
DAMEN
OCEANS OF POSSIBILITIES
Your one-stop maritime solutions provider
Damen Services presentation

# Damen services

- More than 200 employees within Damen Services
- 70 Field Service Engineers
- 11 Service hubs around the world.
- 1 service dock in Curacao.
- 500 ships in warranty
- 10.000 service calls per year

# Damen service hubs location


Service hub location

# Predictive maintenance

## Proof of concept

Arie Schaap



DAMEN

**Predictive Maintenance 4.0**
Predict the unpredictable


# Agenda

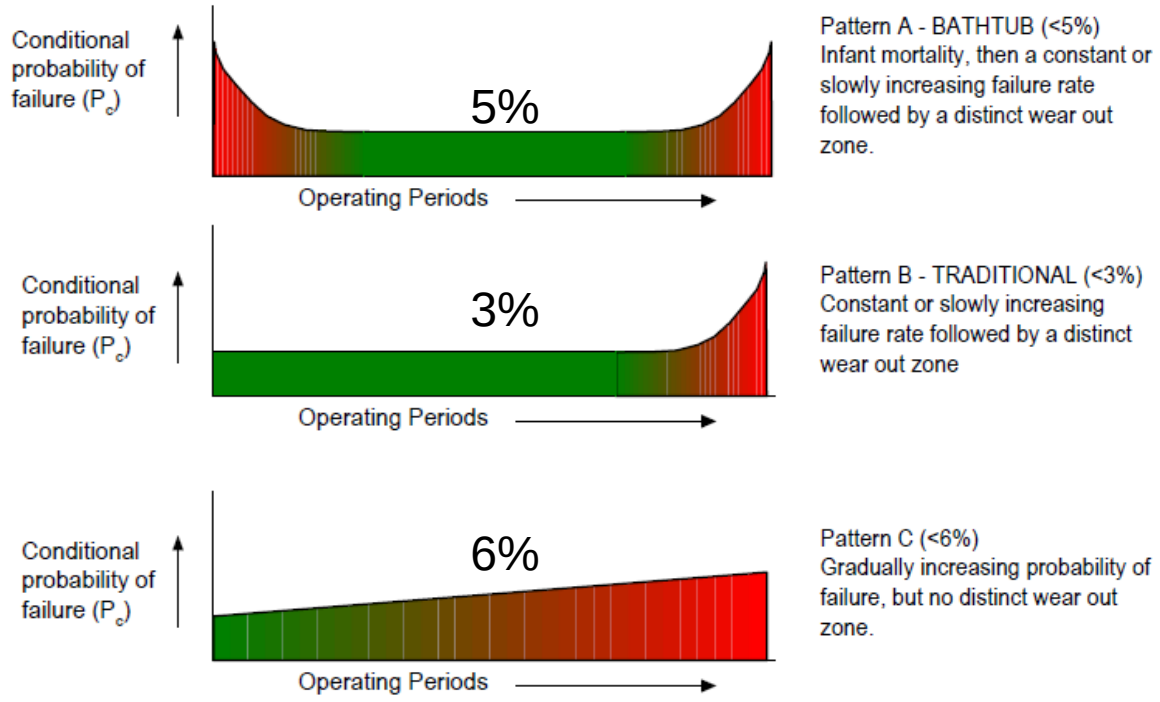
- Maintenance
  - Failure behaviour
  - RCM
- Proof of concept:
  - Approach
  - Test bench
  - Data creation
  - Machine Learning
  - Test on a vessel
  - Way ahead
- Conclusion

# Preventive maintenance

- Failure behaviour
- RCM

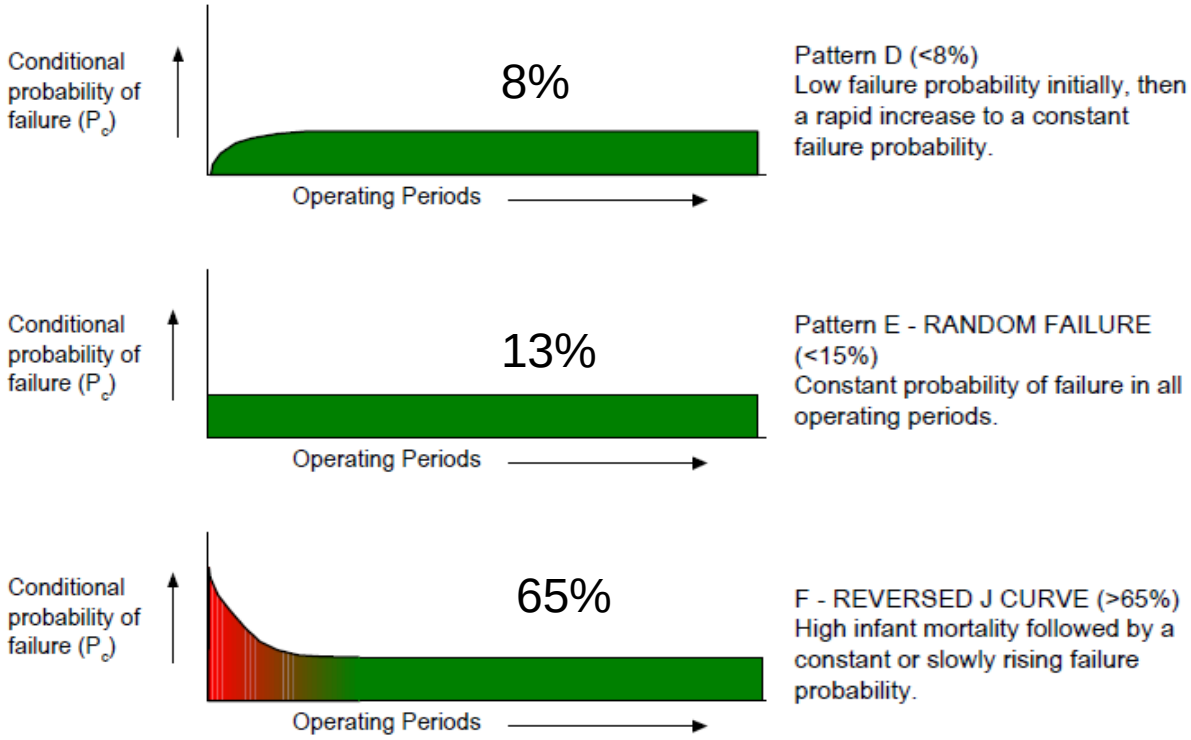
# HOW THINGS FAIL

The percentage figures quoted represent the average occurrence of the failure pattern in modern complex systems (14%)



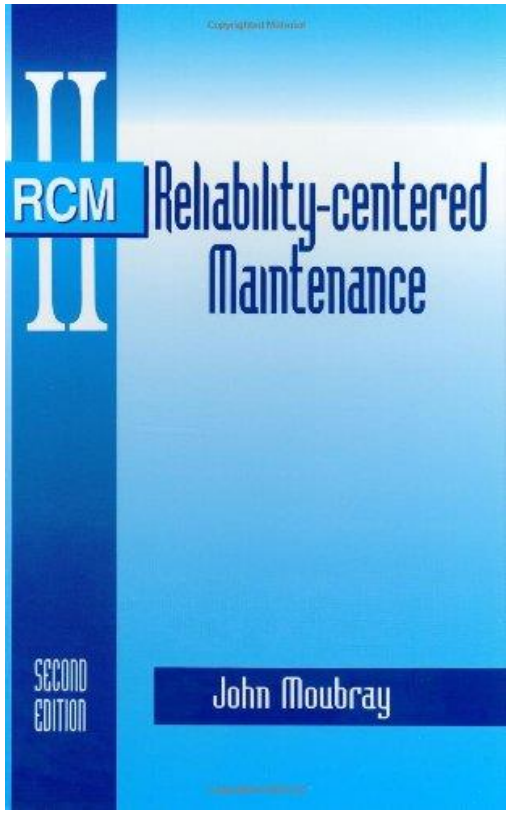
# HOW THINGS FAIL

The percentage figures quoted represent the average occurrence of the failure pattern in modern complex systems (86%)



# RELIABILITY CENTRED MAINTENANCE

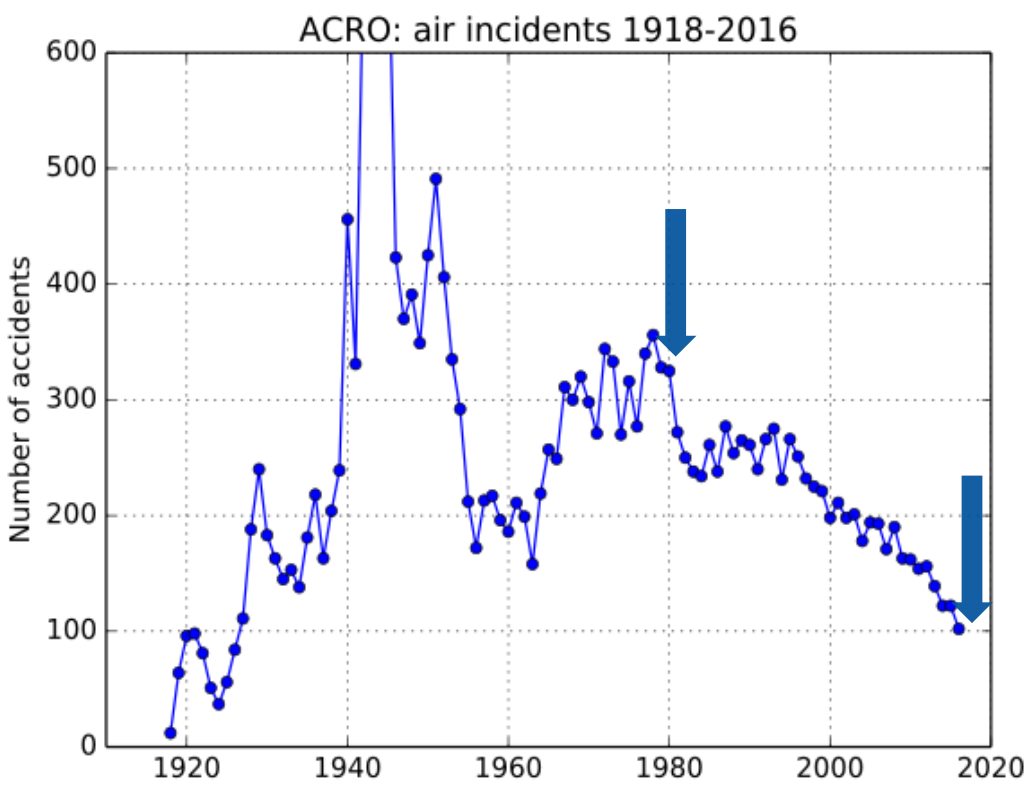
- MSG-1 was first published in 1968 and used for developing scheduled maintenance for B747

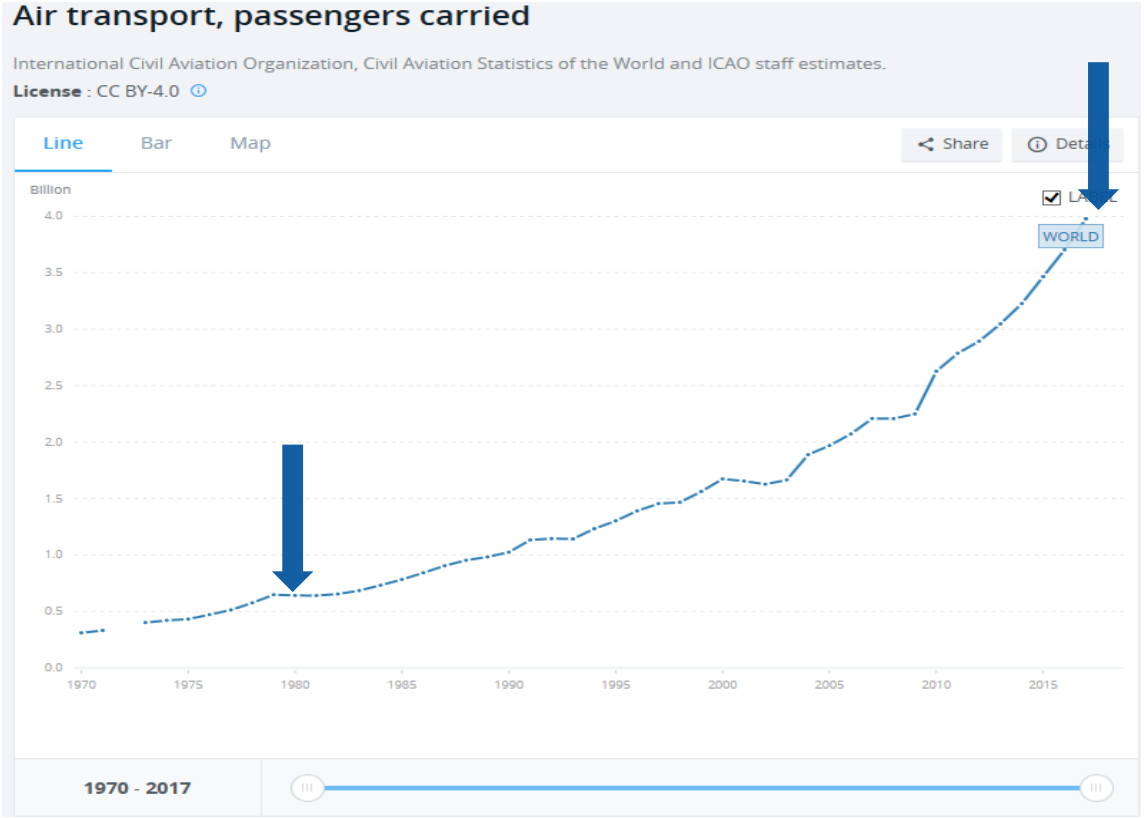



# RELIABILITY CENTERED MAINTENANCE




# RELIABILITY




Accidents 1980 = 300
2016 = 100

800% more travelers in the same period

# EFFICIENCY

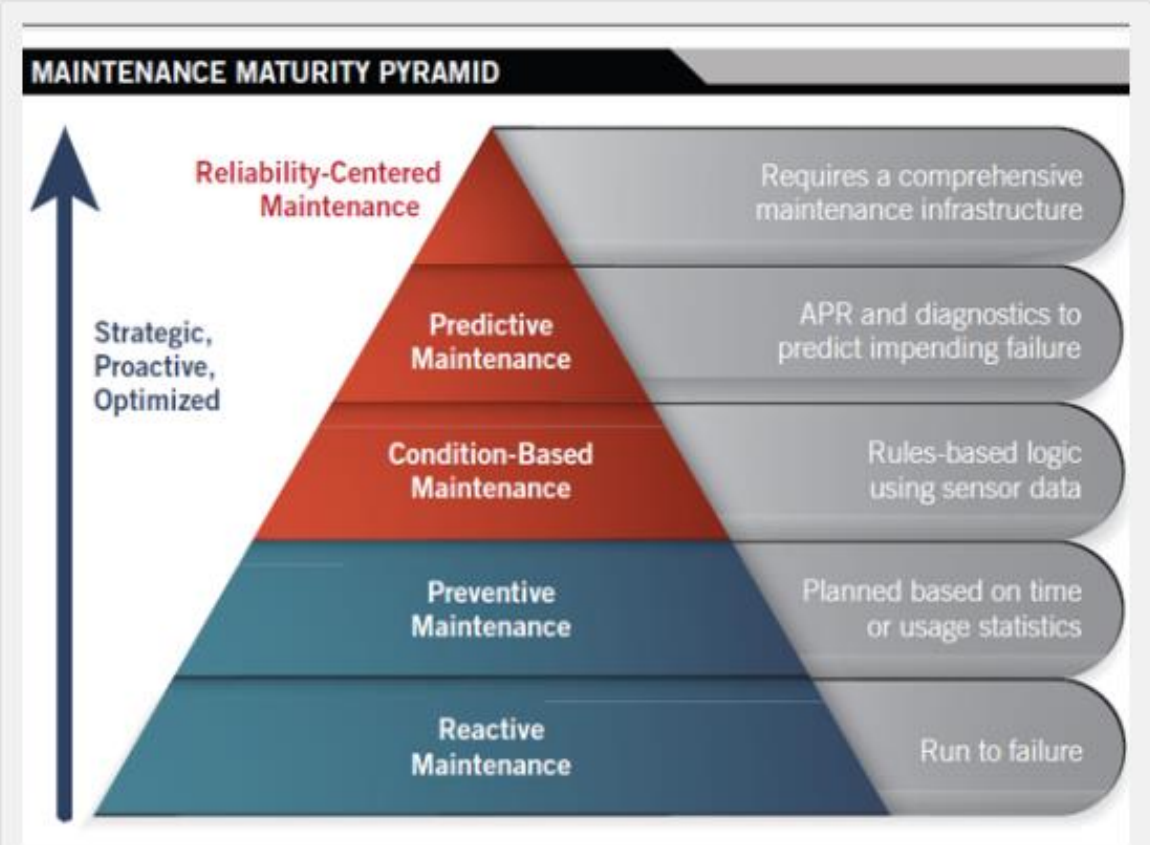
DC-8 aircraft

**4 million labor hours** before reaching 20,000 operating hours.

Boeing 747

**66,000 labor hours** before a major heavy inspection at 20,000 operating hours.

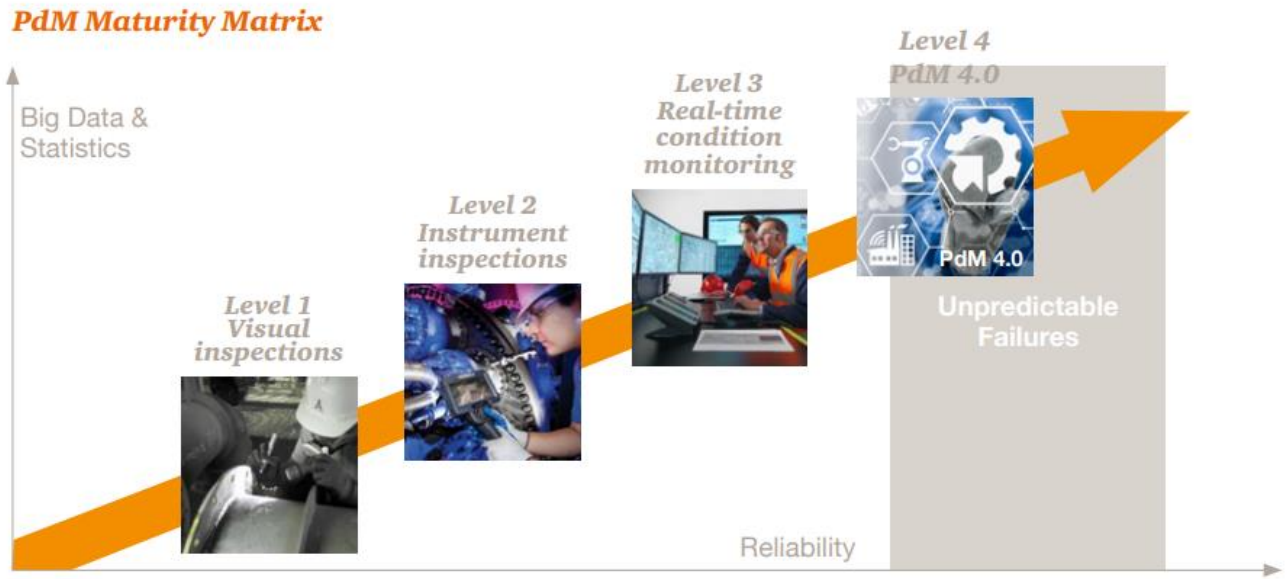
# Predictive maintenance PdM 4.0




The Maintenance Maturity Pyramid

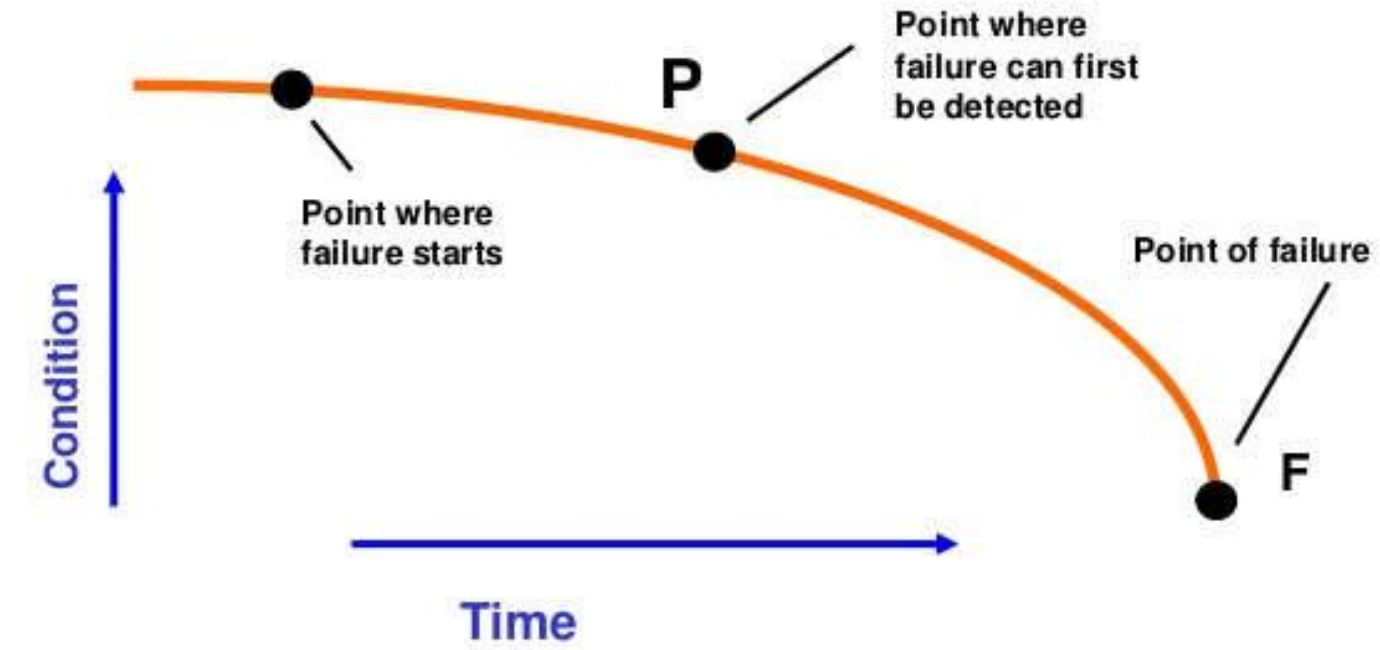
- The application of big data analytics in maintenance represents the fourth level of maturity in predictive maintenance.
- PdM 4.0 is about predicting future failures in assets and ultimately prescribing the most effective preventive measure by applying advanced analytic techniques on big data

# Predictive maintenance PdM 4.0




- Real-time condition monitoring will only get you to a certain level of reliability; a level where you will still be plagued by unforeseeable and inexplicable failures.
- These failures could be tackled with big data analytics. PdM 4.0 involves harnessing the power of artificial intelligence to create insights and detect patterns and anomalies that escape detection

# DETERMINE “P”

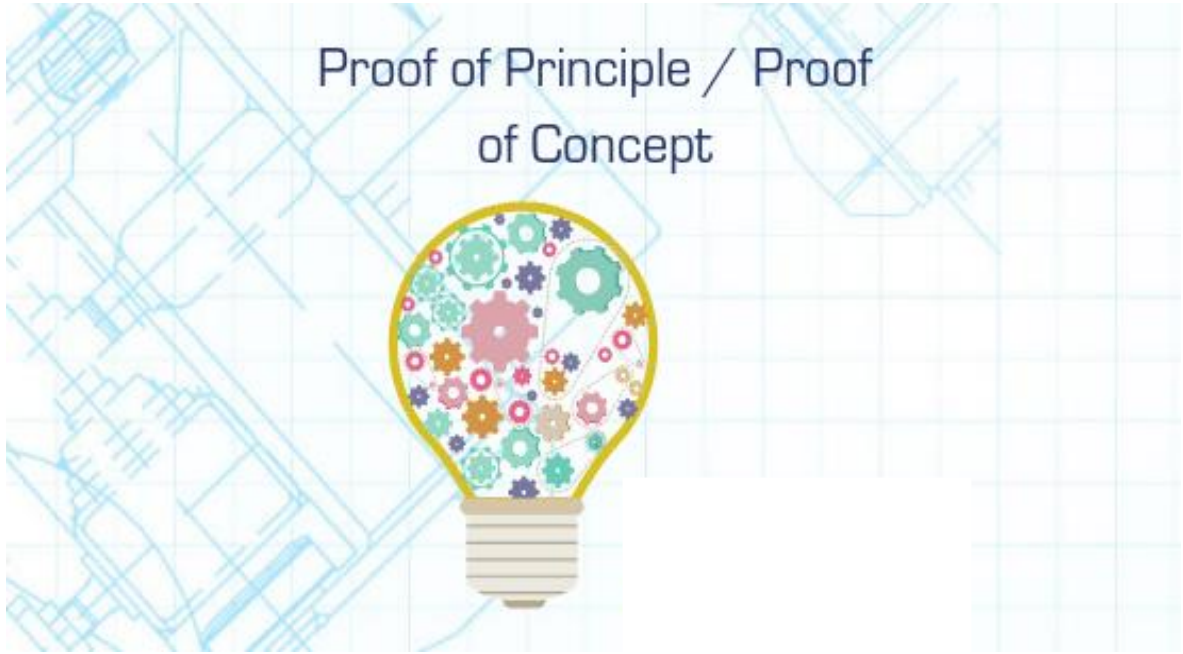



*John Moubray, Reliability Centered Maintenance II*

# Proof of concept

- Approach
- Test bench
- Data creation
- Machine Learning
- Test on a vessel
- Way ahead

# Proof of concept

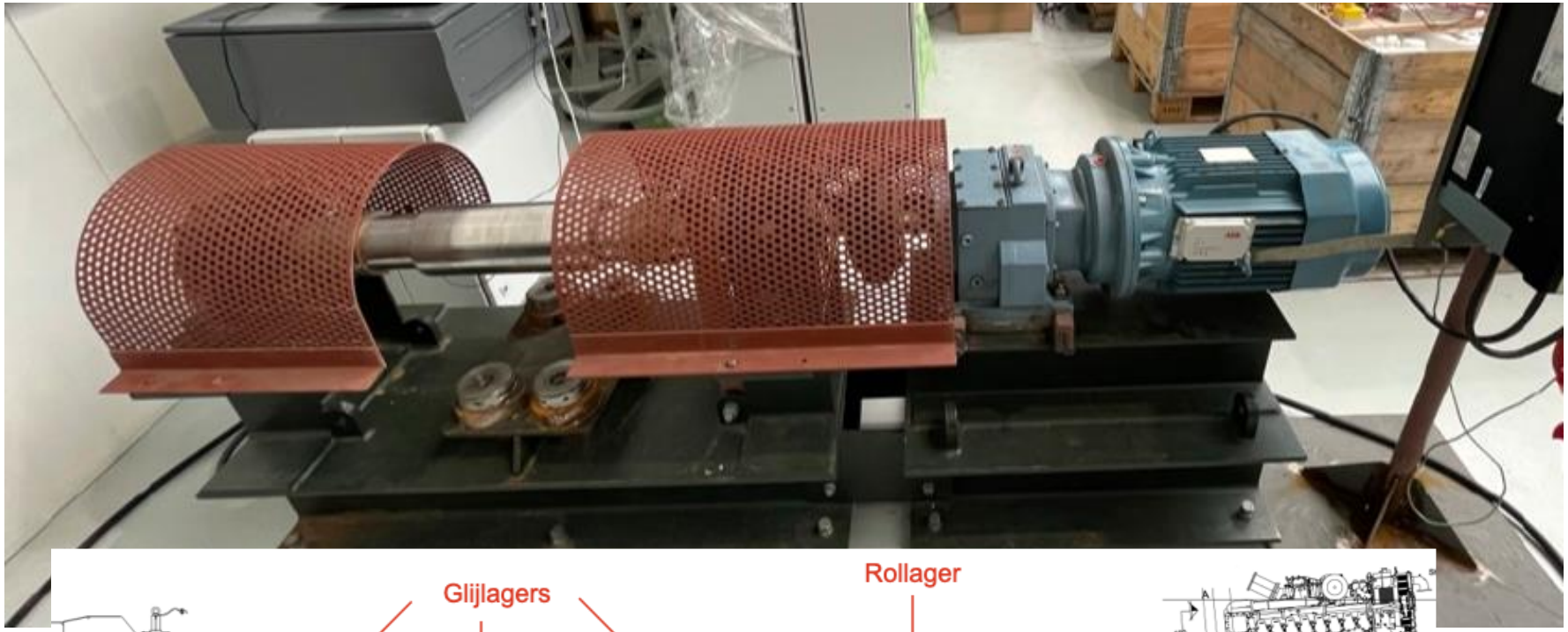



The intention is to trail the interfacing of the different elements necessary to trigger predictive maintenance.

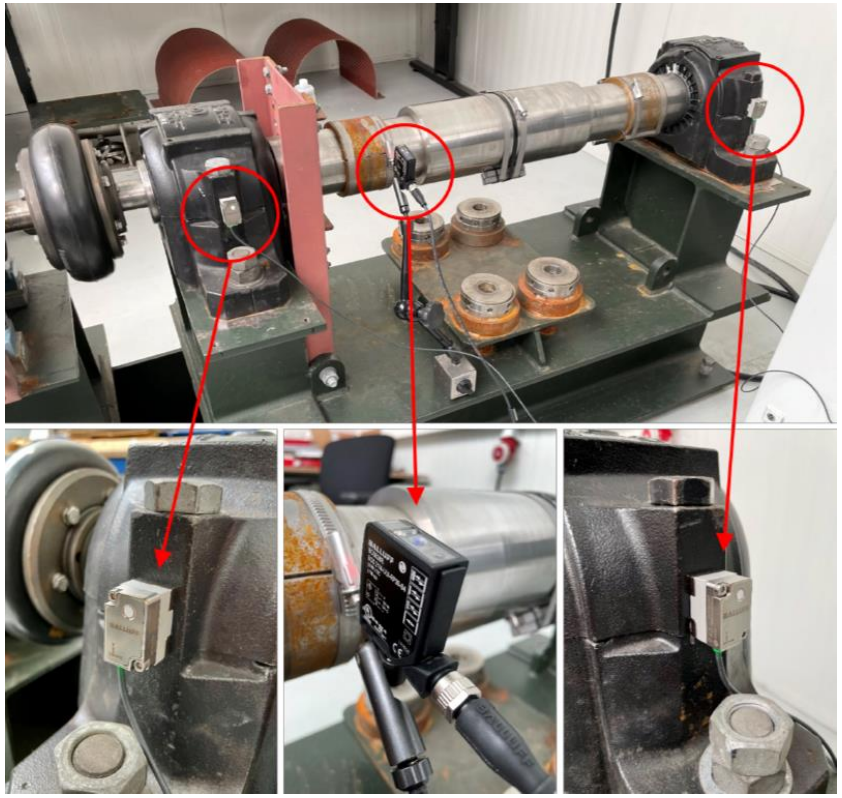
Definition of the elements to be tested and integrated:

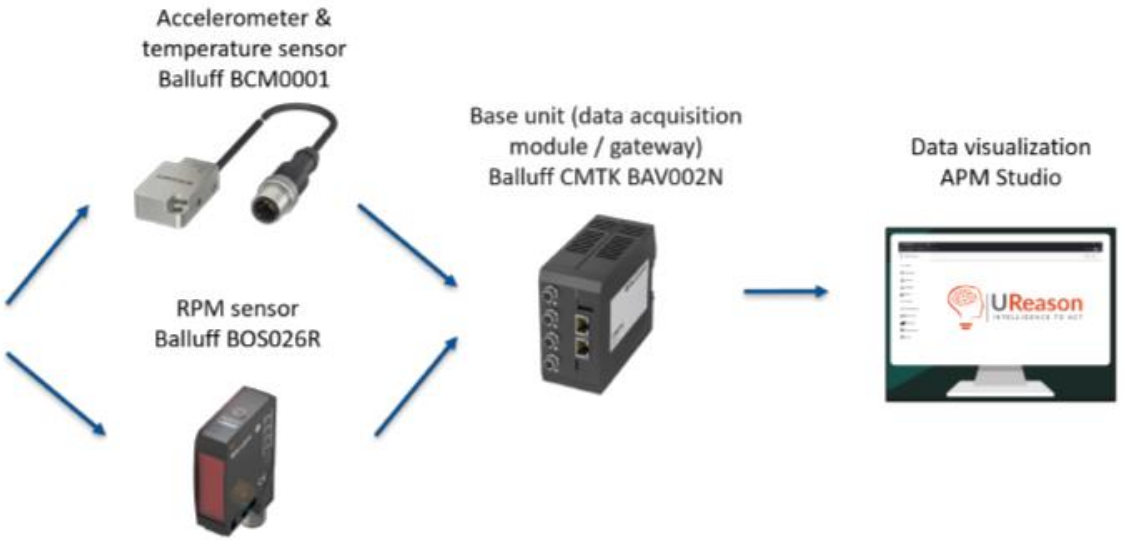
- System with a controllable dynamic behavior
- An operational profile
- Sensors to monitor > 1 system parameter
- Machine Learning model / algorithm to determine when parameters indicate atypical behavior
- Indication that system behavior is atypical

# System simulation

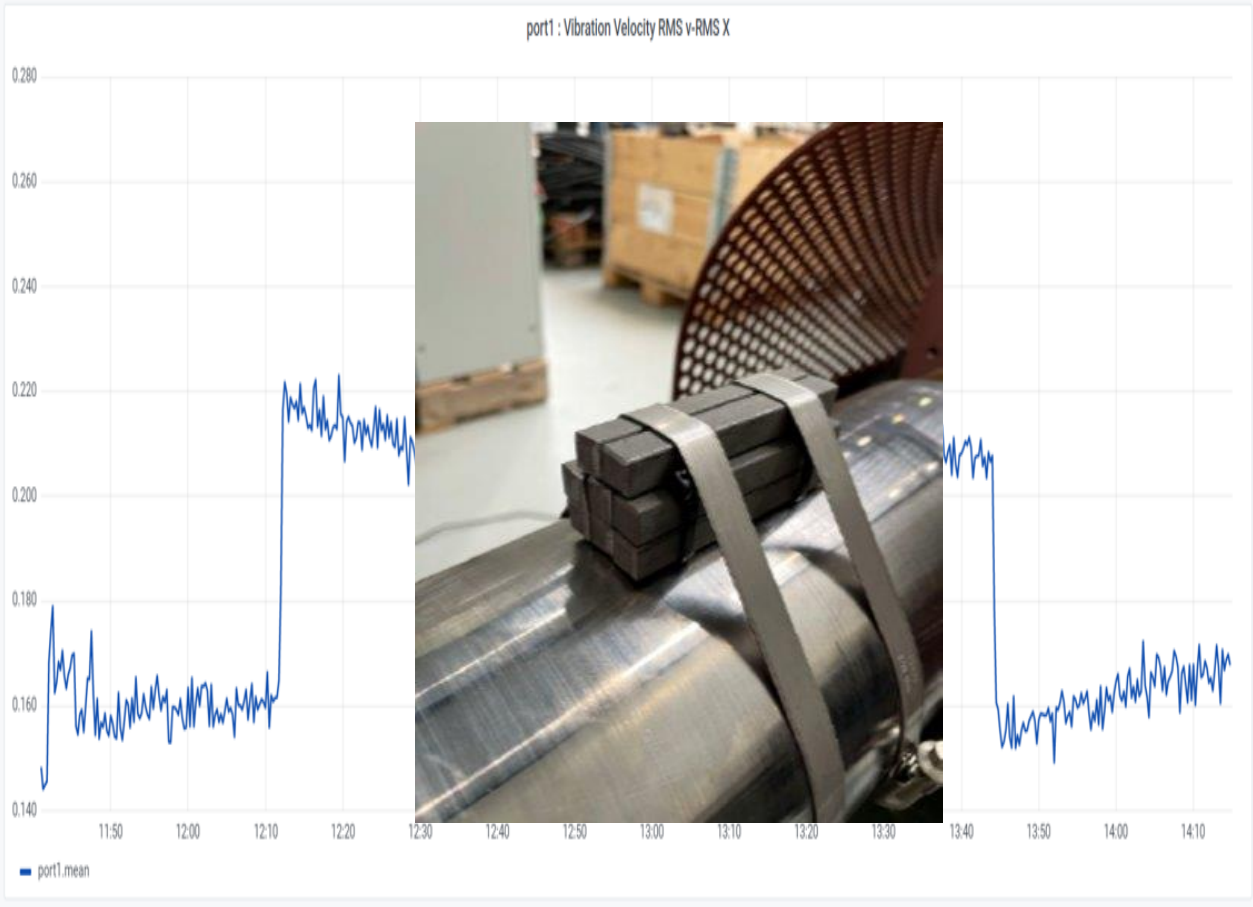


# Pilot



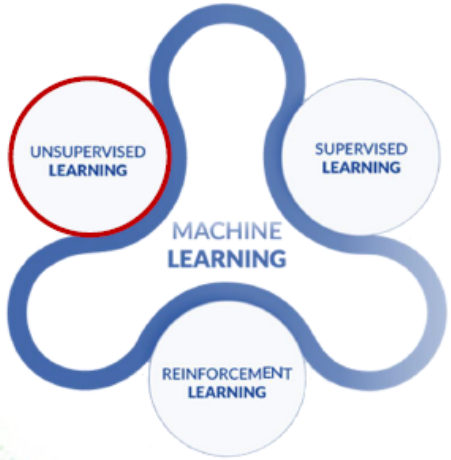

Accelerometer &
temperature sensor
Balluff BCM0001
RPM sensor
Balluff BOS026R
Base unit (data acquisition
module / gateway)
Balluff CMTK BAV002N
Data visualization
APM Studio
UReason

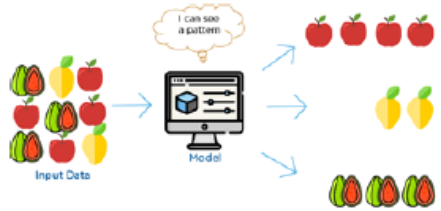
# Data creation



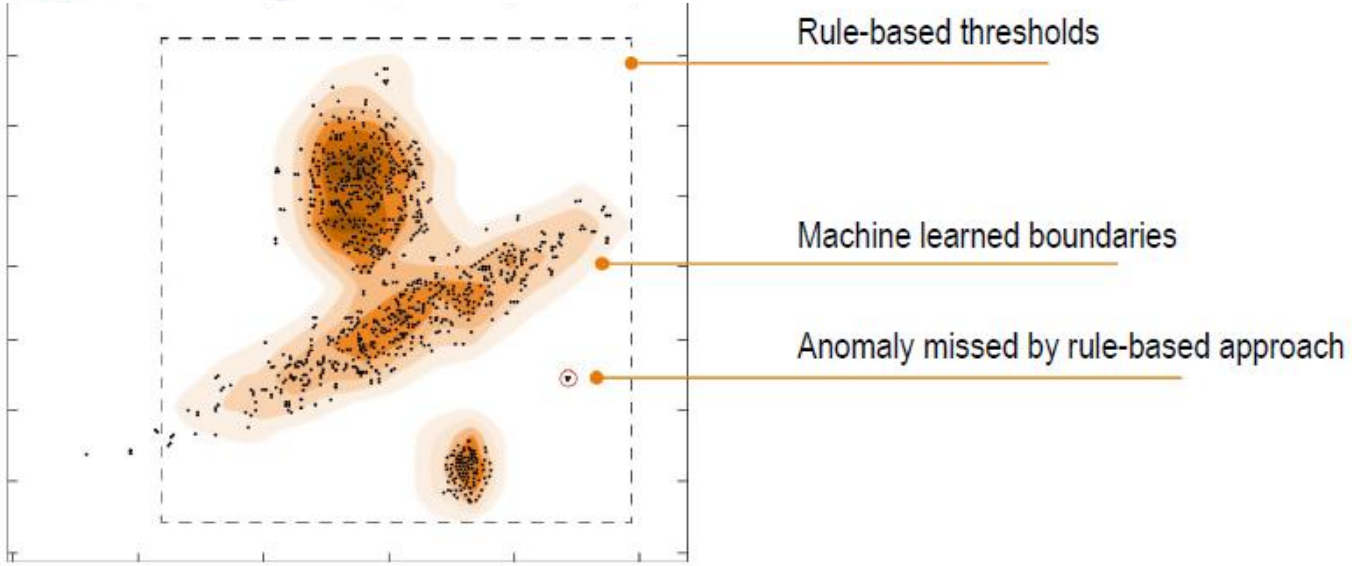

- 1: Vibrations at different normal operational profiles.
- 2: Vibration profiles with anomaly

# Machine learning



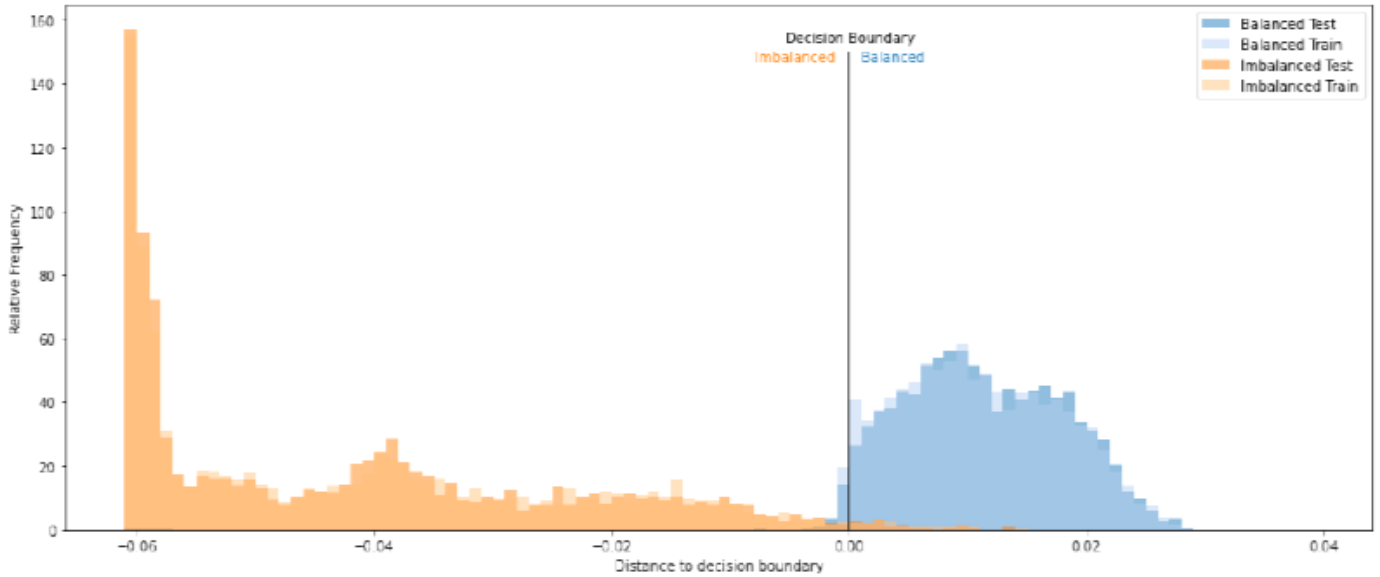

- Training on unlabeled data
- No output categories or labels
- Mainly used for pattern detection and summarization

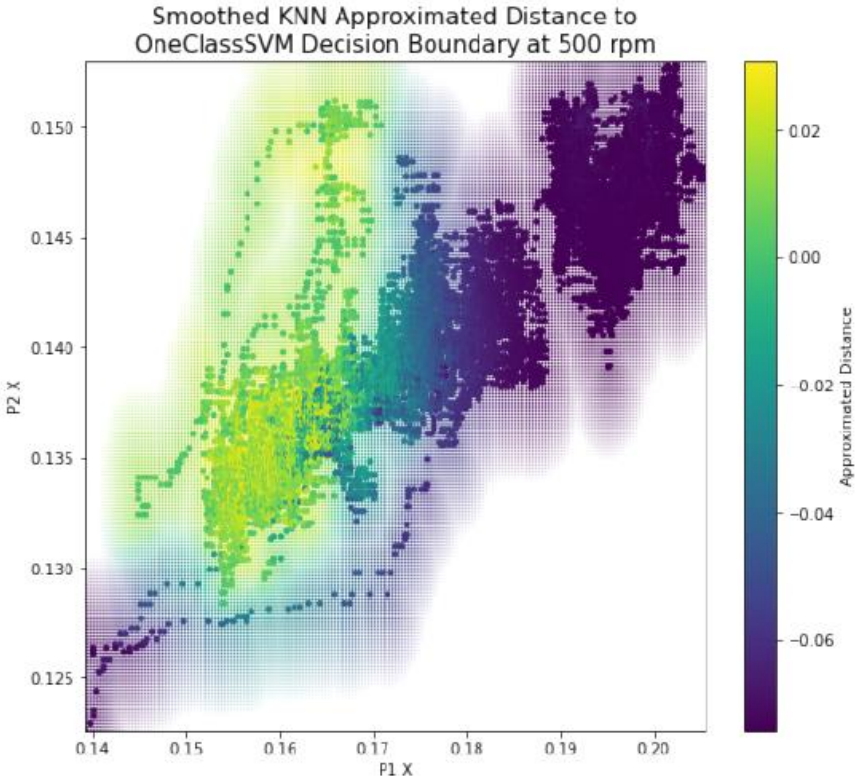



› Machine Learning development requires data to allow the software to recognize the typical behavior of the system.

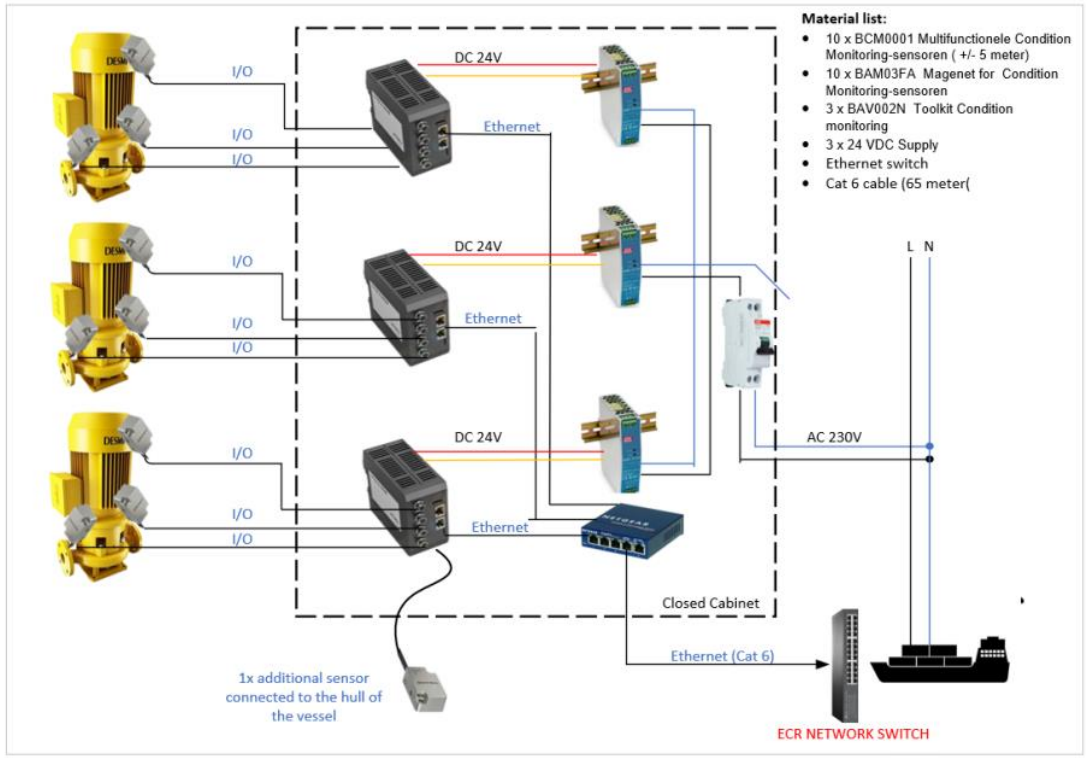
› This data must be generated during the normal operational profile and during anomaly occurrences.

# Results


Decision Boundary
Imbalanced
Balanced
Balanced Test
Balanced Train
Imbalanced Test
Imbalanced Train
Relative Frequency
Distance to decision boundary
160
140
120
100
80
60
40
20
0
−0.06
−0.04
−0.02
0.00
0.02
0.04


Smoothed KNN Approximated Distance to
OneClassSVM Decision Boundary at 500 rpm
P2 X
P1 X
Approximated Distance
0.150
0.145
0.140
0.135
0.130
0.125
0.14
0.15
0.16
0.17
0.18
0.19
0.20
0.02
0.00
−0.02
−0.04
−0.06

# Pilot on vessel

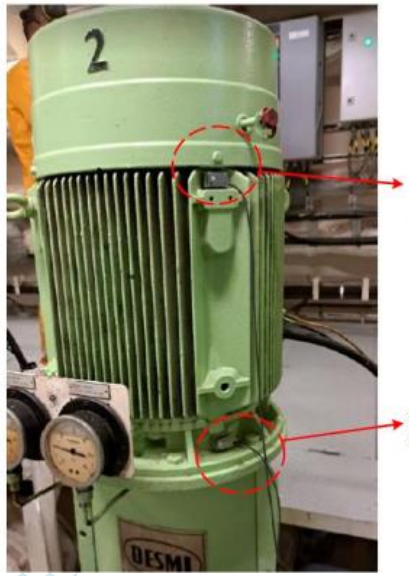



- Replicated the setup onboard of a vessel.
- Create a database during normal operations
- Develop ML algorithm based on the model trained for the test setup.
- Introduce anomalies to validate the system.
- Deploy this model on the vessel and monitor when anomalies occur and create database with labels.

# Current situation


Location of the sensors

Sensors to be installed after the drydock period by Damen services

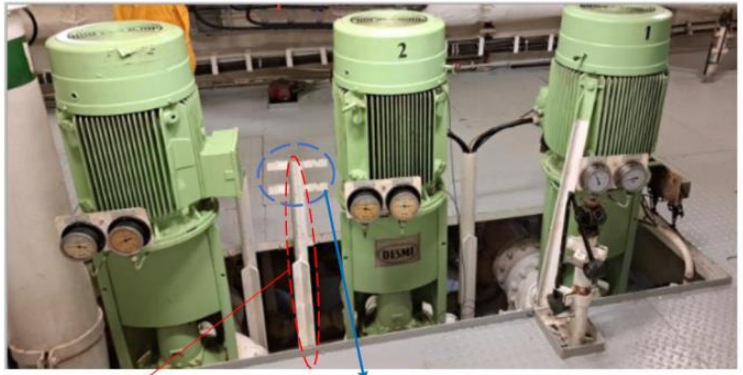



Sensor #1.
NDE electromotor

Sensor #1.
DE electromotor

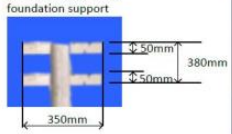
Sensor #3.
Near the centrifugal pump bearing

In dock preparation for the vibration monitoring cabinet foundation




Main foundation support material: H-Profile or Pipe
Size to be determined by installer
Bolt or welt to the floor and base of the pump.
Goal is to support the cabinet with the least amount of vibrations. The cabinet can placed using bolt and nuts after

2 x steel flatbar to be welded or bolted to the main foundation support

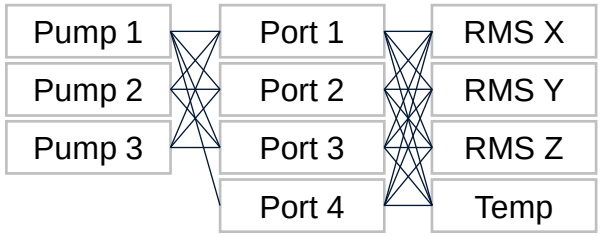



Cabinet front

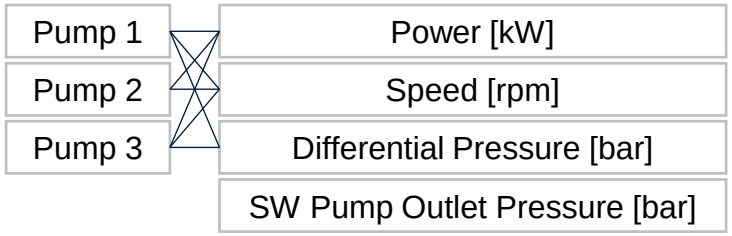
Cabinet back

# Dataset (Normal Condition)

## Vibration Sensor Data




## IoT Sensor Data

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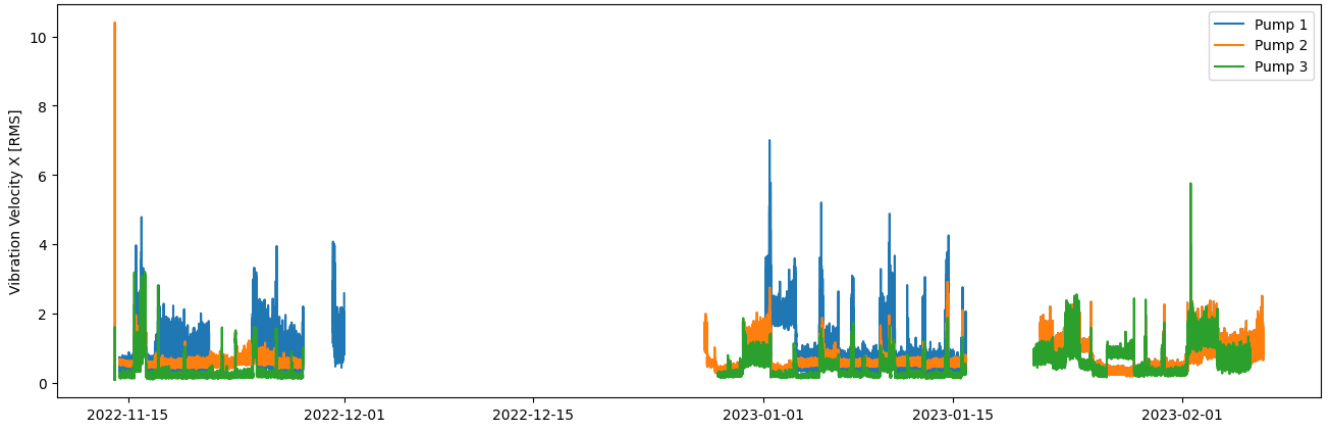
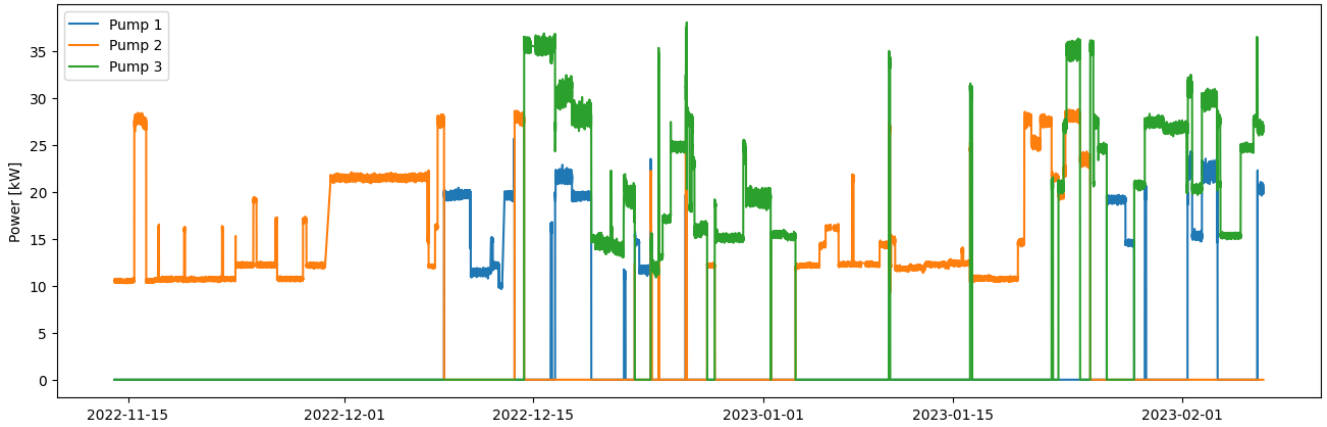
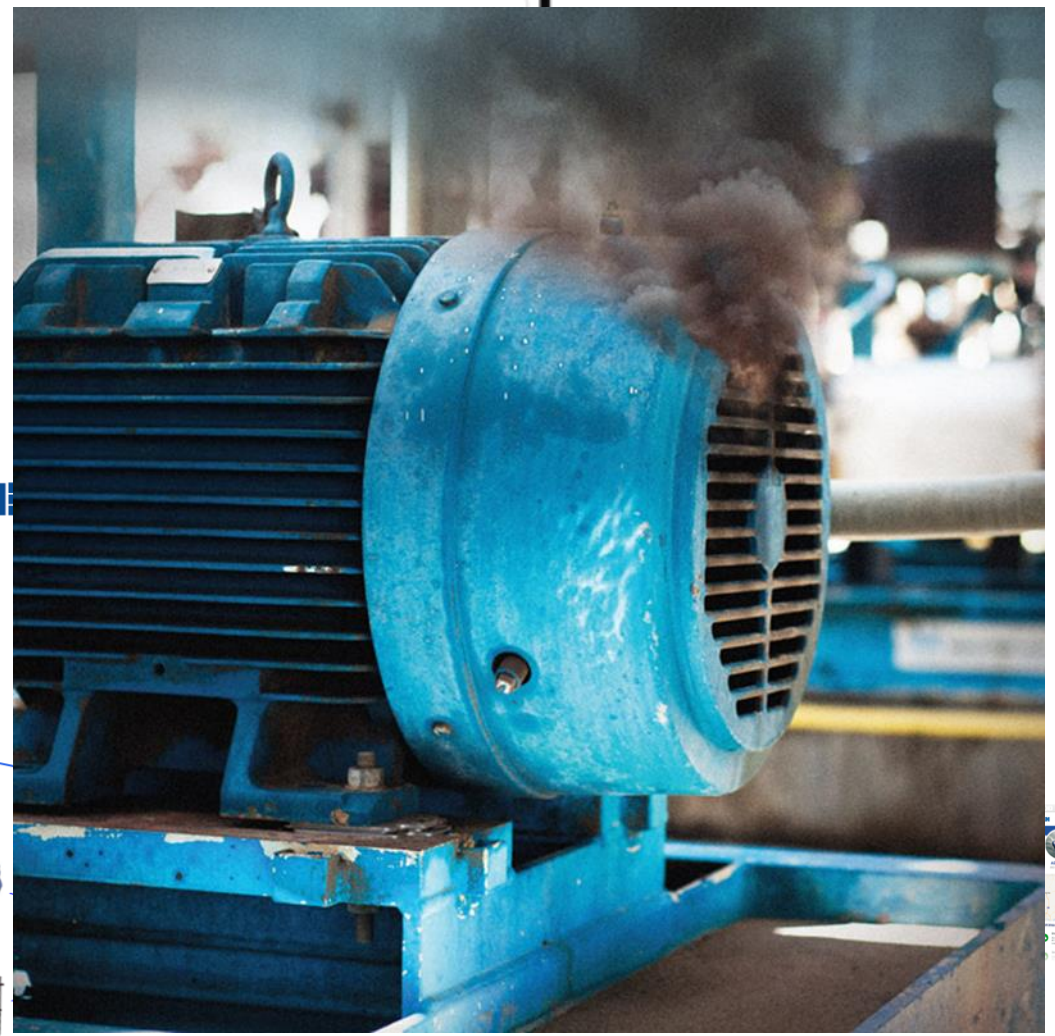
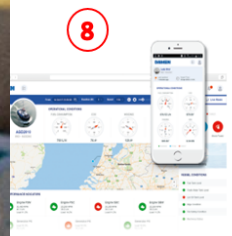




# Way ahead

- Create an operational setup onboard of a vessel.
- Create a vessel “normal” database and develop algorithm.
- Deploy the vessel and monitor when anomalies occur and create database with labels.

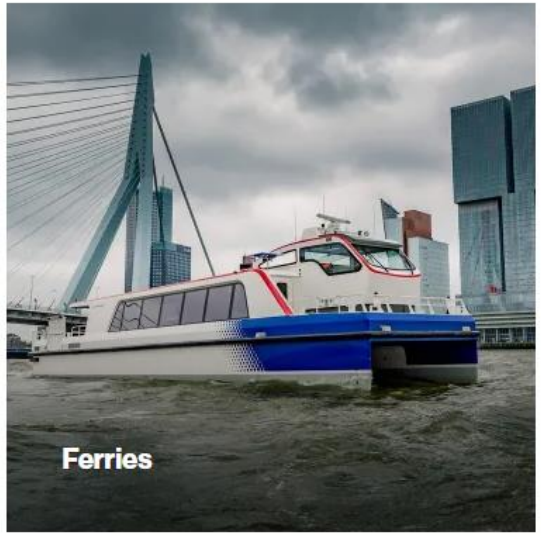

ENGINE ROOM | WHEELHOUSE / ENGINE CONTROL ROOM | DAMEN OFFICE | CLIENT OFFICE

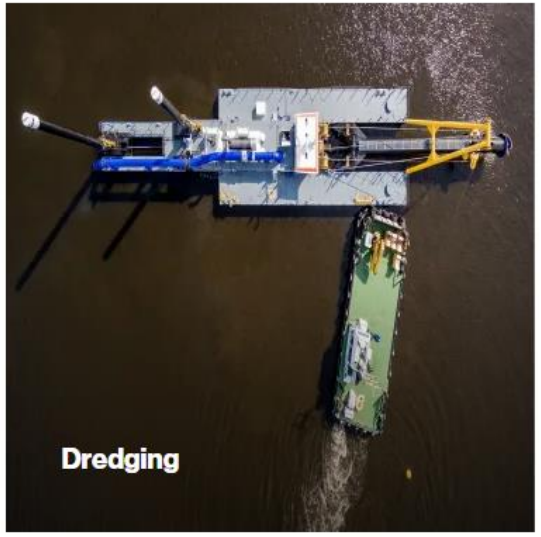
# Way ahead


Tugs


Defence & Security


PILOTS
Pilot & Tender Vessels


Ferries


Dredging


SIEMENS Gamesa

# Damen – We Care