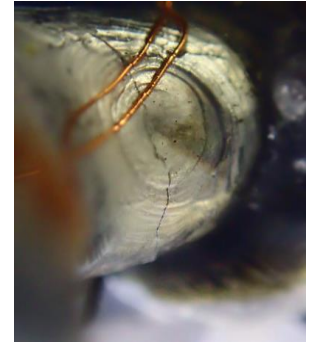
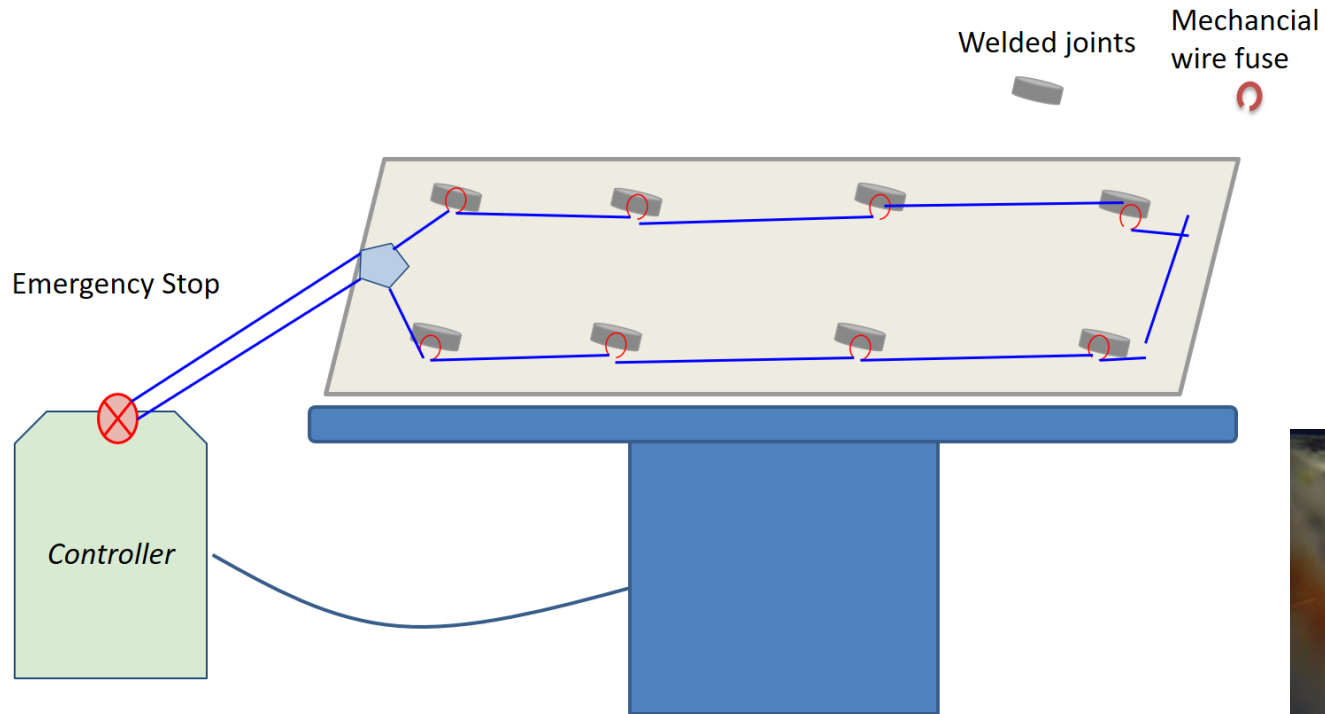
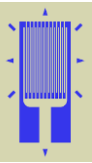
Stop Tests at First Failure

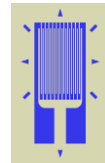


- Detect the main failure mode for an associated validation test (vibration, thermal, etc.)
- Define the design margin (how far from the spec)
- Variability (strength distribution)
- **Calculate the predicted reliability**



Heat Exchanger Vibrations



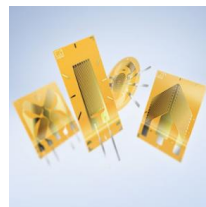


Road load data are becoming bigger

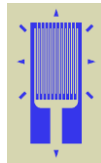
Many sensors mounted by Valeo

CAN BUS data from the OEM

Correlation between input and output?



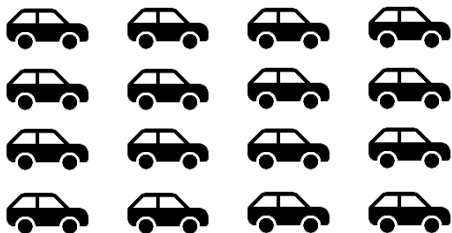
Big Road Load Data



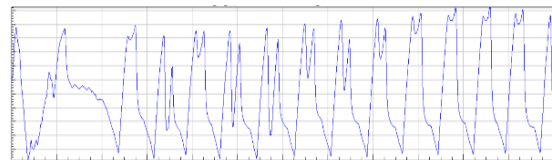
CAN, GPS, Thermal,
Strain



Train a Machine
Learning Model



nCodeDS

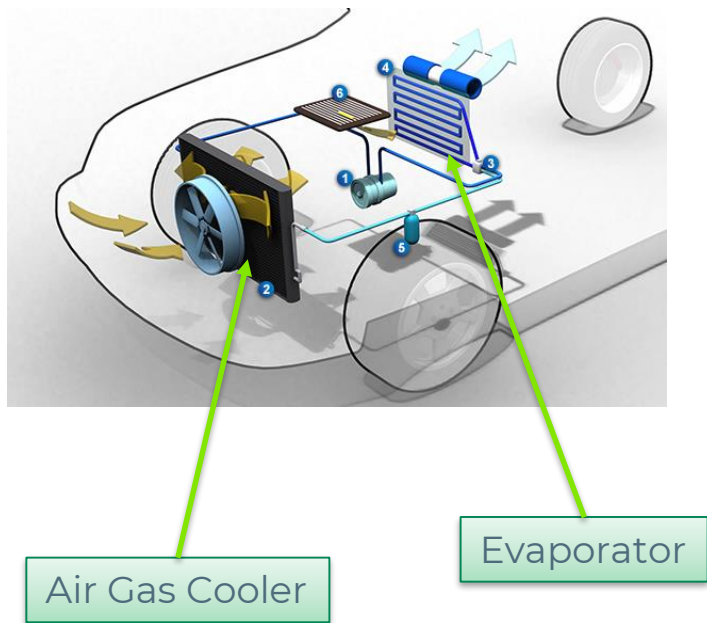


Predicted Strains

CAN, GPS, Thermal

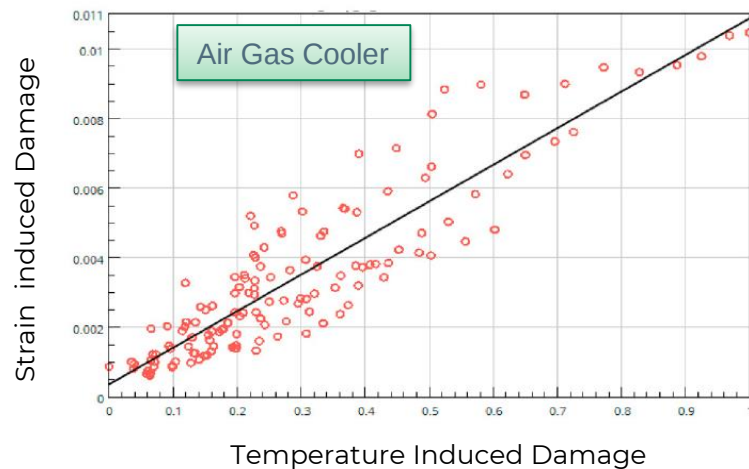
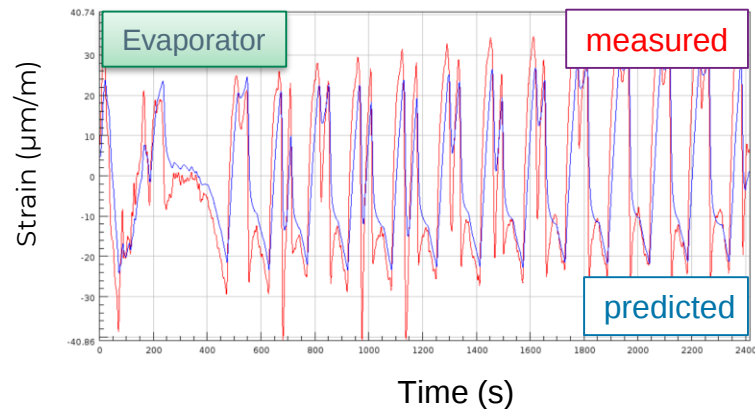
Big Road Load Data

CO₂ refrigerant - Cabin Cooling System (R744)

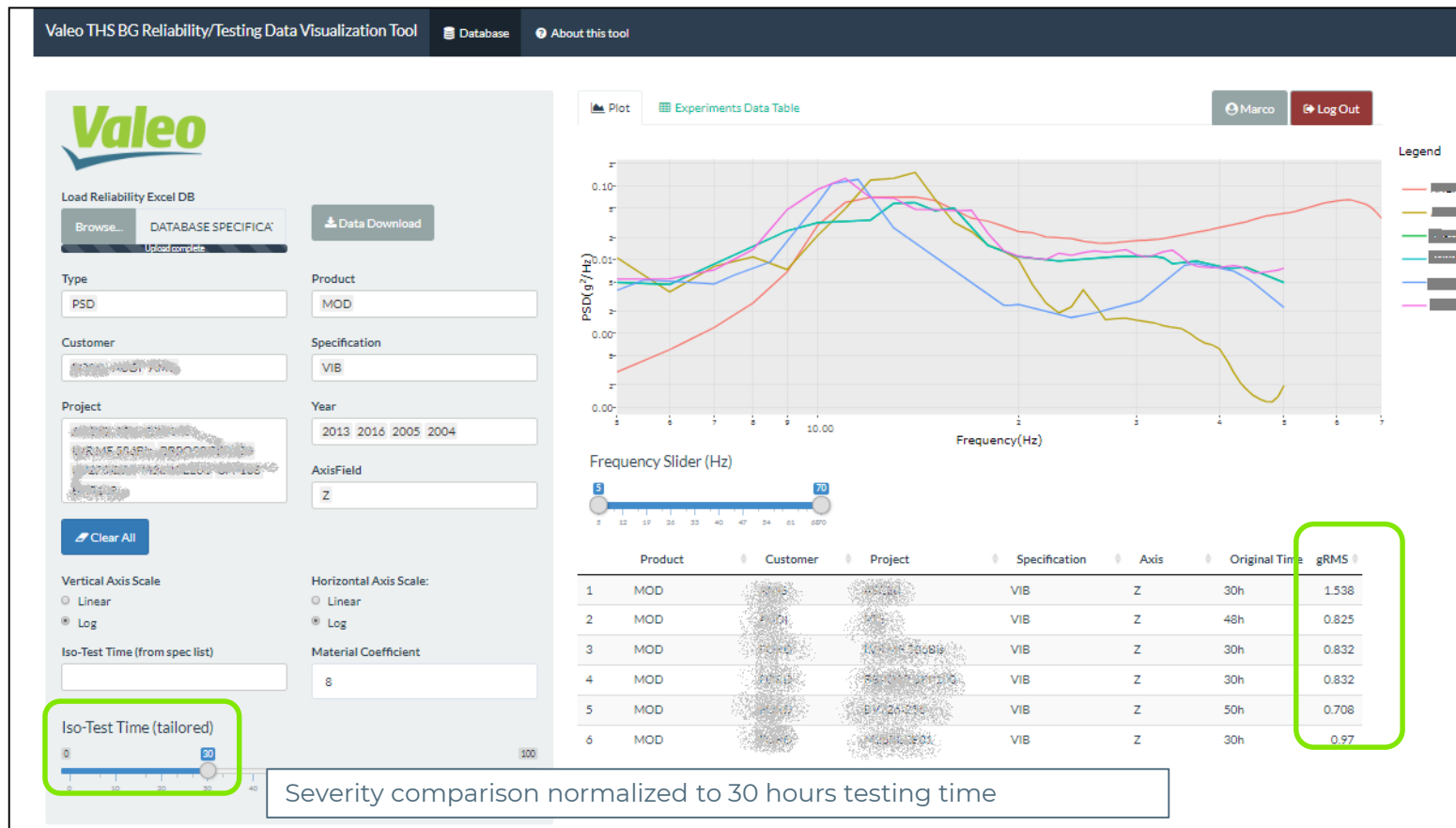


Air Gas Cooler

Evaporator



Specification Visualization Tools

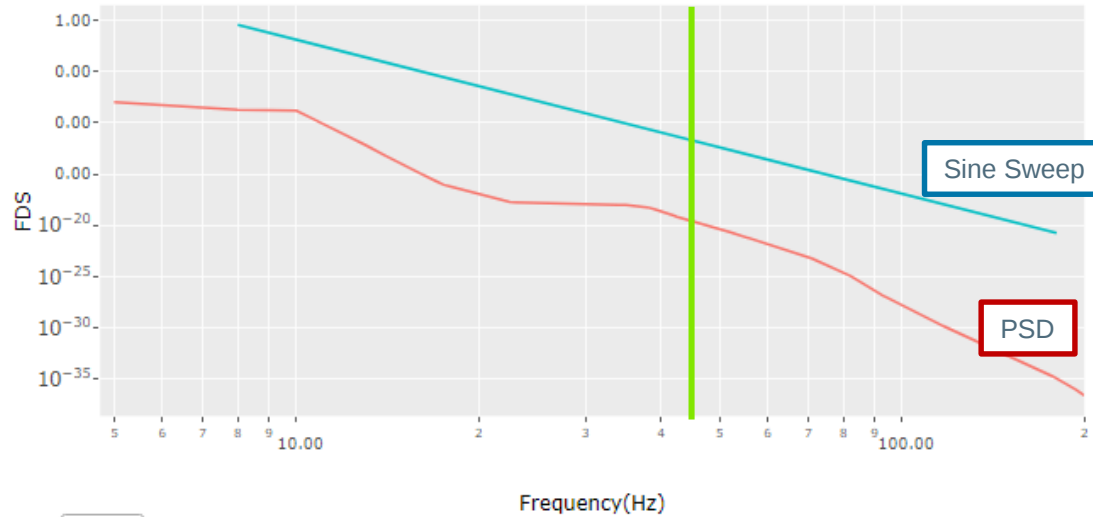


Specification Comparison Tools



New Project

OEM proposing 2 validations specs: 1 harmonic and 1 random
Part resonance expected at **43 Hz**

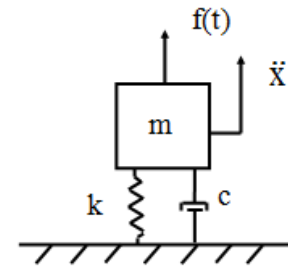


Fatigue Damage Spectrum

$$b = 8$$

$$Q = 25$$

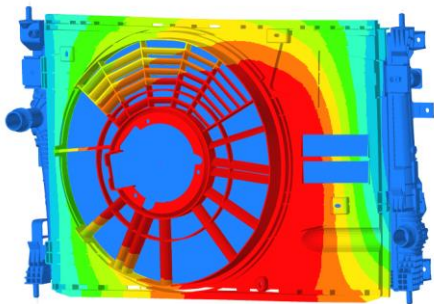
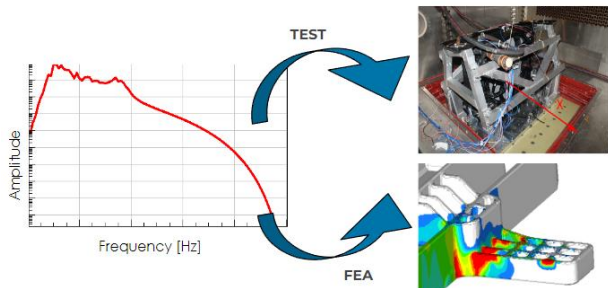
Vibration Damage Ratio
Harmonic/PSD: 10^8



Digital Twins: link with FEA simulation



Vibration Fatigue: Variability and **FEA** parameters

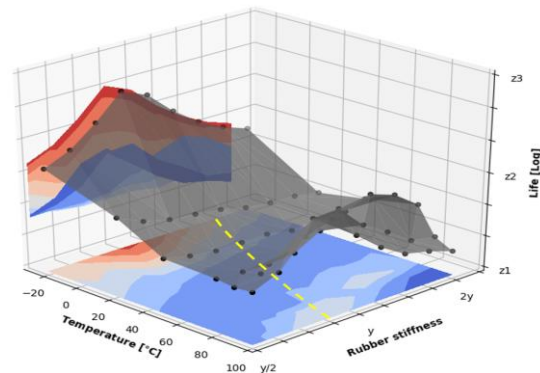
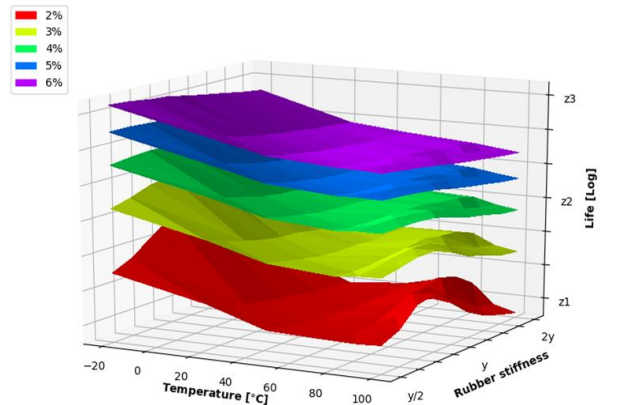


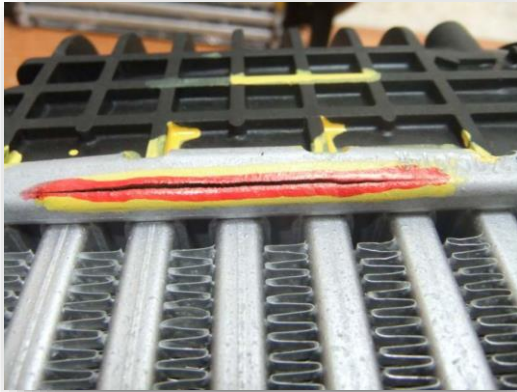
1. Substructure

2. Dedicated flow

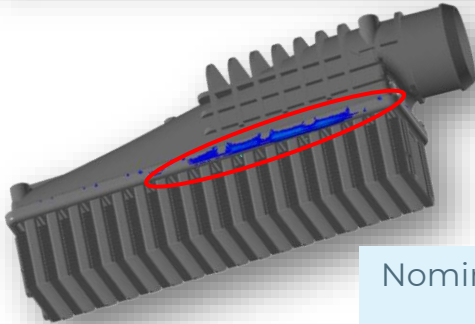
3. Fatigue

4. Response surface

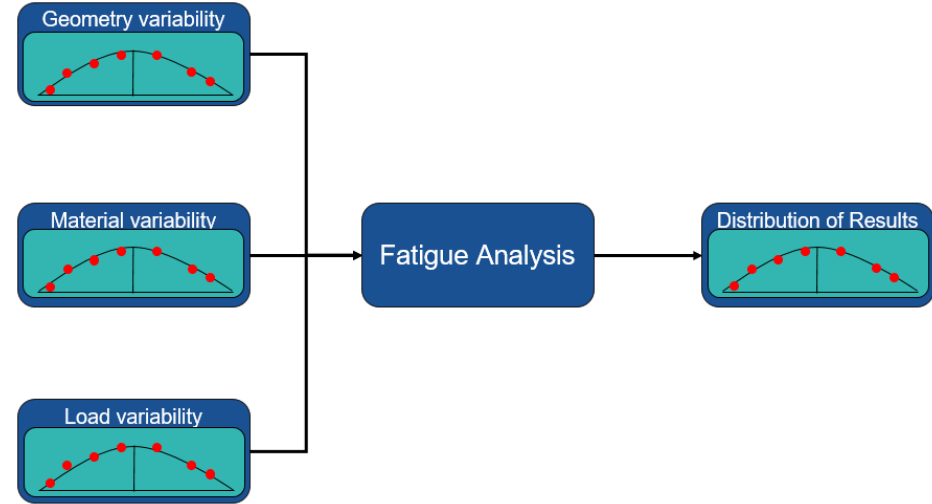




Test	Life in cycles
1 <i>minimum</i>	351,630
2	445,000
3	465,000
4	615,000
5 <i>maximum</i>	649,800
Mean	505,286
Ratio (max:min)	1.848



Nominal Damage Value
VS
Variability

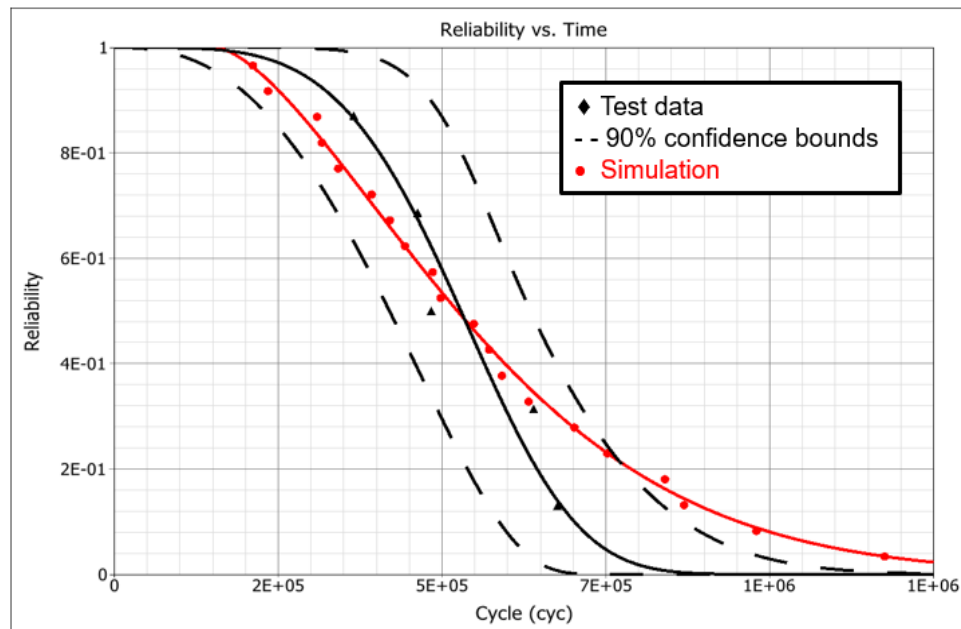
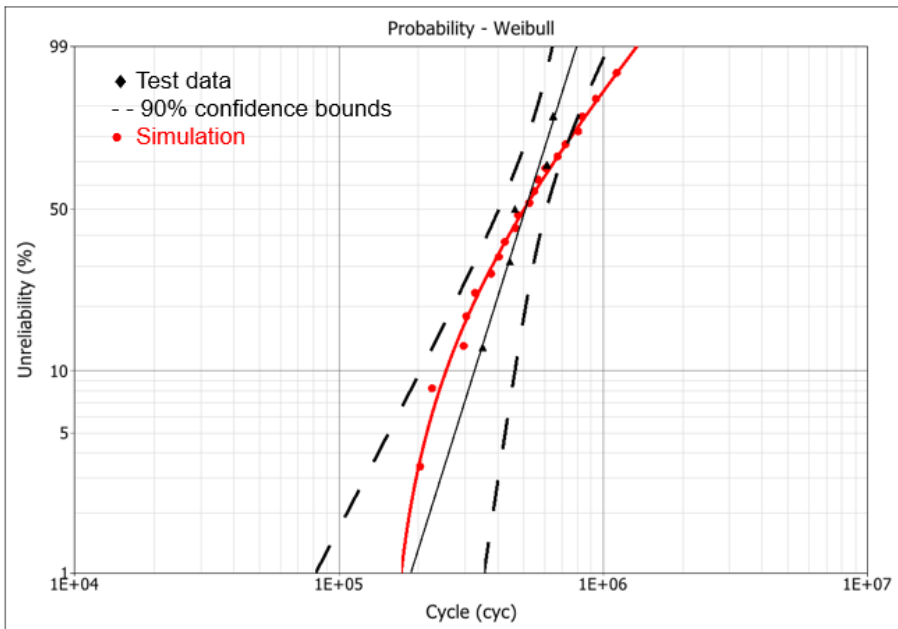


Monte Carlo – Latin Hypercube Sampling

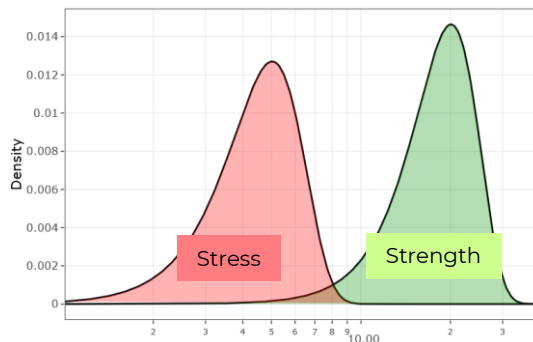
Results: Test vs Simulation



Simulation data lie within the confidence bounds of test data at 90% level

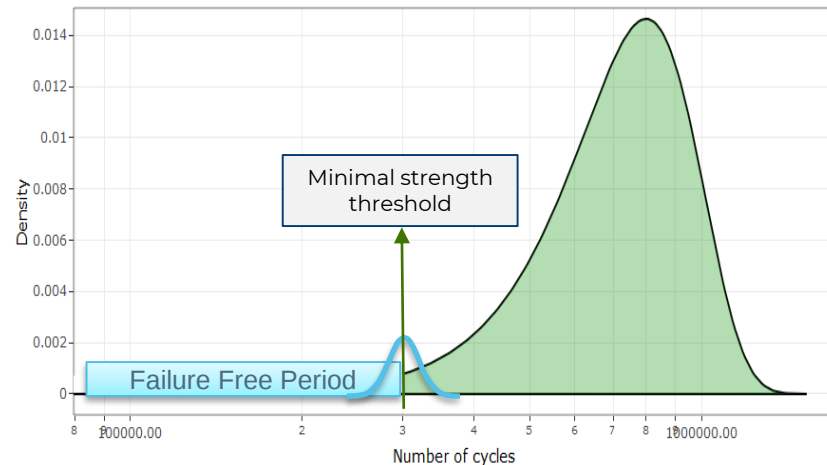
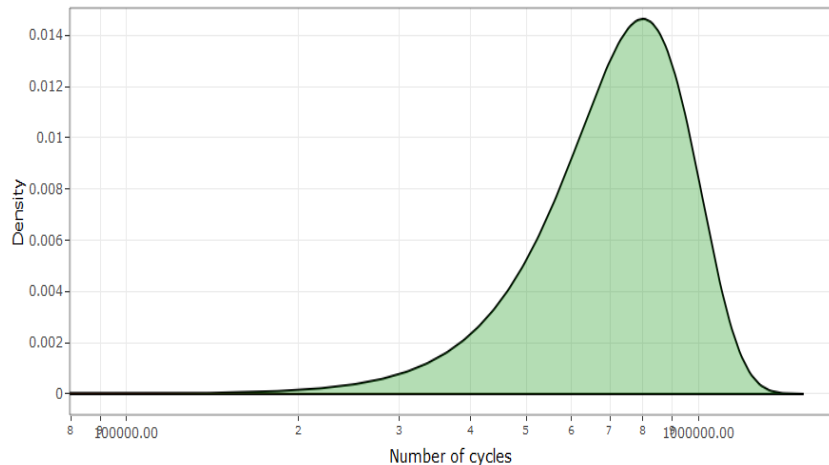


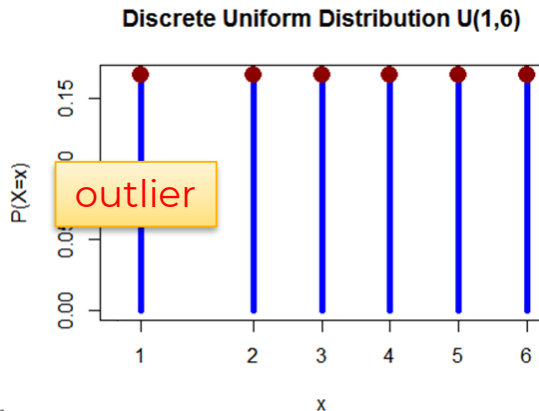
« New » Stress-Strength interference Approach



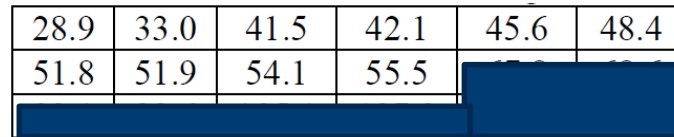
New constrained approach:

- Warranty Extension
- Higher reliability ($P_f < 0,01\%$)
- Small sample size (3-10)
- New tailored approach needed





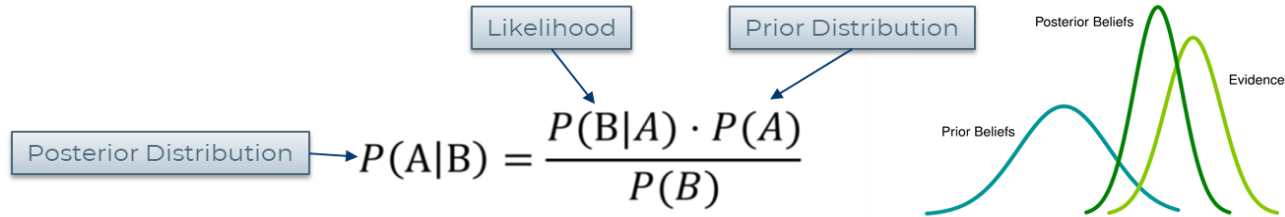
- 1) Bounding
- 2) Irregularity



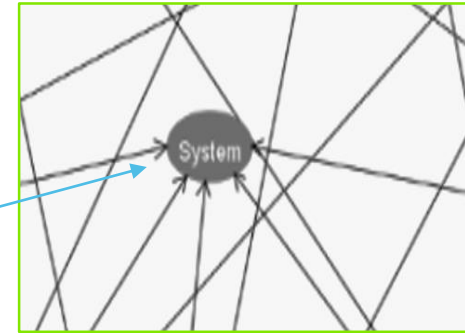
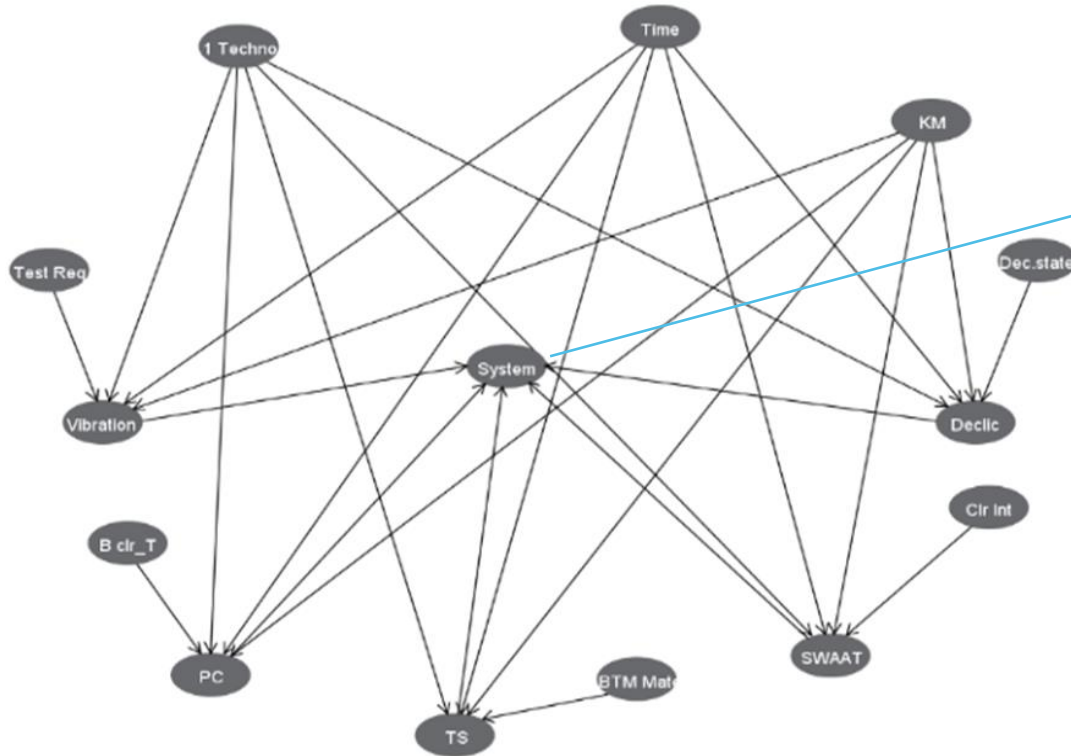
- If n [1-18]: γ W3P : 24,3 kilo-cycles
- If n [1-10]: γ W3P : -2,9 kilo-cycles (*negative*)

New method: $X_{\min} n[1 - 10] = 25.0 \pm 3.3$ kilo-cycles

Bayesian Networks for Reliability Predictions



Bayesian Networks for Reliability Predictions

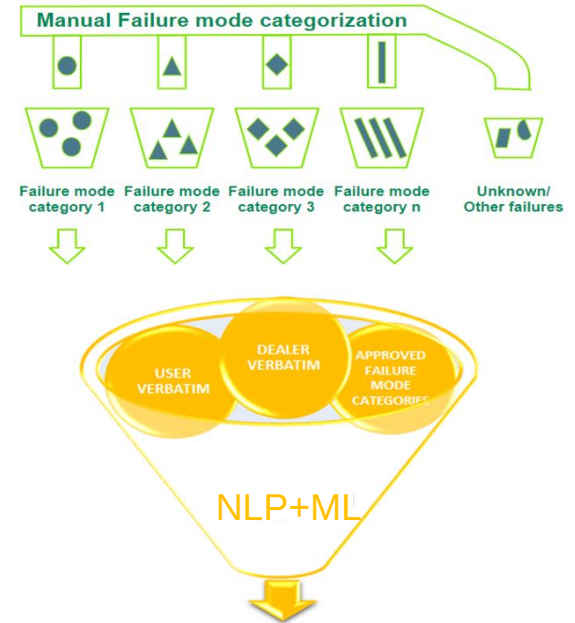
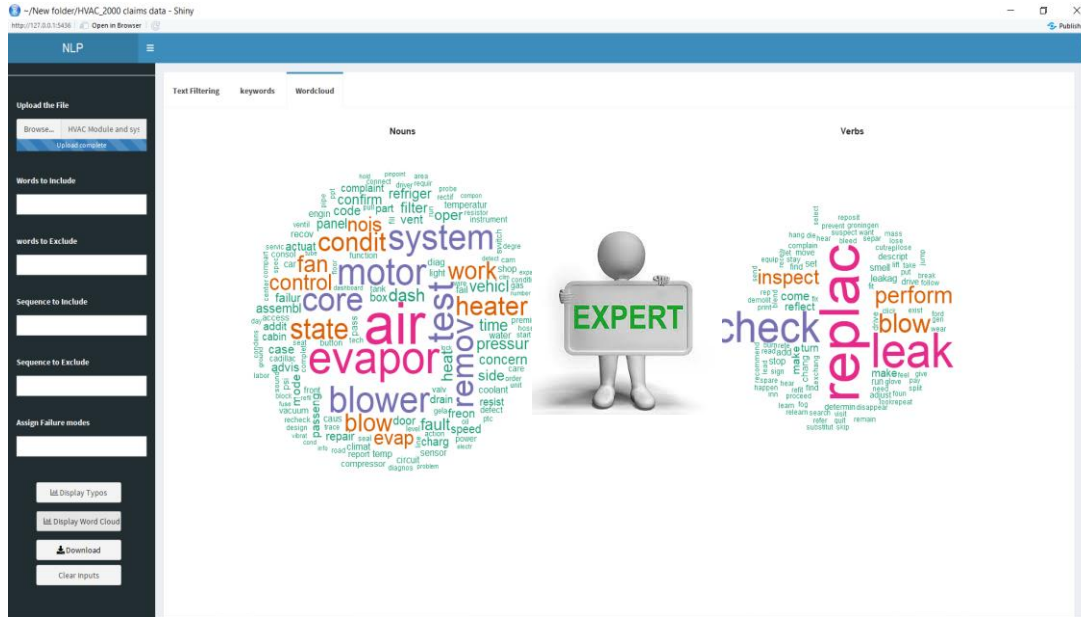


- Each Node can have 2 or more states
- Data is fed in form of Conditional probability tables (CPT)
- The failure probability calculation is done based on given evidences

Data Mining: Warranty & failure mode extrapolation



Implementation of Natural Language Processing and Machine Learning Technics
- Internal databases (validation & warranty)

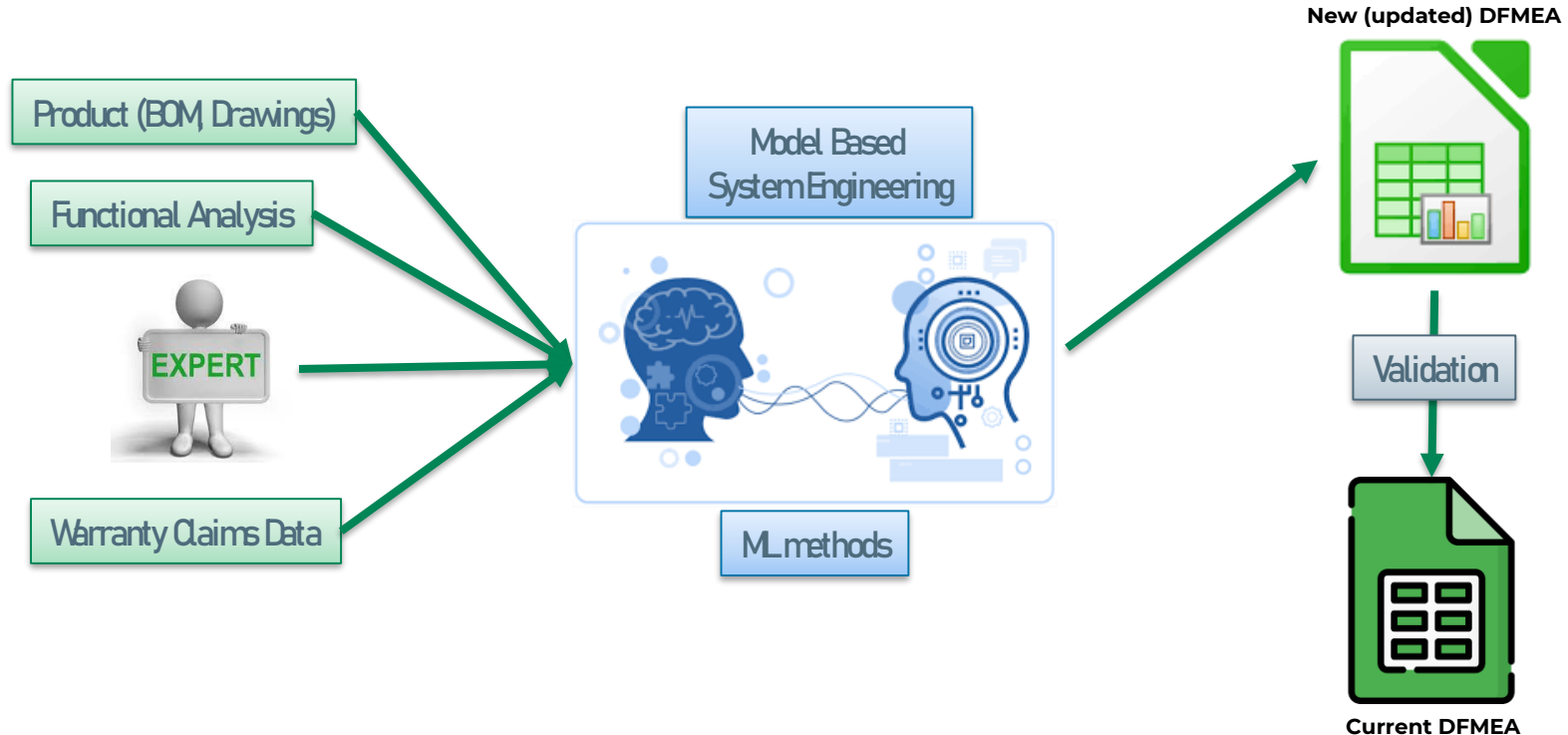


Data Mining: Automatic DFMEA



“The application of ontology-based approach to update design FMEA using warranty claims data”

Younus, Aleksandr Doikin, **Felician Campean**, Sohag Kabir, Amr Abdulatif, David Delaux and Pascal Bonnaud)



Great Thanks to...All my Co authors



Arnaud Maire
Ewelina Czerlunczakiewicz
Maciej Majerczak
Philippe Goge*
Garima Sharma*
Murali Krishnamoorthy



Dr Haytham Younus
Dr Aleksandr Doikin
Prof Felician Campean



Amaury Chabod
Dr Andrew Halfpenny
Dr Frédéric Kihm



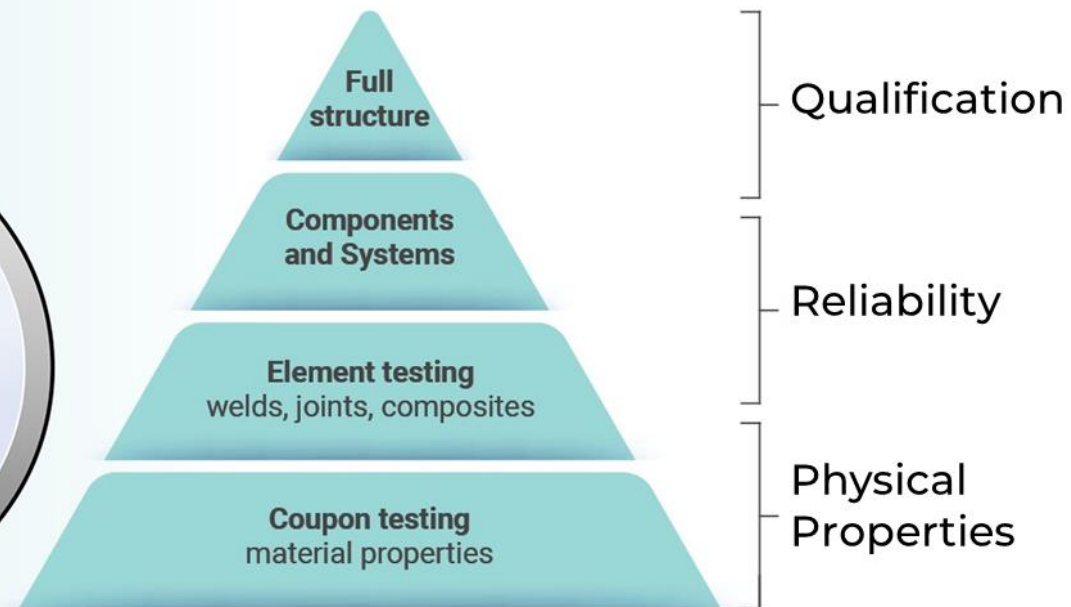
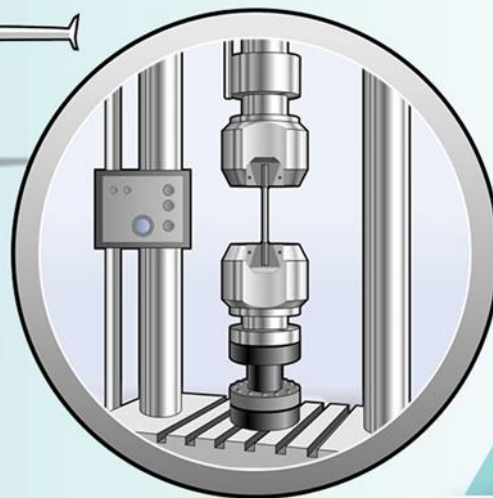
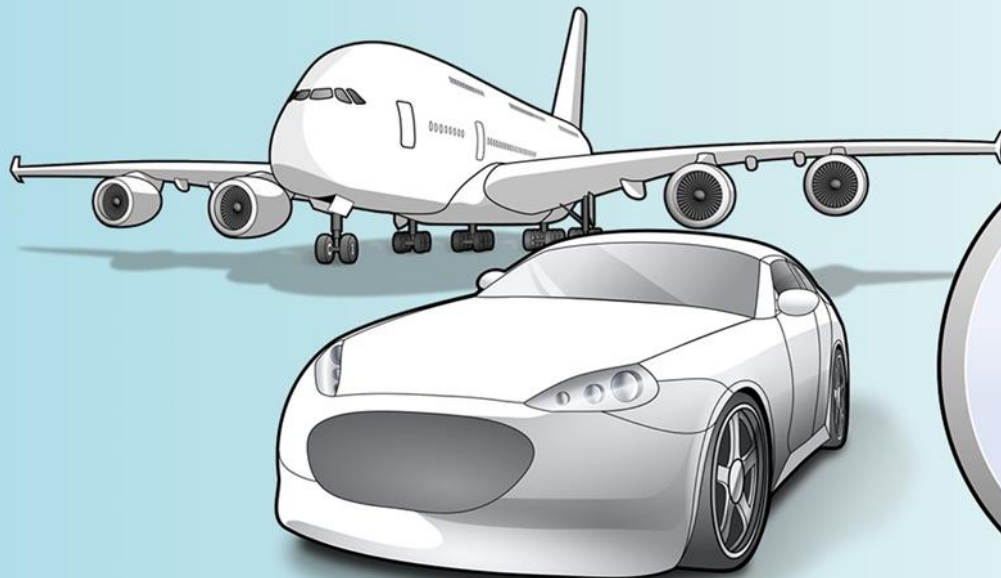
Lambert Pierrat

Thank You for Your Attention





SMART TECHNOLOGY
FOR SMARTER MOBILITY



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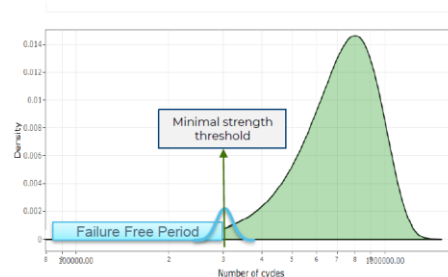
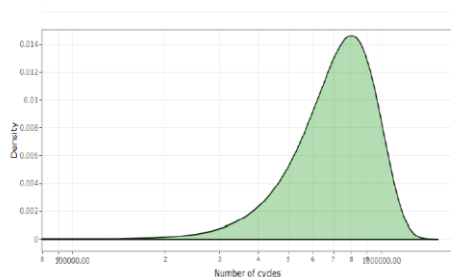
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