Durability & Reliability post-processing from Rail Operational Data

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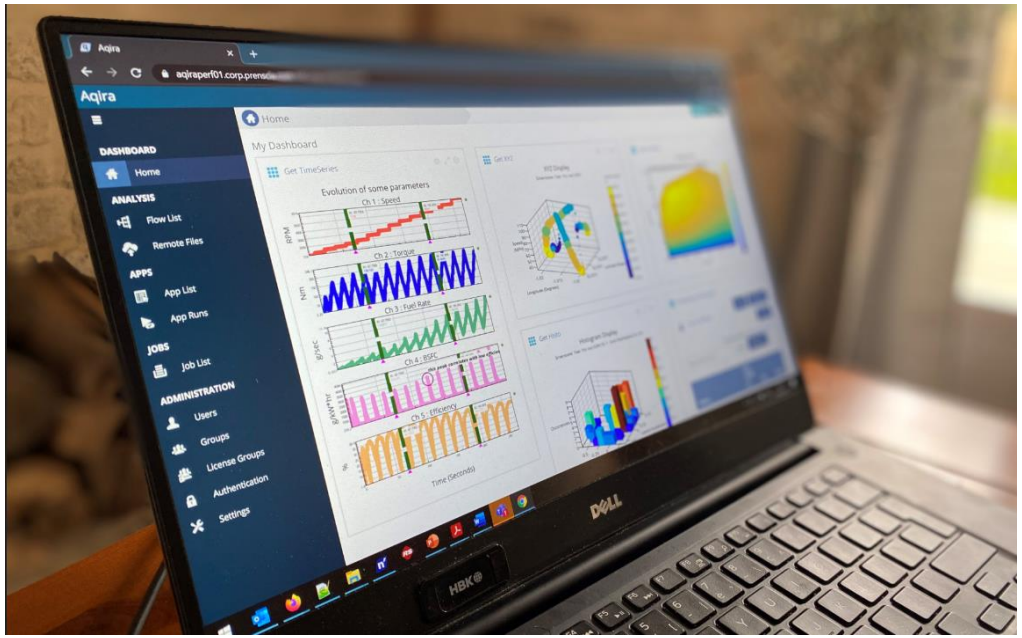
Nicolas Sias

- Application Engineer with HBK over 10 years located in France

- Focus on:
  - **nCode** solutions for understanding fatigue and durability
  - **ReliaSoft** solutions for RAMS studies



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Why does this matter?

- Rail industry has been governed by conservative standards
- A very competitive environment
- With increasingly demanding Life and RAMS targets
- And a need for cost saving
- **Operational Data can help reducing time & cost for product validation and operation**

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HBK - Connecting physical measurements and digital simulation

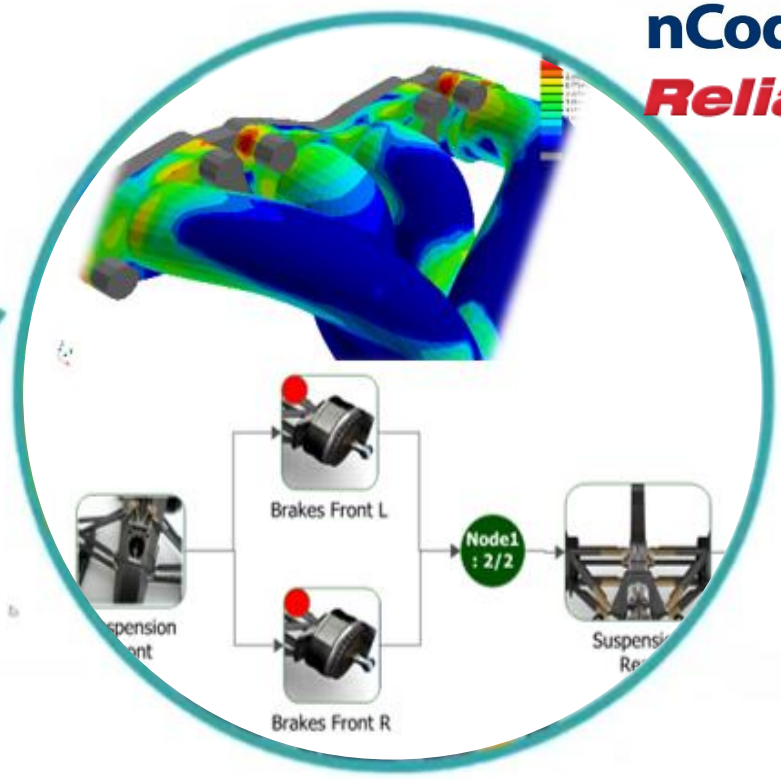
Test and measurement
Precision instruments and sensors

SOLVING THE DATA CHALLENGE

- We drive quality data
- We validate output

Simulation, modelling, control and analysis
Software for data management, analysis and simulation

nCode
ReliaSoft



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Software solutions for the complete lifecycle

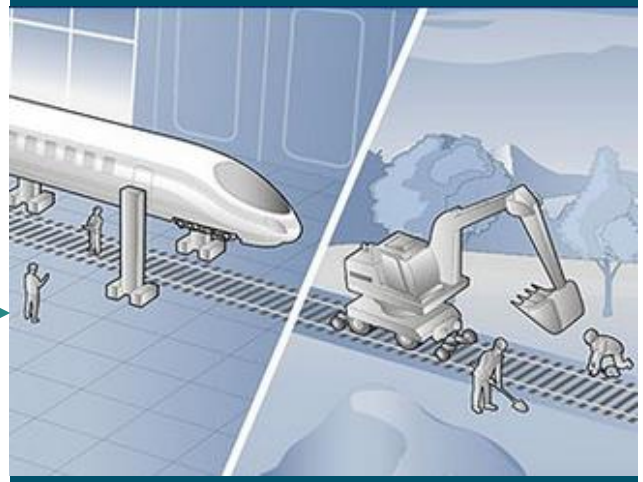
Design

- Safety Analysis (FMEA, FT…)
- Reliability Prediction
- Mission Profiling

Test & Validation

- Accelerated Test Specification
- Virtual Testing
- Test Data Post-Processing

Operation & Maintenance



- Maintenance Plans Optim.
- Spare Parts Forecasting
- KPI Monitoring

Using Operational Data to improve Durability & Reliability predictions

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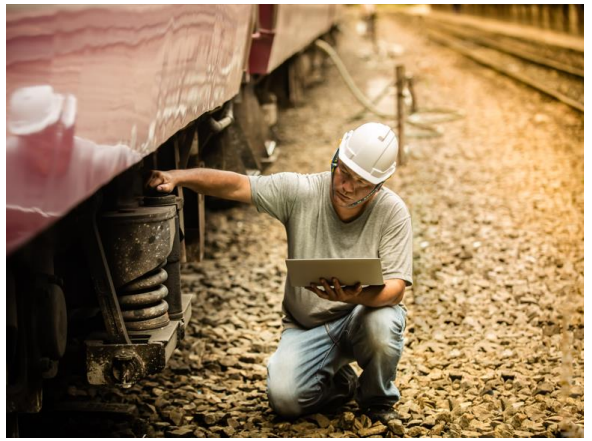
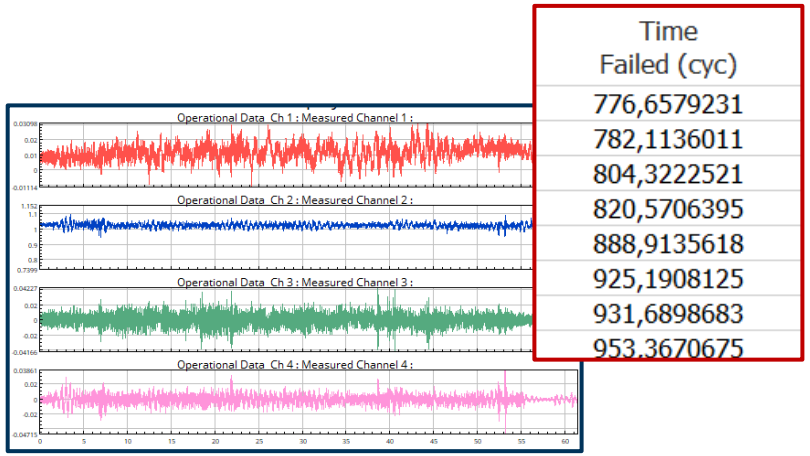
What kind of Operational Data?

- Human expertise
- Maintenance data
- Warranty claims
- On-board measurements
  - In-service loading
  - Weather
  - GPS
  - …





Time Failed (cyc)
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931,6898683
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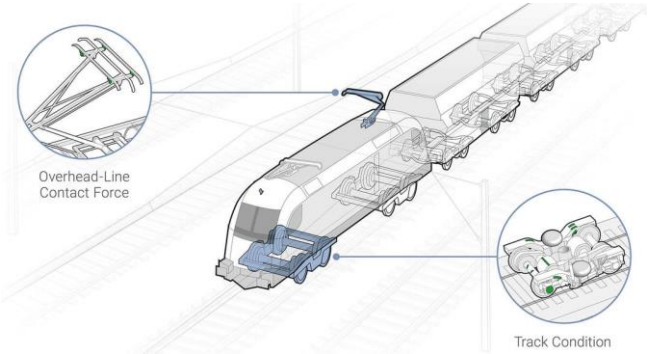

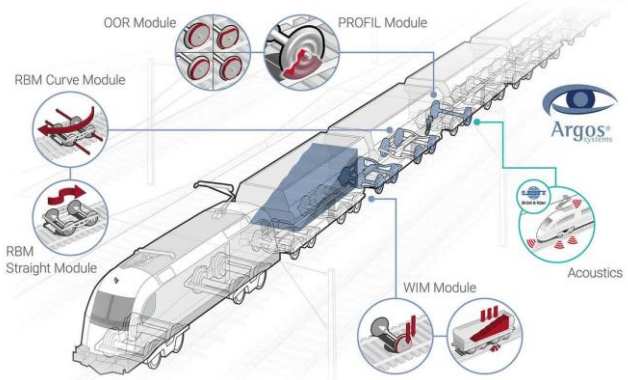

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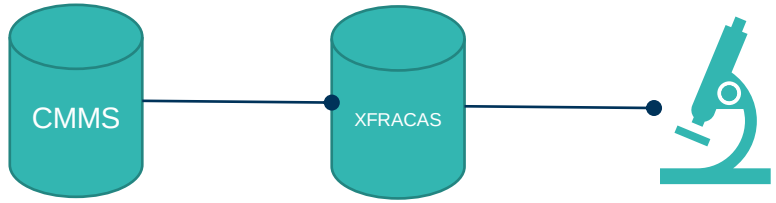
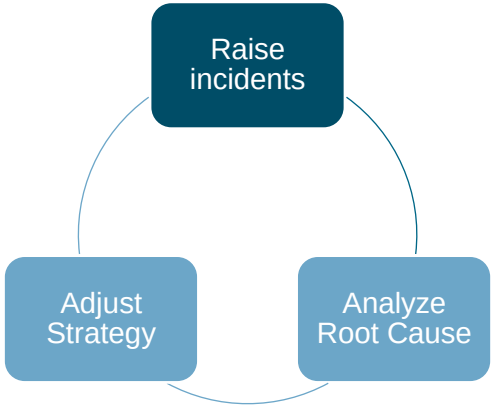
Data Quality



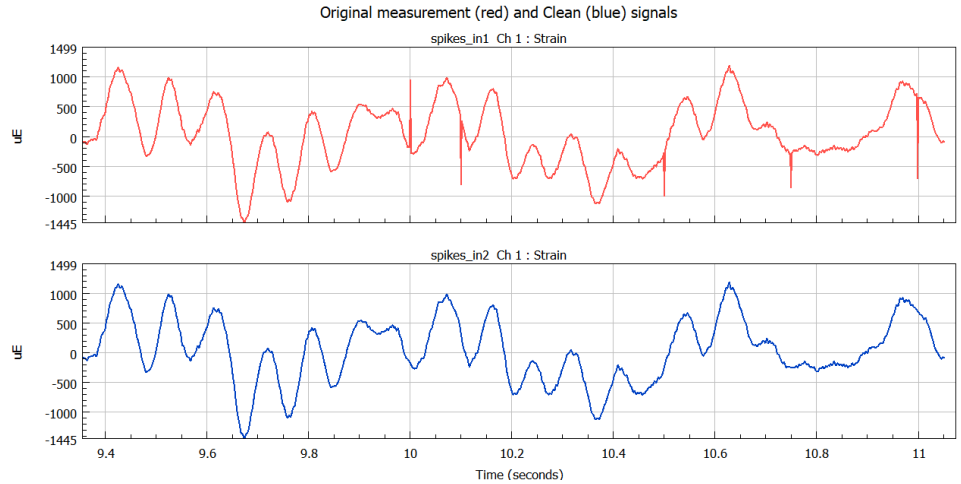
Quality issues are often observed on field data

- Lack of information
- Measurement anomalies (spikes, noise, drifts, …)



Appropriate steps need to be taken prior to analysis:

- **FRACAS** system implementation
- Signal processing - **Data cleaning and prediction** techniques



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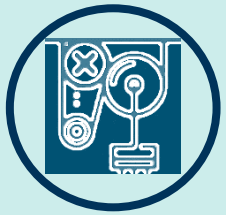

Durability Analysis

*“the ability to withstand wear, pressure, or **damage**”*

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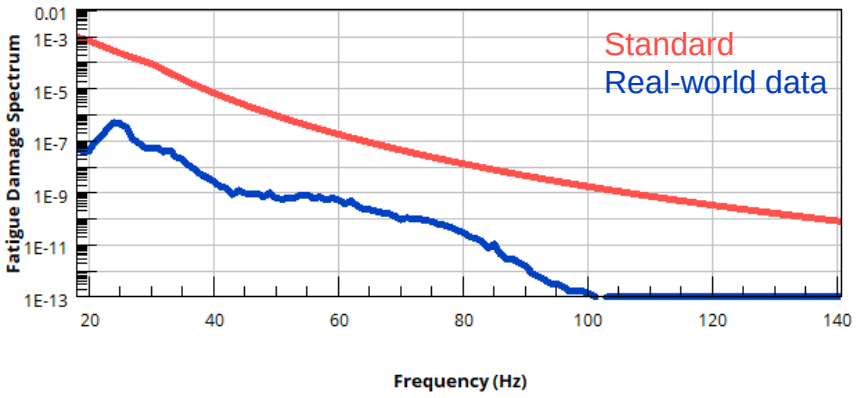
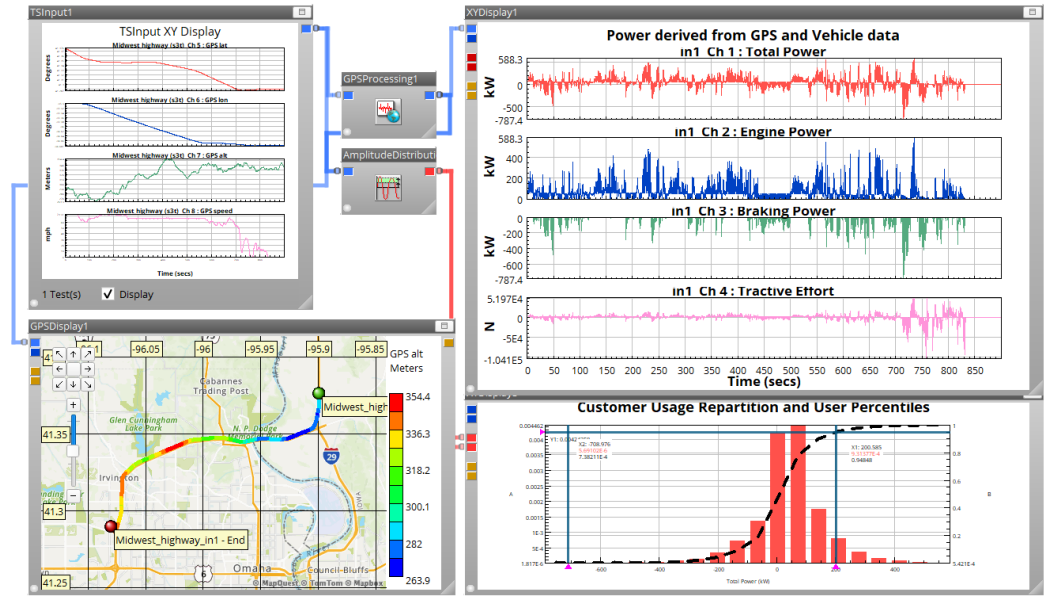
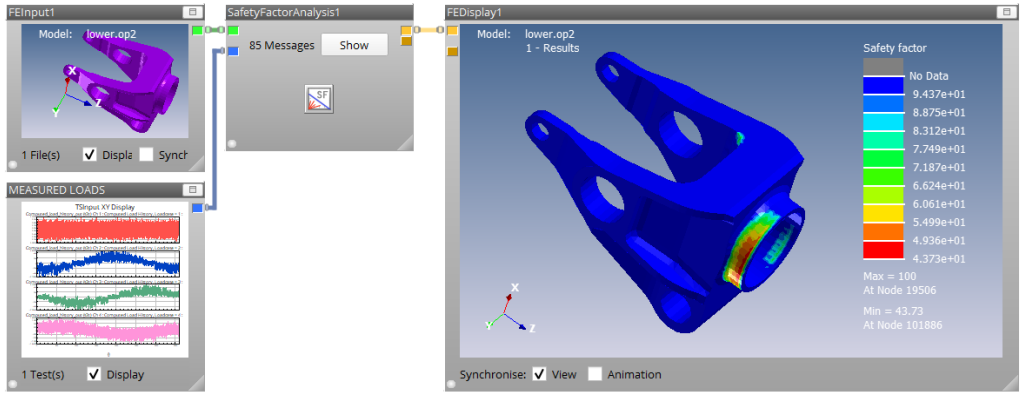
Instrumented vehicles as an input for mission profiling

- Instrumented vehicles and onsite surveys can:

1. Provide accurate **mission profiles**
   - *Time At Level histograms*
   - *Damage assessment by manoeuver/zone/weather*
2. Be a direct source for fatigue calculation
3. Compare current standard with real-world

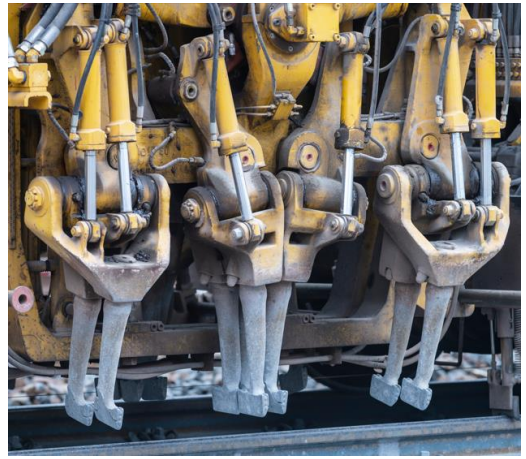


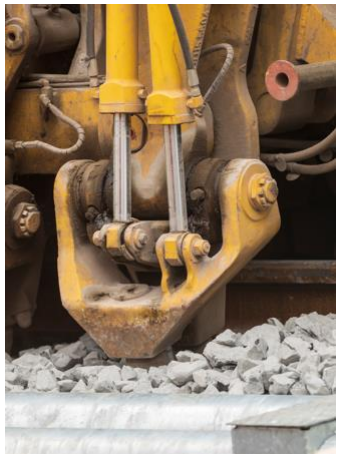


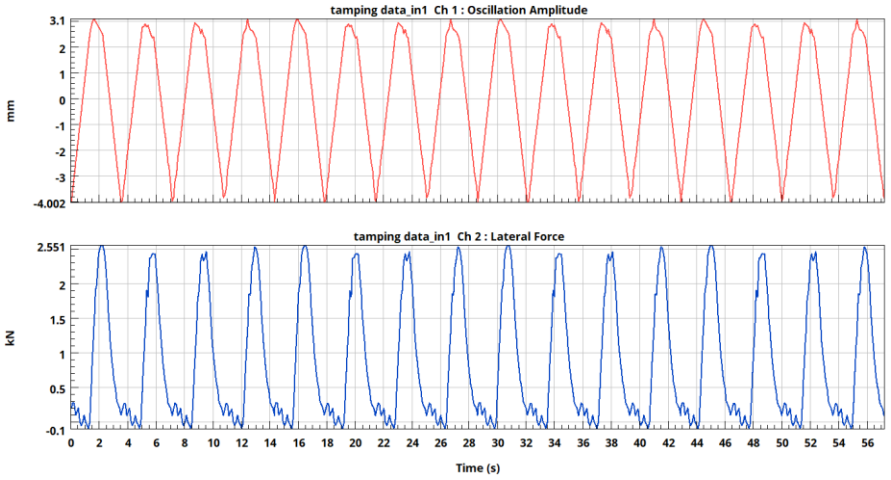


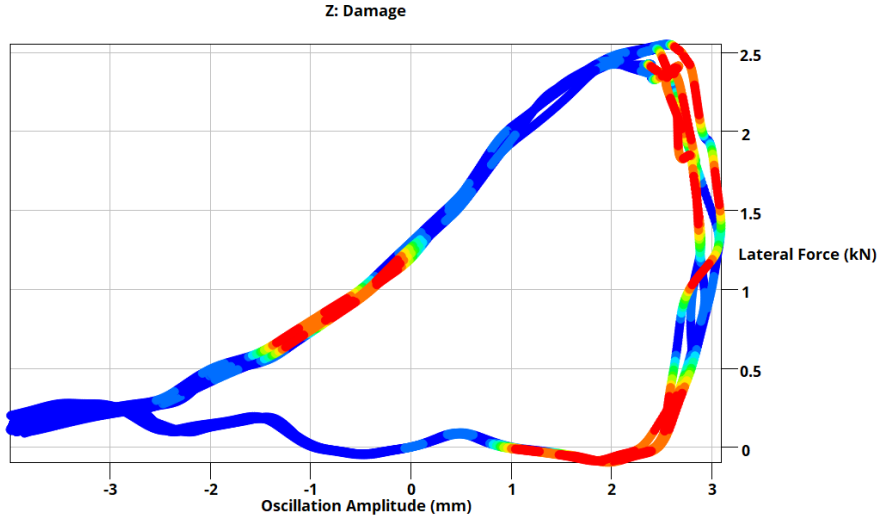
Maintenance activities as an input for durability

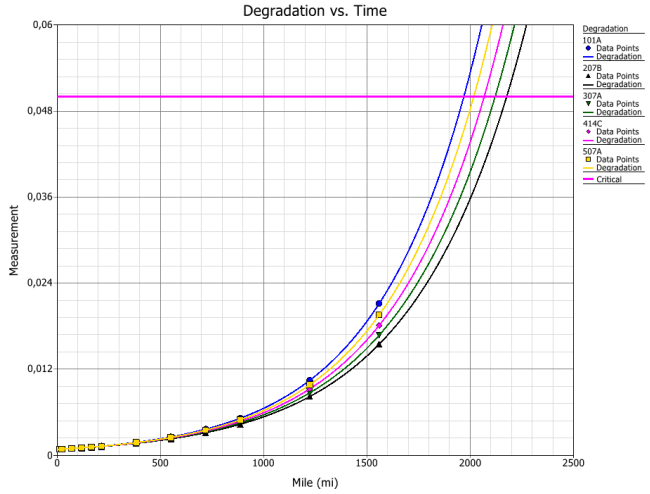
- Rail Maintenance activities such as ballast tamping can also be used as a source of information
- Routine maintenance operations can effectively transform into **degradation monitoring tools**











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Durability post-processing from Operational Data
A case study

The Challenge

- Hydraulic shaker system to run accelerated fatigue tests
- Needs a representative set of time series loading to represent a usage lifetime as quickly as possible

➡ **<u>Objective:</u> Simulate 4.5 million miles of service in a short period of time**

https://www.ncode.com/products/ncode-glyphworks-signal-processing-and-durability-analysis/full-scale-accelerated-fatigue-test-rail-car-ncode-glyphworks

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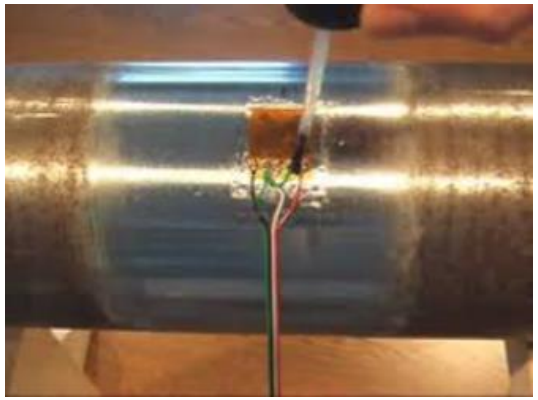
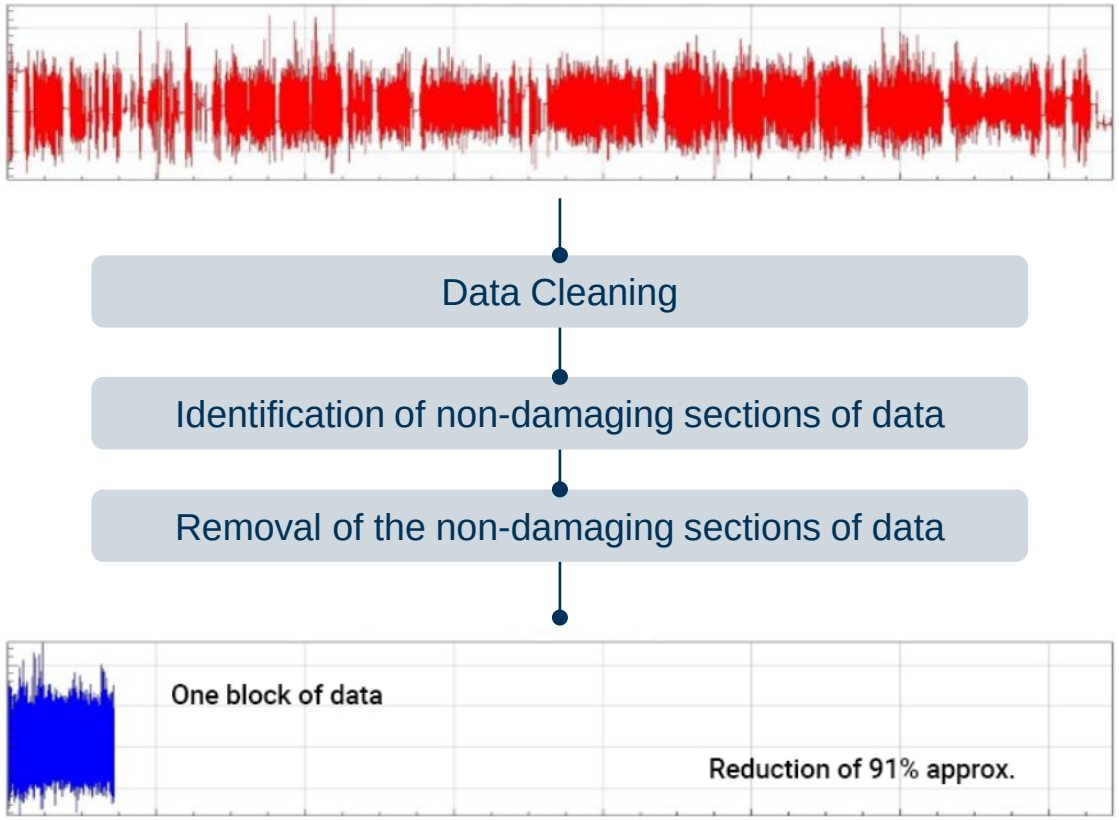
Durability post-processing from Operational Data
A case study

The Solution

- Instrumented rail cars put into regular service operation for several months to capture the different excitations from real usage
- Create equivalent inputs to the hydraulic full size shaker from these excitations





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Reliability Analysis

*"The **probability** that an item will perform its intended function for a designated period of time without 'failure' under specified conditions"*

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Why the need for accurate reliability?

- Reliability is a statistical concept for **failure prediction**
- Key metrics include:
  - Mean Distance Between Failure (**MDBF**)
  - Mean Cycles Between Failure (**MCBF**)
  - Mean Time To Repair (**MTTR**)
  - Mean Remaining Life (**MRL**)
  - …
- Allows for optimized **maintenance strategies and spare part pools**

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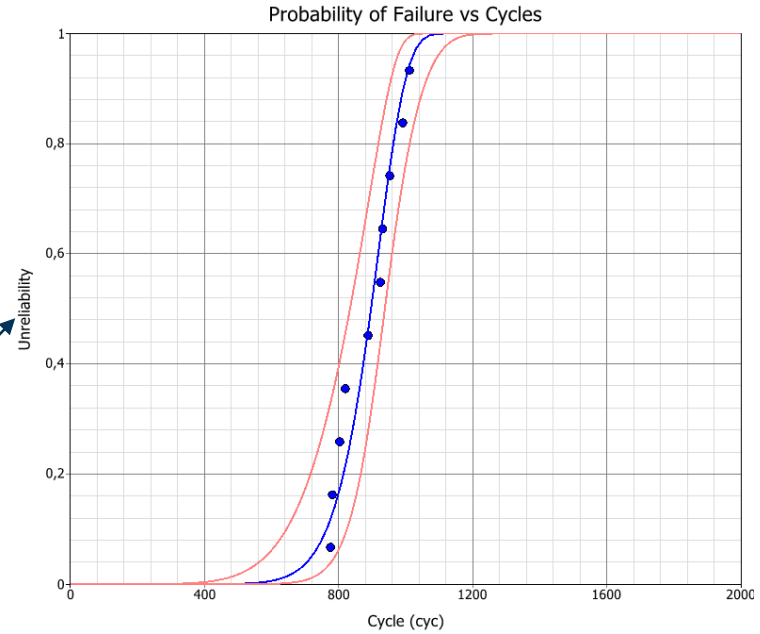
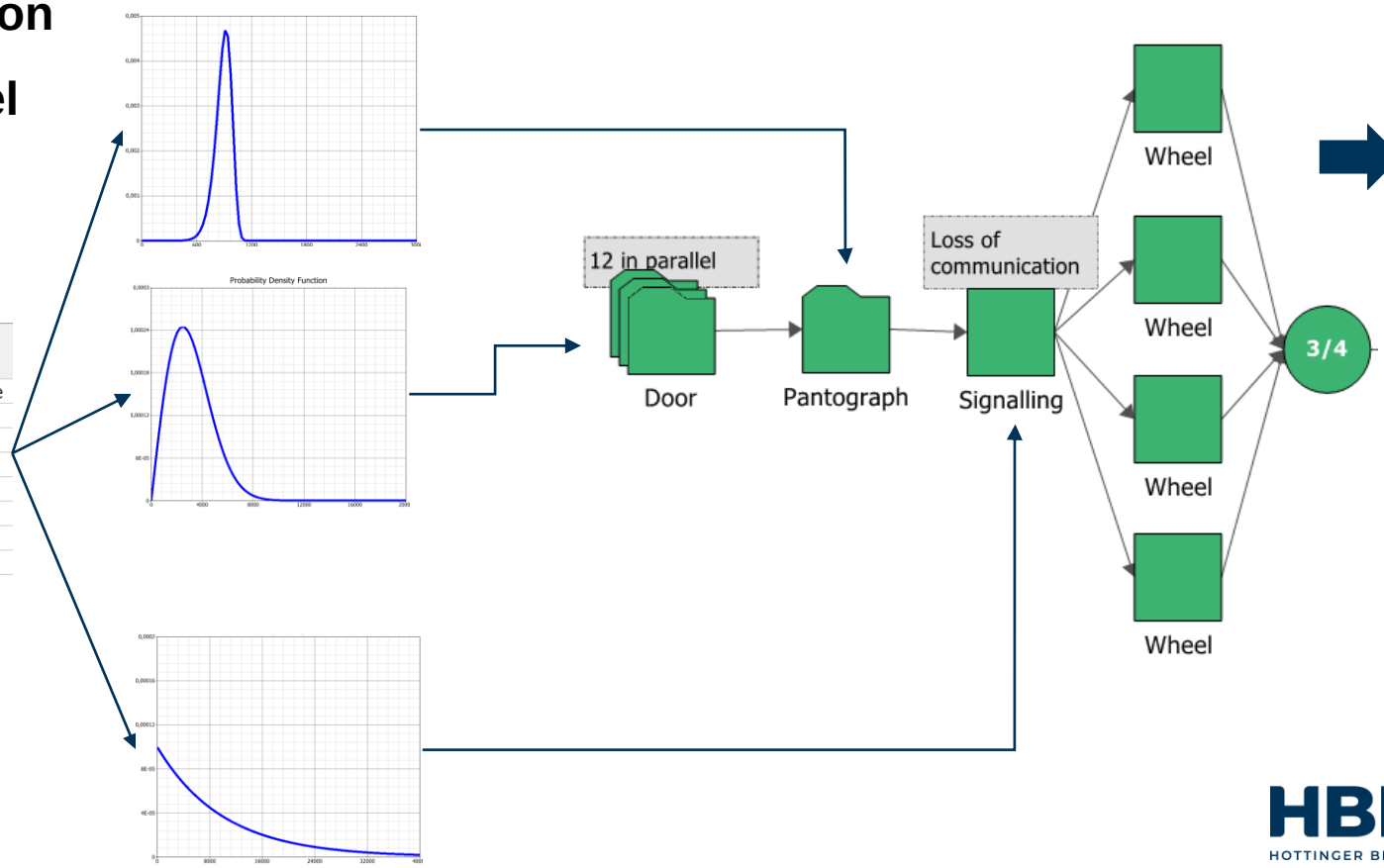


Reliability post-processing from identified failure modes

- Repair information from warranty and maintenance are a gold mine for:
  - **Life distribution estimation**
  - **MTTR at component level**

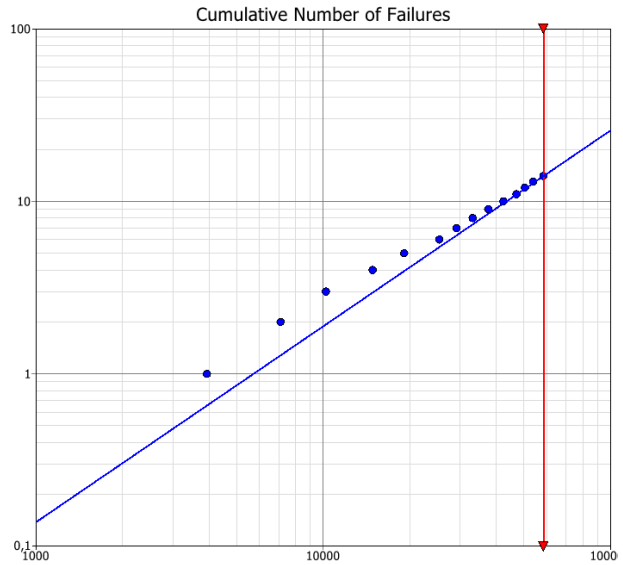
Date Occurred	Time Occurred	Date Restored	Time Restored	Level 1	Level 2
mars-01-04	11:00:00 AM	mars-05-04	9:00:00 AM	Door	Fatigue failure
avr-01-04	2:30:00 PM	avr-03-04	11:00:00 AM	Pantograph	Power loss
mai-03-04	9:00:00 AM	mai-06-04	12:00:00 PM	Signalling	Comm. loss
août-03-04	3:30:00 PM	août-04-04	9:00:00 AM	Signalling	Comm. loss
sept-01-04	4:10:00 PM	sept-02-04	4:00:00 PM	Wheel	Inspections
déc-01-04	10:00:00 AM	déc-02-04	3:00:00 PM	Door	Lubrication
janv-04-05	12:30:00 PM	janv-07-05	7:20:00 AM	Pantograph	Electric spike
févr-01-05	4:00:00 PM	févr-02-05	7:00:00 AM	Pantograph	Power loss

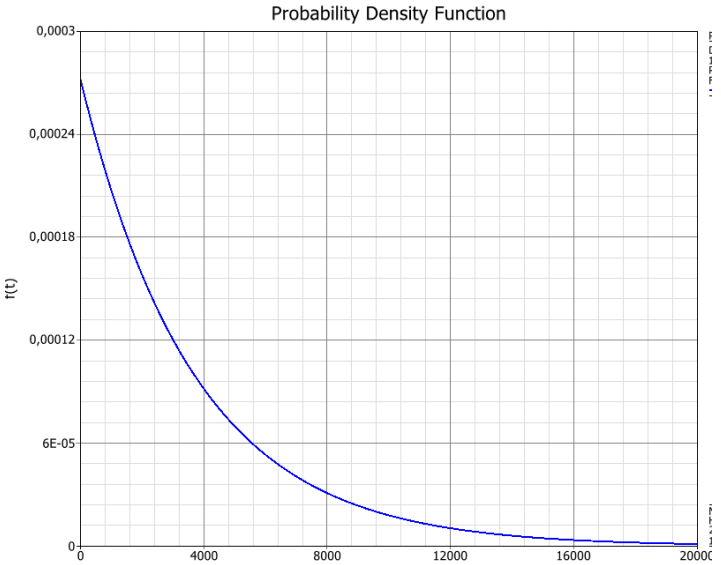


Reliability post-processing from unknown failure modes

- Data collected from the field often **lack information** regarding the actual failure modes
- In this case, **Reliability Growth techniques** can still analyze the subsystem data as a whole

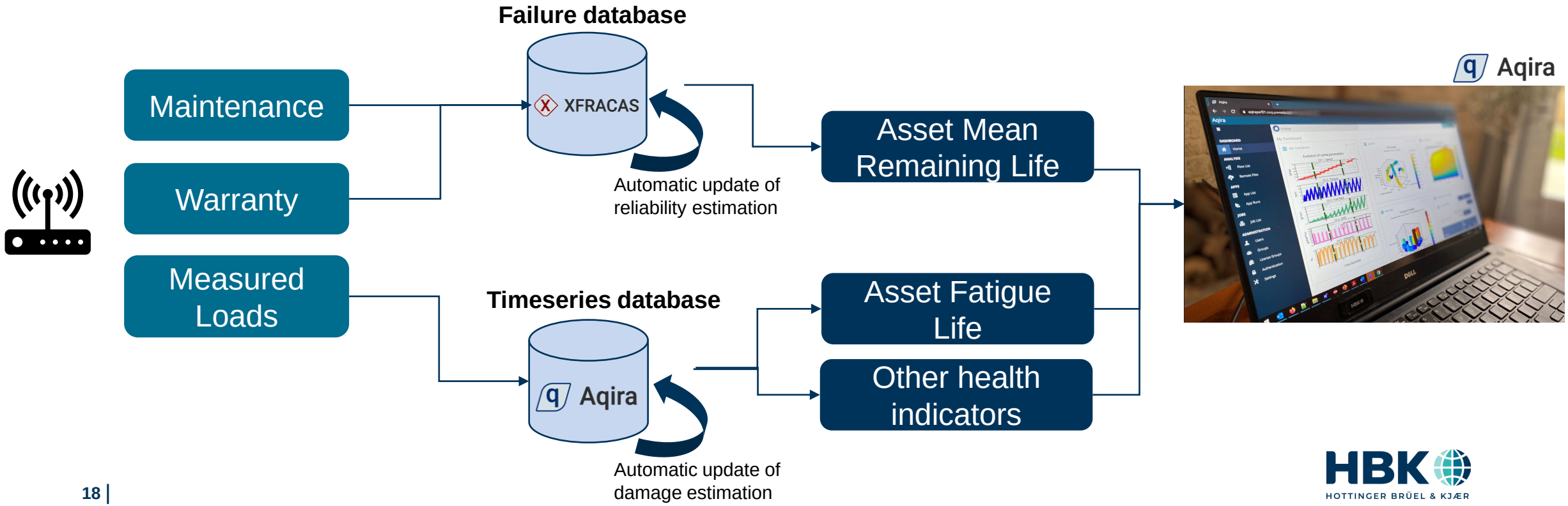
	Door Failures (cyc)	Failure Mode
1	3946,17	Pushbutton
2	3171,497	?
3	3115,159	?
4	4644,131	Actuator
5	4290,018	?
6	6238,337	Pushbutton
7	3775,774	?
8	3998,283	Actuator
9	4386,177	?
10	4895,964	Valve
11	4679,758	Valve
12	3280,928	?
13	3439,068	Pushbutton
14	4603,264	?





A living process

- Operational data can be a continuous source of information for
  - updated durability and reliability predictions
  - trend analysis
  - predictive & prescriptive maintenance



Conclusion

- Operational Data are key information for the reliability and durability engineers
- They can come from different sources, but require proper **cleaning techniques** prior to analysis
- They can be used as an input for **optimized test specification** and **accurate reliability prediction**, accounting for real-world usage
- By including operational data, one can target to:
  - Reduce the **overall testing time**
  - **Improve service availability, regularity and punctuality** by avoiding service-affecting failures and reducing maintenance downtime

Questions?

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Thank You

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