



# Predictive Maintenance with MATLAB

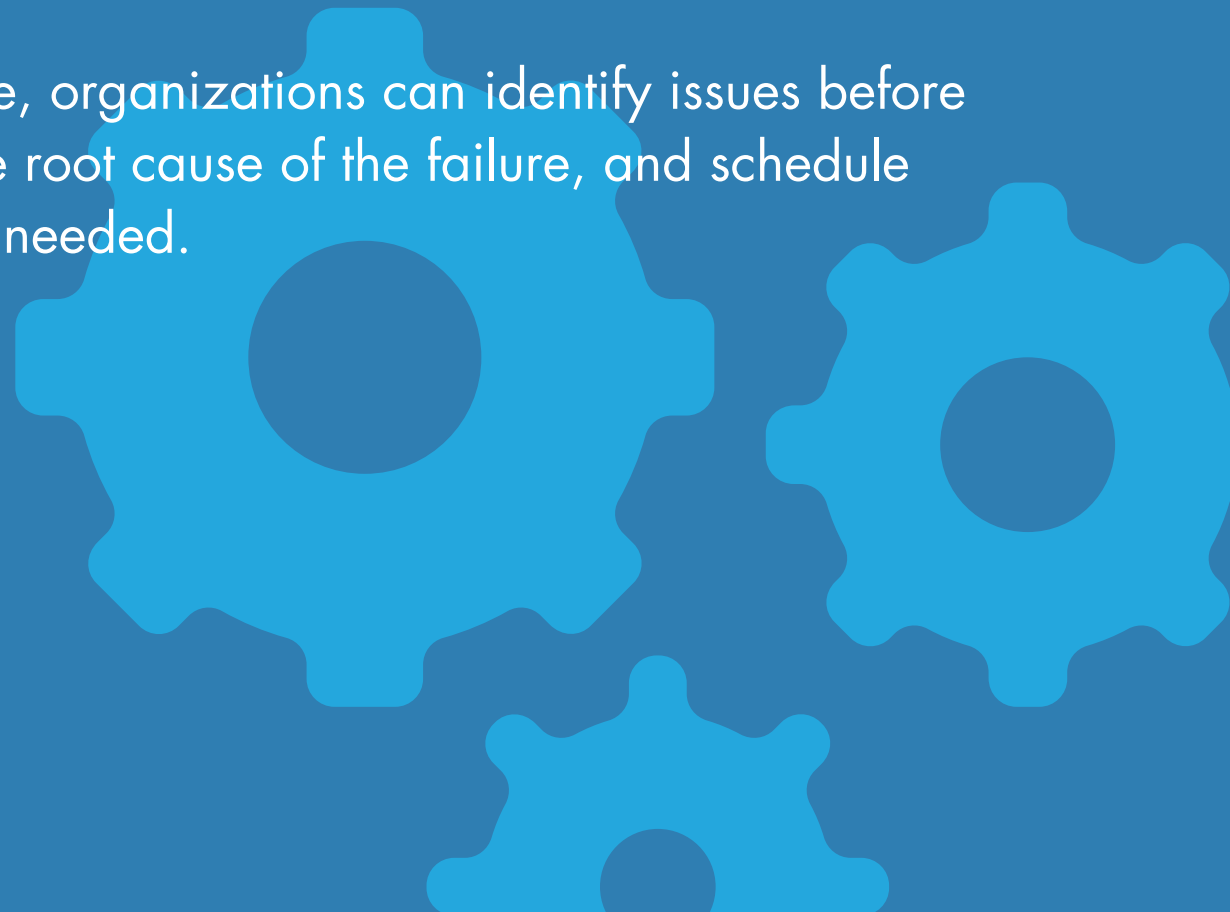
*Avoid costly equipment failures by using  
sensor data analytics*



# What is Predictive Maintenance?

Predictive maintenance is the intelligent health monitoring of equipment to avoid future equipment failure. In contrast to preventive maintenance, which follows a set timeline, predictive maintenance schedules are determined by analytic algorithms and data from equipment sensors.

With predictive maintenance, organizations can identify issues before equipment fails, pinpoint the root cause of the failure, and schedule maintenance as soon as it's needed.



# MATLAB for Predictive Maintenance

Today, more and more manufacturers and other organizations use MATLAB® to develop and deploy monitoring and predictive maintenance software. With MATLAB they can analyze and visualize big data sets, implement advanced machine learning algorithms, and run the algorithms in a production cloud environment.

MATLAB provides an end-to-end solution for predictive maintenance. With MATLAB you can:

- Access and preprocess data from a variety of sources
- Develop predictive models using machine learning techniques
- Create dashboards for visualizing and interacting with the model results
- Deploy predictive maintenance algorithms in production systems and embedded devices



*“Our financial control department determined that we are saving up to 50,000 euros a month by using MATLAB for predictive maintenance. That total is based on just eight machines. We expect that to increase at least fourfold as we analyze the data from more of our machines.”*

— Dr. Michael Kohlert, Mondi  
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# Access and Preprocess Data

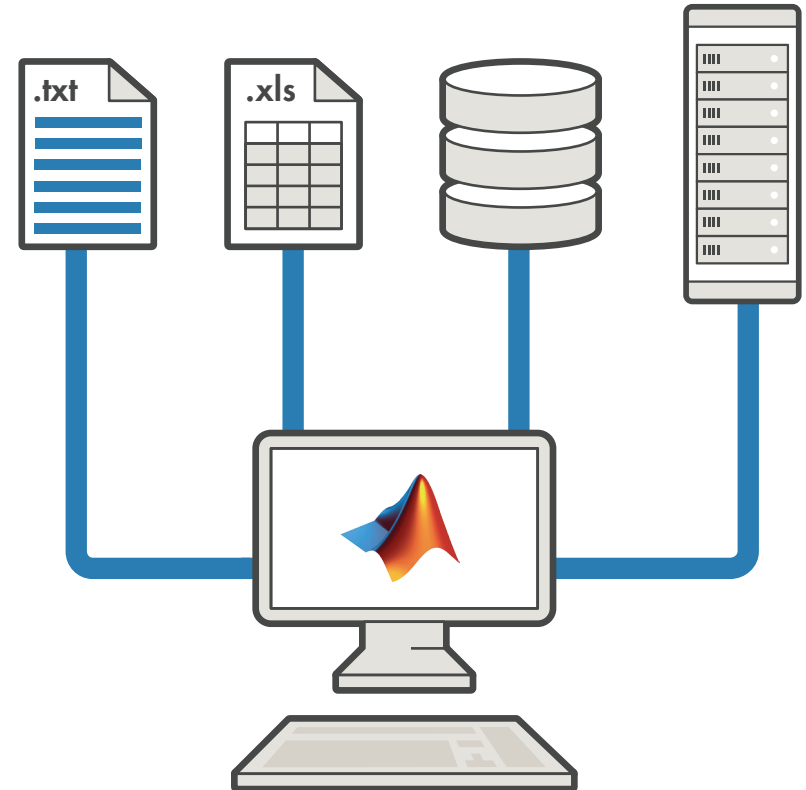
Sensor data from equipment can reside in multiple sources such as text files, spreadsheets, *databases*, and *OPC servers*. Wherever your data is, you can *get to it with MATLAB*.

But not all data is useful data. You start by *preprocessing* with MATLAB, using techniques such as:

- *Time series data synchronization*, to align data that is sampled at different rates and may contain missing values
- Advanced *signal processing* to remove noise from sensor data
- *Feature selection*, extraction, and transformation, to determine which data will be the most helpful for predicting failures

*"We need to filter our data, look at poles and zeroes, run nonlinear optimizations, and perform numerous other tasks. In MATLAB, those capabilities are all integrated, robust, and commercially validated."*

— *Borislav Savkovic, BuildingIQ*  
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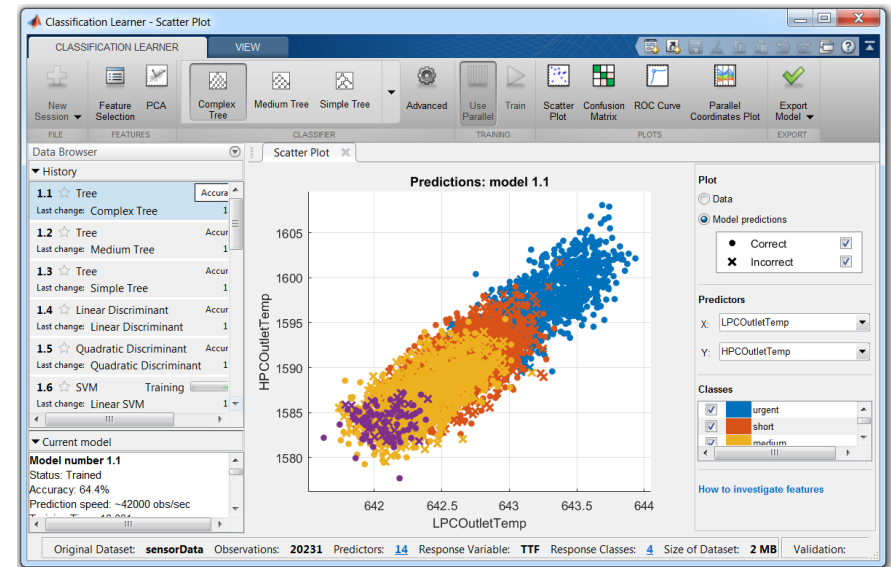
# Develop Predictive Models

Algorithms for *data clustering*, *classification*, and *system identification* are critical to building successful *predictive maintenance models*. These models are typically trained and tested on input data in the form of temperature, pressure, voltage, noise, or vibration to:

- Predict a specific failure
- Monitor the health of the equipment

With MATLAB you can quickly iterate and try different algorithms. MATLAB apps let you:

- Interactively explore your data
- Select the more important variables for your model
- Train common predictive models in parallel
- Assess and compare multiple models



Interactively train and evaluate predictive models using the Classification Learner app.

*"As a process engineer I had no experience with neural networks or machine learning. I worked through the MATLAB examples to find the best machine learning functions for generating virtual metrology. I couldn't have done this in C or Python—it would've taken too long to find, validate, and integrate the right packages."*

— Emil Schmitt-Weaver, ASML  
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# Deploy Models in Production

Once you've developed your models, you want to get them up and running as quickly as possible. MATLAB integrates into enterprise systems, clusters, and clouds, and can be targeted to real-time embedded hardware.

To shorten response times and send less data over the network, you can deploy the models directly on machines.

MATLAB lets you:

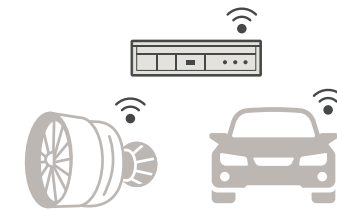
- Automatically generate code from models
- Implement the code in an embedded system
- Target real-time hardware

To make results immediately available to operators on the shop floor, you can

- Create analytics dashboards
- Deploy models in desktop applications
- Operationalize models in a server or cloud environment

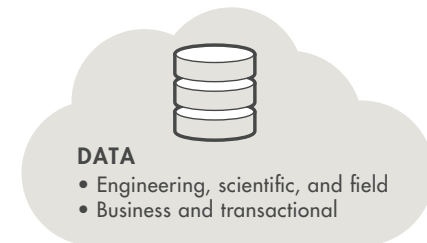
*"There's a misconception that MATLAB is only for research or development. We operate our machines nonstop, even on Christmas, and we rely on our MATLAB based monitoring and predictive maintenance software to run continuously and reliably in production."*

— Dr. Michael Kohlert, Mondi  
[Read user story](#)



## EMBEDDED SYSTEMS

Deploy MATLAB analytics to run in embedded systems



## DATA

- Engineering, scientific, and field
- Business and transactional



## ENTERPRISE IT SYSTEMS

Deploy MATLAB analytics to enterprise IT systems

# Industry Example

## Baker Hughes Develops Predictive Maintenance Software for Gas and Oil Extraction Equipment

Baker Hughes trucks are equipped with positive displacement pumps that inject a mixture of water and sand at high pressures deep into drilled wells. With pumps accounting for about \$100,000 of the \$1.5 million total cost of the truck, Baker Hughes needed to determine when a pump was about to fail. Too-frequent maintenance wasted effort and resulted in still-usable parts being replaced, while too-infrequent maintenance risked damaging pumps beyond repair.

Working in MATLAB, Baker Hughes engineers developed pump health monitoring software that applies machine learning techniques in real time to predict the ideal time to perform maintenance. They processed and analyzed up to a terabyte of data collected at 50,000 samples per second from sensors installed on 10 trucks operating in the field, identified the parameters that were useful in predicting failures, and created and trained a neural network to use sensor data to predict pump failures.

The software is expected to reduce maintenance costs by 30–40%—or more than \$10 million.



Truck with positive displacement pump.

*“MATLAB enabled us to perform our analyses and processing, including machine learning. . . . If we had to write our own code using lower-level language libraries for all the built-in MATLAB capabilities we needed, it would likely have taken an order of magnitude longer to complete this project.”*

*– Gulshan Singh, Baker Hughes  
Read user story*

# Learn More

*Explore these resources to learn more about developing and deploying predictive maintenance models with MATLAB.*

## Watch

[Predictive Maintenance with MATLAB: A Prognostics Case Study](#) 52:22

[Signal Processing and Machine Learning Techniques for Sensor Data Analytics](#) 42:45

## Read

[Mondi Implements Predictive Maintenance for Manufacturing Process](#)

## Explore

[5 Types of Data and How to Analyze them with MATLAB](#)

[Smoothing: Remove Noise from Data Sets](#)

[Select Features for Classifying High-Dimensional Data](#)

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