

Anvendelse af industriel AI model til forebyggende vedligehold

LEAN & SMART Manufacturing conference

25/10-2023

Flowtale

Michael Teglgaard Nielsen
CEO

mtn@flowtale.ai

Rasmus Jones
Senior Data Scientist

Agenda

1	Introduction	Who are Flowtale	How we work Framework & Services	Our journey It all started with . . .
2	Acoustic predictive maintenance	Data-Driven Planning and Uptime Machine breakdown process	Leverages sound and vibration Successful acoustics stands on three pillars	Choosing the right sensor
3	USE-CASES	Manufacturer	Maersk	
4	Benefits	Benefits of Acoustic Predictive Maintenance	Relevancy of acoustics-based predictive maintenance	

INTRODUCTION

FLOWTALE

Rethink Big Data



**Data Engineering and Science
Consultancy**
Project outsourcing



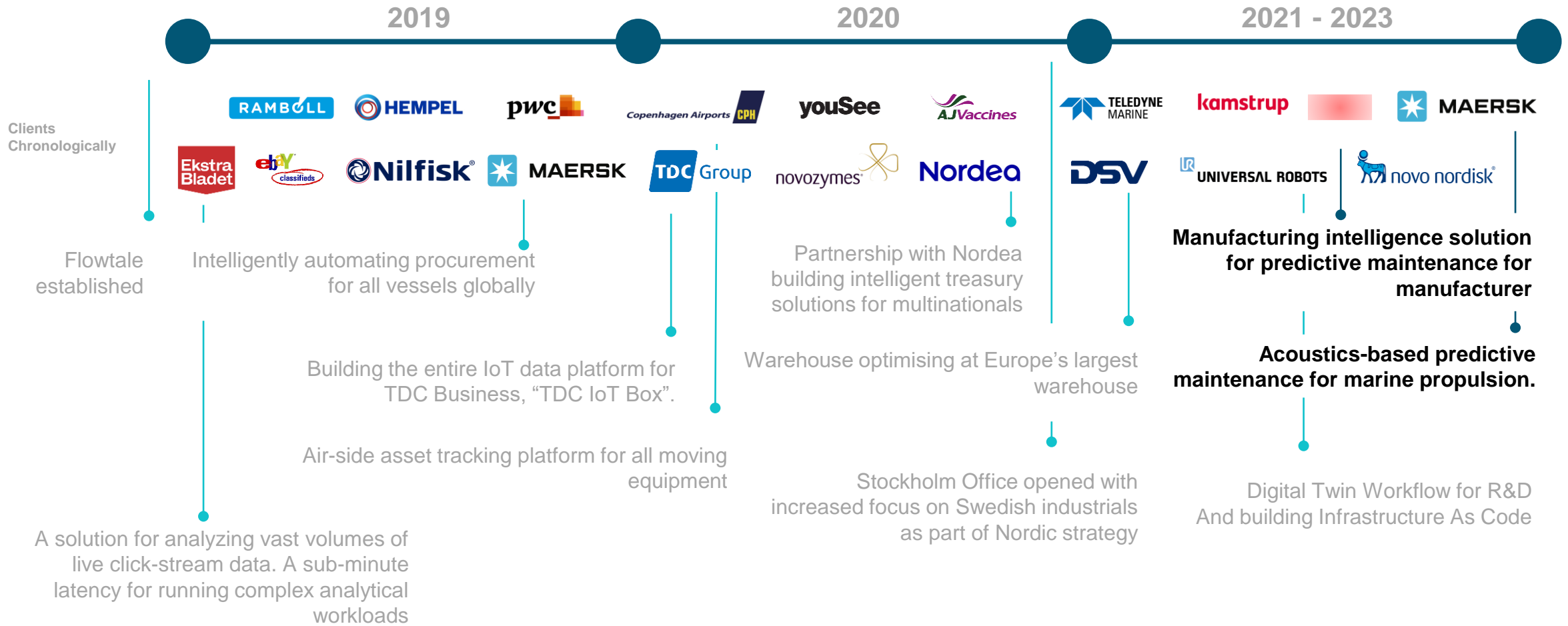
Specialised in
**Optimization and
Automation**



Experienced



FLOWTALE introduction & experience in various industries



ACOUSTIC PREDICTIVE MAINTENANCE

Data-Driven Planning and Uptime

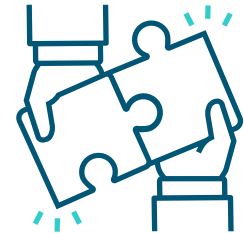
Data reliability

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

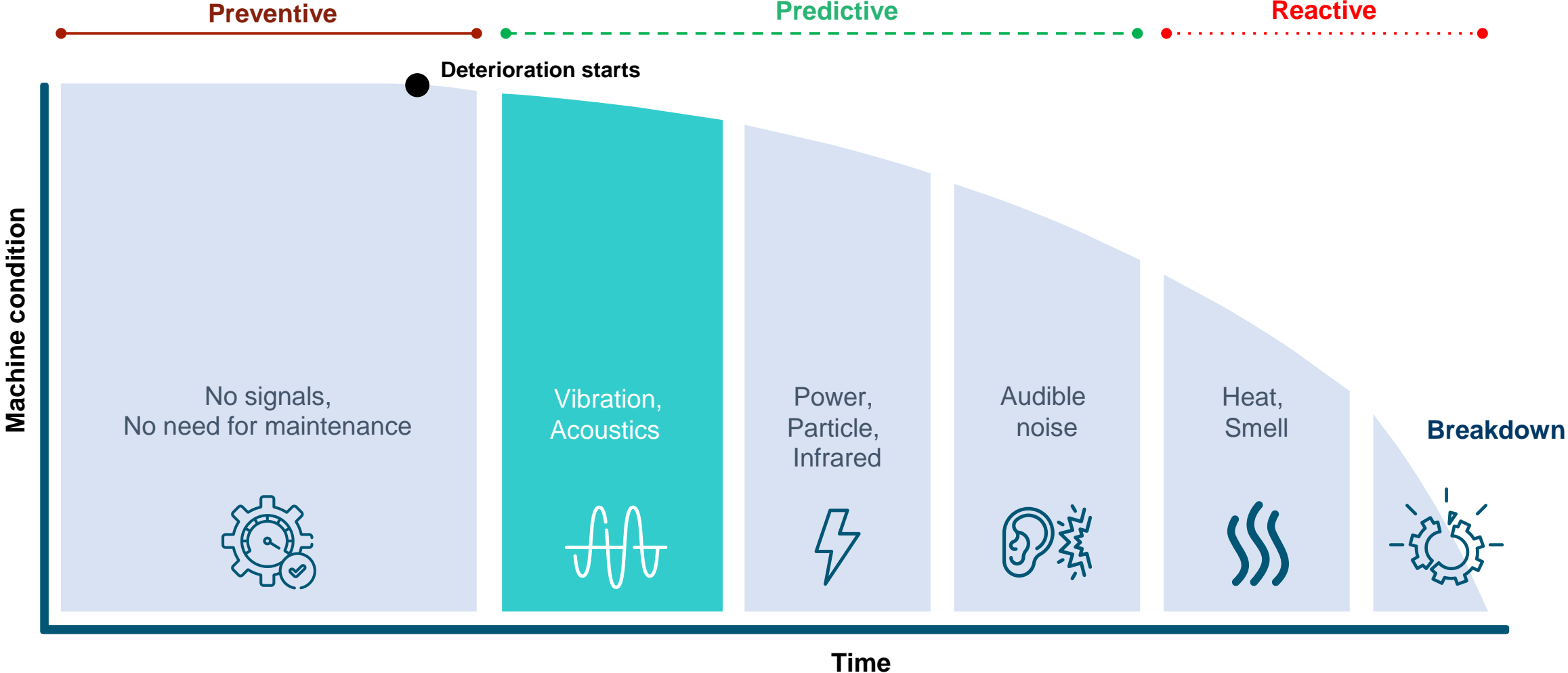
Estimated remaining time until a piece of equipment or machinery is expected to experience a critical malfunction or breakdown.



Generalization / scalability

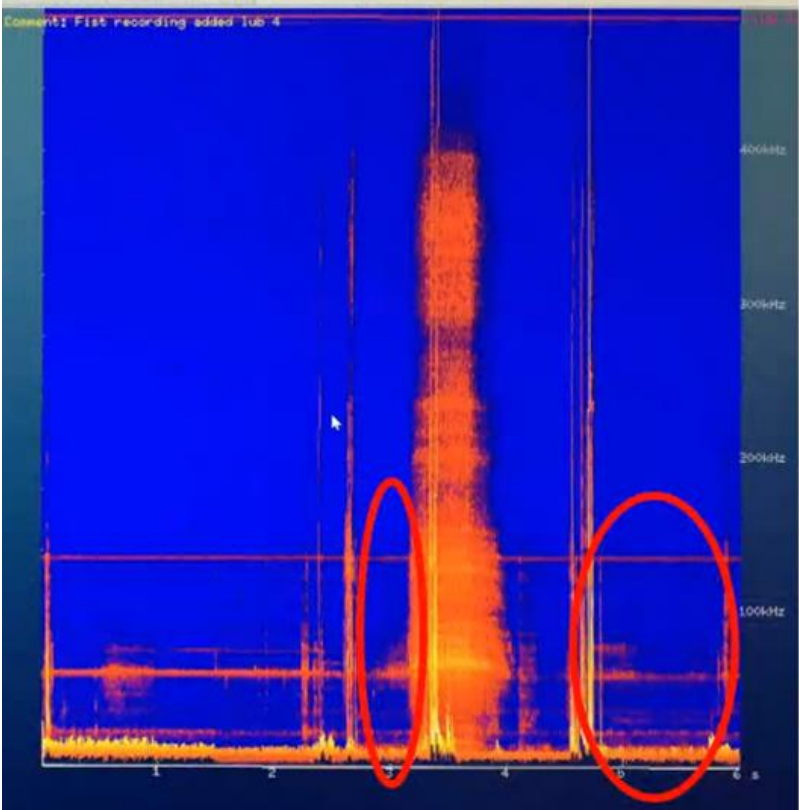
The ability of a machine learning model to effectively apply knowledge learned from historical data to new, unseen equipment or conditions.

Machine breakdown process

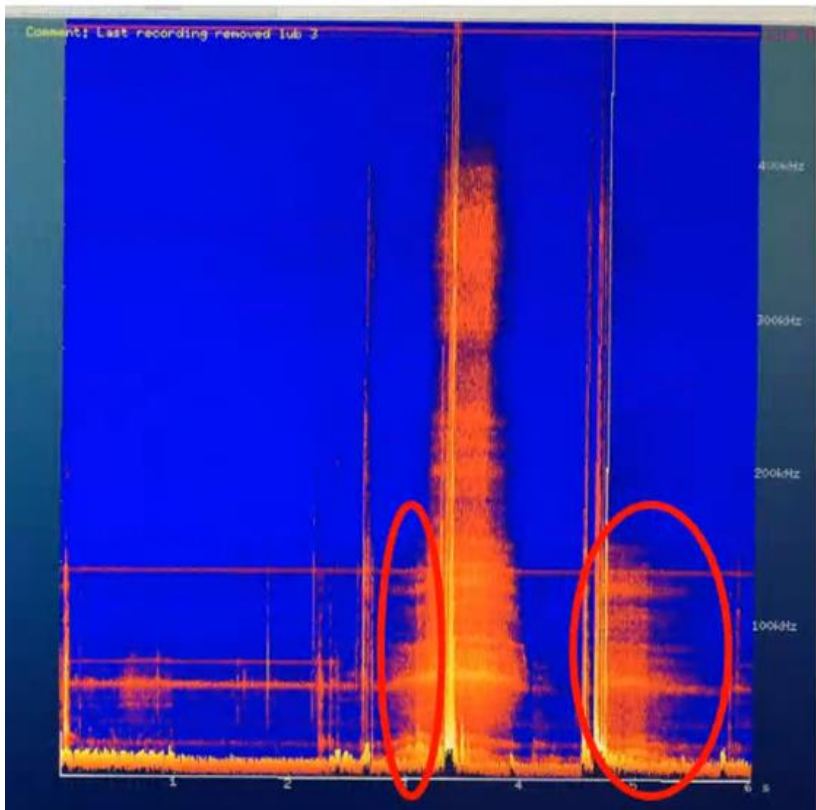


Acoustic Predictive Maintenance for Early Equipment Failure Detection

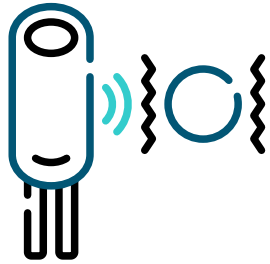
Optimal Spectrogram



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.



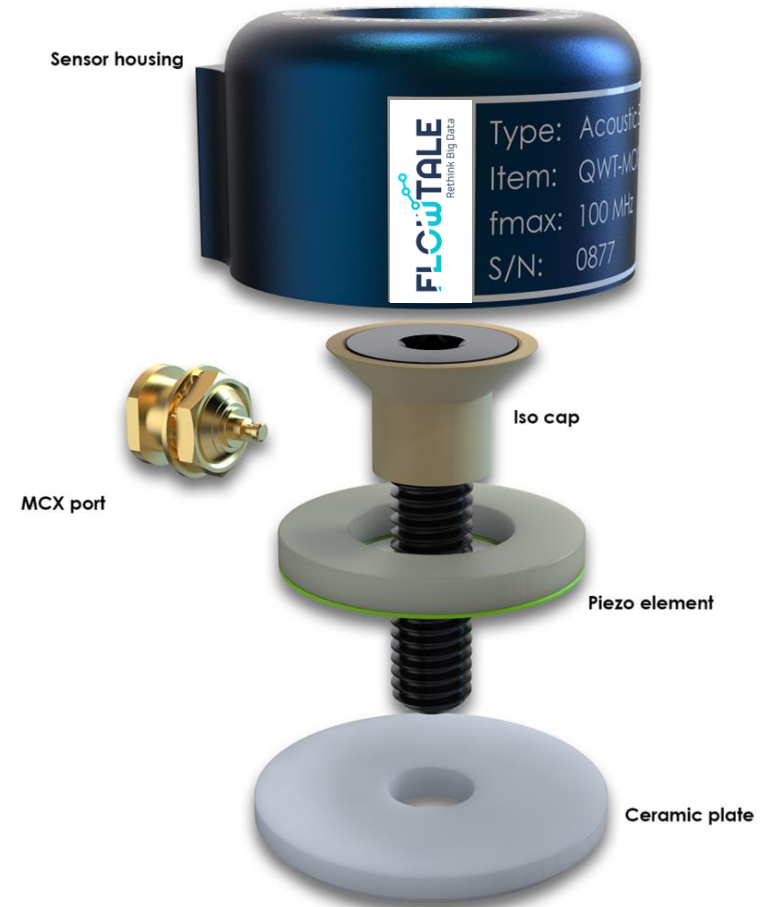
Positioning & Installation

- 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.



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

True label	Adequate lubrication	39	0
	Needs lubrication	0	39
		Adequate lubrication	Needs lubrication

Predicted label

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.

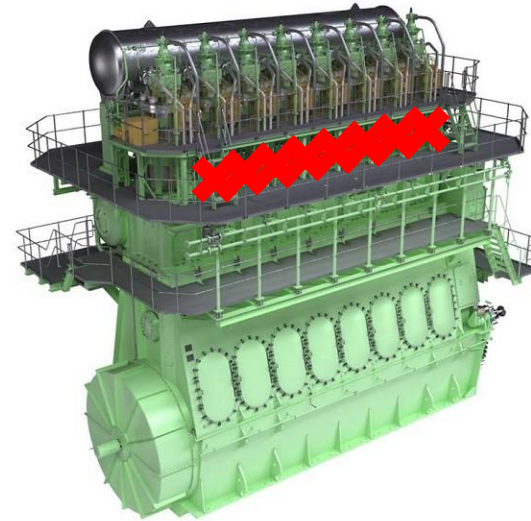
Results



Highly accurate predictions.

See the confusion matrix for detailed performance metrics ->

Sensor placements



Confusion matrix

True label	Low lubrication	153	6
	High lubrication	4	151
		Low lubrication	High lubrication

Predicted label

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

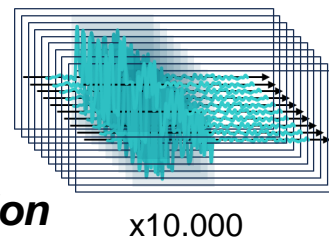
Data Drift: Model degrades as system characteristics evolve

- Requires retraining and potentially new data sources

Annotation bottlenecks

- Expertise and resource constraints

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

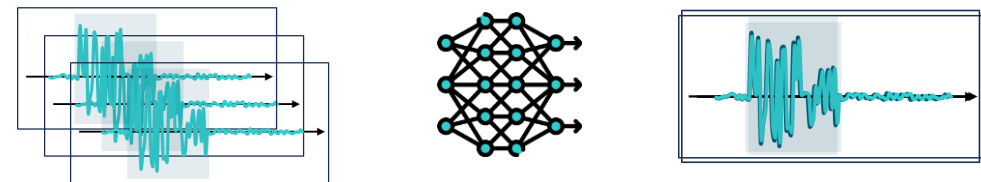
Lack of data diversity leads to:

- 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%

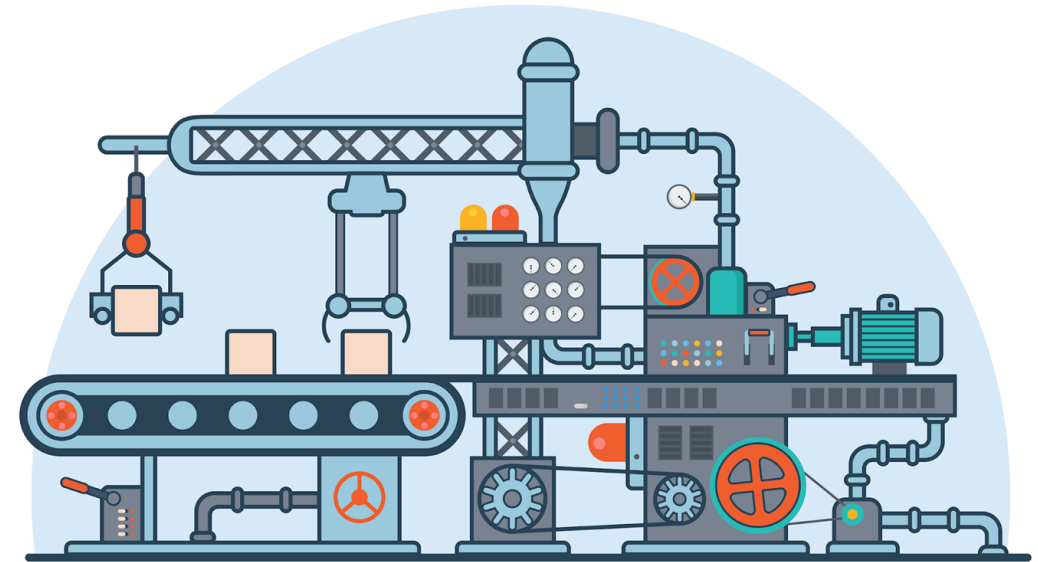
vs. 5-10% for non-acoustic methods.

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 Teglgard Nielsen

CEO

mtn@flowtale.ai

Rasmus Jones

Senior Data Scientist

rj@flowtale.ai

