Pepperl+Fuchs IIoT Cloud Applications

Predictive Mainentance Cloud Solutions in the Age of AI

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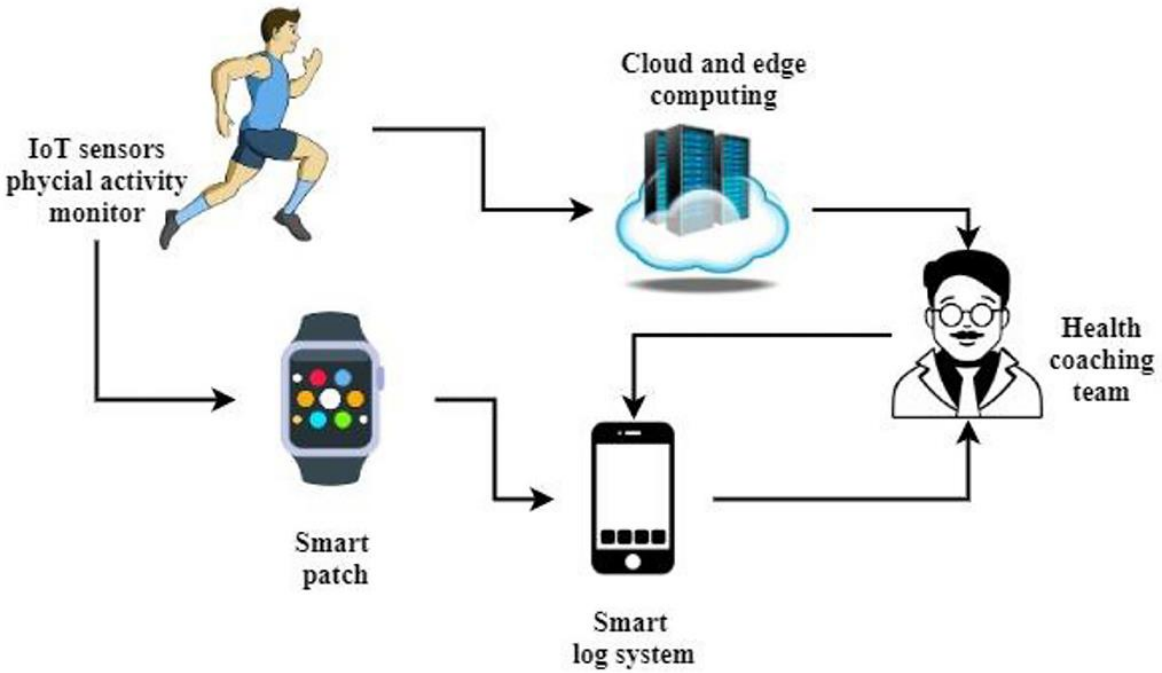
What is Predictive Maintenance and Condition Monitoring?

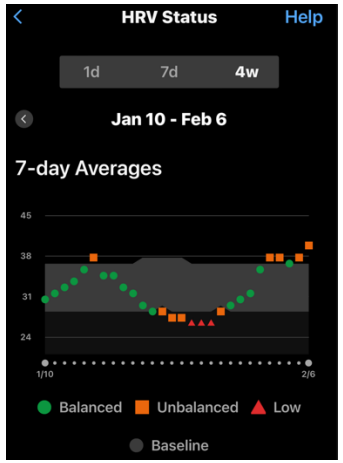


- IIoT is simply sharing real-time data via connected sensors within a machine to provide data about a business/mission critical process
- Vibration, temp, pressure, and flow will help measure condition and machine health
- P+F sensors act like your smartwatch telling you how you are doing
- Smartwatch sensors will measure BloodOx, heart rate, sleep, and stress to determine body health and training progress

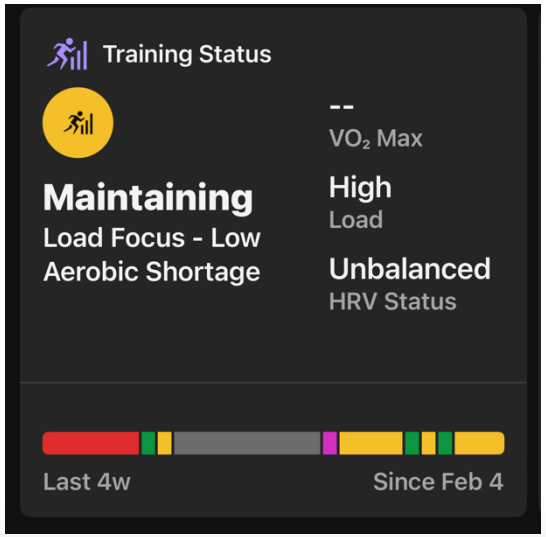
Applications in IIoT Using Digital Twins

Digital twins, powered by real-time data integration, are revolutionizing business operations across industries:

- ✅ Optimize production lines in real-time
- ✅ Enhance fleet management with live vehicle data
- ✅ Improve warehouse efficiency and reduce errors
- ✅ Make smarter, data-driven decisions faster than ever before



- Digital twins provide a business the ability to visually see how an operation is operating and provide guidance on how to repair or maintain a machine/process ahead of machine failure
- Back to the smartwatch example, if stress spikes or HRV drops dramatically you have suggestions on how to fix the condition
- Digital twins will assist you in the prescribed maintenance for the machine to keep it operating optimally



Vibration Monitoring to Determine Bearing Wear

Vibration Monitoring Coupled with Temperature and other sensing technologies provides a real-time view

Typical bearing defects are the following:

- Outer race defects
- Inner race defects
- Rolling element defects
- Cage defects
- Multiple component defects
- Bearing lubrication problems
- Misalignment
- Looseness

Bearings used in industrial applications:

- Fans and turbines
- MRI and MedTech
- CNC machines
- Packaging equipment
- Oil & gas
- Robotics

Unlocking Cost, Risk, and Reliability Gains through AI-Enabled Maintenance

Reducing Failures and Maximizing Throughput via Predictive, Data-Driven Asset Strategies

BOSCH
Invented for life

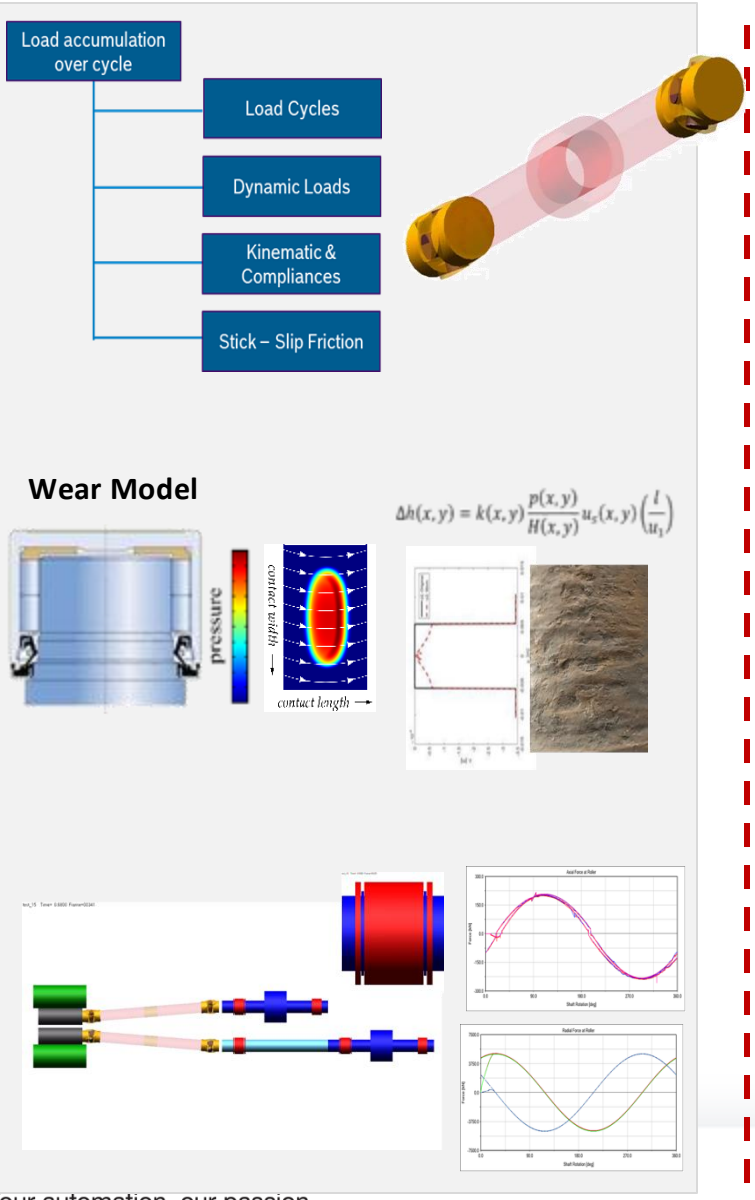
Case Studies – Steel Industry

BOSCH DIGITAL TWIN INDUSTRIES

Maximizing Mill Uptime with Predictive Intelligence

AI-Powered Digital Twins for Cross Joint Reliability and Performance Optimization

Case Study # 1



Key Challenges

Wear & Tear: High operational loads cause wear on cross joints, yoke, and rollers.

Failure Drivers: Lubrication issues, axial/lateral loads, slab temperature, and torque.

Downtime Impact: Unexpected bearing failures disrupt production.

Solution Framework

Virtual Sensors

Simulate load, temperature, lubrication status.

High-frequency data monitoring.

Hybrid Modeling

AI Models: Detect early signs of wear/lubrication failure from historical data.

Tribology: Model lubrication behavior and frictional heat.

MBD & Multiphysics: Simulate thermal, mechanical, and motion loads.

Failure Predictions

Cross & Yoke Wear: Predict fatigue and cracking points.

Roller Wear: Detect misalignment and surface degradation.

Lubrication Issues: Forecast breakdowns, starvation, and friction spikes.

+15% MTBF

Higher reliability through early fault detection

12% Less Downtime

~$300K annual savings

+3% Output

Improved slab throughput

Longer Asset Life

Reduced wear and stress

Smarter Maintenance

Predictive scheduling cuts emergency fixes

PEPPERL+FUCHS

Online Shaft Power Measurement for HSM Efficiency

Real-Time Shaft Power Monitoring for Smarter Roughing Mill Operations

Case Study # 2

Transistor

- Powered from Rotor belt (5V)
- IP65 rated
- Transmits 2 channels of strain
- Wi Fi 2.4GHz
- Acts as strain protection cover

Stator

- RPM speed sensor
- IP65 rated
- Receives data from the transmitter
- Inductively powers the belt
- RS485 serial data to controller

Inductive Power Receiver

Key Challenges

- Frequent **BDM crosshead failures**
- No **real-time shaft torque/power data**
- Unexpected **production downtime**
- High **unplanned maintenance costs**
- Poor **data-to-action conversion** for maintenance

Solution Framework

Health Monitoring:

*Contactless sensors for shaft torque & speed.

*Accurate, real-time torque/speed data capture.

Operational Parameter Monitoring:

*Edge server-based real-time data display.

*User-friendly interface for anomaly detection.

Data Storage & Analysis:

*Scalable data logging to enable long-term analysis.

*Structured data in CSV format for future insights.

Predictive Analytics:

*Correlates torque and operational parameters.

*AI-driven models for predictive maintenance.

Downtime %
30% less downtime
Improved Reliability

Cost Savings
$300K+ saved
In Annual Maintenance

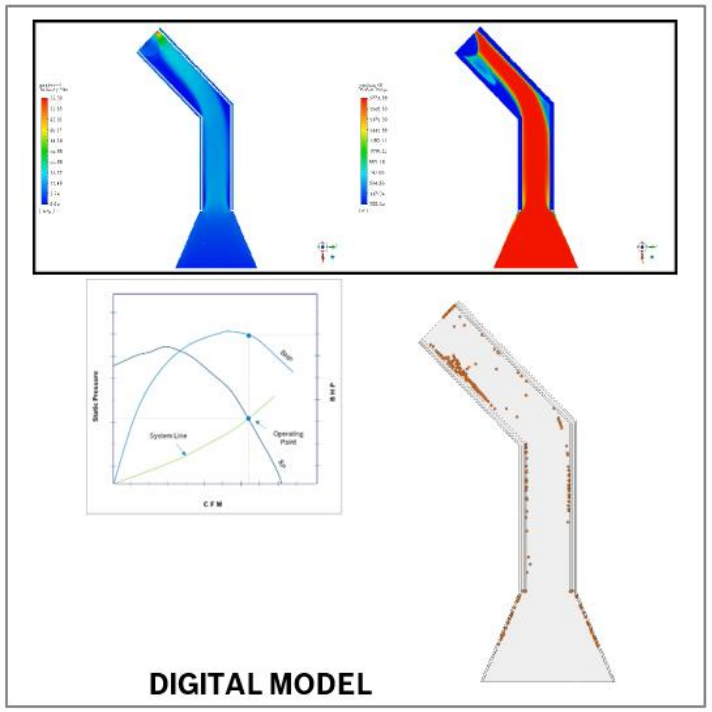
Failure Rate
$0.5M Avoided
In Repair/ Downtime Costs

Efficiency %
5% Efficiency Gain
in Roughing Mill

Prescriptive Maintenance for ID Fans in Steel Melting Shops

AI & Hybrid Modelling for Vibration Control and Failure Prediction

Case Study # 3



Key Challenges

Vibration Shoot-Up from clogging and erosion

Rotor Dynamics impacting performance

Critical Failures: bearings, impeller wear, clogging

High downtime costs and reliability issues

Solution Framework

Virtual Sensors: Real-time load, temperature, and vibration monitoring

AI + Hybrid Modelling:

AI Models: Adaptive prediction strategies

CFD: Airflow modeling for imbalance detection

FEA: Stress analysis for fatigue & wear points

Failure Predictions:

Bearings: Wear, lubrication & failure

Impellers: Misalignment, damage

Blades: Wear patterns, stress-related degradation

20% MTBF increase → higher reliability

16% less downtime, savings ~ $400K/year

6% efficiency gain in ID fan performance

Prescriptive Maintenance for Coke Oven Exhausters

Improving Mechanical Integrity with Digital Twins and Real-Time Failure Prediction

Case Study # 4

Solution Framework

Digital Twin–based Asset Management

Hybrid Models for real-time tar monitoring with alerts

Synthetic Fault Data Generation using physics-based models

Failure Prediction for motor, gearbox, and exhauster (eccentricity, rotor bar damage, gear/bearing faults)

Key Challenges

01

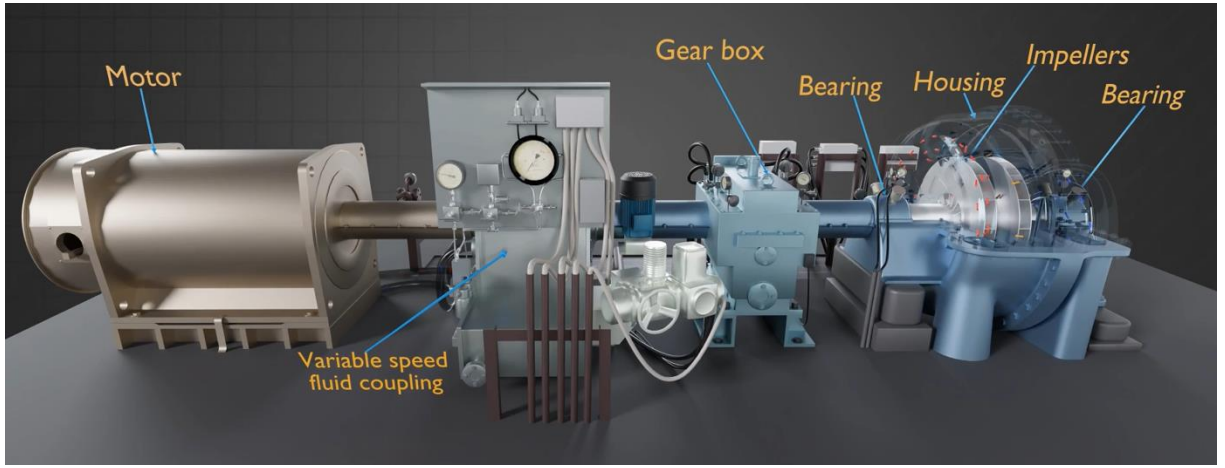
Tar deposition on impeller causing clogging

02

Frequent failures in bearings and rotor bars

03

No historical fault data to support predictive insights



20% MTBF Improvement

12% lower maintenance costs via prescriptive strategy

Scalable across all coke oven plants

Cost savings from:

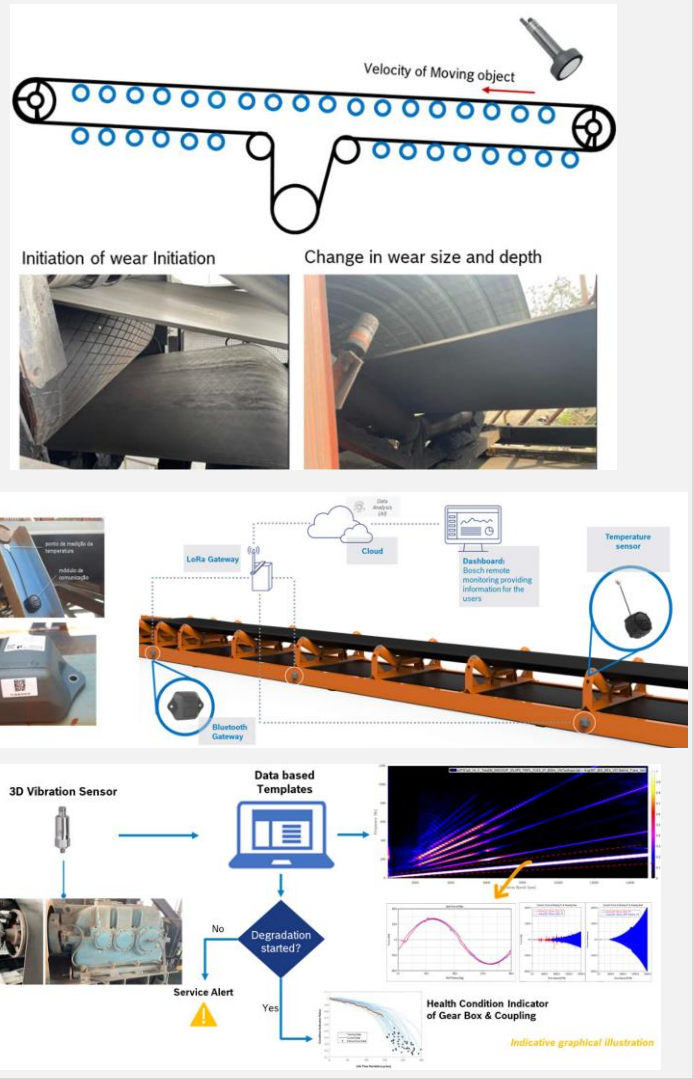
*Avoided CO gas flaring

*Reduced process disruptions

Smart Conveyor Monitoring for Asset Performance Management

Predictive Insights for Belt, Idler, and Drive Health using AI & Cloud Analytics

Case Study # 5



Key Challenges

01 **Belt & Idler Wear**: Causes unplanned downtime

02 **Drive System Failures** (Motor, Gearbox, Coupling)

03 **Parameter Sensitivity**: Impact of speed, load, and environment

04 **Lack of Anomaly Detection**: Early failure signs often missed

Solution Framework

Health Monitoring:

Sensors for belt wear, temperature, current signals

Predictive analytics for faults like misalignment or overheating

Operational Parameter Monitoring:

*Real-time data on load, speed, environment

*AI models for anomaly detection & root cause insight

Cloud Processing:

*AI-based failure prediction

*Scalable to multiple conveyor systems

*Central dashboard for alerts, trends, reports

25% MTBF increase → Higher asset reliability

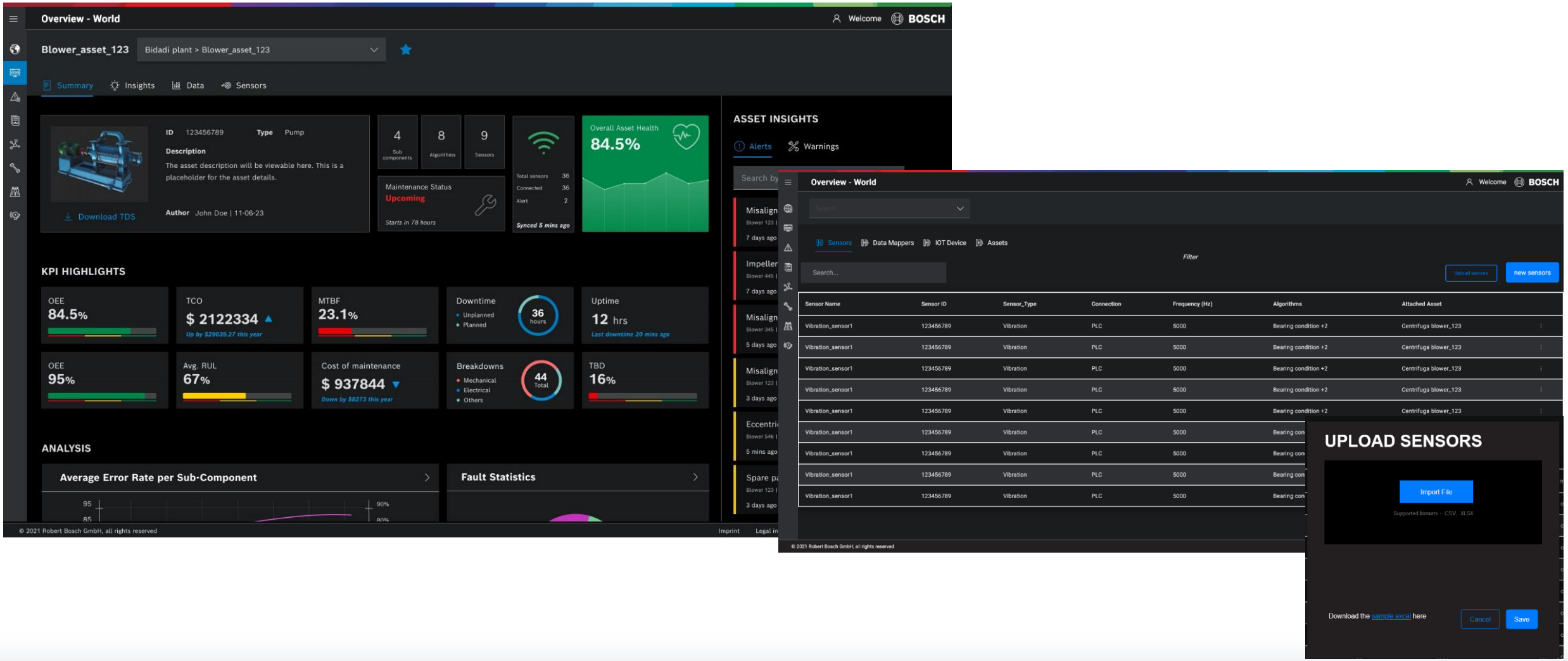
20% downtime reduction, saving $300K/year

10% boost in conveyor performance

Avoided catastrophic failures, cutting repair costs

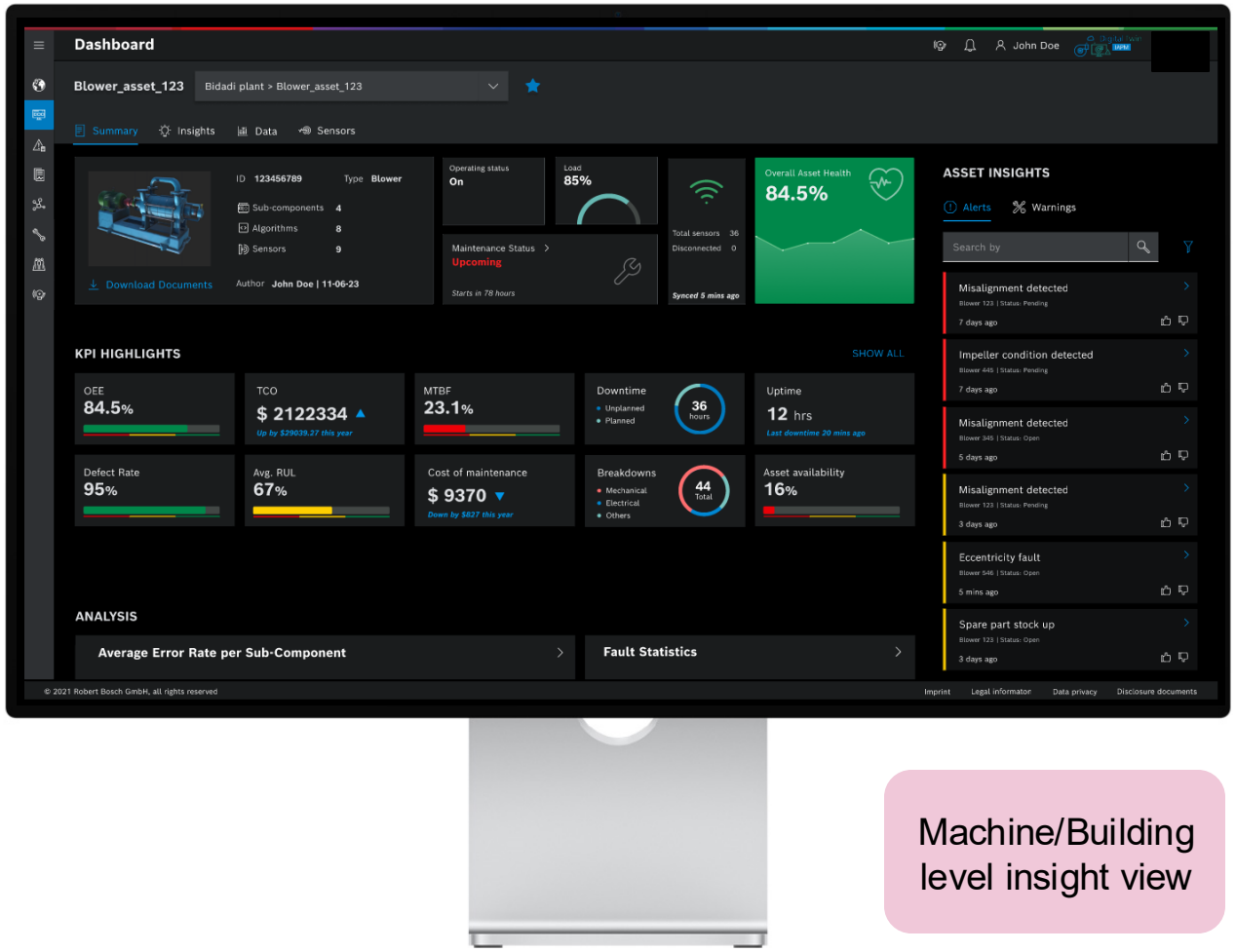
Digital Twin – IAPM

Detailed Views & Scaling by customer enabled

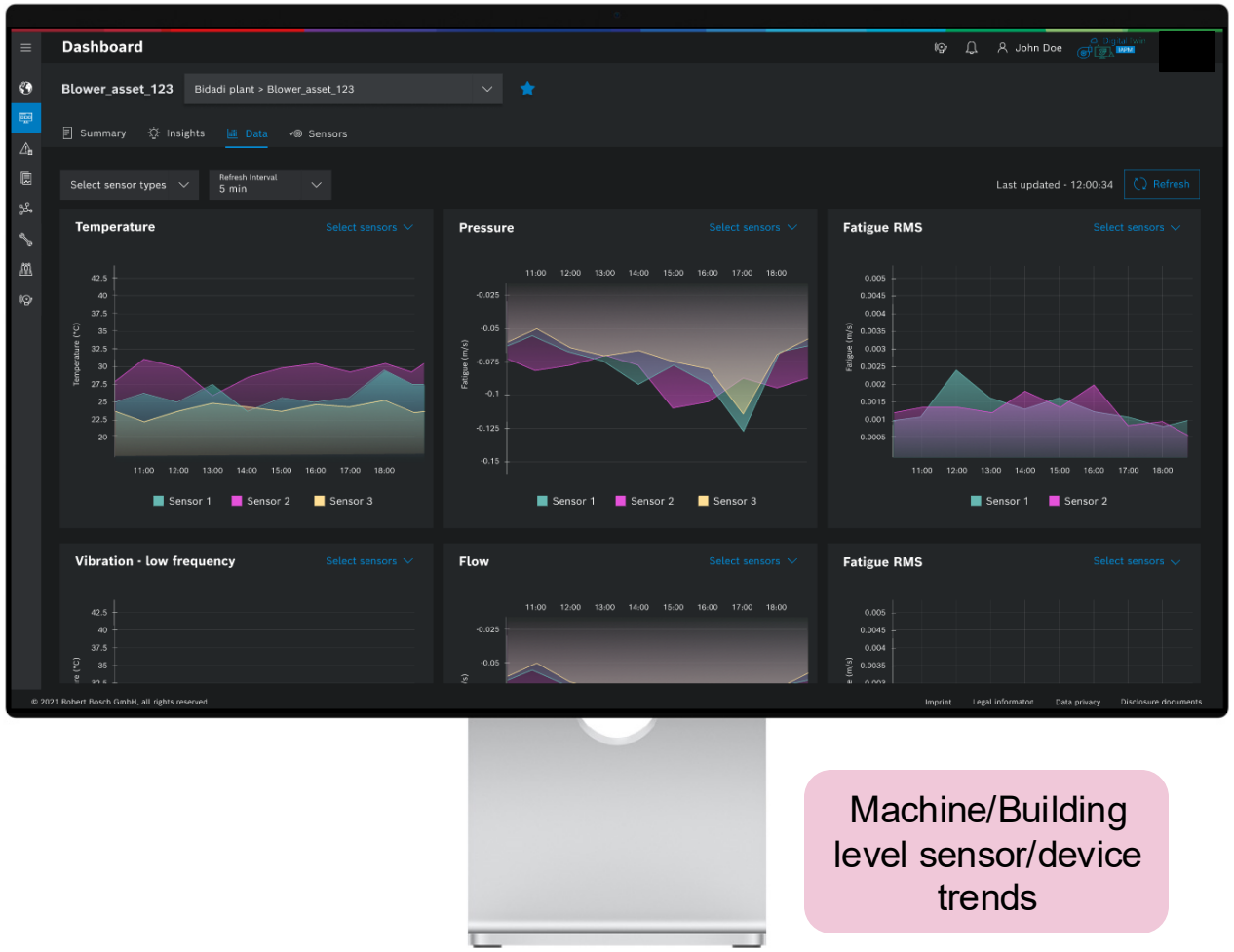


Enterprise Architecture

Insights Interface



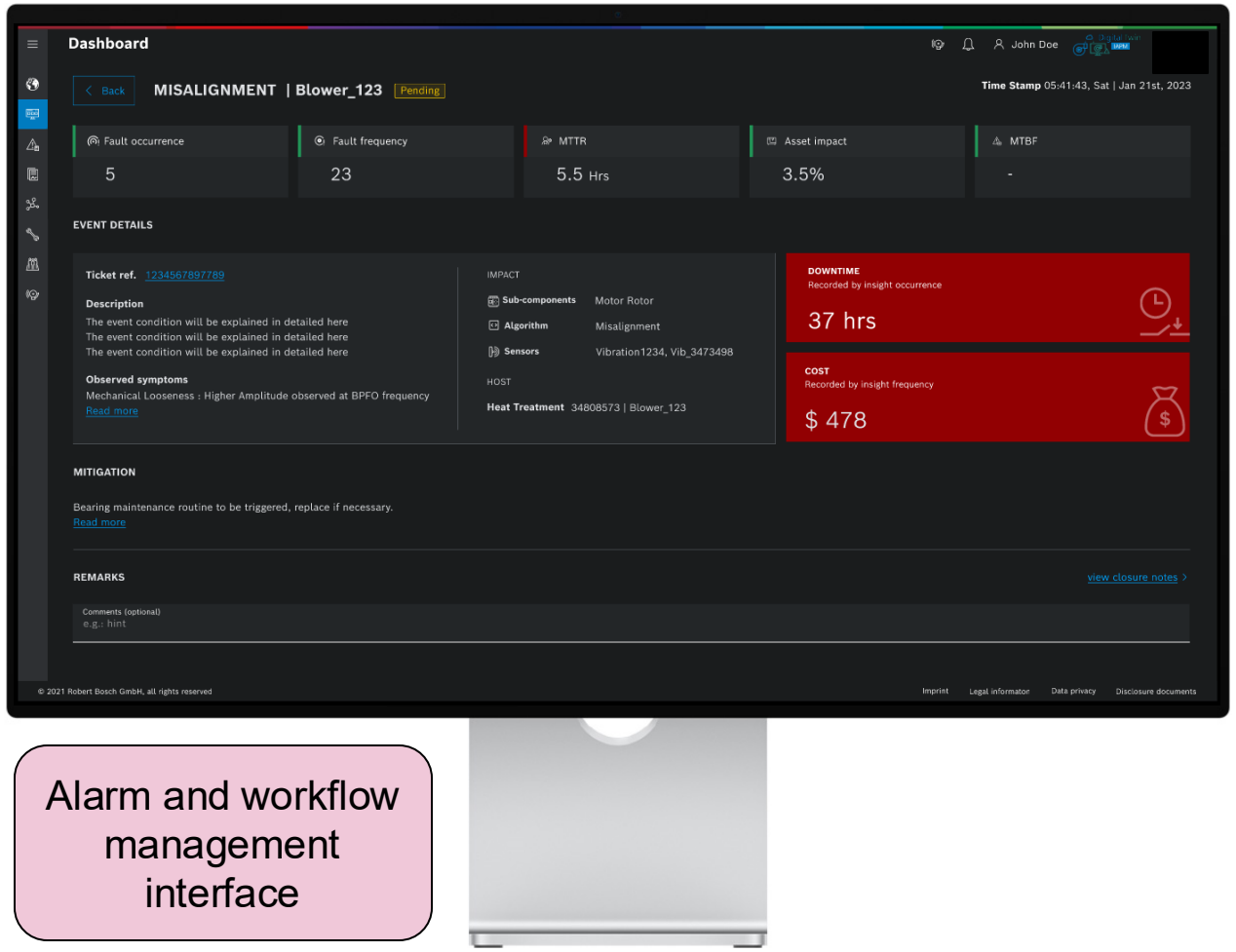
Machine/Building level insight view



Machine/Building level sensor/device trends

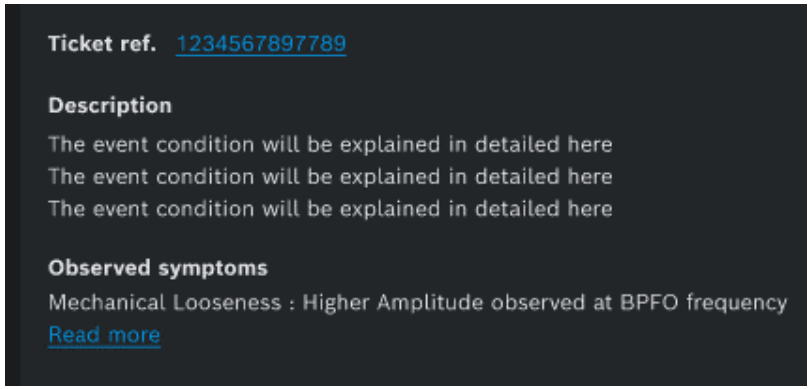
Enterprise Architecture

Alarm & Workflow Management

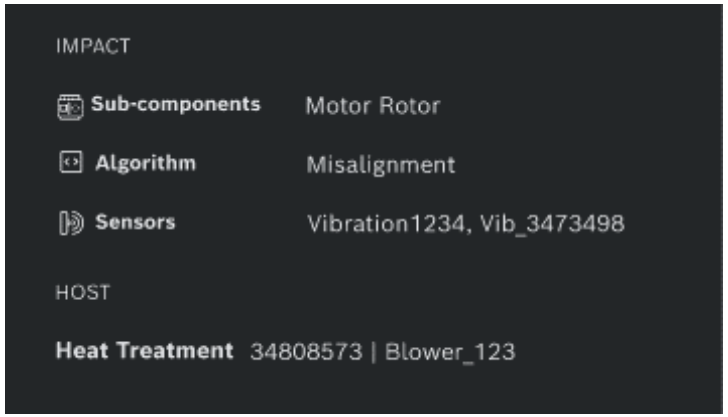


Alarm and workflow management interface

1. Depending on the rules, an alarm is raised



2. If further action is needed, ticket number is followed up

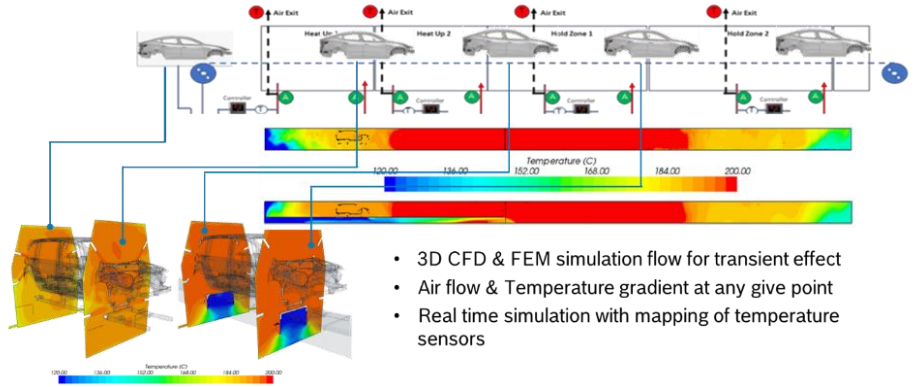


3. Location and host site impact is defined to prioritize a ticket

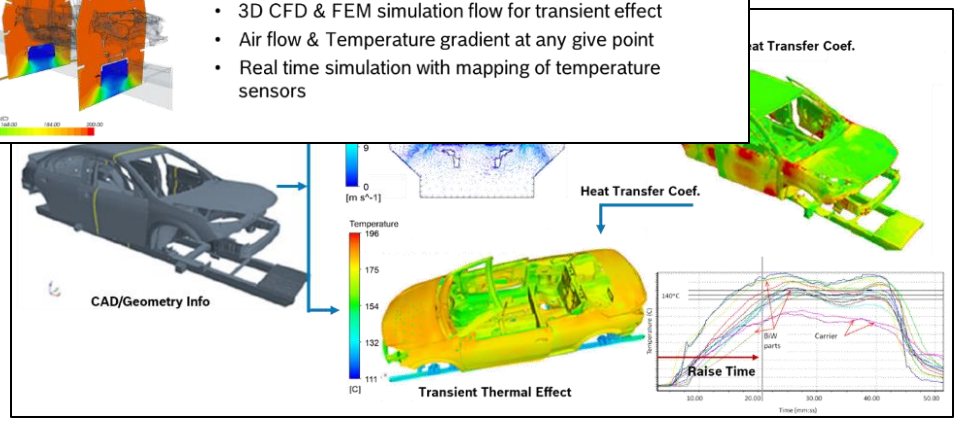
Digital Twin IAPM Paint Shop Project

Temperature Profile Monitoring + Meta & Diagnostic Models

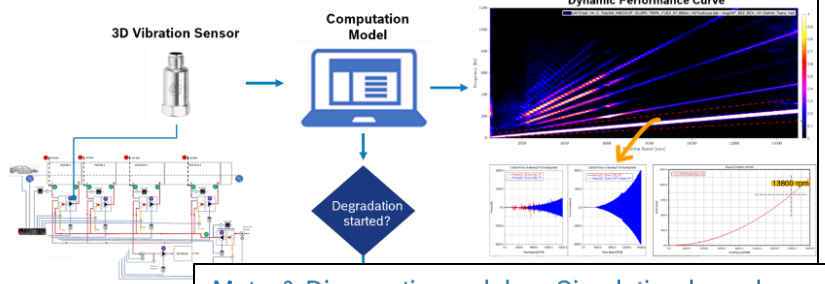
Oven Volume Temperature Gradient monitoring



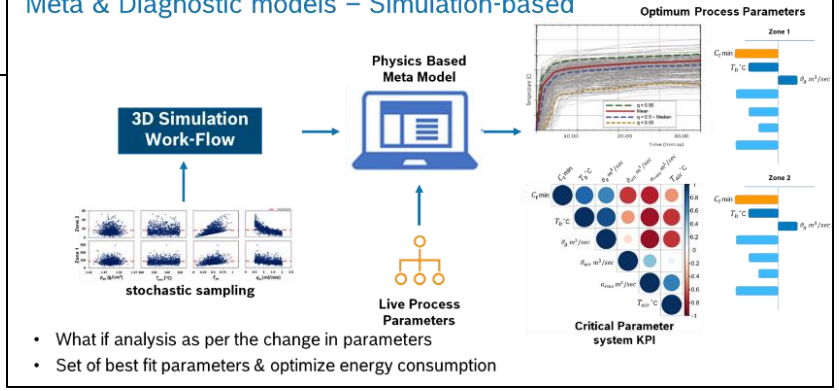
- 3D CFD & FEM simulation flow for transient effect
- Air flow & Temperature gradient at any give point
- Real time simulation with mapping of temperature sensors



Meta & Diagnostic model – Health monitoring

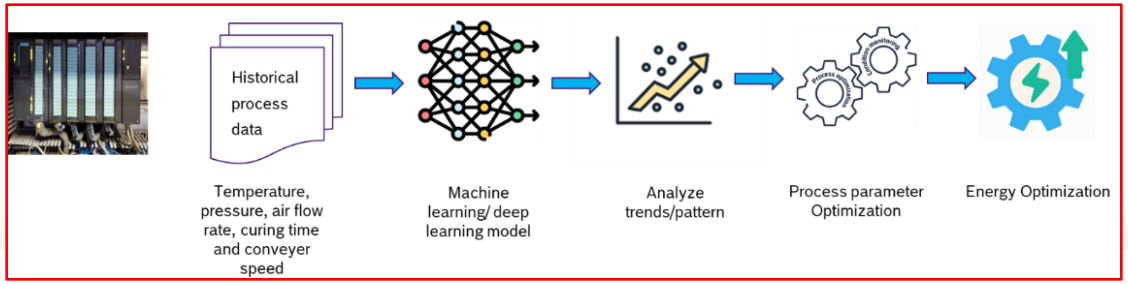


Meta & Diagnostic models – Simulation-based



- What if analysis as per the change in parameters
- Set of best fit parameters & optimize energy consumption

Summary & Result:



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