# MATLAB EXPO 2019

# La maintenance prédictive avec MATLAB et Simulink

Kevin Roblet et Mathieu Cuenant











### **Corrective Maintenance**





### **Planned Maintenance**









# **Condition indicators**

# Remaining Useful Life

Digital twin

IOT, data collection

Deployment





#### **Condition Indicators Basics**

#### Condition Indicators for Monitoring, Fault Detection, and Prediction

A condition indicator is any feature of system data whose behavior changes in a predictable way as the system degrades.

#### Signal-Based Condition Indicators

A signal-based condition indicator is a quantity derived from processing of signal data. The condition indicator captures some feature of the signal that changes as system performance degrades.

#### Model-Based Condition Indicators

A model-based condition indicator is a quantity derived from fitting system data to a model and performing further processing using the model. The condition indicator captures some feature of the model that changes as system performance degrades.

### **Condition Indicators in the Diagnostic Feature Designer**

#### Explore Ensemble Data and Compare Features Using Diagnostic Feature Designer

Workflow for interactively exploring and processing ensemble data, designing and ranking features from that data, and exporting data and selected features.

#### Process Data and Explore Features in Diagnostic Feature Designer

Filter and transform data within the app. Extract features from the imported and derived signals, and assess feature effectiveness.

#### Interpret Feature Histograms in Diagnostic Feature Designer

Interpret feature histograms to assess how well each feature separates labeled groups of data

### **Condition Indicators for Rotating Machinery**

#### **Condition Indicators for Gear Condition Monitoring**

Workflow to identify condition indicators for gear condition monitoring, and their evaluation.



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Signal-Based Condition Indicators

### Featured Examples



#### Rolling Element Bearing Fault Diagnosis

Perform fault diagnosis of a rolling element bearing based on acceleration signals. Apply envelope spectrum analysis and spectral



### Wind Turbine High-Speed Bearing Prognosis

Build an exponential degradation model to predict the Remaining Useful Life (RUL) of a wind turbine bearing in real time. The exponential



#### Fault Diagnosis of Centrifugal Pumps Using Residual Analysis

Use a model parity-equations-based approach for detection and diagnosis of faults in a pumping system.



### Analyze and Select Features for Pump Diagnostics

Use the Diagnostic Feature Designer app to analyze and select features to diagnose faults in a triplex reciprocating pump.



#### Detect Abrupt System Changes Using Identification Techniques

Detect abrupt changes in the behavior of a system using online estimation and automatic data segmentation techniques.

Condition Indicators for Gear Condition Monitoring Workflow to identify condition indicators for gear condition monitoring, and their evaluation.



📣 MathWorks<sup>®</sup>





### Demo: Analog Input Recorder App

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### Demo: Signal Analyzer App





### Demo: Diagnostic Feature Designer App

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# **Condition indicators**

# **Remaining Useful Life**

Digital twin

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Estimating the Remainint Useful Life helps predict its time to failure and optimize maintenance schedules



### RUL is based on time evolution of condition indicator













### **Off-the-shelf RUL models**





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### **Off-the-shelf RUL models: Similarity model**





### **Off-the-shelf RUL models**





### **Off-the-shelf RUL models: Exponential Degradation model**



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RUL: 459 hours (95%Cl: 374-558 hours)







# **Condition indicators**

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# What is a Digital Twin ?



### Model aiming at being used in operation

### Faithful, up-to-date representation of asset

### Composite of modeling approaches – data or physics



### Fai



### "Essentially, all models are wrong, but some are useful"

George E.P. Box

Matlab expo 2019

Composi



# Why a Digital Twin?

Prediction

## What-If Simulations

## **Anomaly Detection**

## **Predictive Maintenance**



# How do I build a Digital Twin?









### Simscape Component

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Resistor		
This block represents an <u>View source for Resisto</u>		
Parameters		
Resistance:	1	Ohm 🔻







algorithm and to test the deployed algorithm.









# **Condition indicators**

# Remaining Useful Life

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# Actual applications?





Performance - Modular analysis - Thermodynamic cycle

Liftoff

- Tracking - Monitoring ignition



- Actuators
   Troubleshooting assistance
   Errors and Warnings



### **Mechanical Health**

- Imbalance
- Vibration Transient events















### MathWorks can help you get started TODAY

- Examples
- Documentation
- Tutorials & Workshops
- Consulting
- Tech Talk Series

