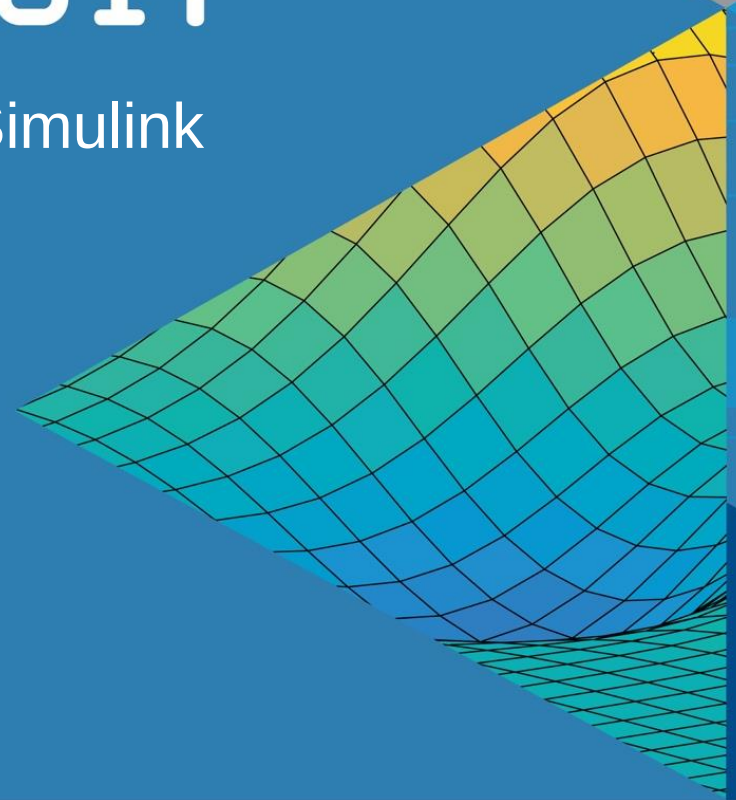
# MATLAB EXPO 2017

## Predictive Maintenance with MATLAB & Simulink

Mehernaz Savai



# Predictive Maintenance

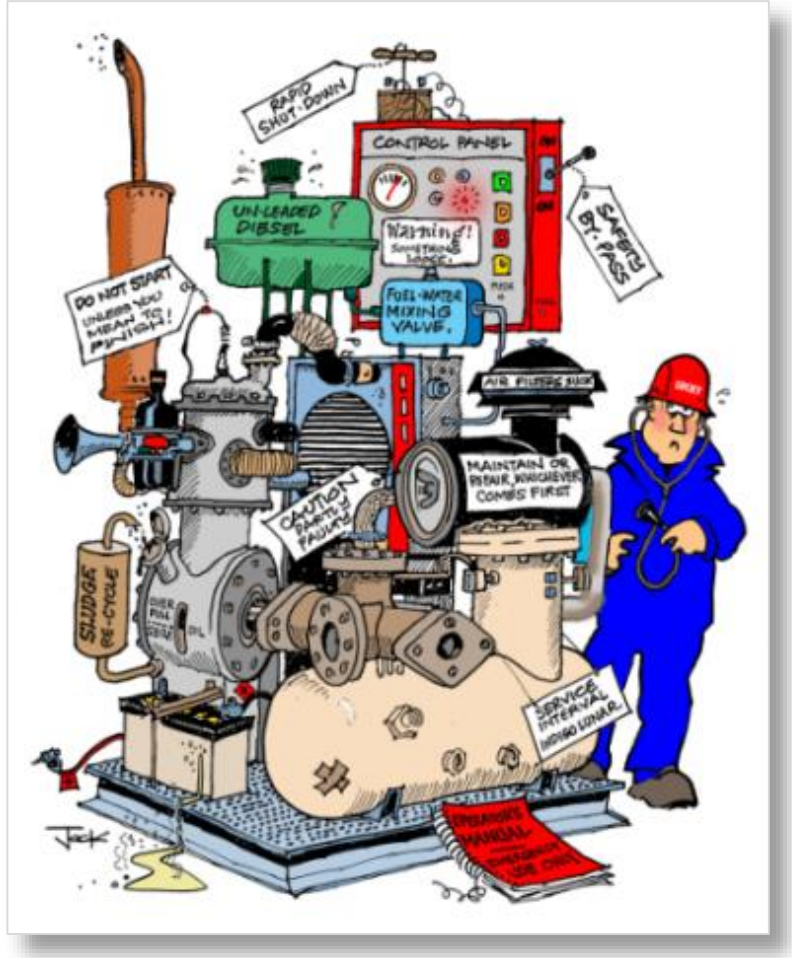
**What is Predictive Maintenance?**

- 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

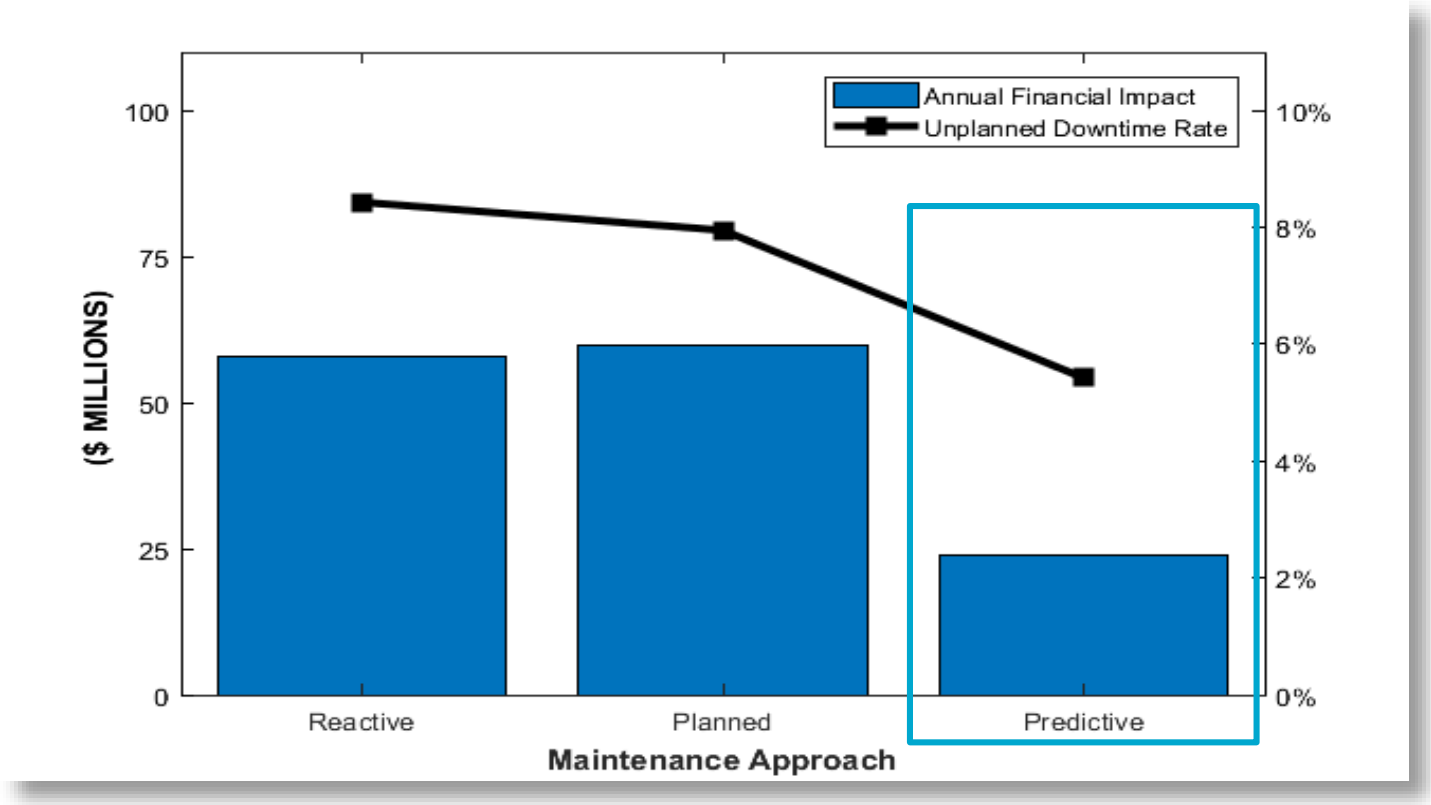
- Relay this information to maintenance engineers, operators, and plant managers




Source: Tensor Systems

# Why is Predictive Maintenance Important?

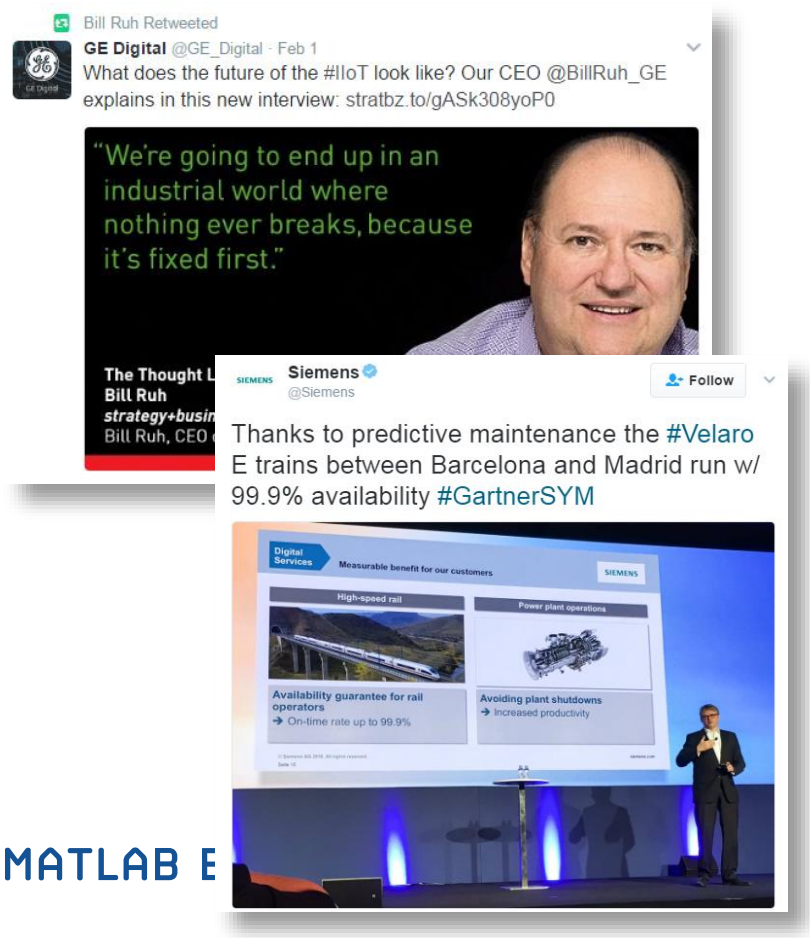
- Improved operating efficiency
- New revenue streams
- Competitive differentiator

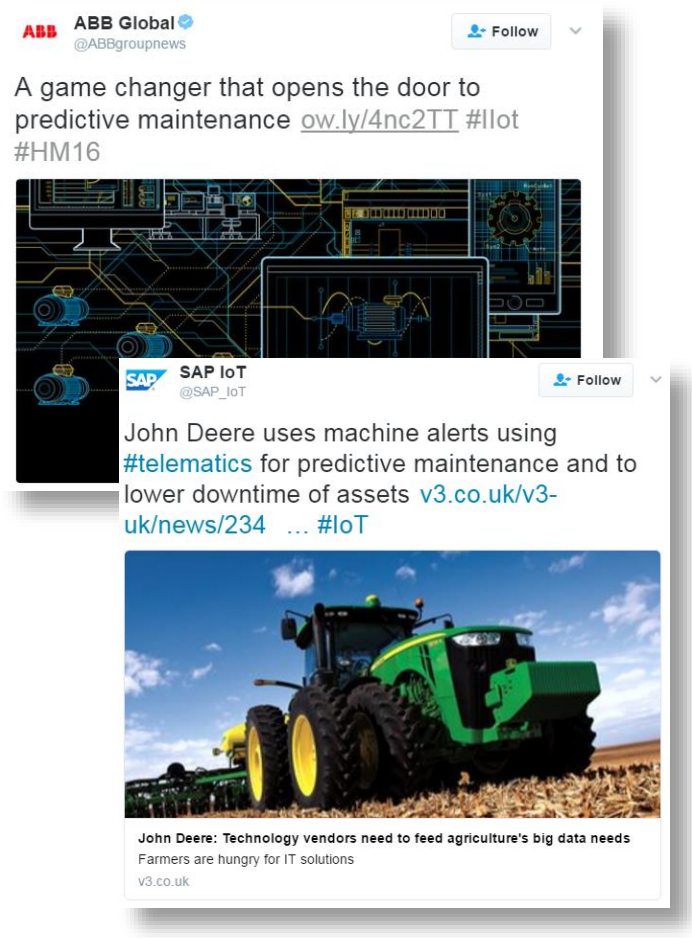


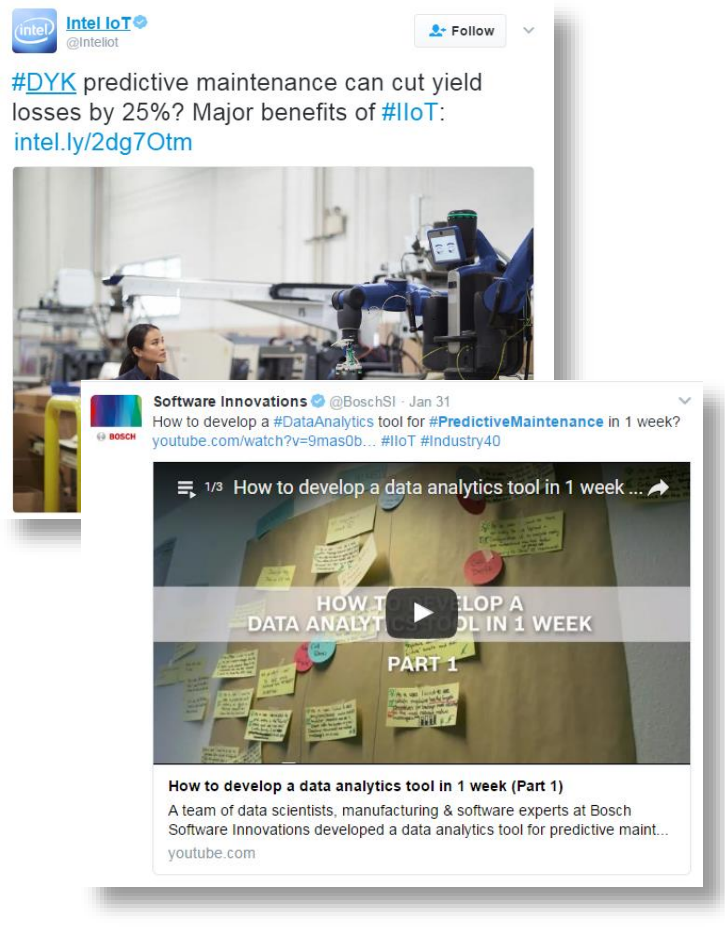

Source: GE Oil & Gas

# Why is Predictive Maintenance Important?

- Improved operating efficiency
- New revenue streams
- Competitive differentiator



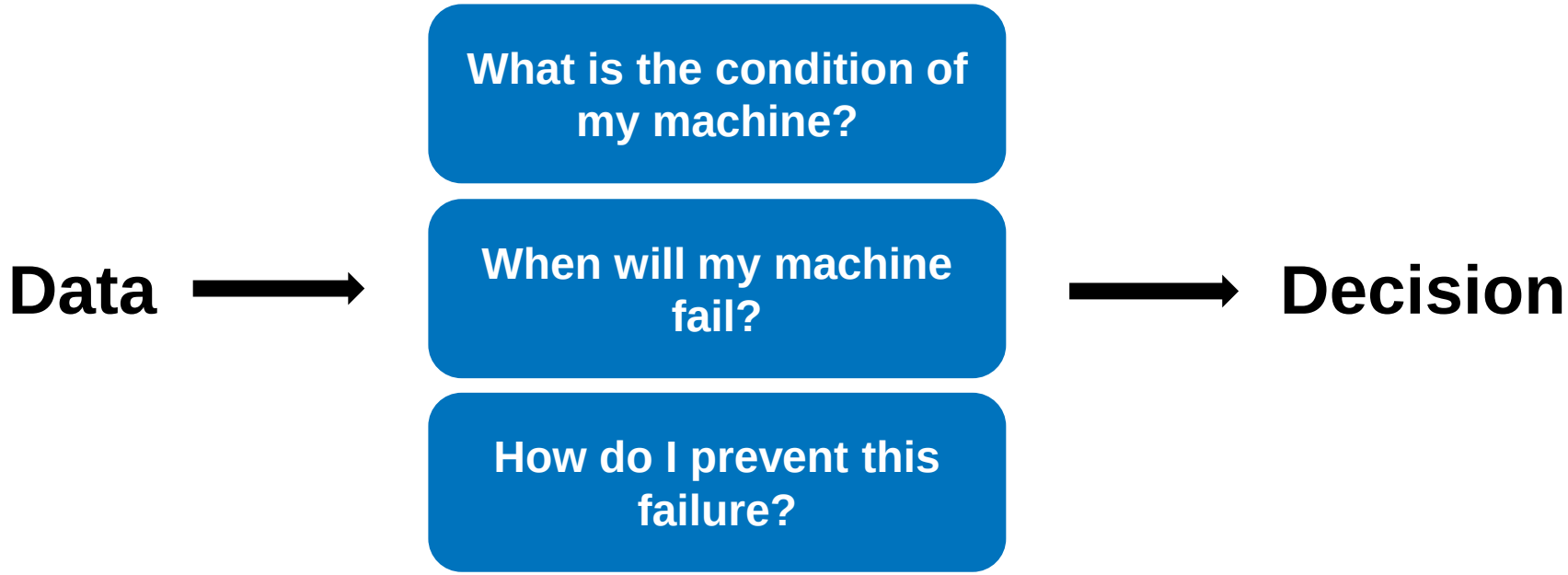




MATLAB E

# What should a Predictive Maintenance Algorithm do?

*Turn large volumes of complex data into decisions*




1. Work with **all of your data**
2. Your **domain experts can do data science**
3. Your algorithms can **run anywhere**

# Predictive Maintenance Algorithm Workflow

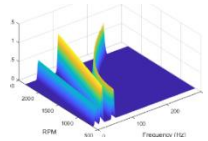
**Access and Explore Data**

**Business Data**

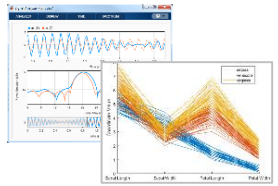

**Sensor Data**

**Preprocess Data**

**Data Reduction/ Transformation**



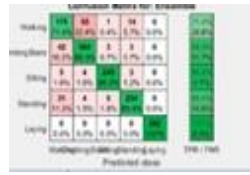
**Feature Extraction**



**Develop Predictive Models**

**Model Creation**


**Model Validation**



**Integrate Analytics with Systems**

**Enterprise Systems**

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

**Embedded Devices**

# Access and Preprocess Data

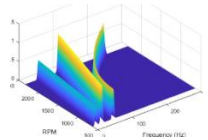
Access and Explore Data → Preprocess Data → Develop Predictive Models → Integrate Analytics with Systems

**Business Data**

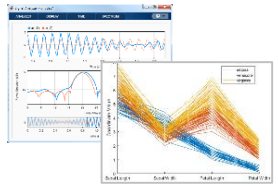

**Sensor Data**

1

**Data Reduction/ Transformation**

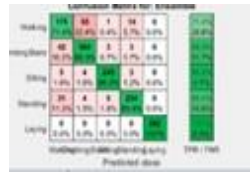


**Feature Extraction**



**Model Creation**

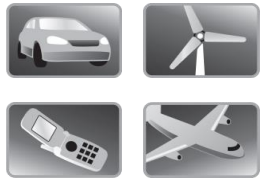

**Model Validation**



**Enterprise Systems**

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

**Embedded Devices**



# Access and Preprocess Data

**Access and Explore Data**

**Business Data**

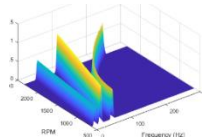

**Sensor Data**

## Challenges

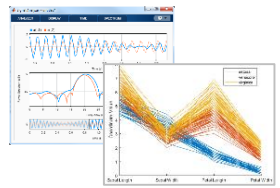
- I have too much data to handle easily
- I don't have enough data
- I have no data
- I have too many data types and data sources
- My data is too messy

**Preprocess Data**

**Data Reduction/ Transformation**



**Feature Extraction**



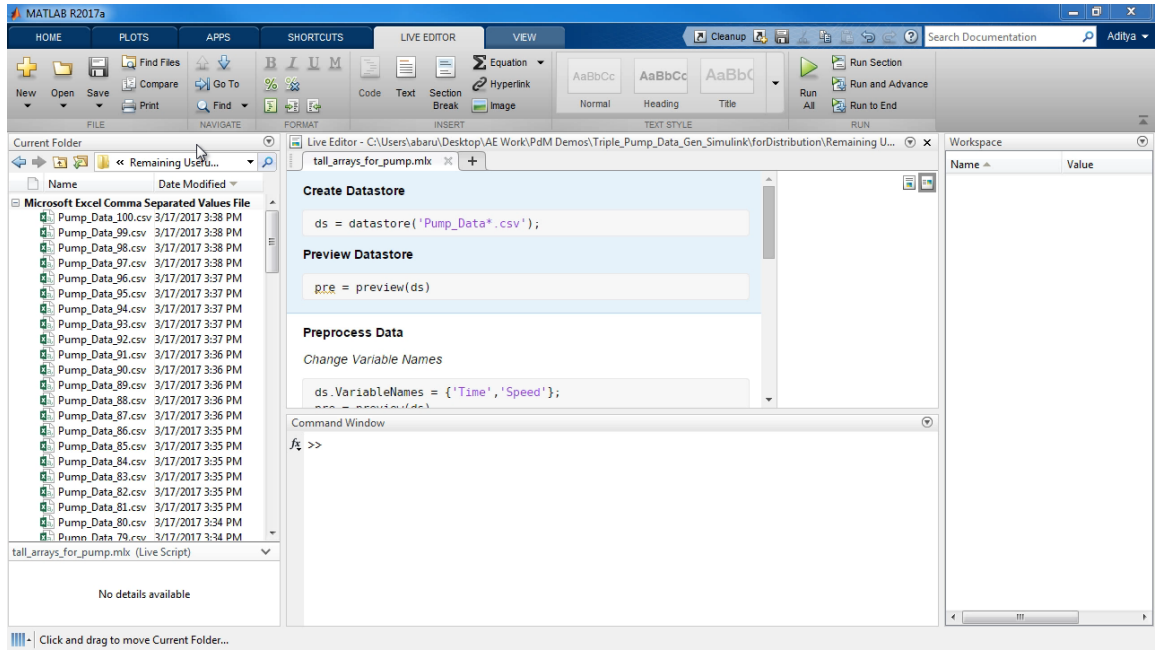
# Access and Preprocess Data

**Access and Explore Data**

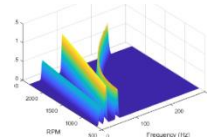
**Preprocess Data**

**Business Data**

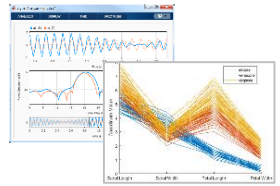
**Sensor Data**




**Data Reduction/ Transformation**



**Feature Extraction**

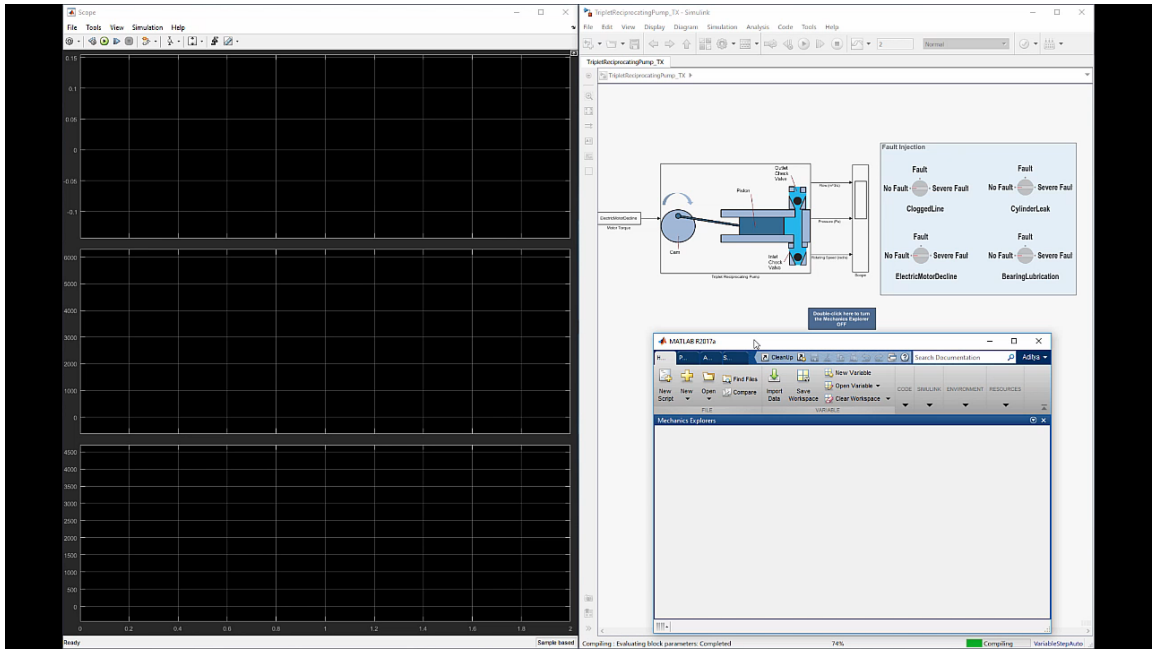


# Access and Preprocess Data

**Access and Explore Data**

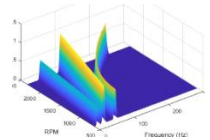
**Business Data**


**Sensor Data**

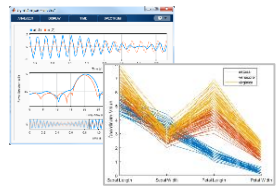


**Preprocess Data**

**Data Reduction/ Transformation**



**Feature Extraction**



# Access and Preprocess Data

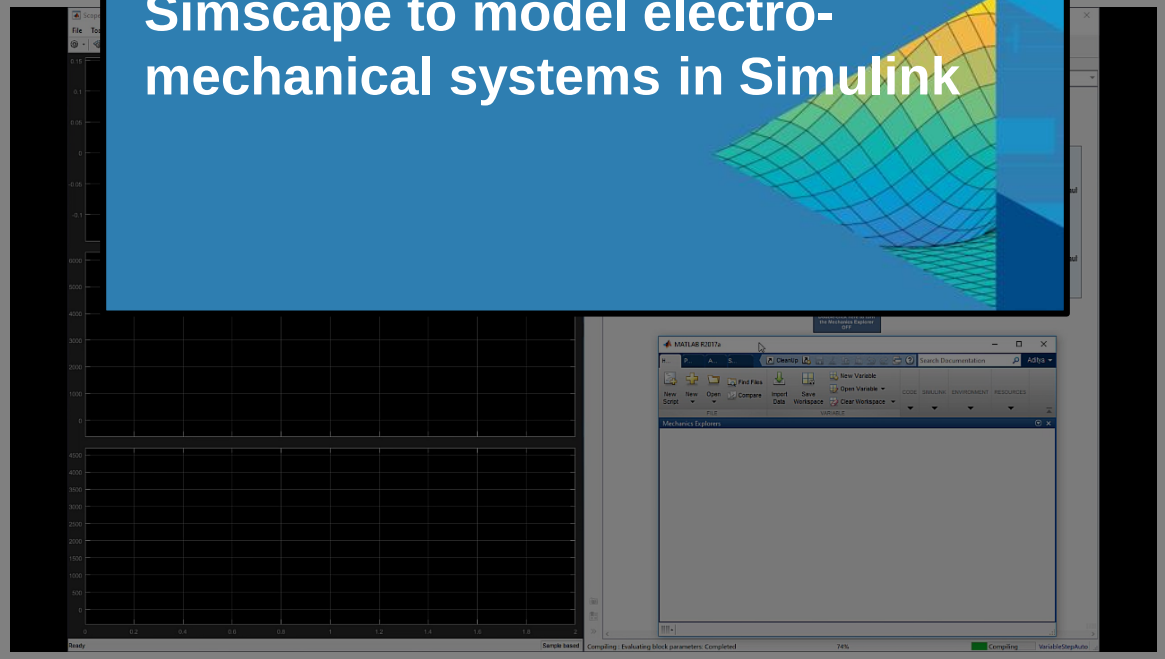
**Access and Explore Data**

**Business Data**


**Sensor Data**

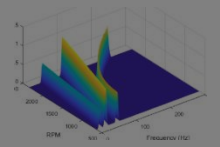
**Find out more:**

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

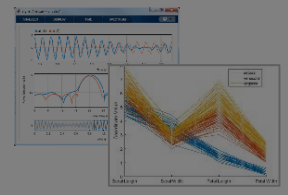


**Preprocess Data**

**Data Reduction/ Transformation**



**Feature Extraction**



# Access and Preprocess Data

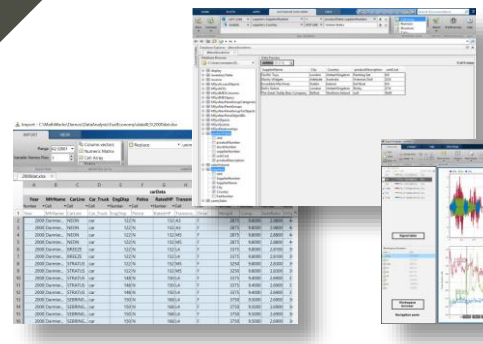
**1** Work with **all of your data**

**Access and Explore Data**

**Business Data**

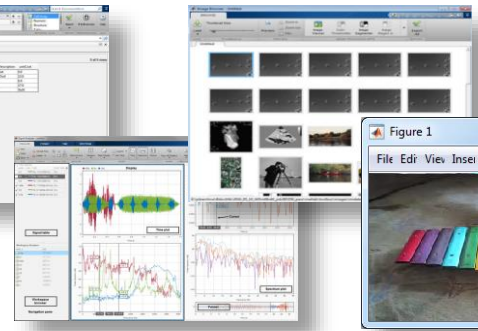

**Sensor Data**

**Databases**



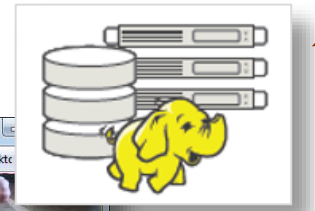
**Files**

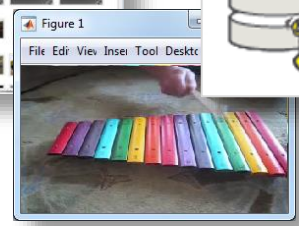
**Images**



**Signals**

**HDFS**

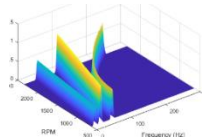




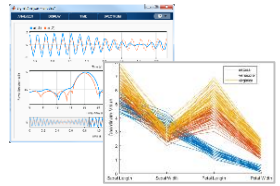

**Videos**

**Preprocess Data**

**Data Reduction/ Transformation**



**Feature Extraction**



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

# Build Predictive Models

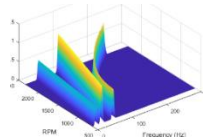
Access and Explore Data → Preprocess Data → Develop Predictive Models → Integrate Analytics with Systems

**Business Data**

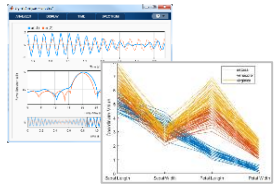

**Sensor Data**

1

**Data Reduction/ Transformation**



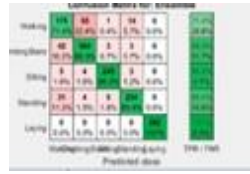
**Feature Extraction**



2

**Model Creation**


**Model Validation**



**Enterprise Systems**

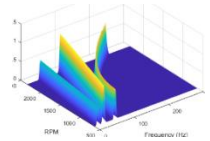
MATLAB Excel .NET C/C++ .exe Java .dll

**Embedded Devices**

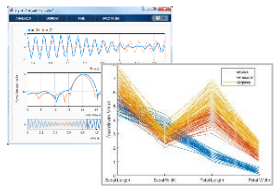
# Build Predictive Models

**Preprocess Data**

**Data Reduction/ Transformation**



**Feature Extraction**



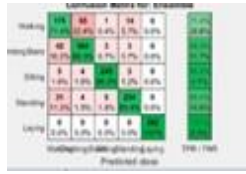
## Challenges

- 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

**Develop Predictive Models**

**Model Creation**


**Model Validation**

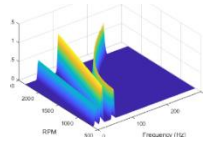


# Build Predictive Models

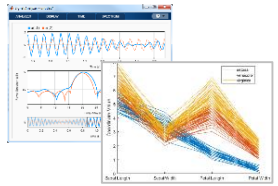
**Preprocess Data**

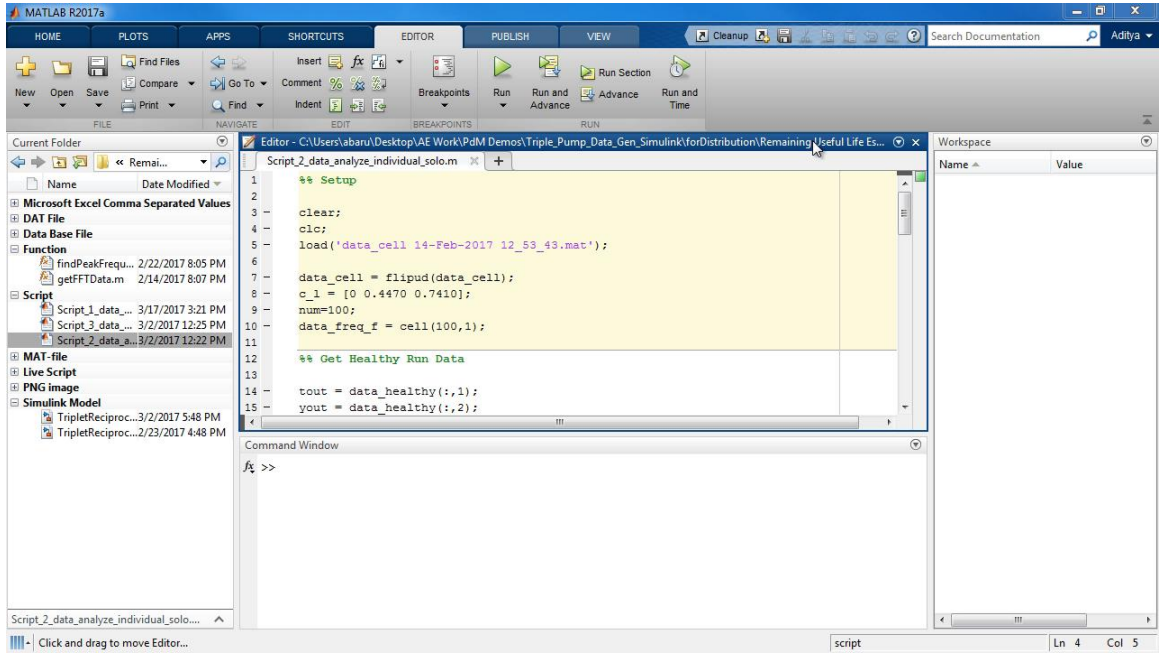
**Develop Predictive Models**

**Data Reduction/ Transformation**



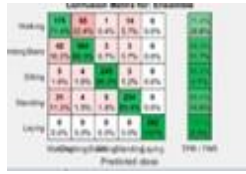
**Feature Extraction**






**Model Creation**


**Model Validation**

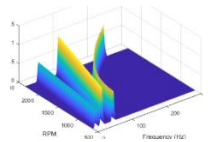


# Build Predictive Models

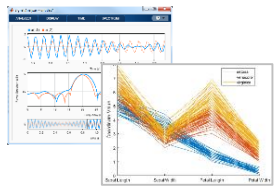
**Your domain experts can do data science** 2

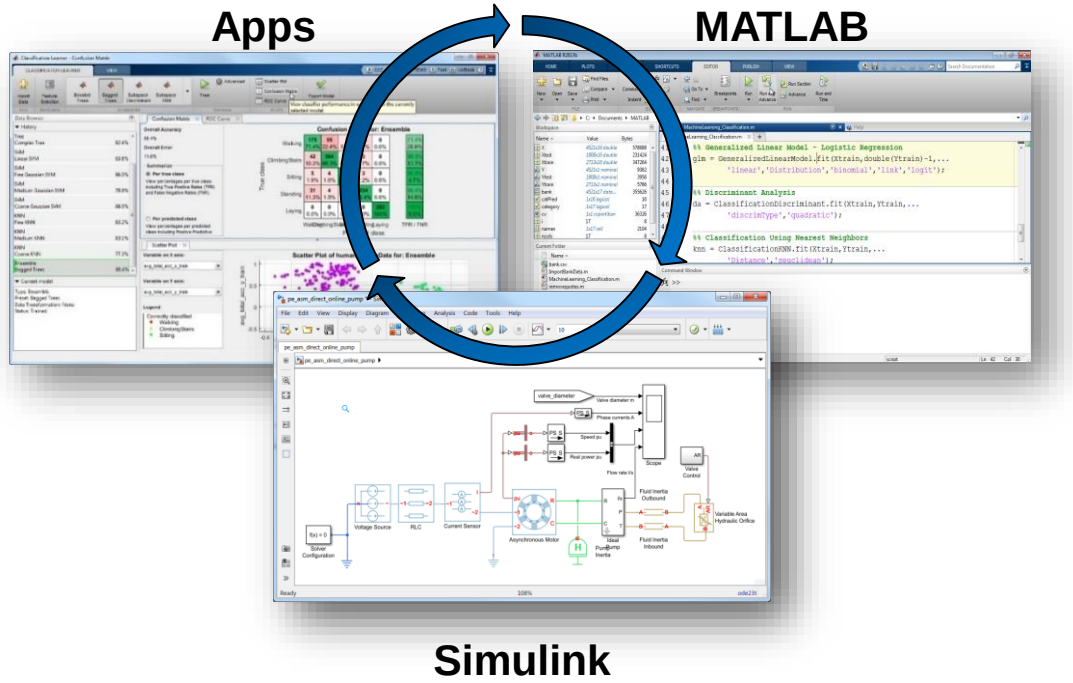
**Preprocess Data**

**Data Reduction/ Transformation**



**Feature Extraction**

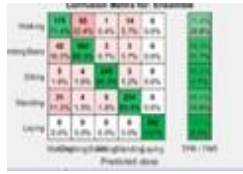





**Develop Predictive Models**

**Model Creation**


**Model Validation**



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

# Deploy and Integrate

Access and Explore Data

Preprocess Data

Develop Predictive Models

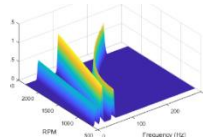
Integrate Analytics with Systems

**Business Data**

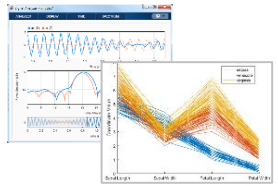

**Sensor Data**

1

**Data Reduction/ Transformation**



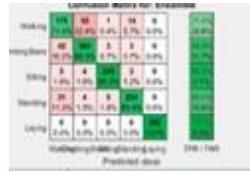
**Feature Extraction**



2

**Model Creation**


**Model Validation**



3

**Enterprise Systems**

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

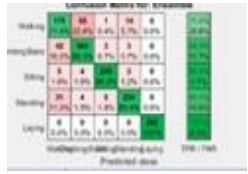
**Embedded Devices**

# 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 .exe C/C++ Java .dll

**Embedded Devices**

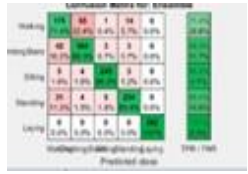
# Deploy and Integrate

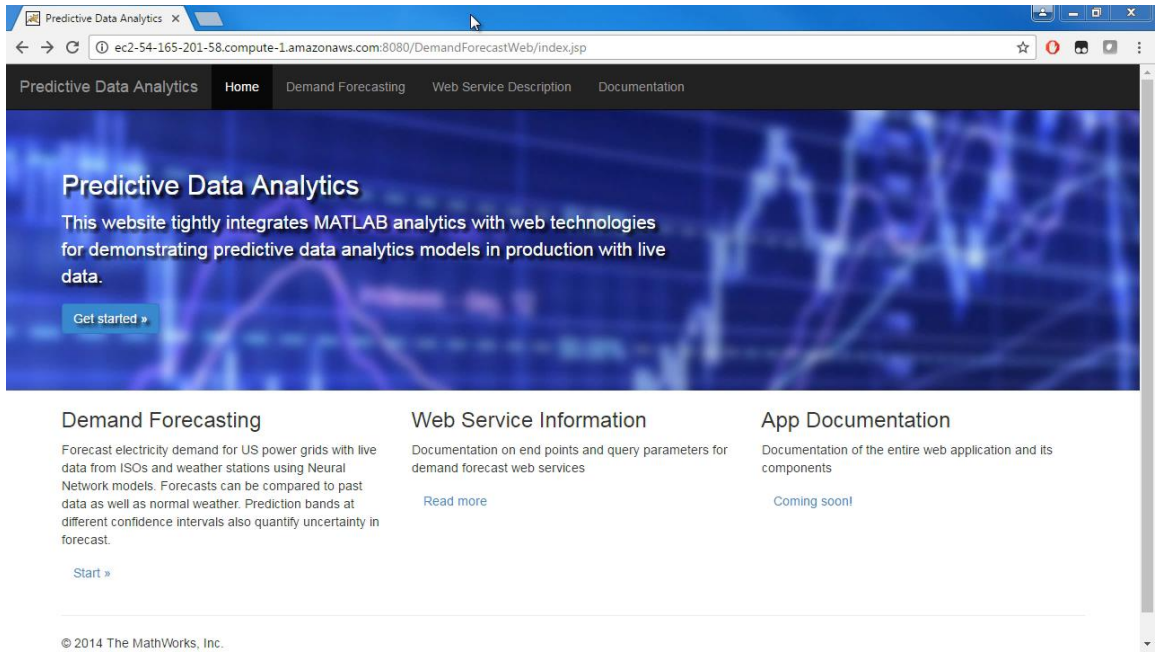
**Develop Predictive Models**

**Integrate Analytics with Systems**

**Model Creation**

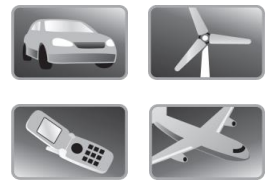

**Model Validation**






**Enterprise Systems**


**Embedded Devices**



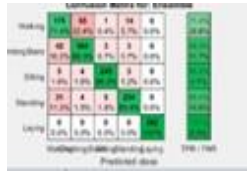
# Deploy and Integrate

Your algorithms can **run anywhere** 3

**Develop Predictive Models**

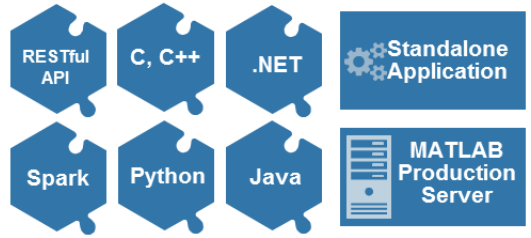
**Model Creation**


**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**


**Embedded Devices**

# Predictive Maintenance  Algorithm Workflow

**Access and Explore Data**

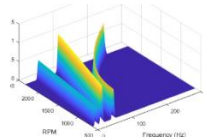
**Business Data**


**Sensor Data**

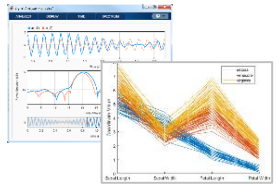
1

**Preprocess Data**

**Data Reduction/ Transformation**



**Feature Extraction**

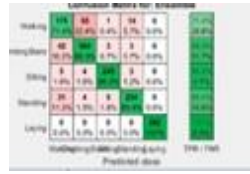


2

**Develop Predictive Models**

**Model Creation**


**Model Validation**



3

**Integrate Analytics with Systems**

**Enterprise Systems**

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

**Embedded Devices**

# What does success look like?

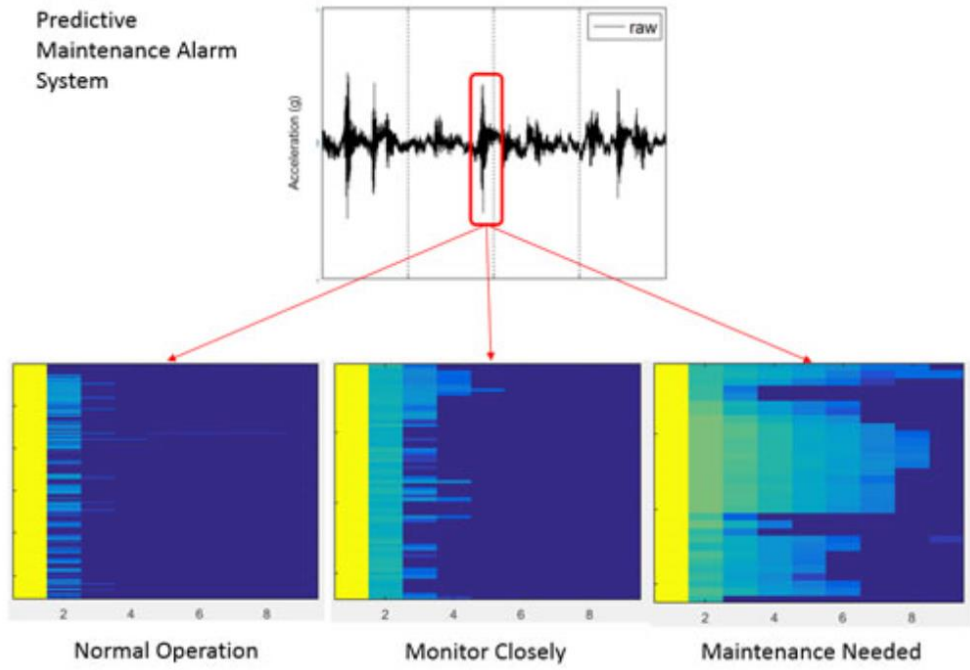
## Baker Hughes: Pump Health Monitoring System


### 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

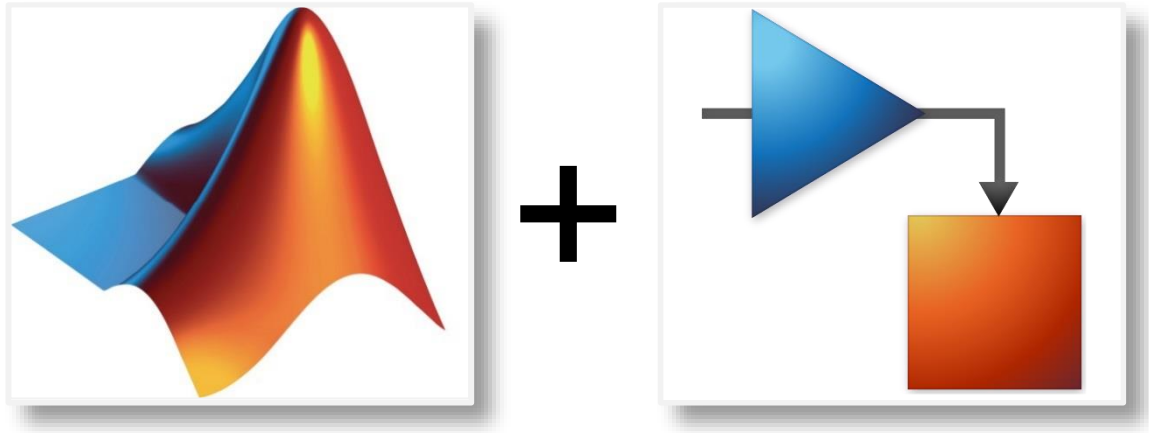



### Results

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

# Key Takeaways

1. Work with **all of your data**
2. Your **domain experts can do data science**
3. Your algorithms can **run anywhere**

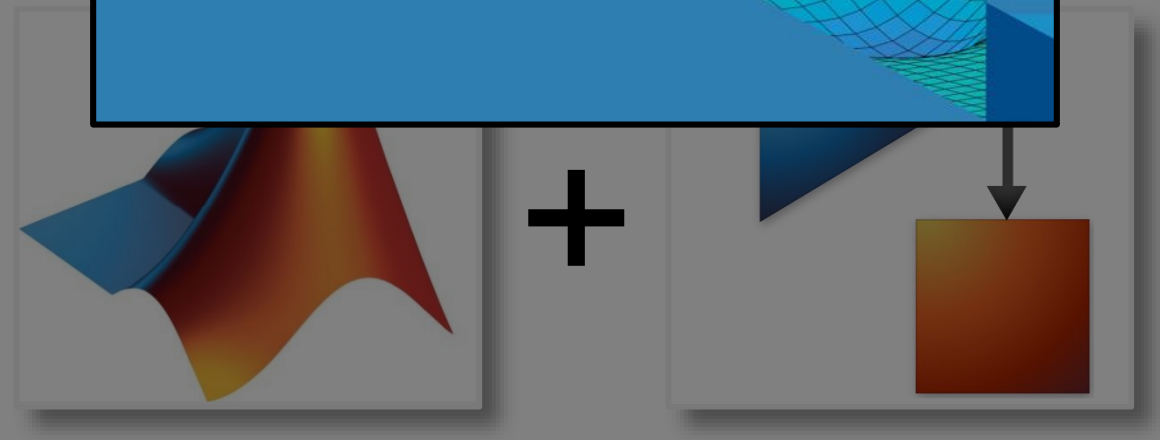


# Key Takeaways

1 Work with **all of your data**

**Find out more:**

**Booth:**
**Data Analytics/**
**Machine Learning**



3 Your algorithms can **run anywhere**