Increase Operational Efficiency by Combining PI System Sensor Data and Maintenance Records

Guga Gugaratshan, Vasileios Geroulas
Prenscia Engineering Solution
HBM nCode Federal

The Challenge of Improving Operational Efficiency

Is my asset operating as expected?

Should I repair or replace the asset?

Is action required?

We do not have the right data…

The maintenance data is incomplete and imperfect…

Some operational sensor data is available, but we cannot add more sensors…

There are no recorded failures for the asset, how can we estimate the RUL?

Should we increase the number of stocked spares?

What are the most critical assets we should focus on?

About Us - Prenscia Engineering Solutions
(formally knows as HBM Prenscia Solutions)

Prenscia Engineering Solutions is part of a global engineering organization

- OSI Partner since 2018
- 6,000 companies served
- 25,000 reliability and durability engineers trained

Empowering decisions through **software and service solutions** to convert engineering data into **actionable information** to improve efficiency, availability, reliability, safety, durability and optimize the overall Asset Lifecycle Management (ALM)

… across multiple industries

Reliability, Durability and Prognostics… Multiple Industries

Software Tools

nCode
Component Performance

- Design Optimization
- Operational Usage
- Safety Design
- Damage prediction
- Vibration analysis
- Deterioration

ReliaSoft
System Performance

- Life Cycle Cost Analysis
- Predicting Reliability
- Forecasting
- Risk Analysis
- Maintenance Strategy

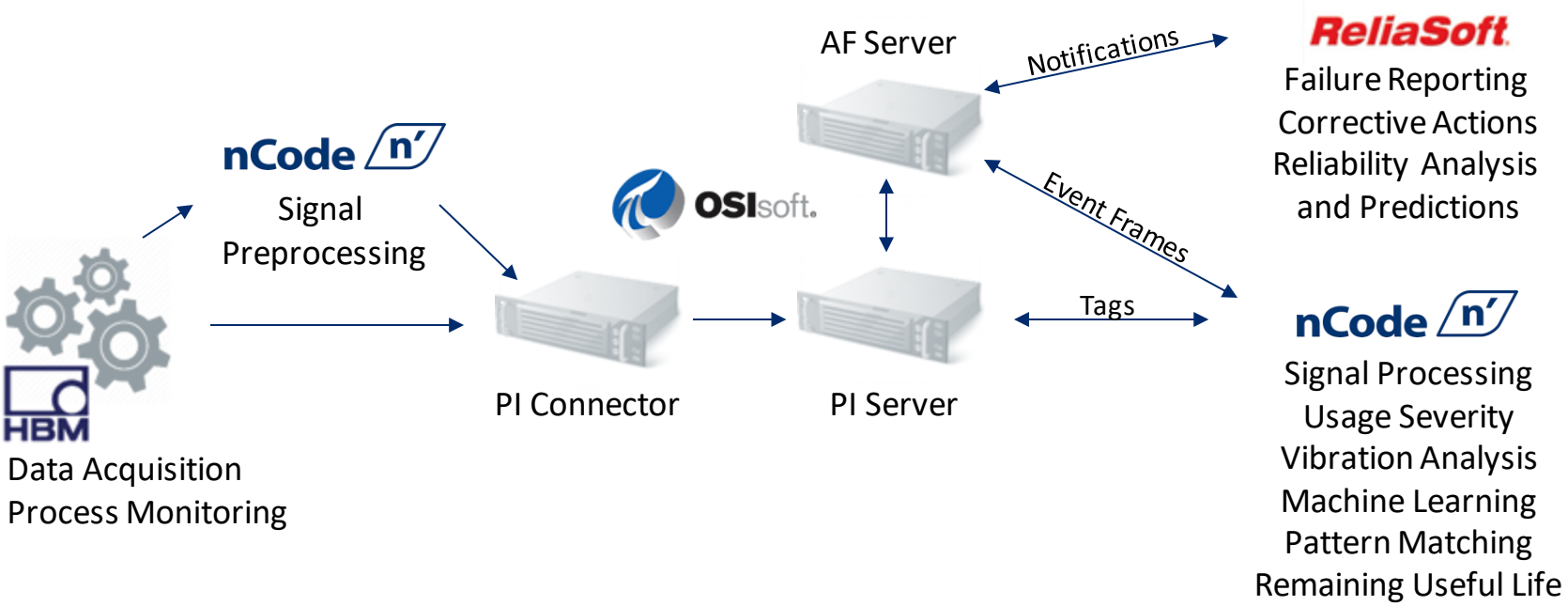
Asset Lifecycle Management Solutions

Prenscia Engineering Solution
Software and services solution provider

- Prognostic analysis for Remaining Useful Life
- Asset hybrid digital twins (combining Machine Learning & Engineering)
- Maintenance Optimization
- KPI and Continuous Monitoring
- Integration with third party systems

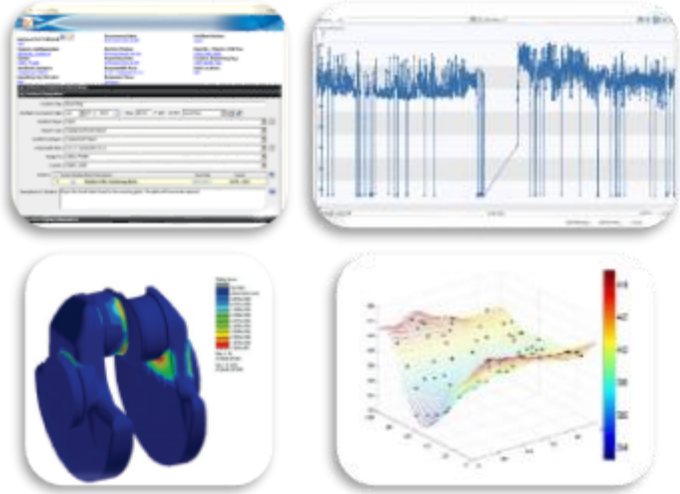
OSI Interfaced Architecture

HBM Prenscia Products – part of a process



Our Business

By utilizing **all the available data** for an asset (operational, maintenance, inspections)



Combining **engineering** principles with **data science** and **machine learning**

… our models, analysis and systems provide high confidence information to support

… accelerated development, risk management, improved operations, improved asset management, and other key business decisions

Analysis Flow

How can we extract the maximum value from the available asset data?

Connectivity → Data Preparation → Analytics → User Interface

Connect to existing customer systems

Present right information to stakeholders

Historian (OSIsoft.)

Operational Data (Time Series)

CMMS

Maintenance Data (Historical Failures)

Data Preparation

Prepare data to be used in analytics

- Data Cleansing
- Feature Extraction
- Systems Sync

nCode

Engineering & Data Science:

- FEA, Vibrations, Fatigue, Physics
- Machine Learning, Pattern Recognition, Outlier Detection

ReliaSoft

Reliability Strategy and Analysis: FMEA, RCM, LDA, RAM, Asset Criticality, Incident Tracking, Root Cause Analysis

Superior Insights, Remaining Useful Life, PdM, KPIs

Trigger workflows for different tasks

How to Get the Answers

Challenges

Our Solution

- Combine all available data sources
- Combine engineering with data science in a hybrid approach
- Answer reliability, availability, remaining useful life, etc

Benefits

- Low cost option
- Use existing systems and data sources
- Increase operational efficiency
- High confidence

1) Do not depend on a single source of data

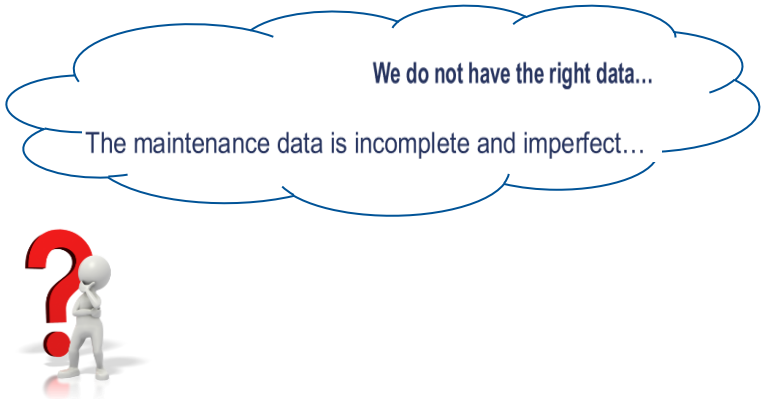
2) ML models need lots of data and can be as good as the available data. Take advantage of the asset physics to overcome these shortcomings.

Example 1

Challenge:

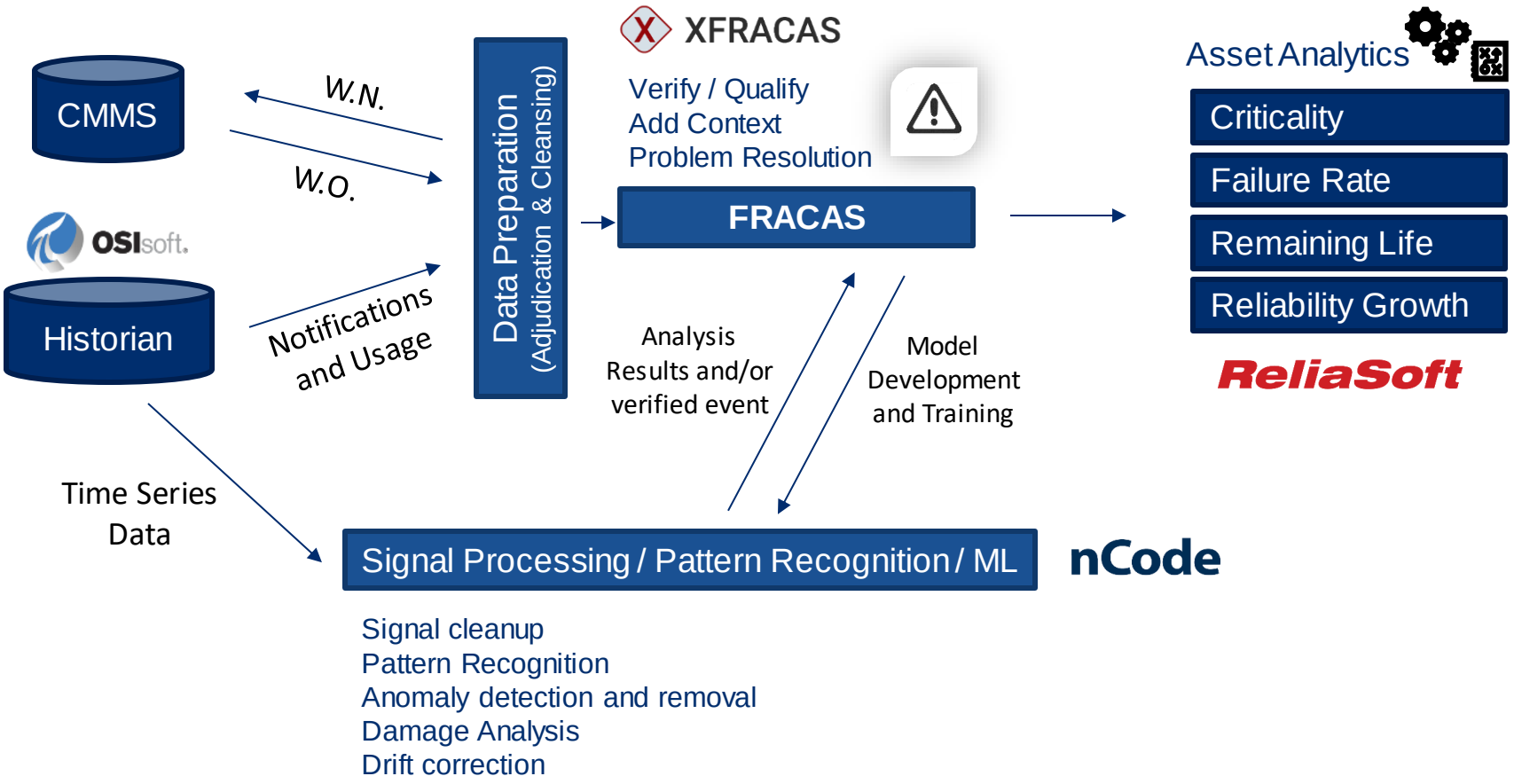
The available data is not trustworthy (incomplete, inaccurate, etc)

How can we extract value from such data?



Most common challenges for CMMS data
Missing information
Incorrect descriptions
Inconsistent descriptions
No actual stop/start information
No true parent-child hierarchical relationship
No usage information
False positives and **mistrust**

Analysis Flow



Case Study

Step 1 Incidents in XFRACAS created from combination of data:

(1) Failure data (CMMS)

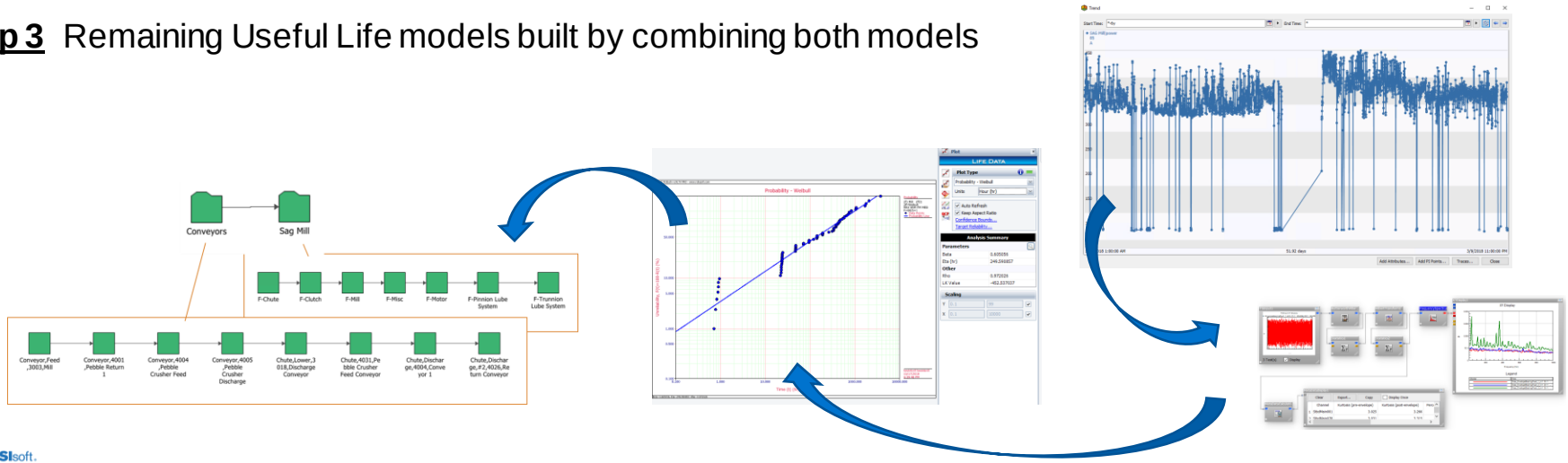
(2) Unplanned trips (Historian)

→ Build **component life models** (Reliasoft)

Step 2 Operational data stored in Historian

→ Build **deterioration models** (nCode)

Step 3 Remaining Useful Life models built by combining both models



Example 2

What we keep hearing from customers:

“When is the asset going to fail?”

How can we answer this question?

Collecting data is very important

Knowing how to analyze and leverage your data is equally important

Analysis Flow

OSIsoft PI Component

Prenscia Component

PI Vision

AF Server

PI Server

1 Component analysis window

2 Data Stream

3 Expected life prediction

4 Expected life

PES Hybrid Approach

XFRACAS

ReliaSoft

Advanced Analysis

Get analysis window

Use hybrid model to estimate asset health and RUL

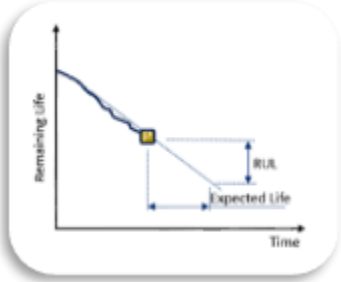
Write back to component

Life Prediction

Given current life and component failure model

Given available population data

Predict life



PES Hybrid Approach – From Data to Decisions

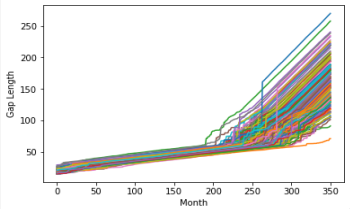
Maintenance Data (CMMS)

Inspections

	A	B	C	D
A	0.7756	0.2126	0.0052	0.0021
B	0	0.9847	0.0093	0.0036
C	0	0	0.8698	0.1187
D	0	0	0	0.9402

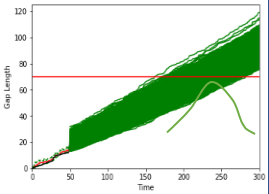
Failures

Asset Deterioration Model

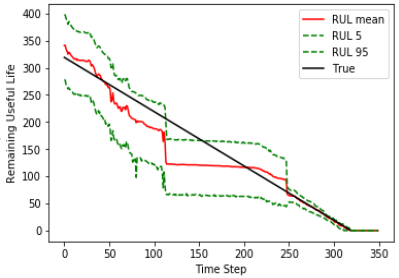


"Average Asset Behavior"
(consider maintenance data of all similar assets)

Updated deterioration model



RUL over time

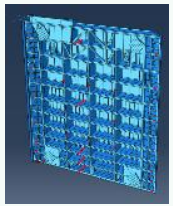


Decision making

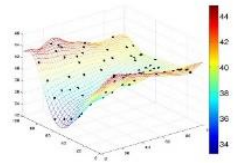
Operational Data OSIsoft.

Time series from sensors

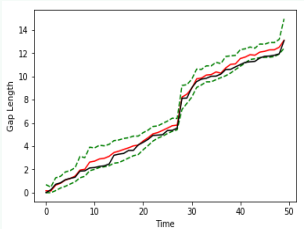
Physics Model



Surrogate Model (ML)



Asset Deterioration Model



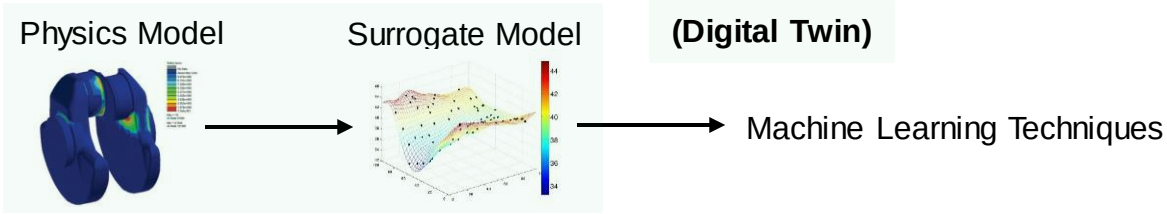
"Specific Asset Behavior"
(consider operational data of the specific asset being monitored)

PES Hybrid Approach – Advantages

- **Capable of estimating RUL even when limited or no failure data is available**

  - Pure machine learning techniques cannot handle such cases

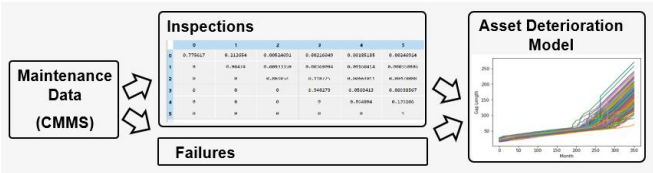
  - Our solution:



- **Increased confidence in available data, by combining more than one data sources**

  - Described in previous example

- **Consider historical data of the population when making predictions for individual asset**



Case Study – Waterway Transportation Corridor

Problem

- Gate bending next to the quoin block (wall)
- The bending creates gaps (between gate and wall)
- Stresses can increase and gate can collapse

Approach

Start with what you have (no extra costs)

- Use **existing strain gauges** that are located on the gate

Limited amount of data --> Use physics

- Build **FE model** of the gate and **generate data** for different scenarios

ML model to estimate asset degradation

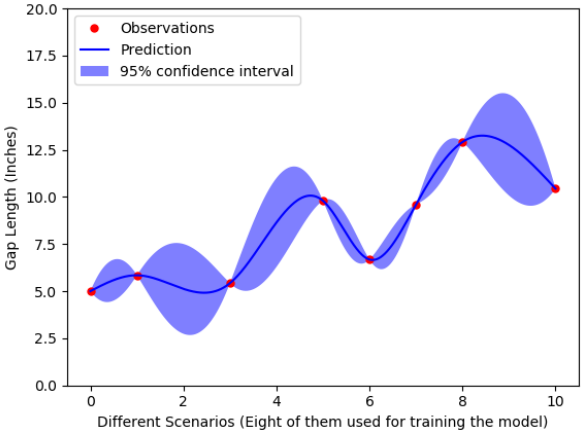
- Apply **ML** to correlate the strain measurements with the gap length

Results

- Correlated strain measurements to gap length
- **Accuracy: 96%** (Neural Networks and Gaussian Process Regression)

Benefits

- Drastically reduce costly underwater inspections
- Prioritize maintenance actions among gates
- Reduce downtimes



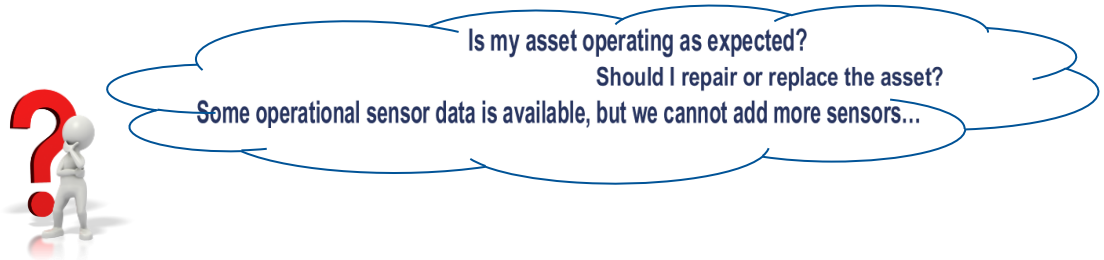
Example 3

Challenge:

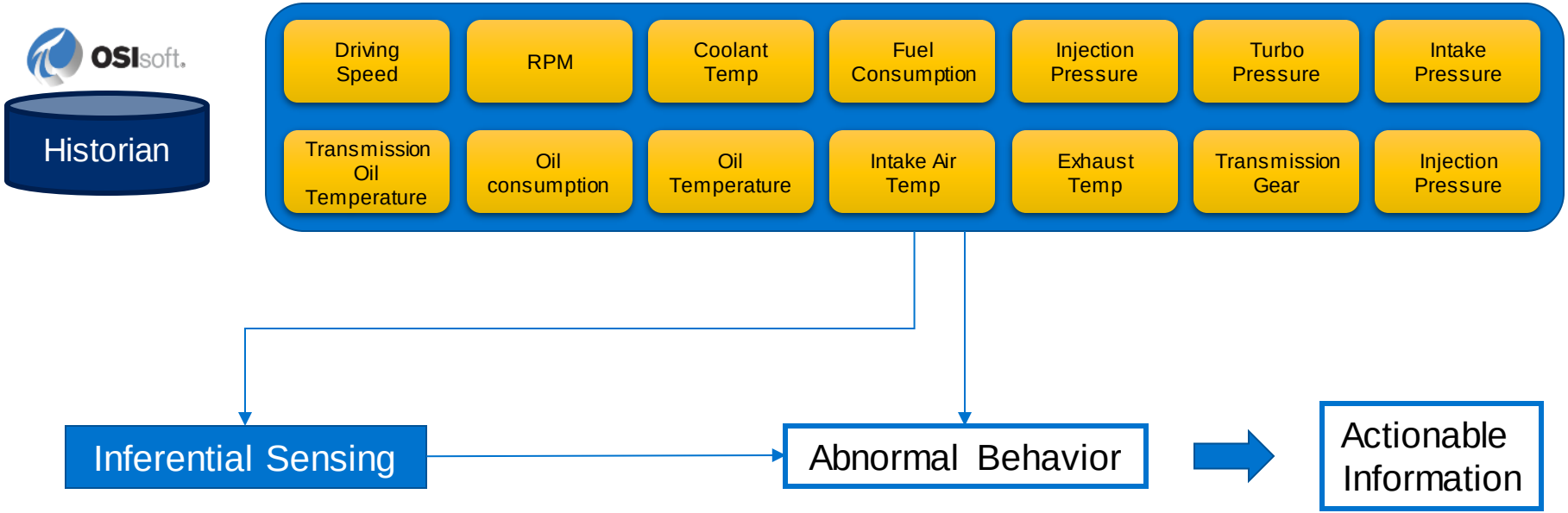
Identify abnormal behaviors in a fleet of vehicles.

The maintenance data and DTC codes are not very trustworthy.

We cannot install more sensors than the existing ones (CAN bus data).



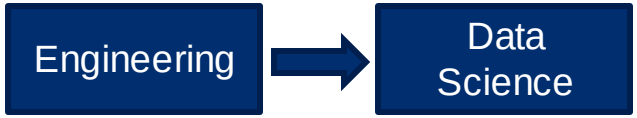
OSIsoft PI Data Stream



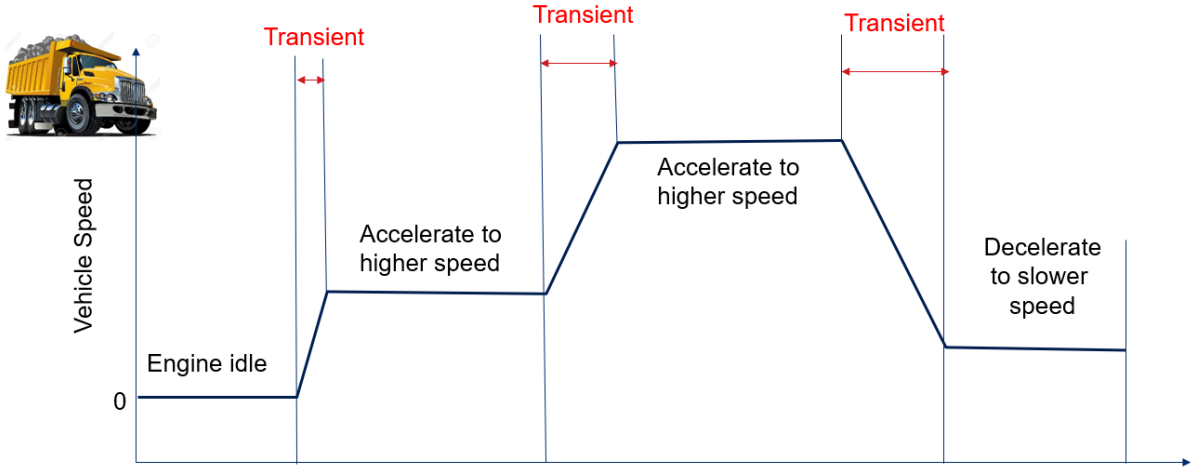
Predict key parameters (impractical to measure directly, but required for modelling) using the available data, based on engineering and physics

Example: Engine Efficiency

Mapping Vehicle Performance



- **Transient** – rate of change is not equal to zero
- **Steady state** – rate of change is equal to zero



We need to understand the way an engine is supposed to operate in different operating conditions.

Why don't we simply use some Machine Learning technique?

We would need abundant data representing all the regions of normal operation of the engine
--> In most cases, this data is not available…

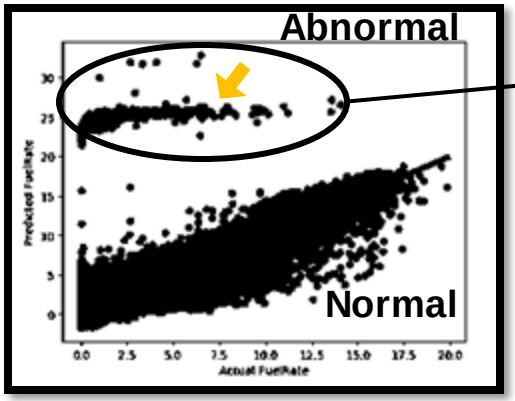
Case Study – Identify Abnormal Vehicle Behavior

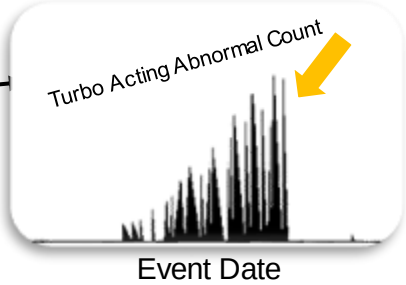
Problem

- Identify abnormal vehicle behavior using only the available CAN bus data
- Some DTCs and maintenance data available (can be used for verification)

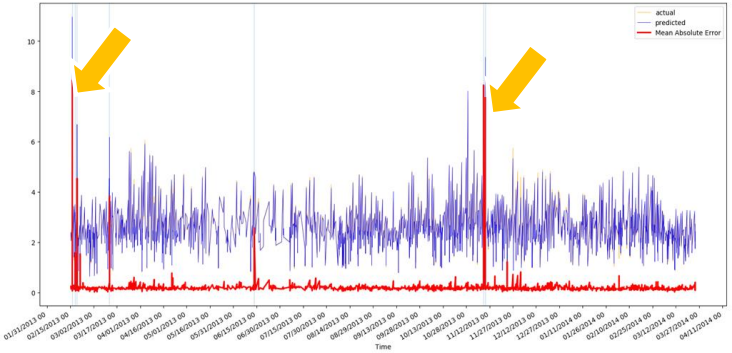
Results

Failure Mode: **Turbo Boost Pressure Failing**





Verify using number of failures obtained from CMMS



Peaks correspond to abnormal behavior (vs time)

Summary

Prenscia Solutions

Providing tools, analysis, people and solutions to enhance system reliability, durability, safety, and optimize the overall Asset Lifecycle Management

CHALLENGE	SOLUTION	RESULTS
• Extend asset life • Increase system availability • Optimize maintenance • Improve product designs • Accelerate product testing	• Understand why assets fail • Integrate with OSIsoft PI System and CMMS systems • Utilize all available data sources • Combine engineering with data science (hybrid approach)	• Significant reduction in maintenance costs (on average 10%) • Comparable improvement in system availability • Enhanced business decision making by answering questions about reliability, remaining useful life, etc

Presenters

- **Guga Gugaratshan**
- Head of Partner Solutions
- HBM nCode Federal / Prenscia Engineering Solutions
- guga.gugaratshan@ncodefederal.com

- **Vasileios Geroulas, PhD**
- Engineering Solutions Consultant
- Prenscia Engineering Solutions
- vasileios.geroulas@hbmprenscia.com

Questions?

Please wait for the **microphone**

State your **name & company**

Save the Date...

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OSIsoft. PI World