Key Takeaways

➢ Use Industrial applications to learn about:
  ▪ IIoT architecture
  ▪ Building and Using Digital Twin

➢ MathWorks key building blocks for developing IIoT applications:
  ▪ Data Analysis and Physical Modeling
  ▪ Operational Deployment and Integration

➢ MathWorks teams can help you get your project started
  ▪ Training
  ▪ Consulting
Digital Transformation and IIoT

Customer Goal

By connecting machines in operation, you can use data, algorithms, and models to make better decisions, improve processes, reduce cost, improve customer experience.

- Industrial IoT
- Digital Twin
- Industry 4.0
- Smart ‘XYZ’
- Digital Transformation
Transpower Ensures Reliability of New Zealand National Grid with Reserve Management Tool

“We record frequencies on the grid, inject them into our Simulink model, and compare the simulation results to the actual system response. With Simulink we can continually calibrate and improve our model, and ultimately improve the accuracy of our reserve estimates.”

— Heidi Heath, Transpower

Challenge

Calculate the amount of reserve power needed to ensure that New Zealand’s national grid can continue to operate if a generator fails.

Solution

Use Simulink to run simulations of the entire grid, including generators, loads, and HVDC links, every 30 minutes.

Results

• Critical updates rapidly implemented
• Simulations verified using real data
• Updates made in-house
Case Study:

Objective: Always have enough reserve energy

Digital Twin:
- Simulink model of entire grid
- Simulate 100s future scenarios to predict maximum energy needed.

Outcome: Provided operators control setpoints for sufficient energy reserves

“We record frequencies on the grid, inject them into our Simulink model, and compare the simulation results to the actual system response. With Simulink we can continually calibrate and improve our model, and ultimately improve the accuracy of our reserve estimates.”

— Heidi Heath, Transpower
Industrial IoT architecture

- **Smart assets**
  - Data Ingestion
  - Local Communications

- **Edge systems**
  - Edge Processing
  - Model-Based Design, code generation

- **OT Infrastructure**
  - Stream Processing
  - Model-Based Design, code generation
  - Long-Range Communications
  - Edge Management

- **IT Systems**
  - Integration

**Hard real-time control**

**Real-time decisions**

**Time-sensitive decisions**

**Big Data processing on historical data**

- **Model-Based Design with MATLAB & Simulink, code generation**
- **Edge Processing**
- **Stream Processing** with MATLAB Production Server
- **Hadoop/Spark integration** with MDCS, Compiler

**Technologies**

- C/C++
- MQTT
- kafka
- Kinesis
- Event Hub

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Estimate Remaining Useful Life using Digital Twin

Edge Device Publishing Data

Consume data and Update RUL
Challenges in building IIoT applications:

– Data is not available to represent every operating scenario

– Receive rapid streams of data to maintain effective Digital Twins

– Scale your Digital Twins to match the number of assets

– Keep Assets, Digital Twins and Analytics connected at all times
Realtime Condition Monitoring Detection

Monitor
Analyze
Predict
Control
Optimize
Creating Multi-Domain Physical Models using Simscape

Monitor ➔ Analyze ➔ Predict ➔ Control ➔ Optimize

Pump Hardware
Acquire Real-Time Data for Updating Digital Twin

Monitor | Analyze | Predict | Control | Optimize

Pump Hardware

MODBUS TCPIP

Digital Twin

MathWorks

m = modbus('tcpip', '192.168.2.1', 308)
m =

Modbus TCPIP with properties:

DeviceAddress: '192.168.2.1'
Port: 308
Status: 'open'
NumRetries: 1
Timeout: 10 (seconds)
ByteOrder: 'big-endian'
WordOrder: 'big-endian'
Use Simulink Design Optimizer to

- Monitor
- Analyze
- Predict
- Control
- Optimize

✓ Setup Experiments
✓ Parameterize
✓ Save Sessions
✓ Generate Code
Parameter Estimation – Behind the scenes

Monitor → Analyze → Predict → Control → Optimize

% Group the model parameters and initial states to be estimated together.
% v = [p; s];

% Estimation Function
estFcn = @(v) sdoPumpEstimation_Objective(v, Simulator, Exp);

% Optimization options
opt = sdo.optimizeOptions;
opt.Method = 'lsqnonlin';

% Estimate the Parameters
vOpt = sdo.optimize(estFcn, v, opt)
Why Predictive Maintenance?

- Operating conditions vary
- Variance in component life
Generate Possible in-field Scenarios

Monitor   Analyze   Predict   Control   Optimize

Valve Opening

Pressure

RPM

Valve Opening

Pressure

RPM
Scale up with MATLAB Parallel Server

MATLAB Parallel Server

Cluster Workers

Digital Twin 1

Digital Twin 2

Desktop System Workers

Monitor

Analyze

Predict

Control

Optimize

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100 days

120 days

200 days
Use Parallel Simulation Manager to scale up

Monitor, Analyze, Predict, Control, Optimize
Develop Predictive Models using Digital Twin

- Monitor
- Analyze
- Predict
- Control
- Optimize

**Table:**

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<th>Time</th>
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<th>BlockingFault</th>
<th>BearingFault</th>
<th>FaultType</th>
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<td>2.8472</td>
<td>-0.1477</td>
<td>1.8000/AII</td>
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</table>

**Steps:**

1. Represent Signals
2. Label Faults
3. Train Model
4. Validate Model
5. Predict
6. Control
7. Optimize
Realtime decisions in field

“A blowout preventer (BOP) is an expensive pressure control safety device used during drilling and completion of wells. Approximately 50% of the unplanned downtime for an offshore drilling rig is caused by the BOP. Providing a solution that improves the availability of a BOP will benefit the drilling process and safety.”  

Transocean performed CPM of a BOP using an adaptive physics-based modeling approach with Simscape.

“If we can reduce the energy consumption of the pump and the cooling fan, then energy will be saved significantly. To do that, we have to install the VFD (Variable Frequency Drive) instead of the control valve. VFD is the final control element,” informed Dr Sarkar.

A digital twin model of VFD controller was created to make physical controller (VFD) more efficient.
Backbone Infrastructure for Preventive, Predictive, Reactive, Actionable

- Smart assets
- Edge systems
- OT Infrastructure
- IT Systems

Value of data to decision making:
- Hard real-time control
- Real-time decisions
- Time-sensitive decisions
- Big Data processing on historical data

Speed:
- Milliseconds
- Seconds
- Minutes
- Hours
- Days
- Months

Technologies:
- C/C++
- MODBUS
- TCP/IP
- MQTT
- docker
- Kafka
- Kinesis
- Event Hub
- Azure

Technologies for IoT, SCADA, and Hadoop/Spark integration with MDCS, Compiler.
Keep Assets, Digital Twins and Analytics connected at all times

Edge
Generate telemetry

Production System
- MATLAB Production Server
  - Worker processes
  - Request Broker
- Worker processes
- State Persistence
- Apache Kafka
- Connector
- Storage Layer

Analytics Development
- MATLAB Compiler SDK
- Debug
- Package & Deploy
- Model
- Algorithm Developers

Business Decisions
- Presentation Layer
- kibana
- End Users

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MathWorks Cloud Reference Architecture
Receive rapid streams of data to maintain effective Digital Twins

DEMO BOOTH: Deploying AI in Cloud

Production System

Azure

Virtual Network

Management Server

MATLAB Production Server(s) scaling group

Application Gateway Load Balancer

https management endpoint

Enterprise Applications

Connectors for Streaming/Event Data

State Persistence

Connectors for Storage & Databases
Develop and Deploy: Live Estimation for Remaining Useful Life

Model Coeff: $\phi = 2.1396$, $\theta = 0.038836$, $\gamma = 0.13184$
In Conclusion

MathWorks is investing in this area and has key building blocks for your solution:

- Physical Modeling libraries to **build Digital Twins and Operating Scenarios**
- Data Science libraries to build **Intelligent & Insightful Applications**
- Deployment workflows for **edge, on premise server & cloud platforms**

**IIoT and Digital Twin are new areas evolving rapidly**

“Come talk to us about your IoT application and discuss how we can support you!”
Call to Action

>> IIoT & Digital Twin Booth

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>> Master Class

Deploying AI Algorithms on Cloud for Near Real-Time Decision Making
Pallavi Kar, MathWorks

>> Attend Data Science Sessions

14:30
Developing and Deploying Machine Learning Solutions for Embedded Applications
Nitin Rai, MathWorks

15:00
Predictive Maintenance with MATLAB
Amit Doshi, MathWorks

16:45
Building and Sharing Desktop and Web Apps
Dr. Lakshminarayan Vig
Ravichendran, MathWorks

16:15
Innovative Method of Deploying MATLAB Based Applications Across an Organization Using MathApps, a Web-Based Platform
Chandrakant Deshmukh, Saifee Aliakbar, and Jannat Manchanda, Mahindra and Mahindra Ltd.
Resources: IIoT and Digital Twin

- Building IoT solutions
- Developing and Deploying on Cloud
- Build Digital Twins with Physical Modeling workflow
- Learn: How to build Predictive Maintenance Applications?
- Learn Data Science with MATLAB