

# MATLAB EXPO 2017

Predictive Maintenance with MATLAB & Simulink

Mehernaz Savai

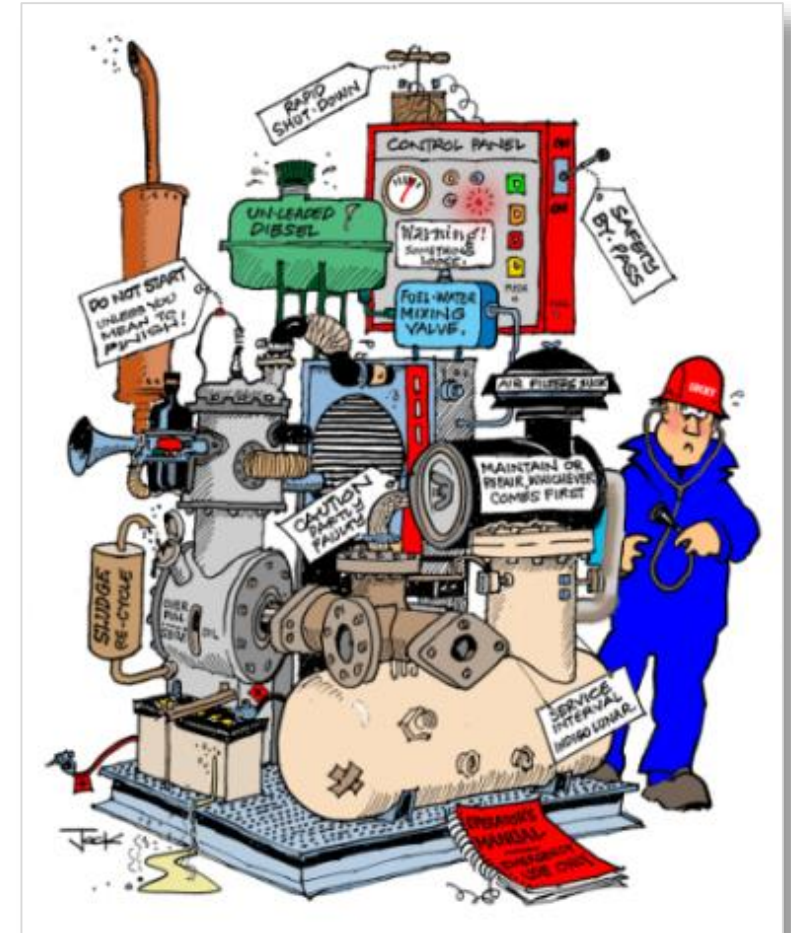
# Predictive Maintenance

## What is Predictive Maintenance?

- Maintenance technique that reduces unnecessary maintenance and eliminates unplanned downtime

## What does a Predictive Maintenance solution do?

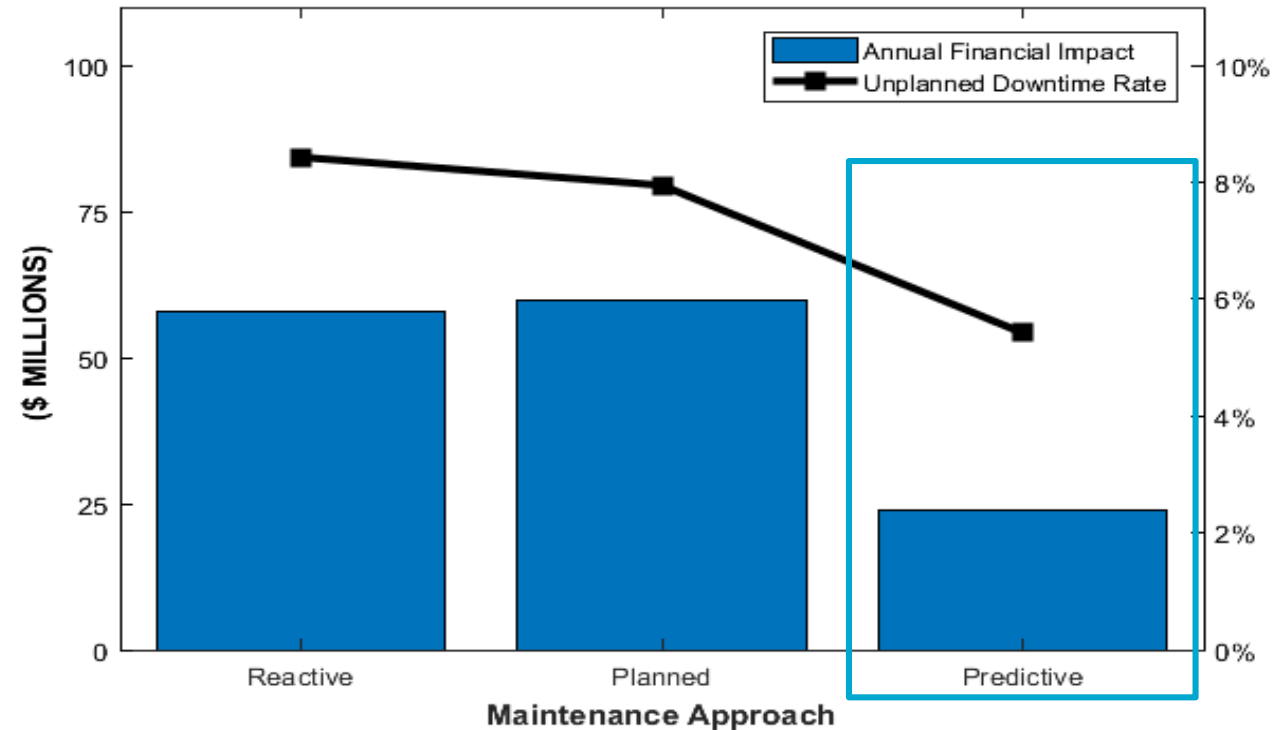
- Uses historical data + sensor data to predict Time-to-Failure or Remaining Useful Life
- Relay this information to maintenance engineers, operators, and plant managers



Source: Tensor Systems

# Why is Predictive Maintenance Important?

- Improved operating efficiency
- New revenue streams
- Competitive differentiator



# Why is Predictive Maintenance Important?


- Improved operating efficiency

Bill Ruh Retweeted  
**GE Digital** @GE\_Digital · Feb 1  
 What does the future of the #IIoT look like? Our CEO @BillRuh\_GE explains in this new interview: [stratz.to/gASk308yoP0](http://stratz.to/gASk308yoP0)



**The Thought Leader**  
 Bill Ruh  
 strategy+business  
 Bill Ruh, CEO

**Siemens** @Siemens  
 Thanks to predictive maintenance the #Velaro E trains between Barcelona and Madrid run w/ 99.9% availability #GartnerSYM



- New revenue streams

**ABB Global** @ABBgroupnews  
 A game changer that opens the door to predictive maintenance [ow.ly/4nc2TT](http://ow.ly/4nc2TT) #IIoT #HM16



**SAP IoT** @SAP\_IoT  
 John Deere uses machine alerts using #telematics for predictive maintenance and to lower downtime of assets [v3.co.uk/v3-uk/news/234](http://v3.co.uk/v3-uk/news/234) ... #IIoT



**John Deere: Technology vendors need to feed agriculture's big data needs**  
 Farmers are hungry for IT solutions  
[v3.co.uk](http://v3.co.uk)

- Competitive differentiator

**Intel IoT** @IntelIoT  
 #DYK predictive maintenance can cut yield losses by 25%? Major benefits of #IIoT: [intel.ly/2dg7Otm](http://intel.ly/2dg7Otm)



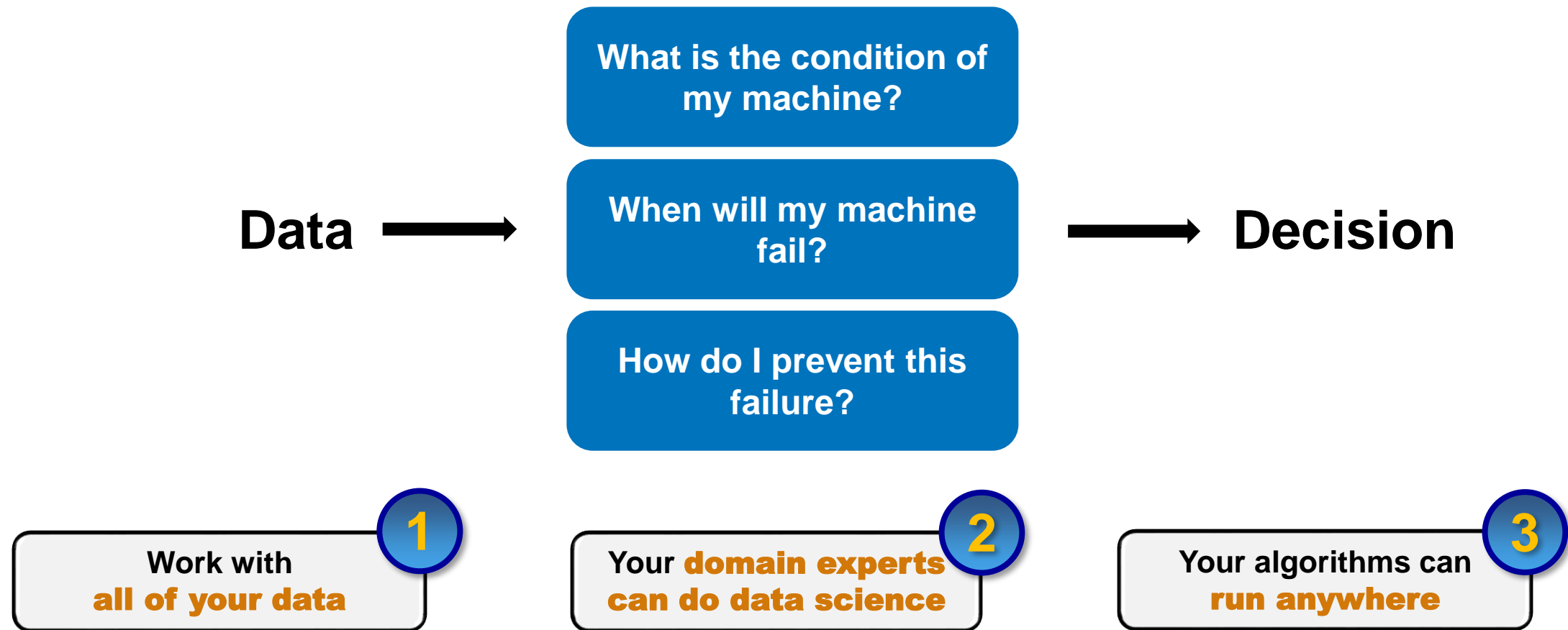
**Software Innovations** @BoschSI · Jan 31  
 How to develop a #DataAnalytics tool for #PredictiveMaintenance in 1 week? [youtube.com/watch?v=9mas0b...](http://youtube.com/watch?v=9mas0b...) #IIoT #Industry40



**How to develop a data analytics tool in 1 week (Part 1)**  
 A team of data scientists, manufacturing & software experts at Bosch Software Innovations developed a data analytics tool for predictive maint...  
[youtube.com](http://youtube.com)

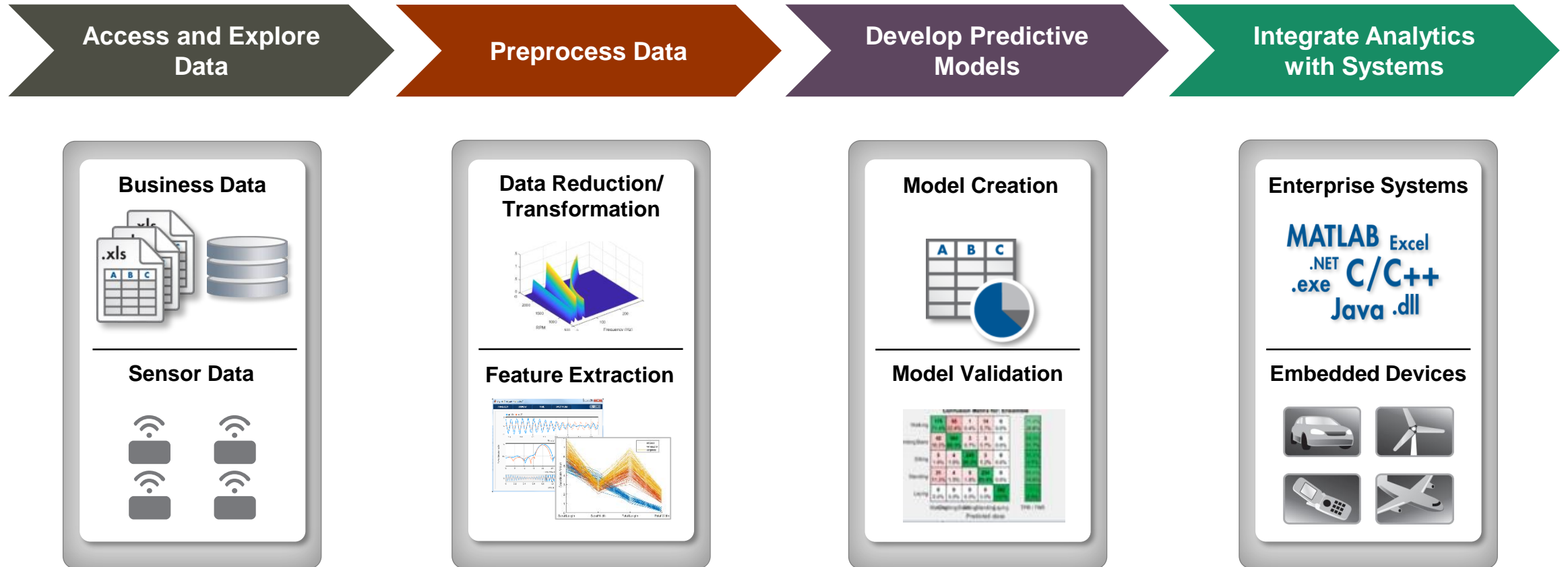
# What should a Predictive Maintenance Algorithm do?

*Turn large volumes of complex data into decisions*





# Predictive Maintenance Algorithm Workflow



# Access and Preprocess Data



**Business Data**

---

**Sensor Data**

1

**Data Reduction/  
Transformation**

---

**Feature Extraction**

**Model Creation**

---

**Model Validation**

**Enterprise Systems**

MATLAB Excel  
.NET C/C++  
.exe Java .dll

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**Embedded Devices**

# Access and Preprocess Data

## Access and Explore Data

### Business Data



### Sensor Data

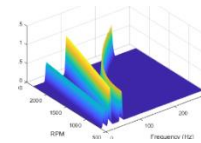


## Challenges

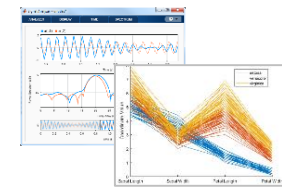
- I have too much data to handle easily
- I don't have enough data
- I have no data
- I have too many data types and data sources
- My data is too messy

## Preprocess Data

### Data Reduction/ Transformation



### Feature Extraction





# Access and Preprocess Data

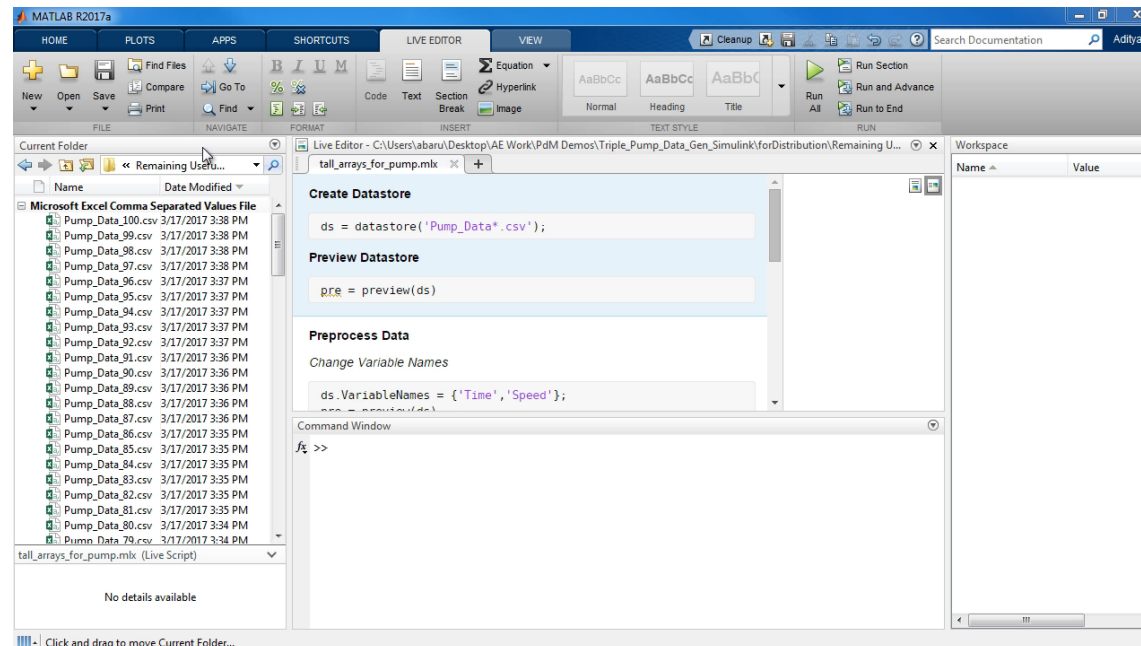
Access and Explore Data

Preprocess Data

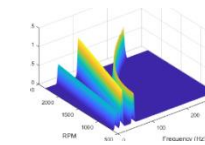
Business Data



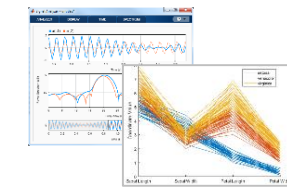
Sensor Data



Data Reduction/  
Transformation



Feature Extraction



# Access and Preprocess Data

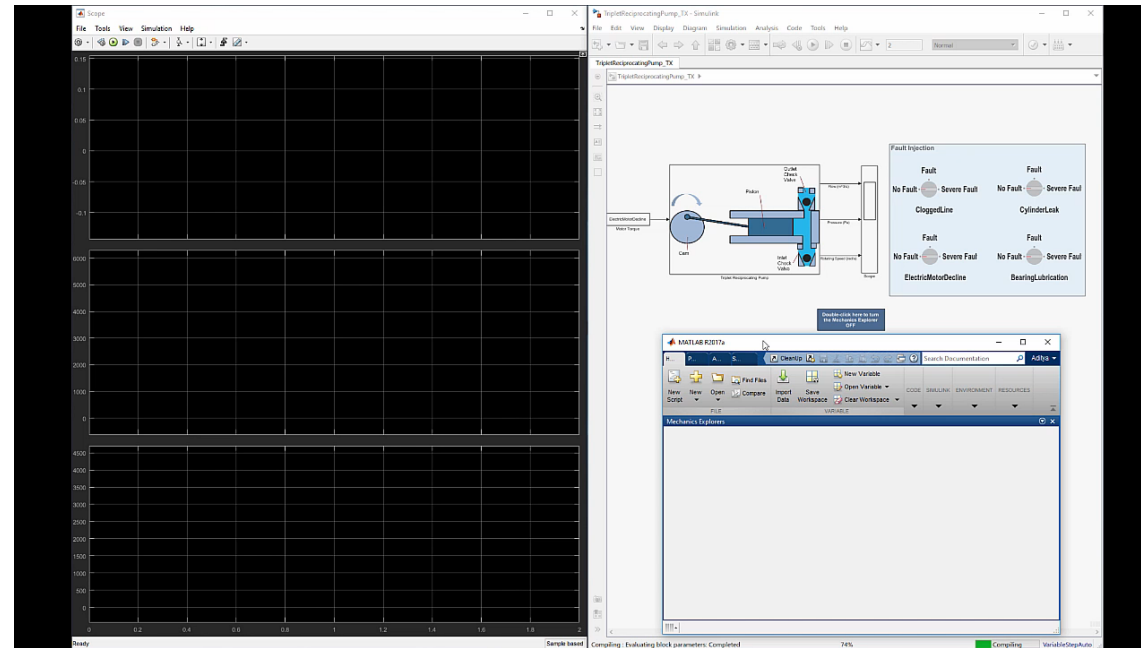
Access and Explore Data

Preprocess Data

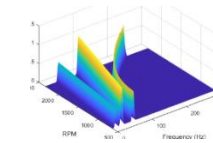
Business Data



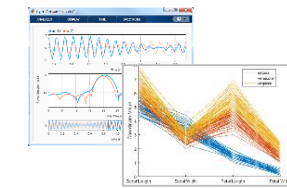
Sensor Data



Data Reduction/  
Transformation



Feature Extraction



# Access and Preprocess Data

Access and Explore Data

**Business Data**

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**Sensor Data**

**Find out more:**

**2 PM Session: Employing  
Simscape to model electro-  
mechanical systems in Simulink**

Preprocess Data

**Data Reduction/  
Transformation**

---

**Feature Extraction**

# Access and Preprocess Data

1  
Work with **all of your data**

Access and Explore Data

Preprocess Data

**Business Data**

---

**Sensor Data**

**Databases**

**Images**

**HDFS**

**Files**

**Signals**

**Videos**

- Point and click tools to access variety of data sources
- High-performance environment for big data
- Built-in algorithms for data preprocessing

**Data Reduction/Transformation**

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**Feature Extraction**

# Build Predictive Models



**Business Data**

---

**Sensor Data**

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**Data Reduction/  
Transformation**

---

**Feature Extraction**

2

**Model Creation**

---

**Model Validation**

**Enterprise Systems**

MATLAB Excel  
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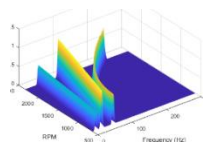
**Embedded Devices**

# Build Predictive Models

## Preprocess Data

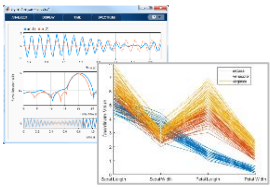
## Develop Predictive Models

**Data Reduction/  
Transformation**




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**Feature Extraction**



**Challenges**


- I need to incorporate my domain knowledge
- I need to extract and verify health indicators
- I lack machine learning experience
- I have deadlines to meet

**Model Creation**




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**Model Validation**





# Build Predictive Models

Preprocess Data

Develop Predictive Models

**Data Reduction/Transformation**

---

**Feature Extraction**

```

1  Script_2_data_analyze_individual_solo.m
2
3  %% Setup
4  clear;
5  clc;
6  load('data_cell_14-Feb-2017_12_53_49.mat');
7
8  data_cell = flipud(data_cell);
9  c_1 = [0 0.4470 0.7410];
10 num=100;
11 data_freq_f = cell(100,1);
12
13 %% Get Healthy Run Data
14 tout = data_healthy(:,1);
15 yout = data_healthy(:,2);
    
```

**Model Creation**

---

**Model Validation**

	RMSE	MAE	MAPE	MAE	MAPE
Healthy	0.000	0.000	0.00%	0.000	0.00%
HealthyData	0.000	0.000	0.00%	0.000	0.00%
Unhealthy	0.000	0.000	0.00%	0.000	0.00%
Healthy	0.000	0.000	0.00%	0.000	0.00%
Unhealthy	0.000	0.000	0.00%	0.000	0.00%

# Build Predictive Models

2

Your domain experts can do data science

Preprocess Data

**Data Reduction/Transformation**

---

**Feature Extraction**

**Apps**

**MATLAB**

**Simulink**

Develop Predictive Models

**Model Creation**

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**Model Validation**

- Easy to use apps across multiple domains
- Documentation, examples, and videos to get started
- Automatic MATLAB code generation

# Deploy and Integrate



**Business Data**

---

**Sensor Data**

1

**Data Reduction/  
Transformation**

---

**Feature Extraction**

2

**Model Creation**

---

**Model Validation**

3

**Enterprise Systems**

MATLAB Excel  
.NET C/C++  
.exe Java .dll

---

**Embedded Devices**

# Deploy and Integrate

## Develop Predictive Models

### Model Creation



### Model Validation



## Challenges

- I have multiple end users – plant managers, operations analysts, maintenance staff, etc.
- I have to allow access through different target platforms
- I need to scale to meet production needs
- I need to reduce bandwidth consumption

## Integrate Analytics with Systems

### Enterprise Systems

MATLAB Excel  
.NET C/C++  
.exe Java .dll

### Embedded Devices



# Deploy and Integrate

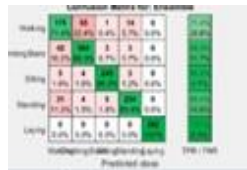
Develop Predictive Models

Integrate Analytics with Systems

## Model Creation



## Model Validation



Predictive Data Analytics

Home Demand Forecasting Web Service Description Documentation

**Predictive Data Analytics**  
This website tightly integrates MATLAB analytics with web technologies for demonstrating predictive data analytics models in production with live data.

[Get started »](#)

**Demand Forecasting**

Forecast electricity demand for US power grids with live data from ISOs and weather stations using Neural Network models. Forecasts can be compared to past data as well as normal weather. Prediction bands at different confidence intervals also quantify uncertainty in forecast.

[Start »](#)

**Web Service Information**

Documentation on end points and query parameters for demand forecast web services

[Read more](#)

**App Documentation**

Documentation of the entire web application and its components

Coming soon!

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## Enterprise Systems

MATLAB Excel  
.NET C/C++  
.exe Java .dll

## Embedded Devices



# Deploy and Integrate

3
 Your algorithms can **run anywhere**

Develop Predictive Models

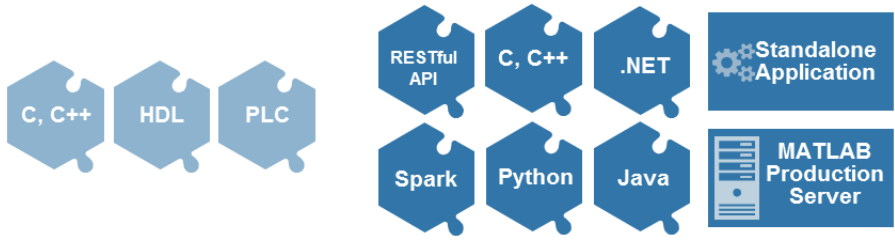
**Model Creation**

---

**Model Validation**

MATLAB + SIMULINK

Code Generation
Compiled Applications



**Embedded Hardware**      **Enterprise Systems**

- Royalty-free deployment
- Web services, apps, and cloud platforms
- Computation on smarter edge devices
- Automatic C/C++ code generation

Integrate Analytics with Systems

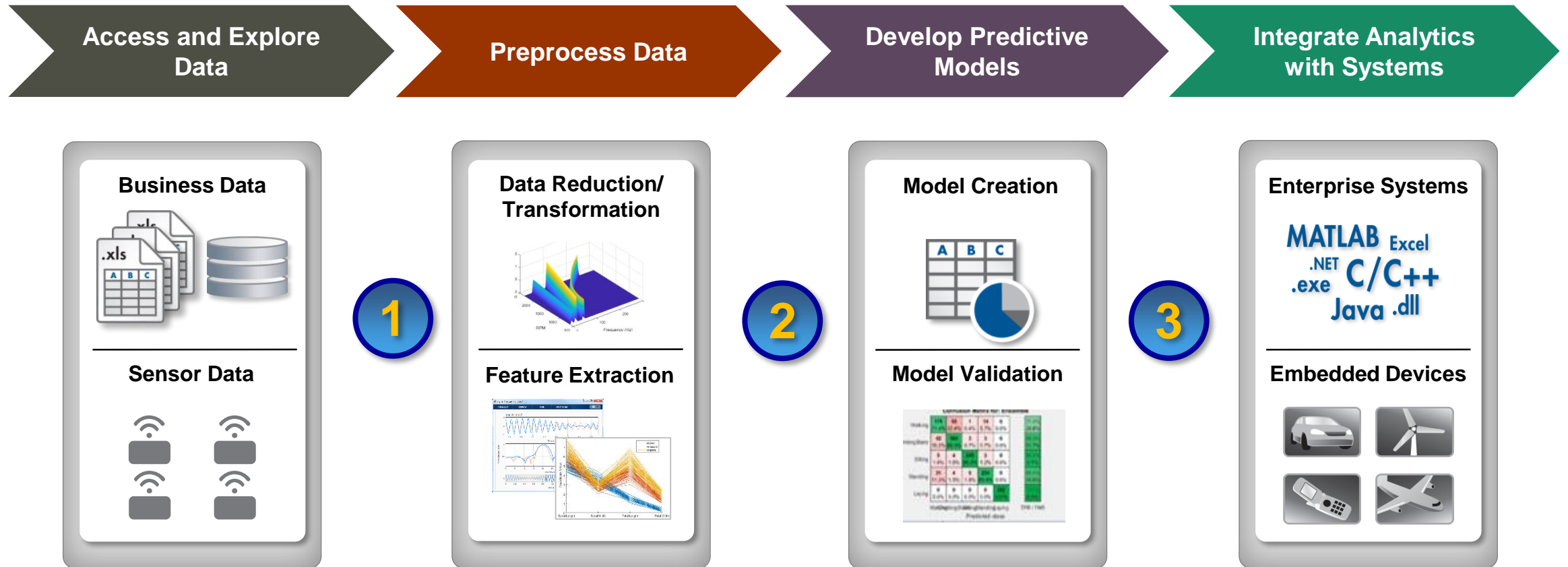
**Enterprise Systems**

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**Embedded Devices**



# Predictive Maintenance Algorithm Workflow



# What does success look like?

## Baker Hughes: Pump Health Monitoring System

### Challenge

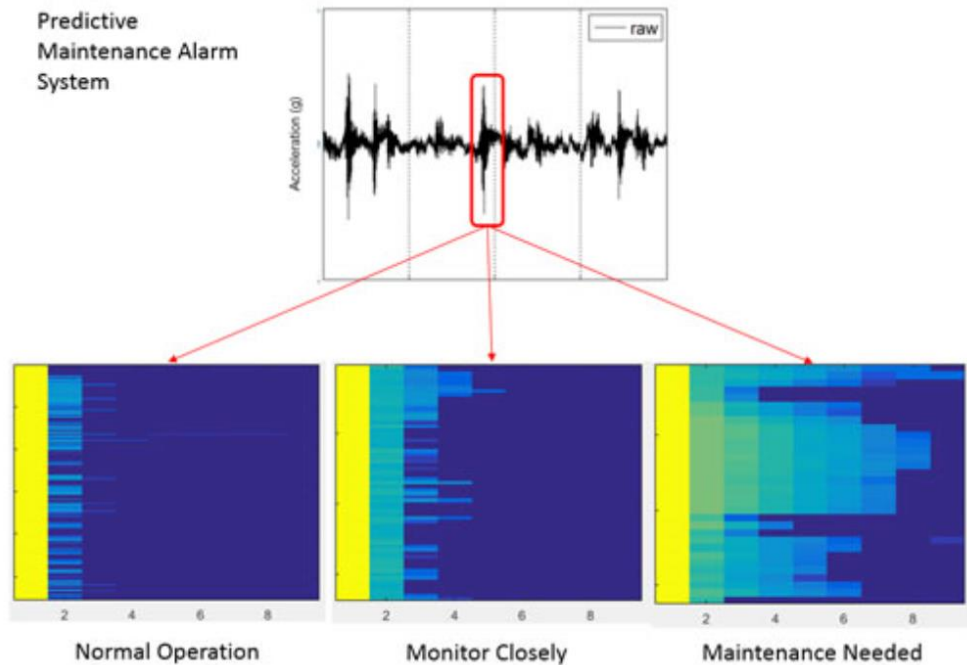
- As many as 20 trucks operate around the clock at a well site
- A truck with a pump failure must be immediately replaced

### Solution

- Analyzed a **terabyte of data** collected at 50,000 samples/second
- Performed **FFTs and spectral analysis** to filter large movements of the truck, pump, and fluids
- Best model was a **neural network** using pressure, vibration, and timing sensor data of the valves and valve seats

### Results

- Savings of **more than \$10 million** projected
- Development time reduced tenfold



# Key Takeaways

1

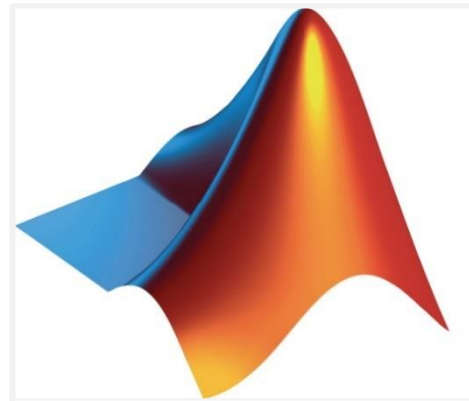
Work with  
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2

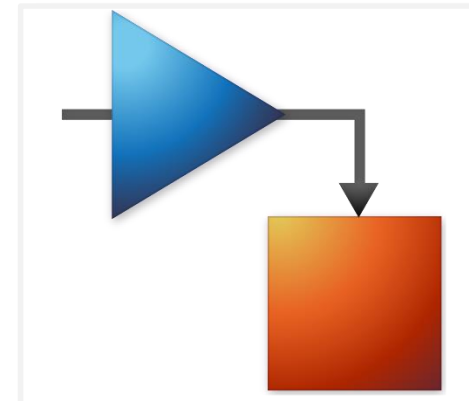
Your **domain experts**  
**can do data science**

3

Your algorithms can  
**run anywhere**



+



# Key Takeaways

