Deploying Predictive Maintenance Solutions To The Cloud & The Edge

성호현, The MathWorks Korea

Predictive Maintenance Promises Improved Operating Efficiency, New Revenue Streams, & A Competitive Differentiator

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

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A game changer that opens the door to predictive maintenance ow.ly/4nc2TT #IIot #HM16

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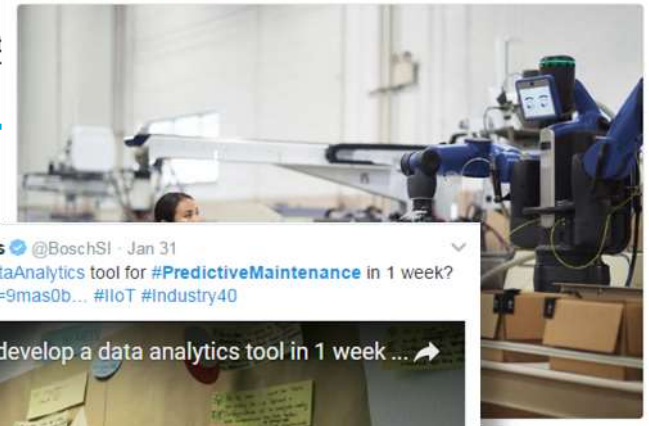
#DYK predictive maintenance can cut yield losses by 25%? Major benefits of #IIoT: intel.ly/2dg7Otm



SAP IoT
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John Deere uses machine alerts using #telematics for predictive maintenance and to lower downtime of assets v3.co.uk/v3-uk/news/234 … #IoT

John Deere: Technology vendors need to feed agriculture's big data needs
Farmers are hungry for IT solutions
v3.co.uk

Impact
ntime Rat

Planned
nance Approach

Software Innovations @BoschSI · Jan 31
How to develop a #DataAnalytics tool for #PredictiveMaintenance in 1 week?
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

Predictive Maintenance Matters To Every Single Industry That Is Manufacturing Or Operating Machinery

Aerospace and Defense

Automotive

Medical Devices

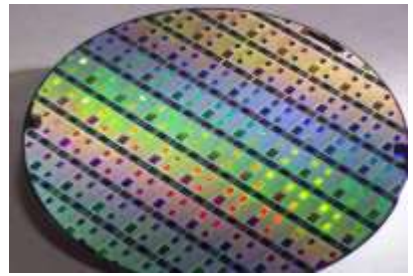
Electronics

Energy Production

Industrial Machinery

Process Manufacturing

Railway Systems



Semiconductors

MATLAB & Simulink Are Being Used Today For Predictive Maintenance

The Challenges Associated With Predictive Maintenance Are Consistent Across Industries, for both Data Scientists & Engineers

Too many options for machine learning, feature extraction, etc.

Integrating algorithms with existing infrastructure

Lack of failure data

Hard to get started

Our Solution Addresses Every Challenge By Providing a Workflow That Spans Algorithm Development & Deployment

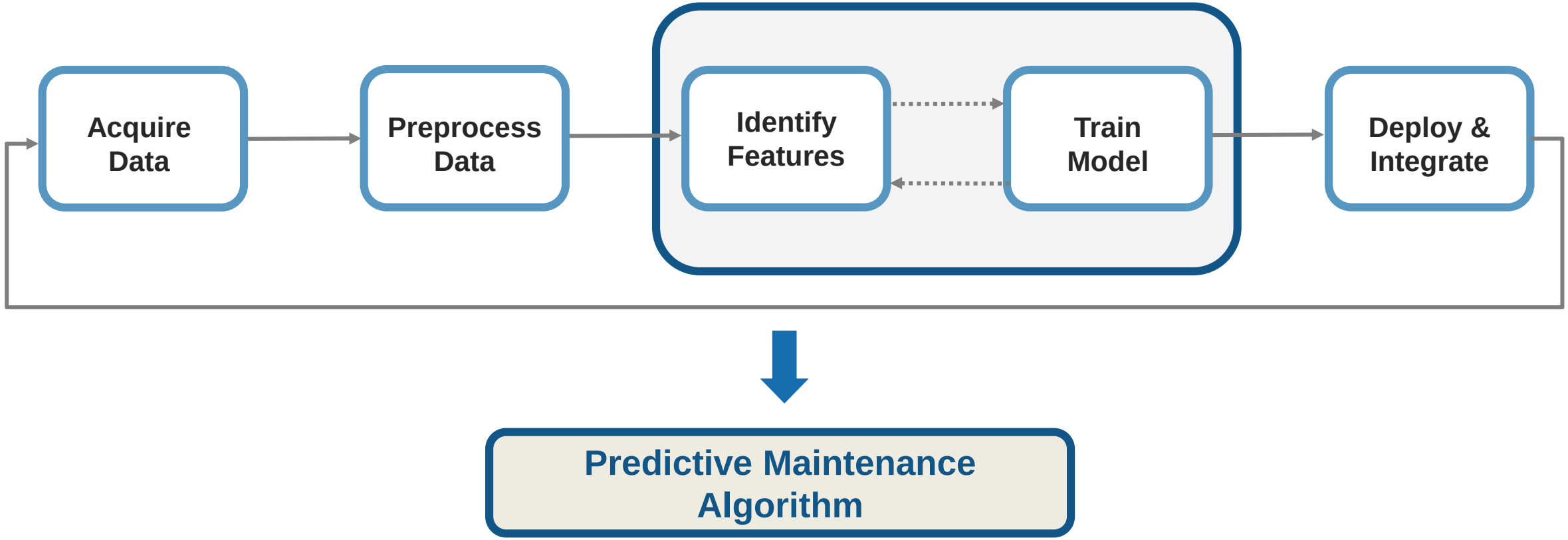
- Explore and automate feature extraction & machine learning tasks

- Target edge devices through C/C++ codegen
- Integrate with on-premise or cloud-based Enterprise IT/OT systems

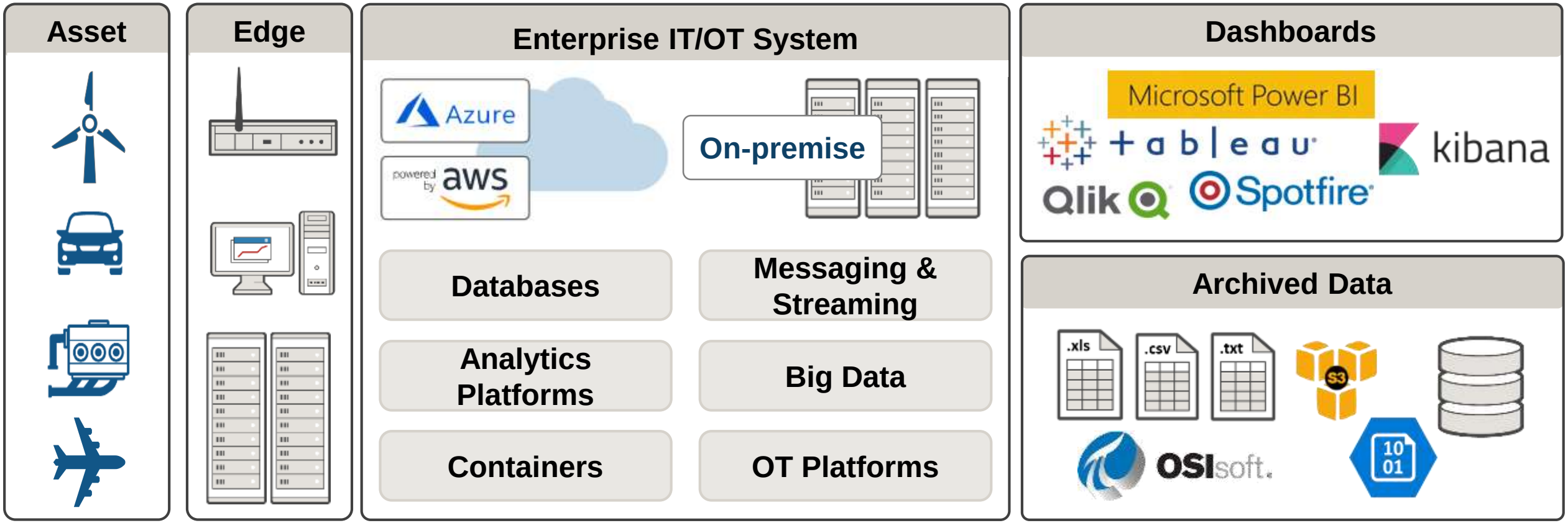
- Generate failure data from Simulink & Simscape models of machines

- Get started using Reference Examples
- Work with our Consulting group to scope & define a project

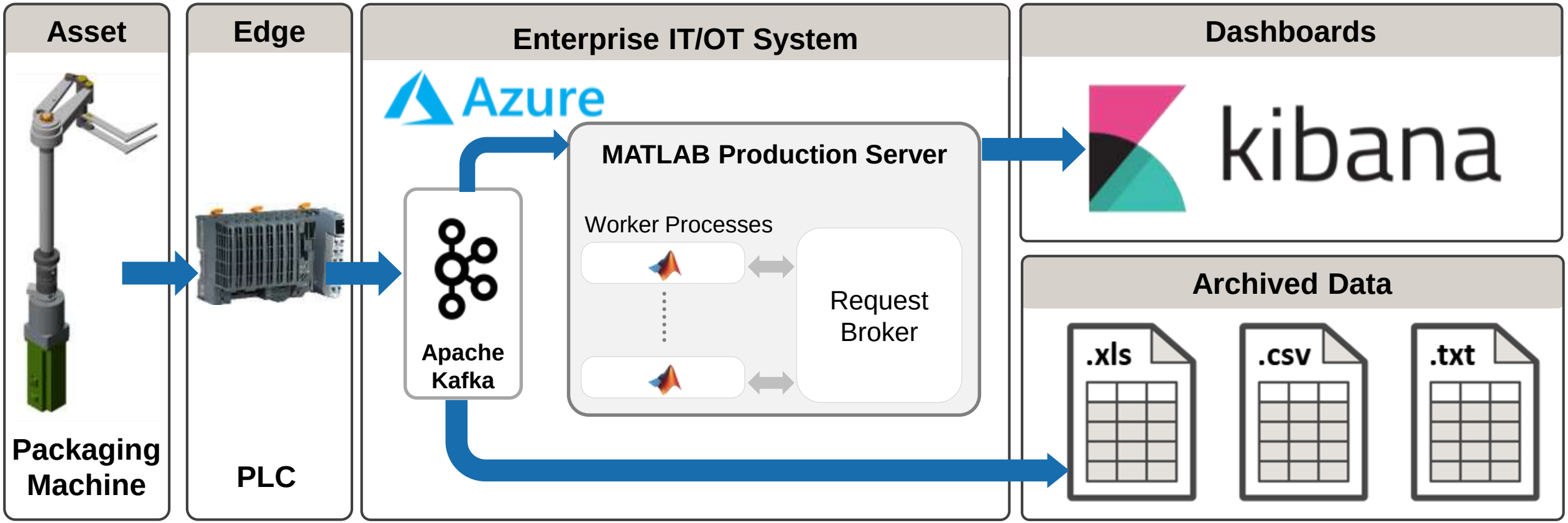
Developing A Predictive Maintenance Algorithm Requires Domain Expertise and Machine Learning Techniques…



…But Deploying a Predictive Maintenance Algorithm Successfully Is Much More Complicated



Today, We Will Demonstrate How To Deploy A Predictive Maintenance Algorithm To The Edge & Enterprise IT/OT Systems



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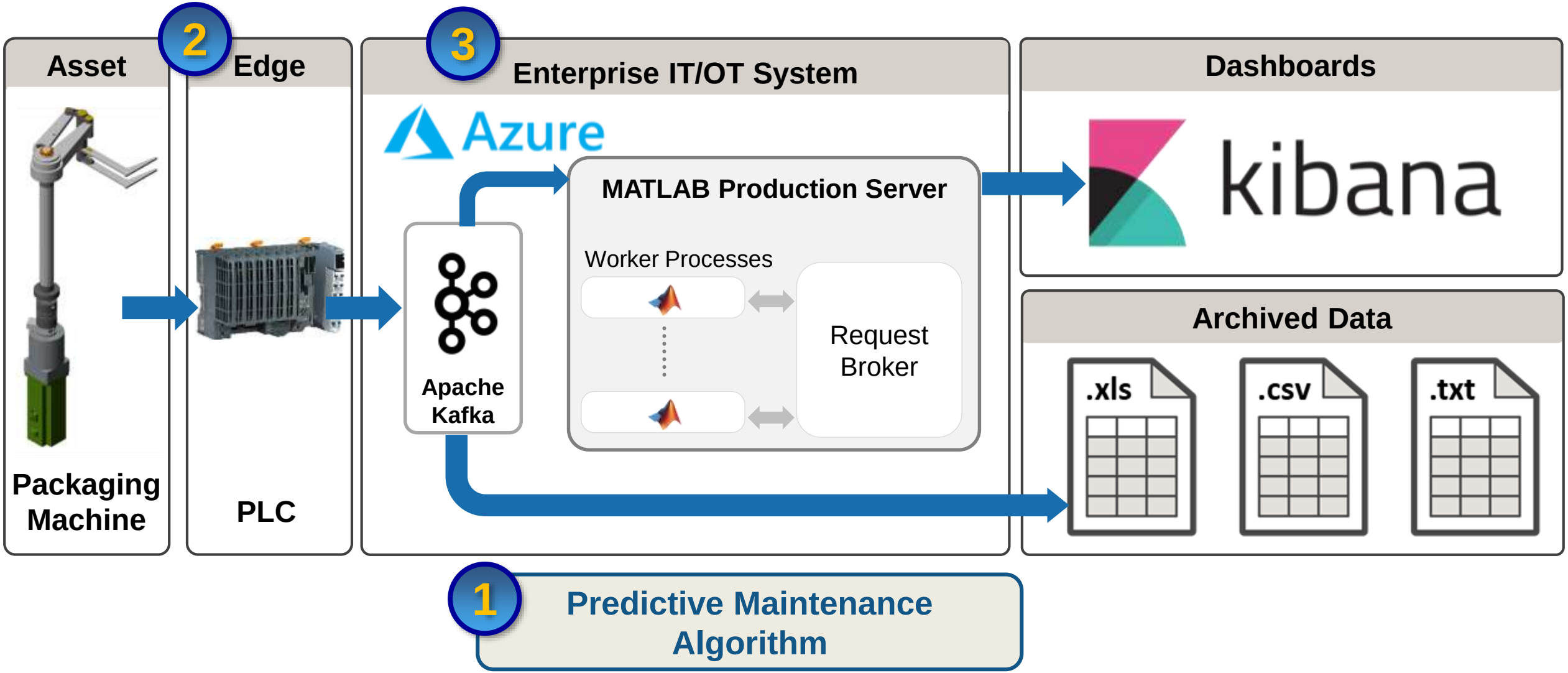

Agenda For Today's Talk

1. Predictive Maintenance Algorithm Development
   - Predictive Maintenance Toolbox
2. Algorithm Test & Deployment To Edge Device
   - Simulink Real Time & Simulink Coder
3. Algorithm Deployment to Azure-based IT System
   - MATLAB Compiler & MATLAB Production Server

Algorithm Development Includes Remaining Useful Life Estimation, Anomaly Detection, Fault Classification, & Condition Monitoring

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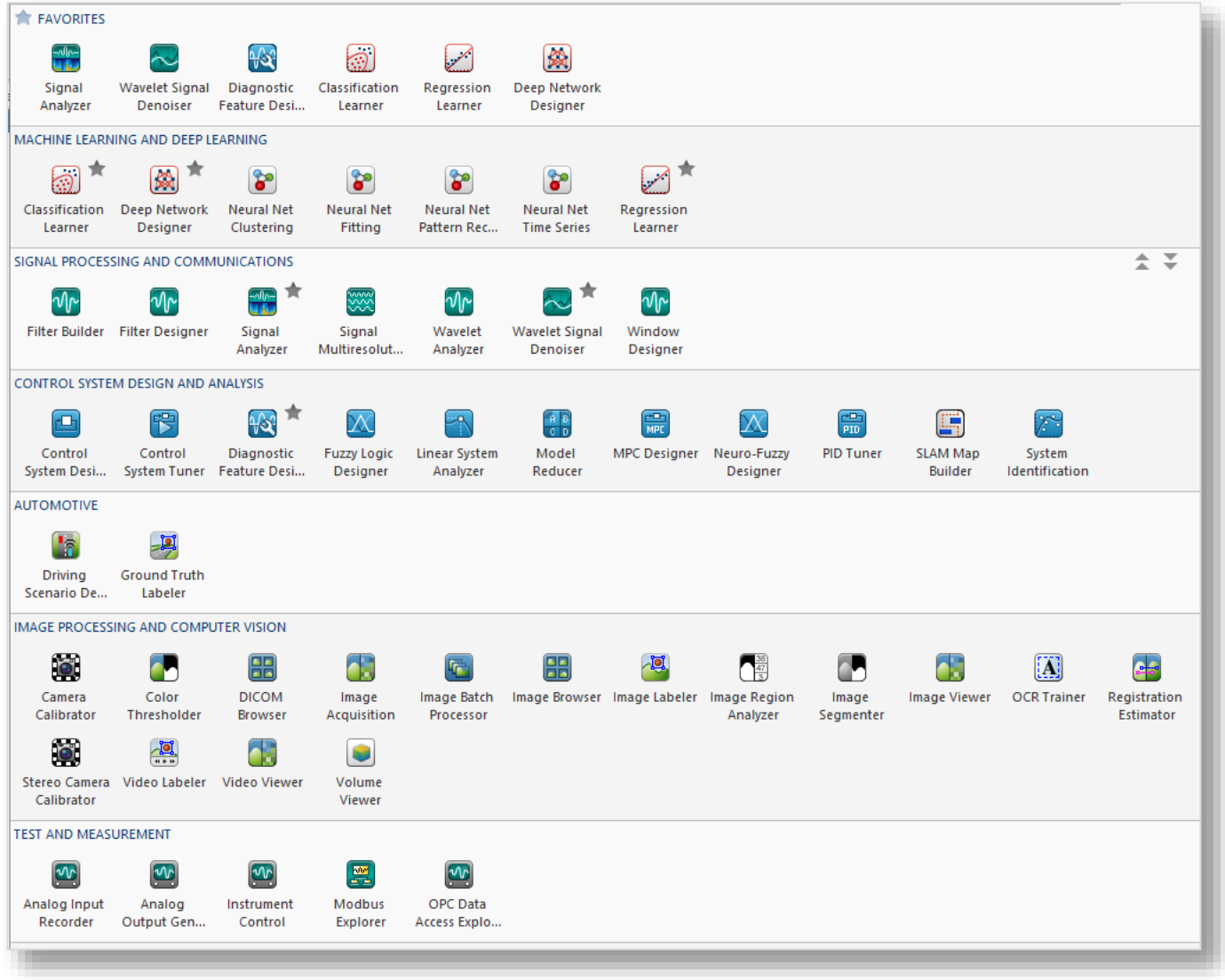
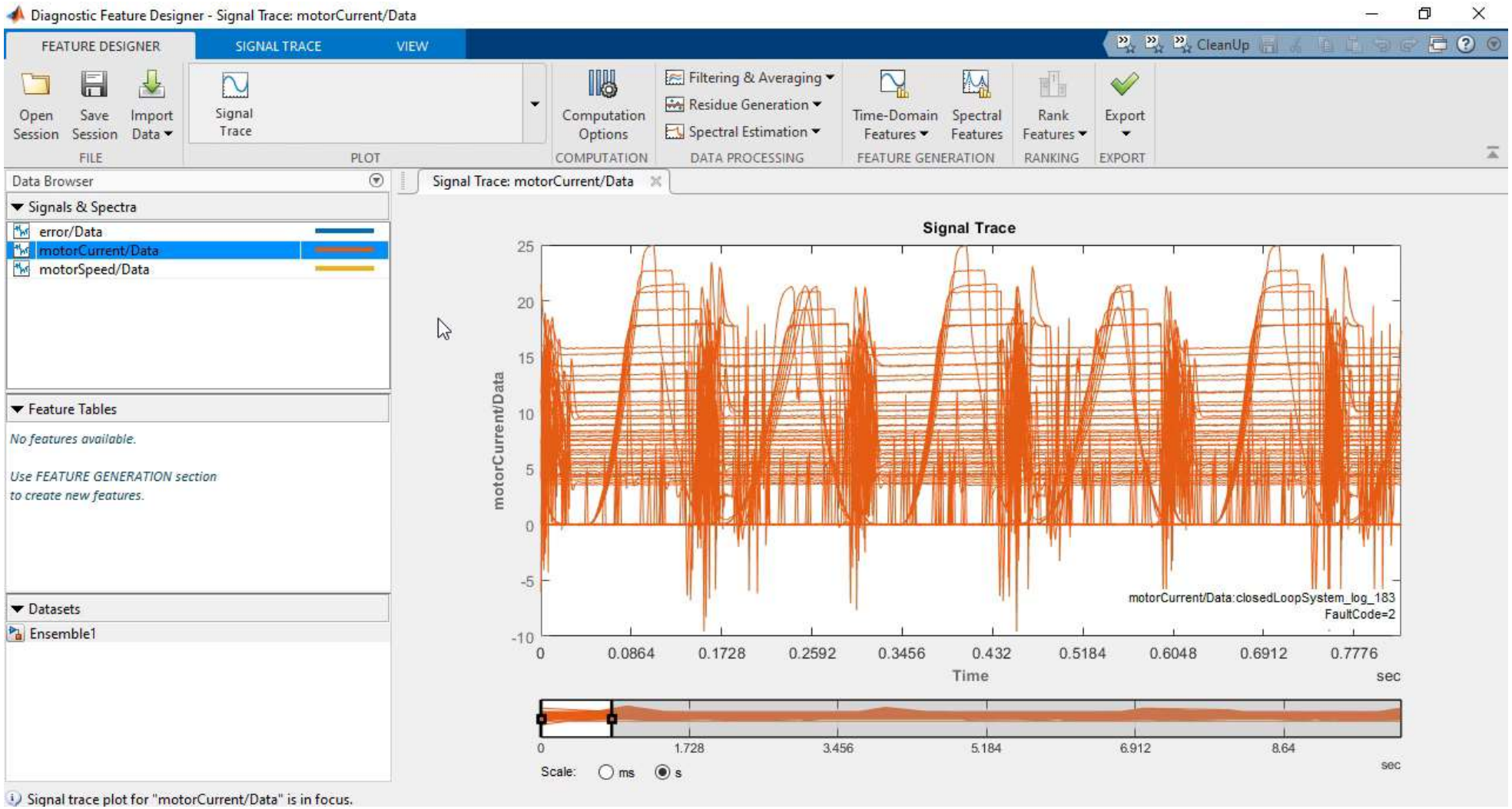
Explore and automate feature extraction & machine learning tasks using MATLAB Apps

- Signal Analyzer
- Wavelet Denoiser
- Diagnostic Feature Designer
- Classification Learner
- Regression Learner
- Deep Network Designer
- …and many more



Visualize Data, Try Different Feature Extraction Methods & Compare Results Without Writing Any MATLAB Code



Metro de Madrid and IMA Are Using MATLAB For Developing Predictive Maintenance Algorithms

Metro de Madrid Adopts Machine Learning for Predictive Maintenance in Tunnels

Raúl Rico, Metro de Madrid

Every day, Metro de Madrid stores more than 10 GB of new data acquired from different sources. Many available tools can only analyze data from a single sensor, and such approaches lack domain expertise. In order to use all the data they acquire for predictive maintenance, Metro de Madrid needed to integrate the data from a wide variety of sensors and customize their signal analysis algorithms.

Metro de Madrid used MATLAB® and Statistics and Machine Learning Toolbox™ to automate the data merging, signal analysis, and algorithm sharing, which enables people without MATLAB experience to perform advanced signal analysis.

Advantages of using MATLAB:

- Save time in the data validation and analysis phase
- Integrate data from different sources
- Share algorithms with non-MATLAB users

> "We have created a **degradation model** of the catenary that allows us to **anticipate and optimize** the **maintenance actions**."

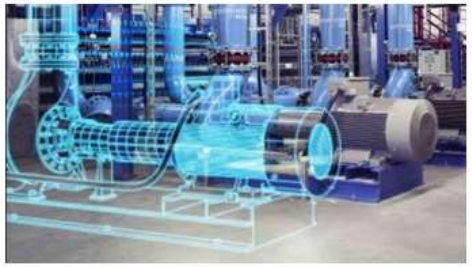
IMA ACTIVE

Conclusions and Future Activities

- Using MATLAB tools we managed to extract and select the best features to build a classification model
- The most promising algorithm uses 5 features and has an accuracy of 89%
- Ongoing: check capability of generalization using data of other parts that did not break
- In the future: acquire new data and test the model on-line

Safran Uses Simulink to Generate Failure Data To Train Neural Networks To Detect Anomalies and Predict Failures in Factories

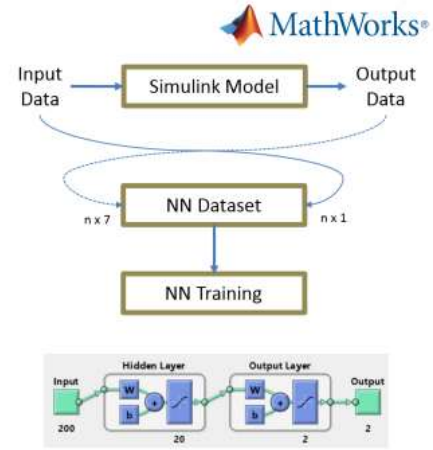
Engineering Technology – Digital Twin



1. Due to traditional Maintenance Cycles, run-to-failure data are normally missing from collected Data Base.
2. Run-to-failure data are necessary for Smart Prediction.
3. Digital Twins simulate anomalies to generate these data.
4. Digital Twins follow Physical Responses.

Application – Hydraulic Press

1. **Data base**
   - NN Dataset & Training is developing by switching Input-Output.
2. **ANN Generation**
   - Build the ANN architecture with Deep Learning Toolbox.
3. **Training**
   - Adjust relative neural parameters to reach desired values.
4. **Validation**
   - Iterative process using physical inputs to validate ANN and Virtual Model.



Supervised learning process

[MATLAB Expo Talk Link]

Edge Device Deployment Enables Data Reduction & Faster Results

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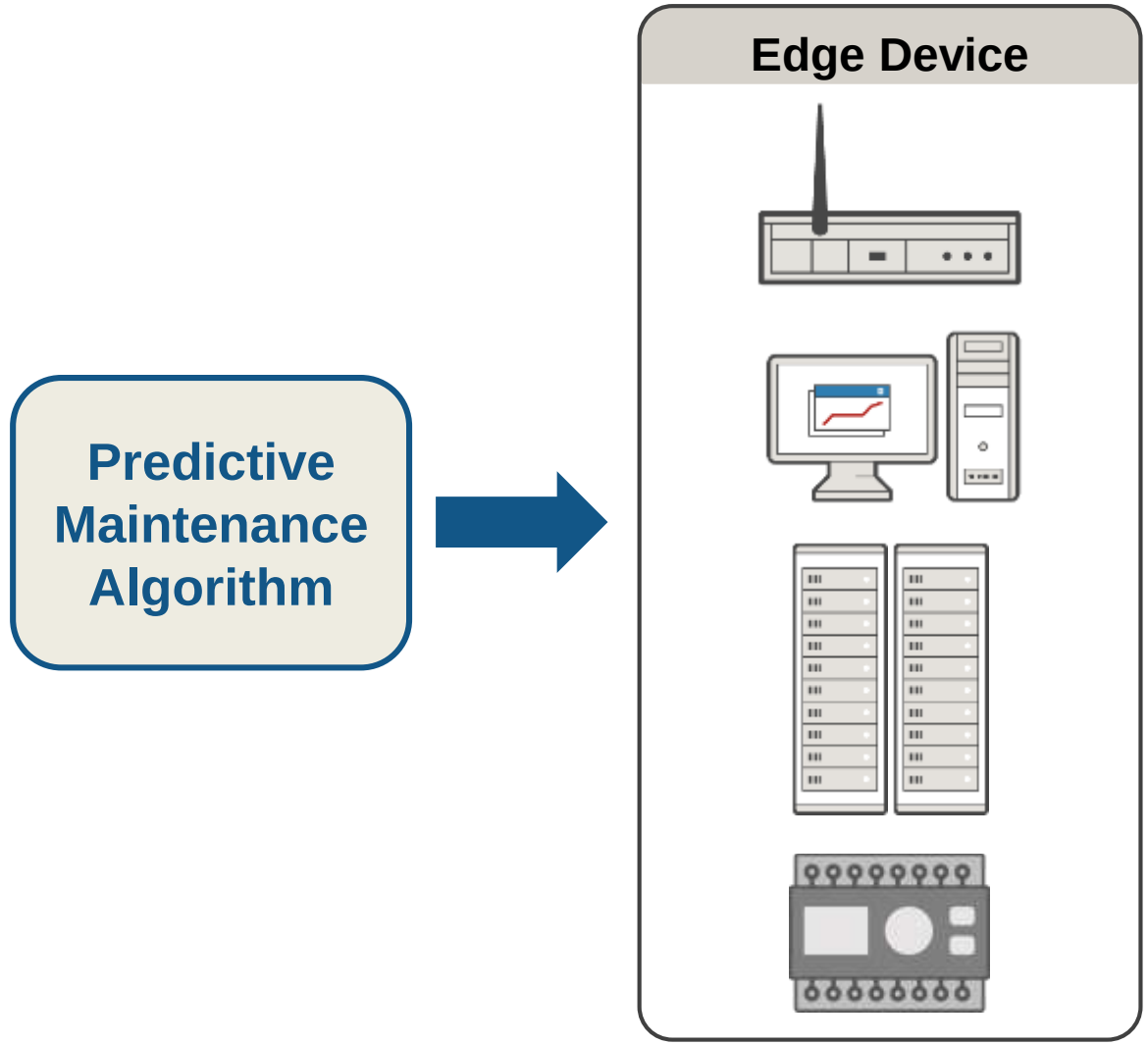
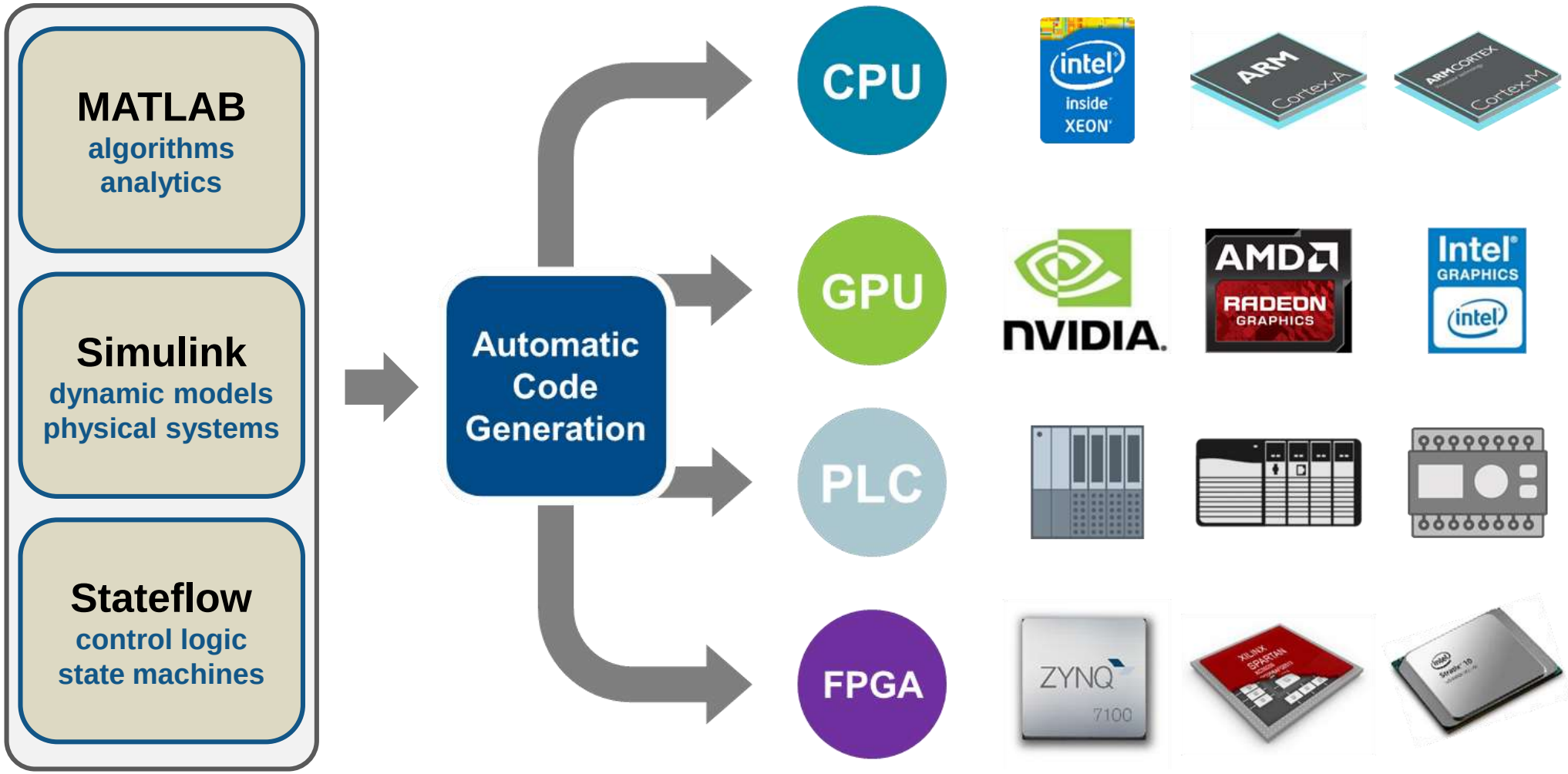
The Steps Associated With Deploying To Hardware Are Complex, But Model-Based Design Is Perfectly Suited To This Application

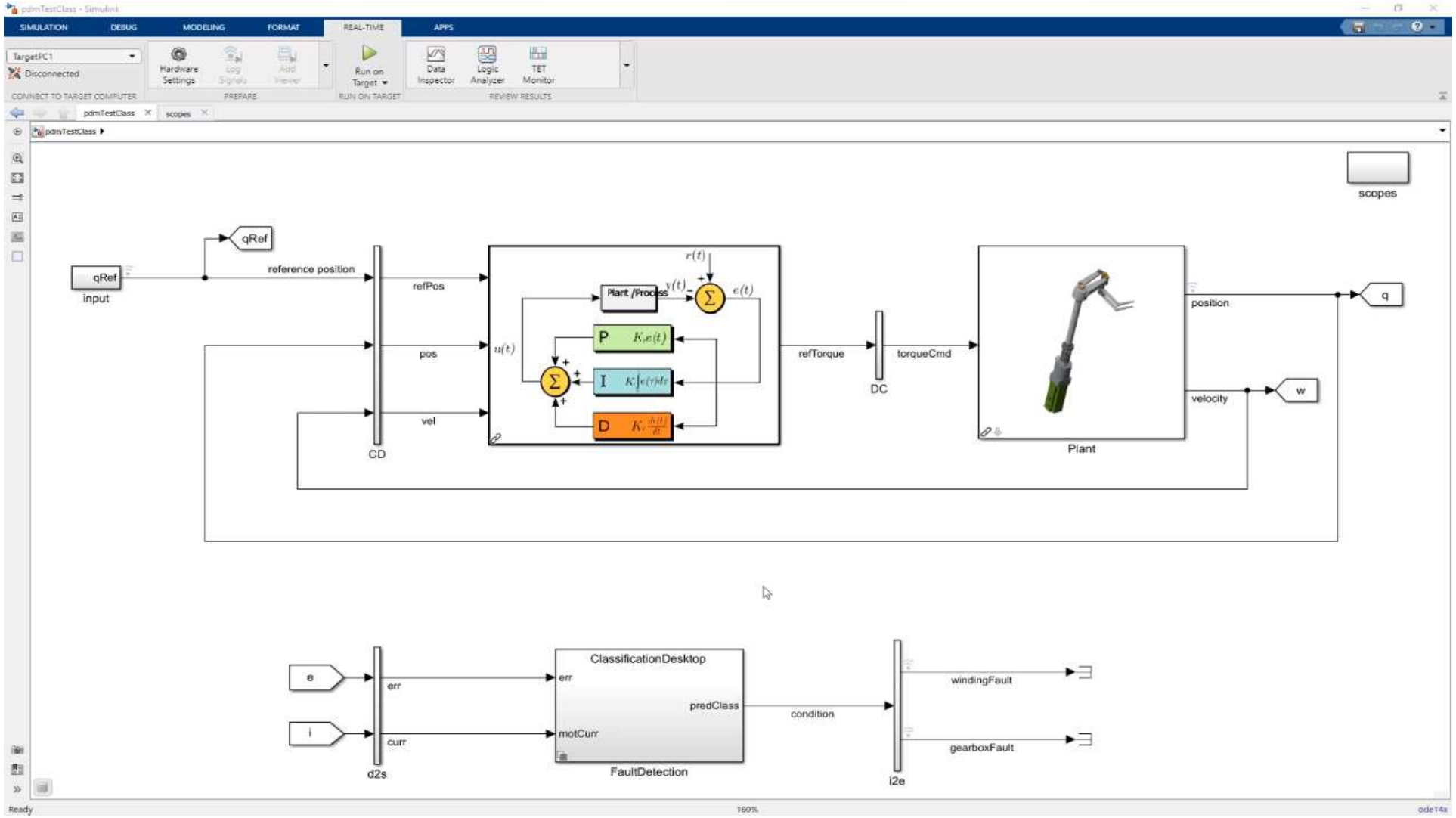
1. Develop algorithm that can run on a resource-constrained edge device
2. Test algorithm in simulation
3. Verify performance using real-time testing
4. Deploy to actual hardware



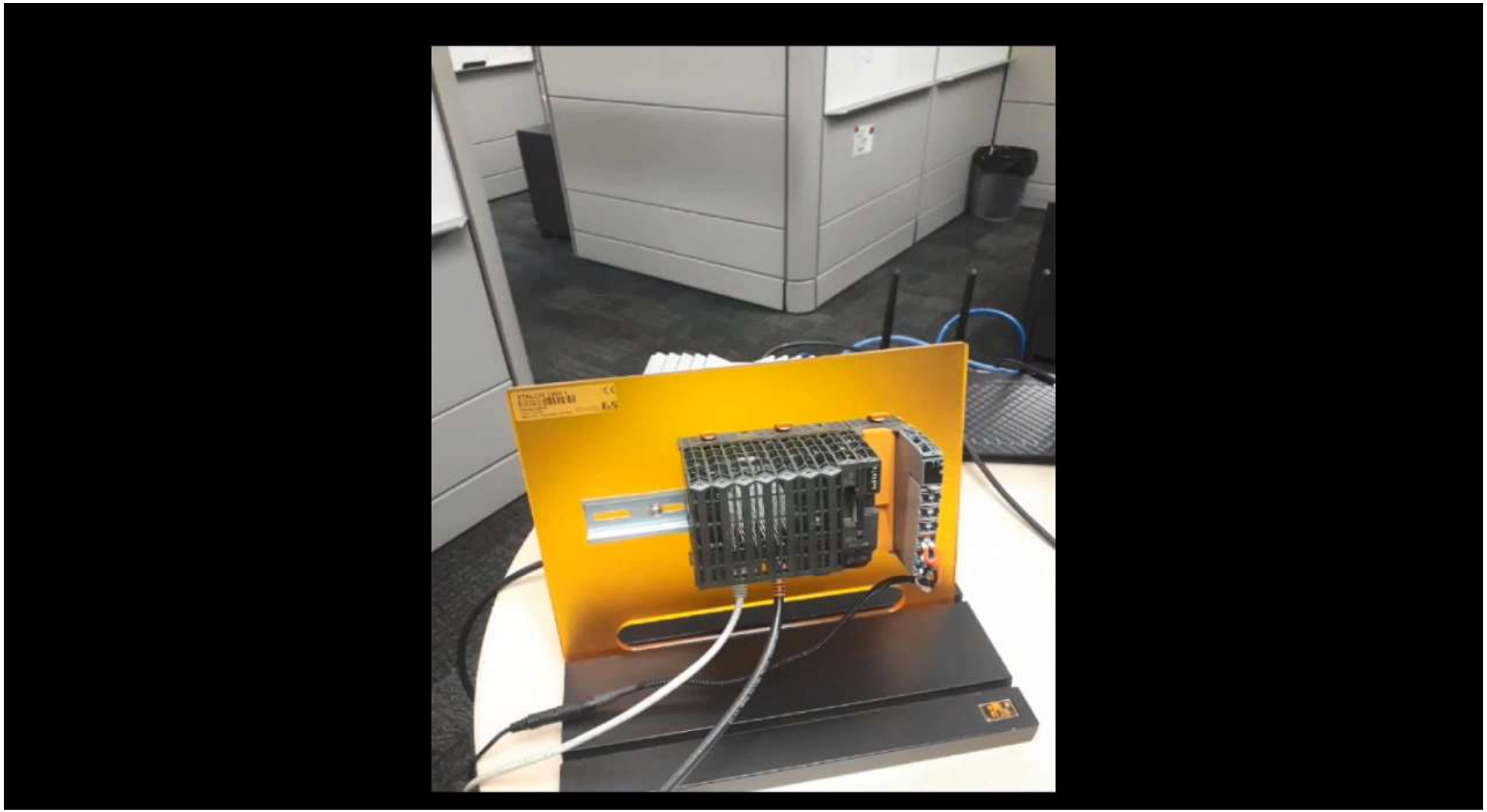
Automatic Code Generation From MATLAB & Simulink Simplifies This Process



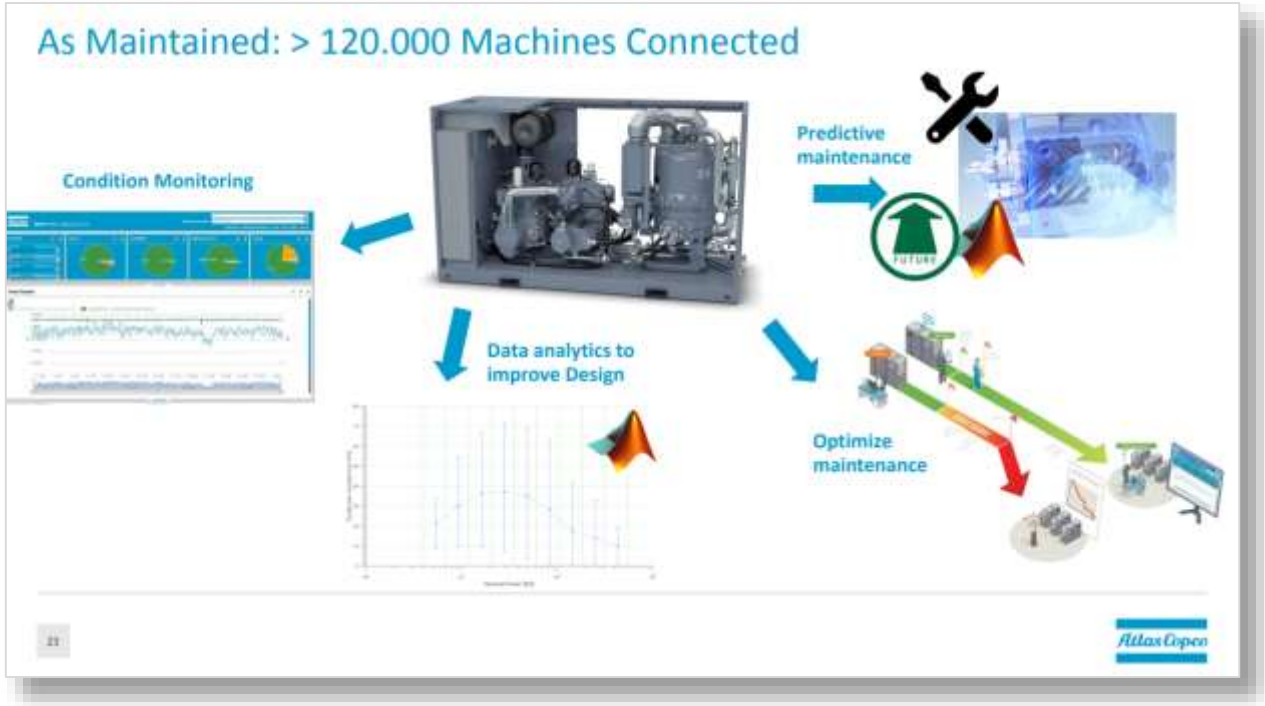
Check If Fault Classification Algorithm Behaves As Expected Using Simulation

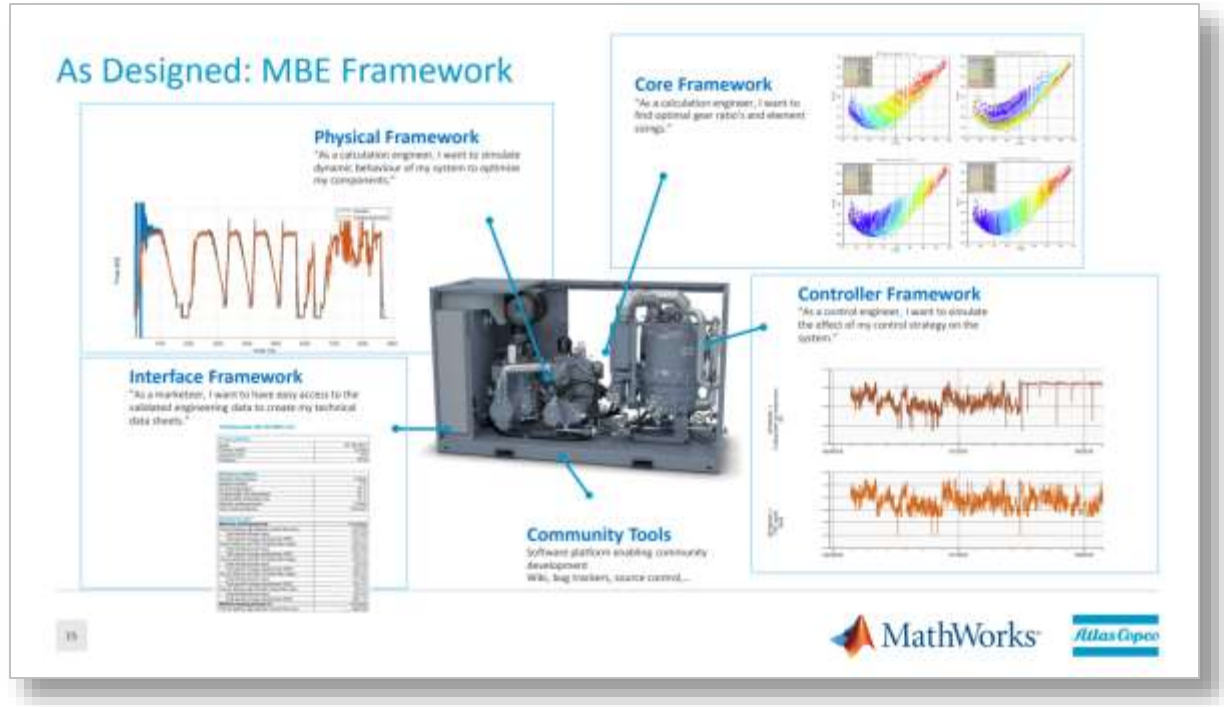


Deploy Algorithm To PLC Using Automatic Code Generation & Verify Performance Using Real-Time Testing



Atlas Copco Is Using Model Based Engineering and Digital Twins For Minimizing Cost





[MATLAB Expo Talk Link]

End Users Require Easy Access To Actionable Information. Dashboards Integrated With IT & OT Systems Make This Possible

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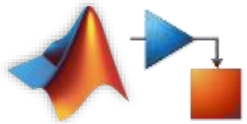
Building Such A System Requires 3 Different Skill Sets: Algorithm Development, Data Visualization, & Data Management

Engineer & Data Scientist

Develops algorithms in MATLAB and Simulink



Dashboard Builder

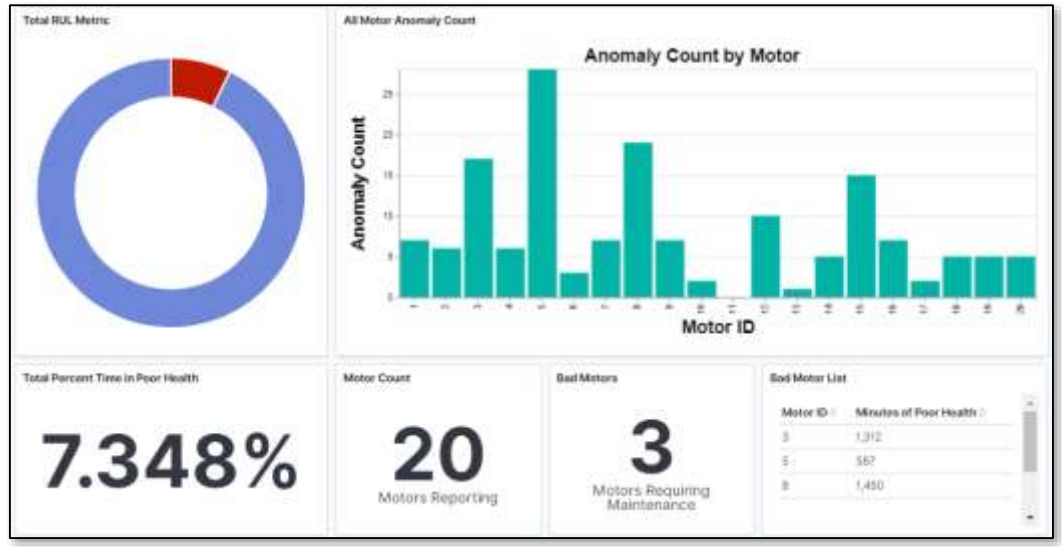
Designs visualization for plant operator

kibana

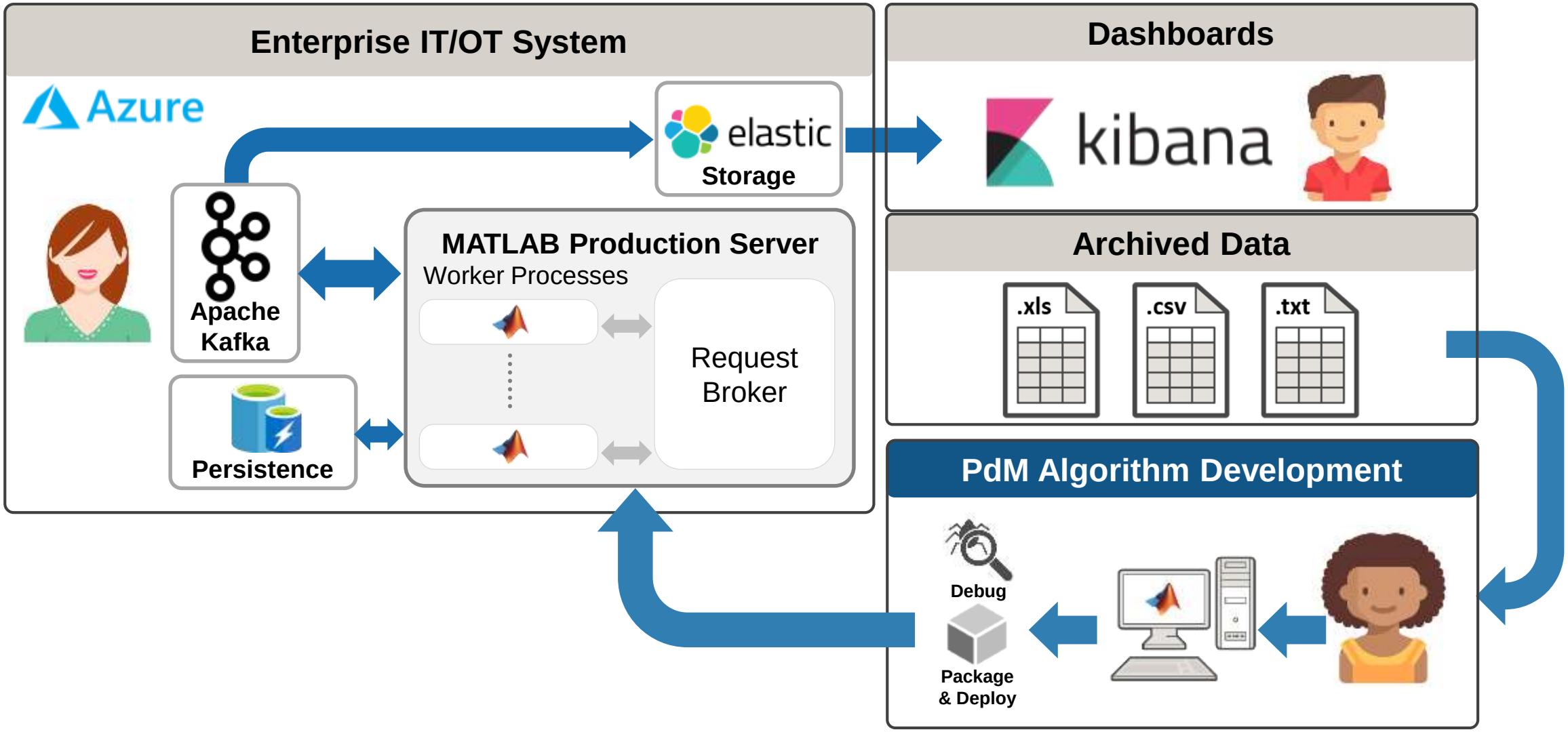
System Architect

Deploys and operationalizes model on Azure cloud

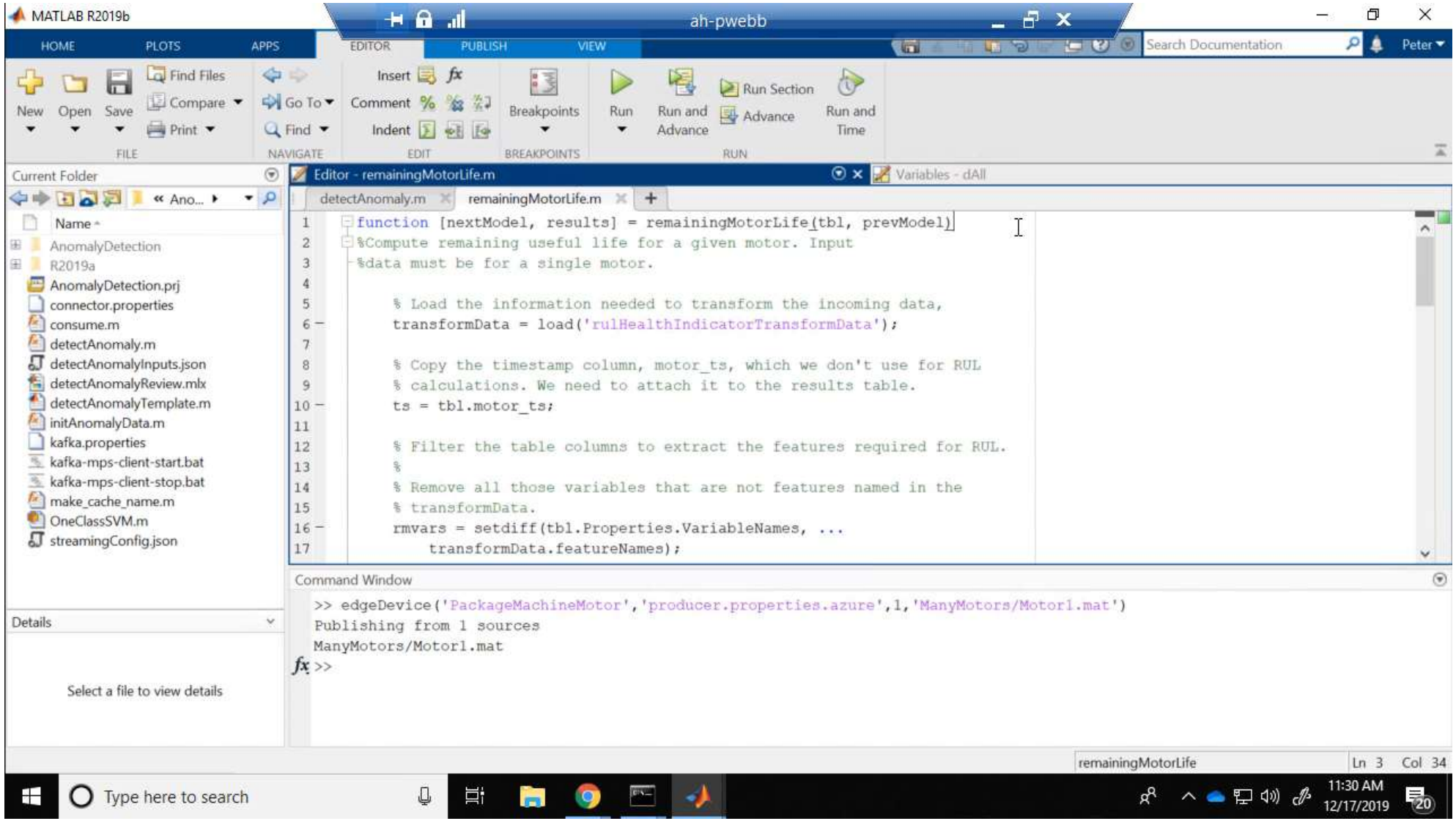
Azure



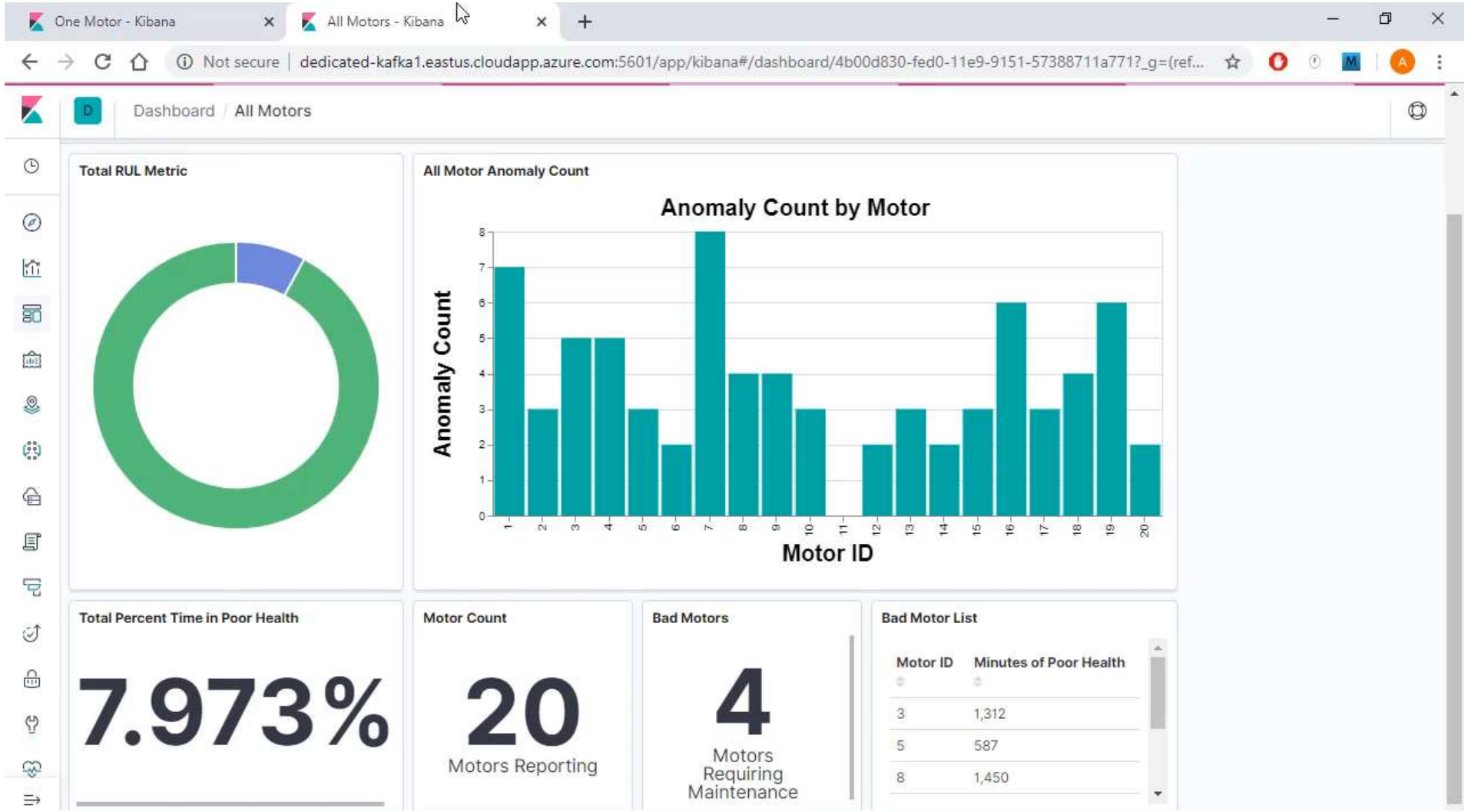
Engineers & Data Scientists Can Package Their Algorithms As Standalone Executables Or Shareable Libraries Using MATLAB



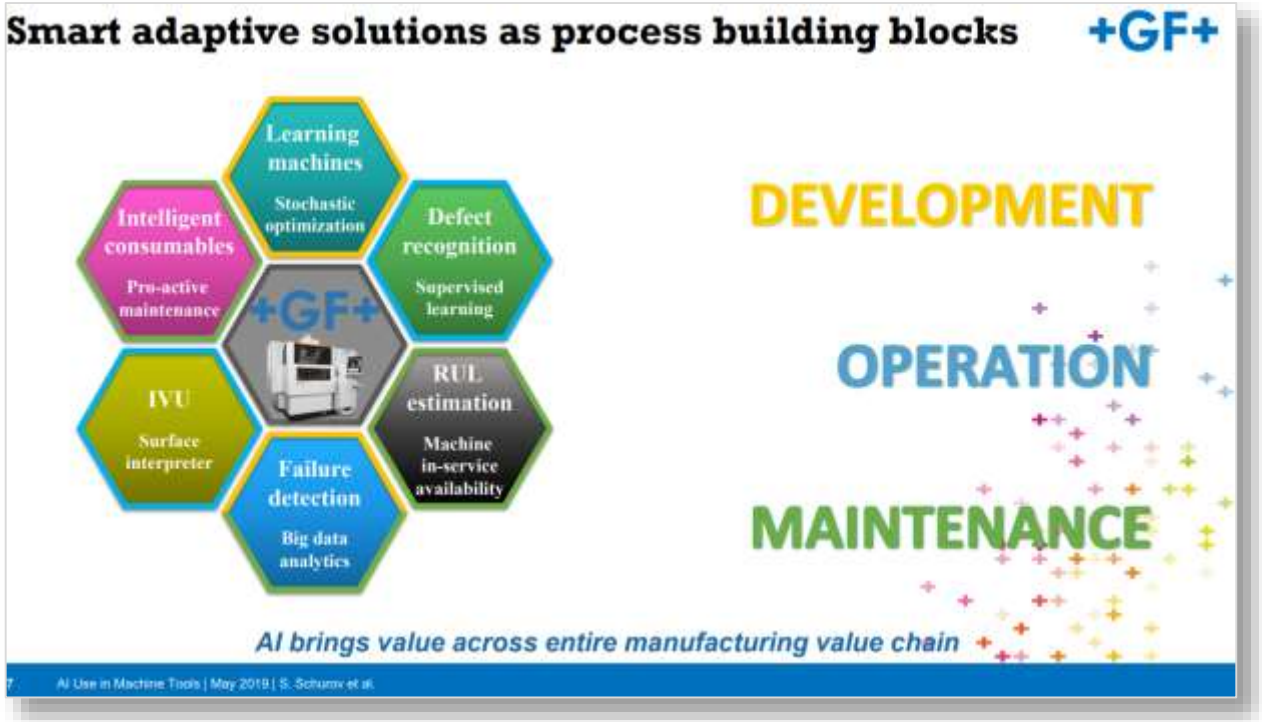
Well Defined Interfaces For Cloud Architectures & One-Click Creation of Cloud-Deployable Applications

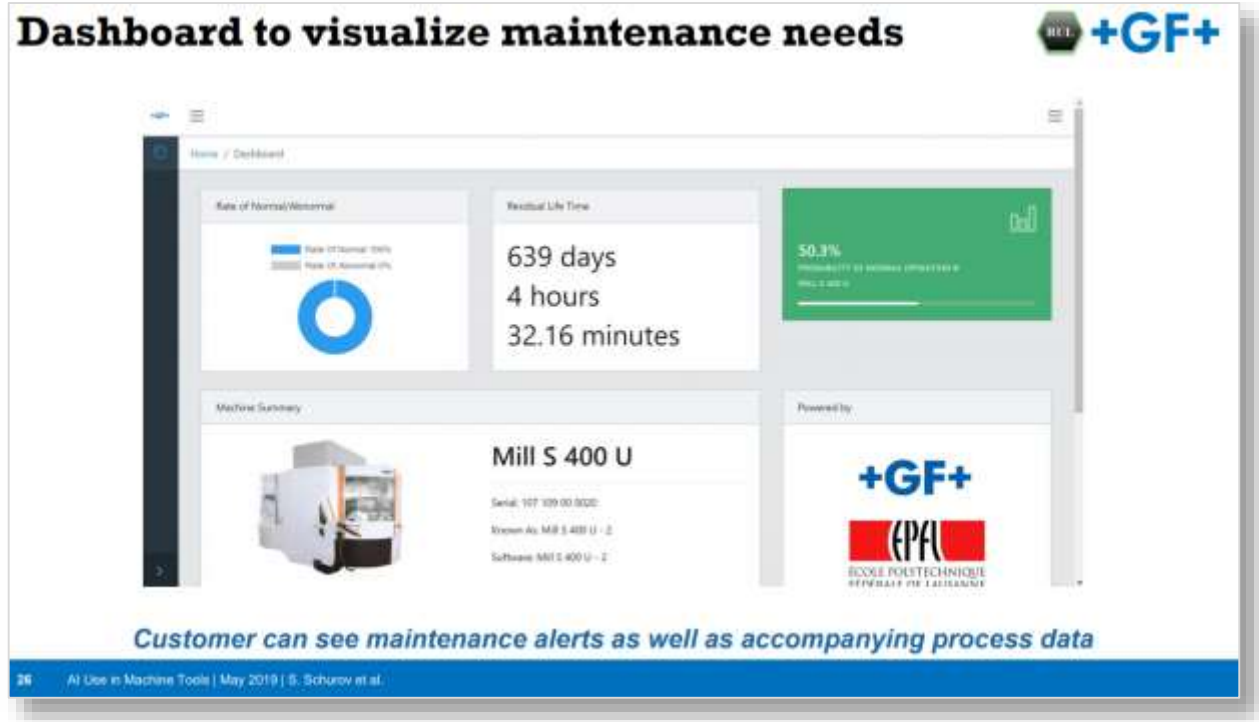


Integrate MATLAB Analytics For Predictive Maintenance With Your Dashboards & Existing IT/OT Infrastructure



GF Machining Solutions Built Condition Monitoring Dashboards To Visualize Maintenance Needs & Predict Failures





[MATLAB Expo Talk Link]

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Learn More

- Predictive Maintenance Toolbox
  - https://www.mathworks.com/products/predictive-maintenance.html
- Predictive Maintenance Solutions with MATLAB and Simulink
  - https://www.mathworks.com/solutions/predictive-maintenance.html
- Consulting for Predictive Maintenance
  - https://www.mathworks.com/services/consulting/proven-solutions/predictive-maintenance.html