Anvendelse af industriel AI model til forebyggende vedligehold

LEAN & SMART Manufacturing conference

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Flowtale

Michael Teglgaard Nielsen
CEO

mtn@flowtale.ai

Rasmus Jones
Senior Data Scientist

FLOWTALE
Rethink Big Data

Agenda

INTRODUCTION

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Rethink Big Data

Data Engineering and Science Consultancy

Project outsourcing

Specialised in **Optimization and Automation**

Experienced

UNIVERSAL ROBOTS

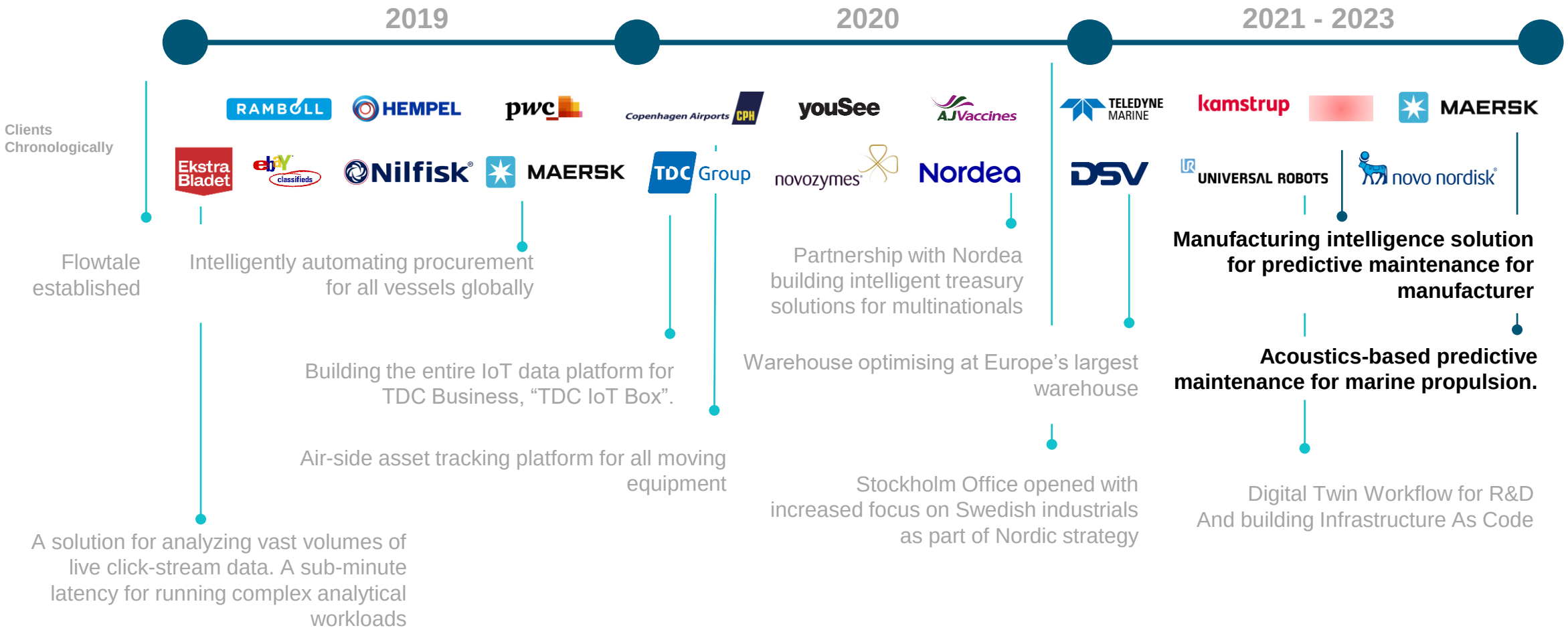
MAERSK

kamstrup

AJVaccines

novo nordisk®

FLOWTALE introduction & experience in various industries



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ACOUSTIC PREDICTIVE MAINTENANCE

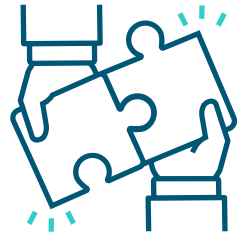
Data-Driven Planning and Uptime

Data reliability

IoT solutions provide high-quality, reliable data, serving as the backbone for any effective predictive maintenance system.

ERP Integration

Integrate seamlessly with ERP platforms, enabling these systems to simulate and predict planning with accuracy.



Uptime

Through predictive maintenance, experience improved equipment uptime, leading to optimized operational planning and efficiency.

Critical success factors of a predictive maintenance system

Performance

The ability of a model or system to accurately forecast equipment failures or maintenance needs.

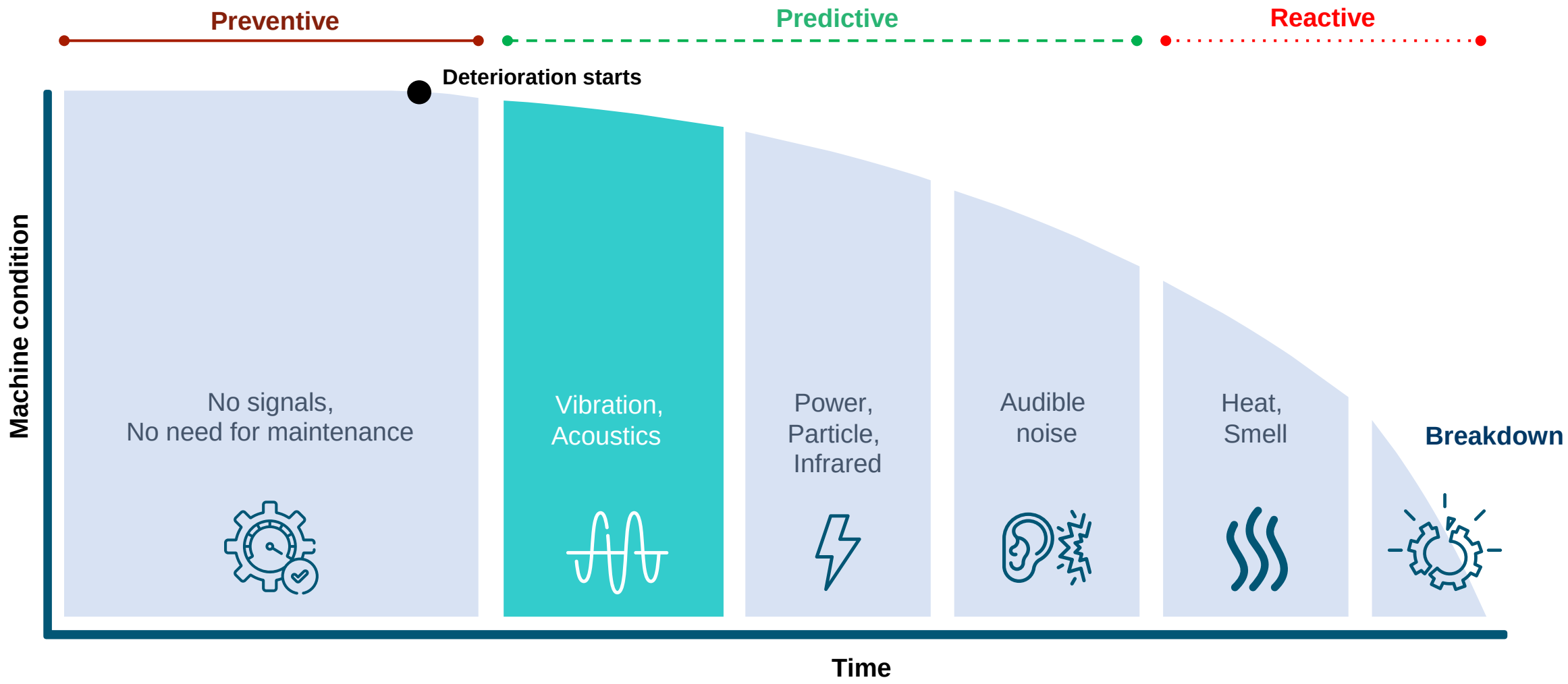
Time-to-failure

Estimated remaining time until a piece of equipment or machinery is expected to experience a critical malfunction or breakdown.

Generalization / scalability

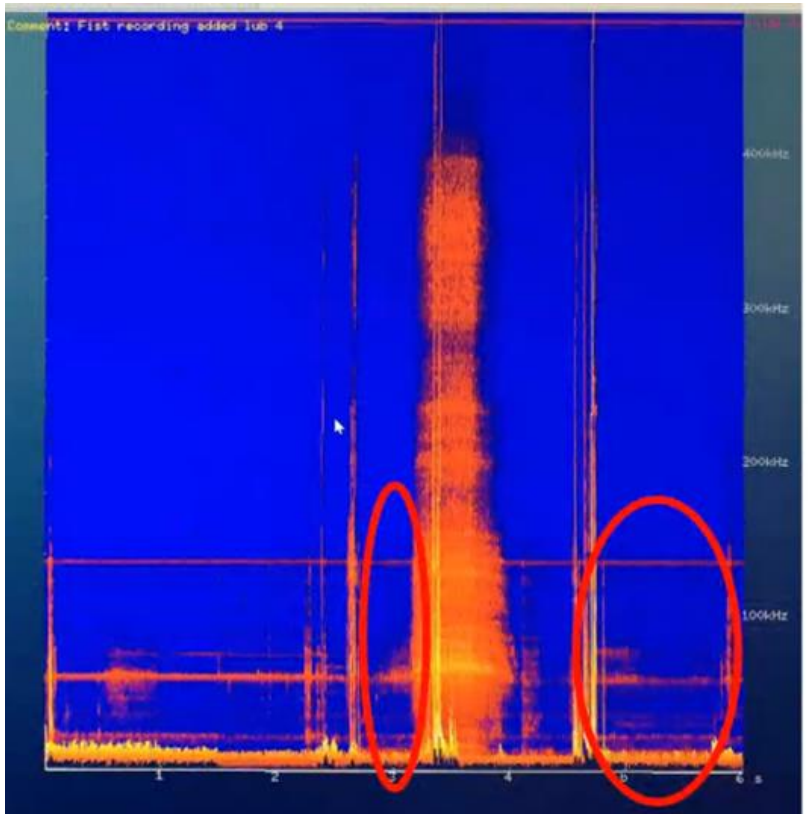
The ability of a machine learning model to effectively apply knowledge learned from historical data to new, unseen equipment or conditions.

Machine breakdown process

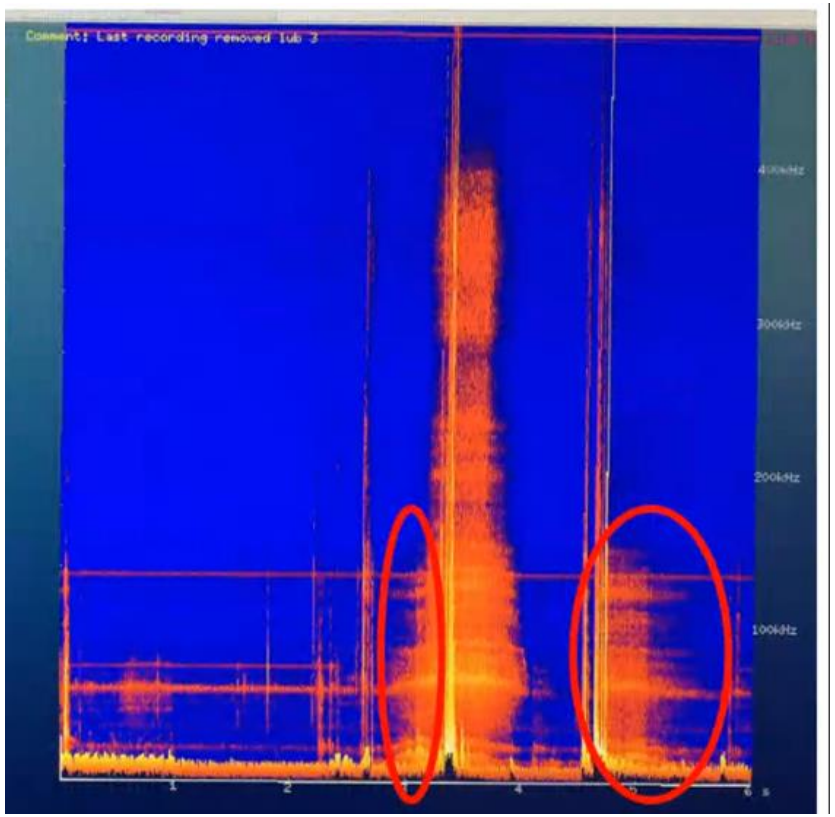


Acoustic Predictive Maintenance for Early Equipment Failure Detection

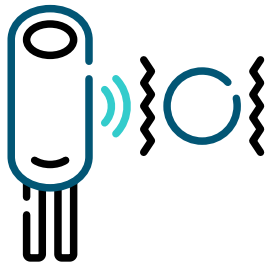
Optimal Spectrogram



Sub-optimal Spectrogram



Successful acoustics stands on three pillars



Sensors

- **Sensitivity & Frequency Range**
  Right frequency range sensitivity is vital.
- **Durability & Environmental Tolerance**
  Sensors must withstand manufacturing environment.
- **Positioning & Installation**
  Correct placement is crucial for accurate readings.

Preprocessing

- **Normalization / standardization**
  Adjusting to common scale to ensure consistent representation.
- **Operational reproducibility**
  Ensuring consistent data transformation processes to achieve identical outcomes.

Training

- **Expert review**
  An expert assessment to train the quality and accuracy of predictions.
- **Probability of event**
  Numerical probability score as output, indicating the likelihood of an event.
- **Threshold for alert**
  A predefined probability level, cutoff point, that triggers the alert.

Choosing the right sensor and sensor provided

Sensitivity & Frequency Range

- Operates in required frequency range.
- High sensitivity for subtle changes.
- Good Signal-to-Noise ratio.

Durability & Environmental Tolerance

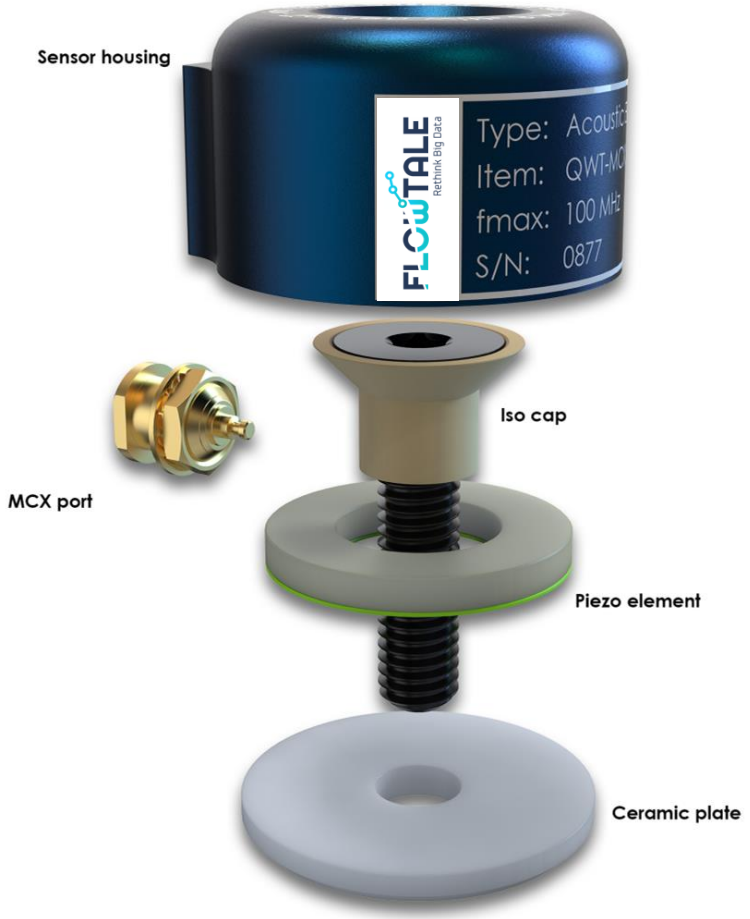
- Withstands manufacturing conditions.
- Material durability.
- Anecdote: Sensor melted from engine heat.

Positioning & Installation

- Accurate placement for precise readings.
- Easy installation.
- Provider flexibility in setup.

Modern Software Stack

- Python interface for integration.
- Availability of APIs or SDKs.
- Compatible with modern analytics tools.



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USE-CASES

Case #1 – **Plastic moulding at manufacturer**

Problem statement

Minimize unexpected mould breakdowns and optimize lubrication schedules using cost-effective, low-frequency sensor data.

Monitoring Setup

Three specialized surface microphones record mould conditions in various modes.

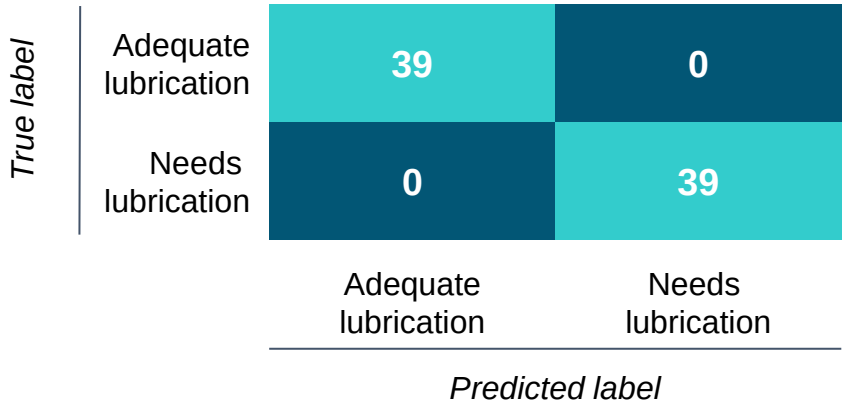
Results

Highly accurate predictions.

See the confusion matrix for detailed performance metrics ->

Sensor placements

Confusion matrix



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Case #2 – **Engine pistons on container vessel**

Problem statement

Every 2 years, 282 vessels experience one scuffing event, costing $55,000 in parts and labour and resulting in 10 hours of downtime per event. Basically prevent breakdown.

Monitoring Setup

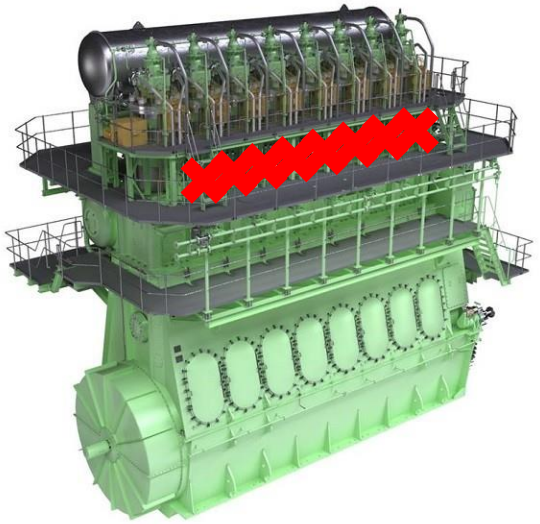
Acoustic sensors on engine cylinders, signal processing stations, cables to the lubrication control unit, and a visual sensor for RPM data. Furthermore, save oil and the cost that it comes with.

Results

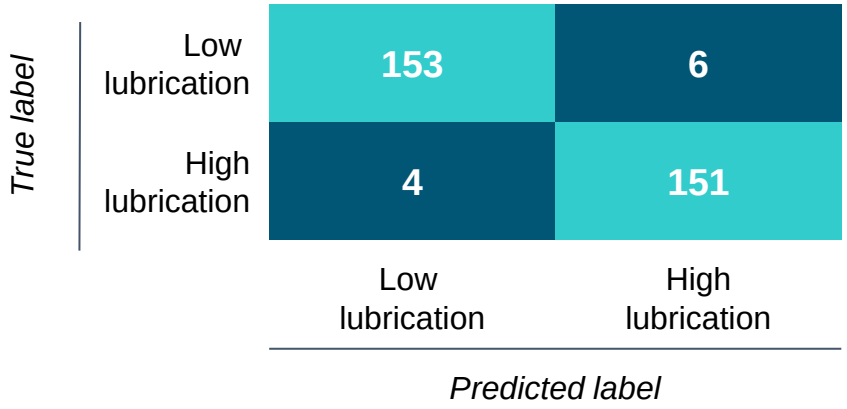
Highly accurate predictions.

See the confusion matrix for detailed performance metrics ->

Sensor placements



Confusion matrix



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Challenges of Predictive Maintenance for Machine Learning Models

Data and Scalability Challenges

Extensive data requirements for robust machine learning models

- Consider the ROI of `data collection vs model performance`

Variance of the data dependent on:

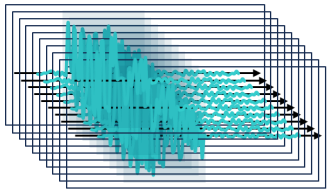
- Sensor types
- Moulding forms
- Engine types

Data Drift: Model degrades as system characteristics evolve

- Requires retraining and potentially new data sources

Annotation bottlenecks

- Expertise and resource constraints



x10.000

Unsupervised/semi-supervised techniques for automatic annotation and data drift detection

Risk of Incomplete Data

Overfitting: Good performance on training set, but generalizes poorly

- Think of it as optimizing for quarterly KPIs but missing the annual goals

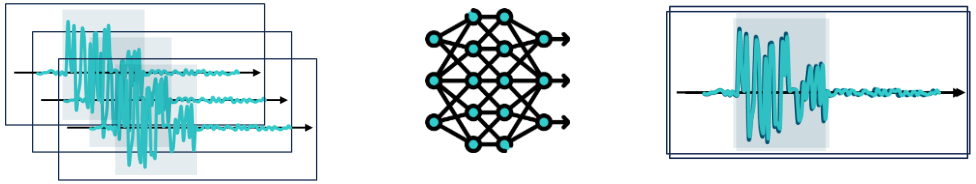
Lack of data diversity leads to:

- Model bias towards over-represented categories

High Costs of Errors:

- Incorrect predictions can lead to maintenance failures, impacting uptime

Machine Learning models with better data/sample efficiency



BENEFITS

Benefits of Acoustic Predictive Maintenance

Downtime

30-50%

vs. 20-30% for non-acoustic methods.

Cost savings

20-40%

vs. 10-20% for non-acoustic methods.

Efficiency

10-20%

vs. 5-10% for non-acoustic methods.

Source: 1. Barbara Zaparoli Cunha, Christophe Droz, Abdelmalek Zine, Stéphane Foulard, Mohamed Ichchou. A Review of Machine Learning Methods Applied to Structural Dynamics and Vibroacoustic. 2022.
2. Husaković, Adnan, Anna Mayrhofer, Ali Abbas, and Sonja Strasser. 2023. "Acoustic Material Monitoring in Harsh Steelplant Environments" *Applied Sciences* 13, no. 3: 1843.
3. Valerio Dilda, Lapo Mori, Olivier Noterdaeme, and Christoph Schmitz . *McKinsey*, Manufacturing: Analytics unleashes productivity and profitability, 2017.

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Relevancy of acoustics-based predictive maintenance

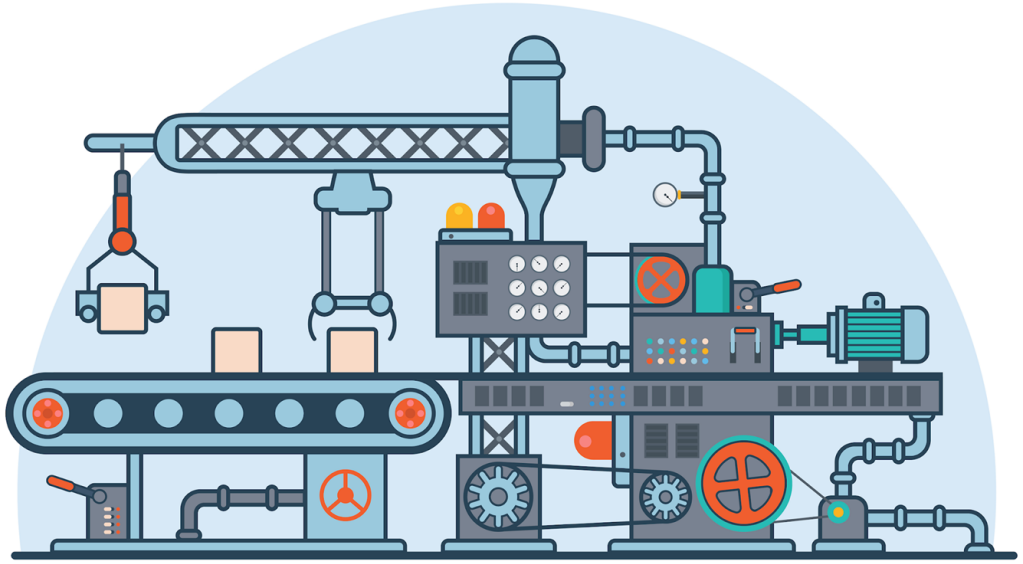
Acoustics-relevant characteristics

Equipment characteristics with most to gain from choosing specifically vibroacoustic-based maintenance includes:

- **Rotating Machinery**
  Such as pumps, motors, fans, compressors, and turbines, can benefit greatly from vibroacoustic-based maintenance.

- **Gears and Gearboxes**
  Gears are uniquely susceptible to wear, pitting, and tooth damage.

- **Bearings**
  Specifically for early signs of bearing deterioration, including faults such as rolling element damage or lubrication issues.



Manufacturing

Thank you!

Michael Teglgaard Nielsen
CEO
mtn@flowtale.ai

Rasmus Jones
Senior Data Scientist
rj@flowtale.ai