MATLAB EXPO 2019

# What’s New in MATLAB and Simulink

Mehernaz Savai

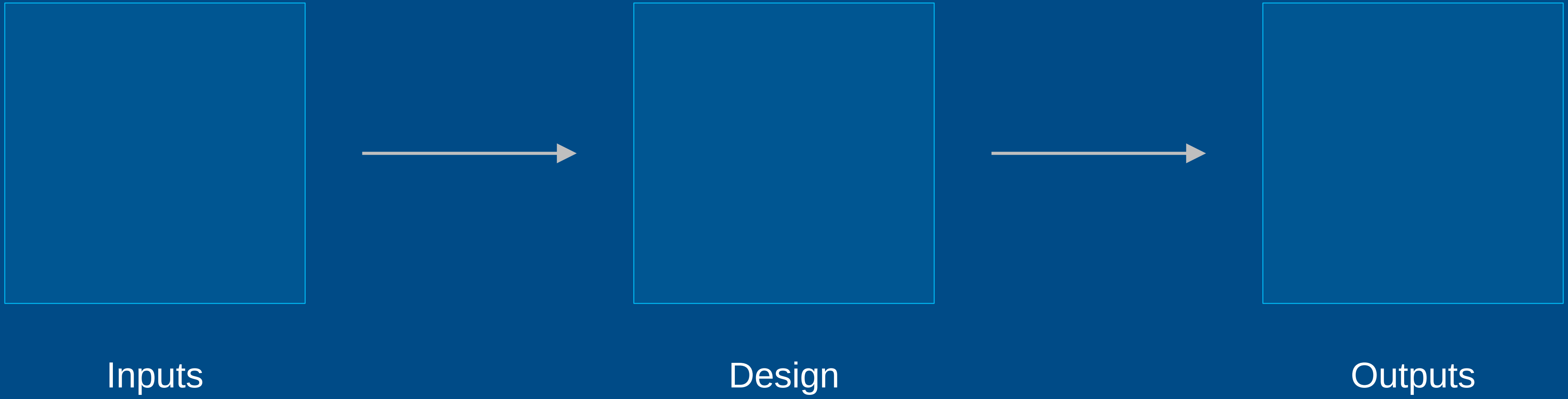
# Using MATLAB & Simulink to Build Algorithms in Everything

## Simplifying your work…

## …often at higher levels of abstraction.

MATLAB®&SIMULINK®

# Using MATLAB & Simulink to Build Algorithms in Everything



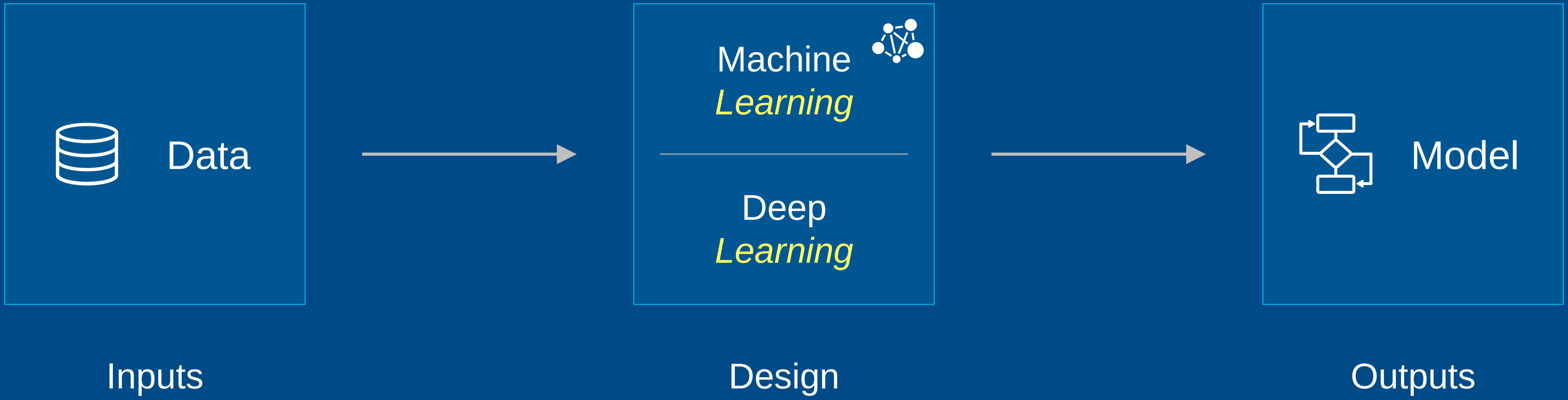
Inputs

Design

Outputs

MATLAB® & SIMULINK®

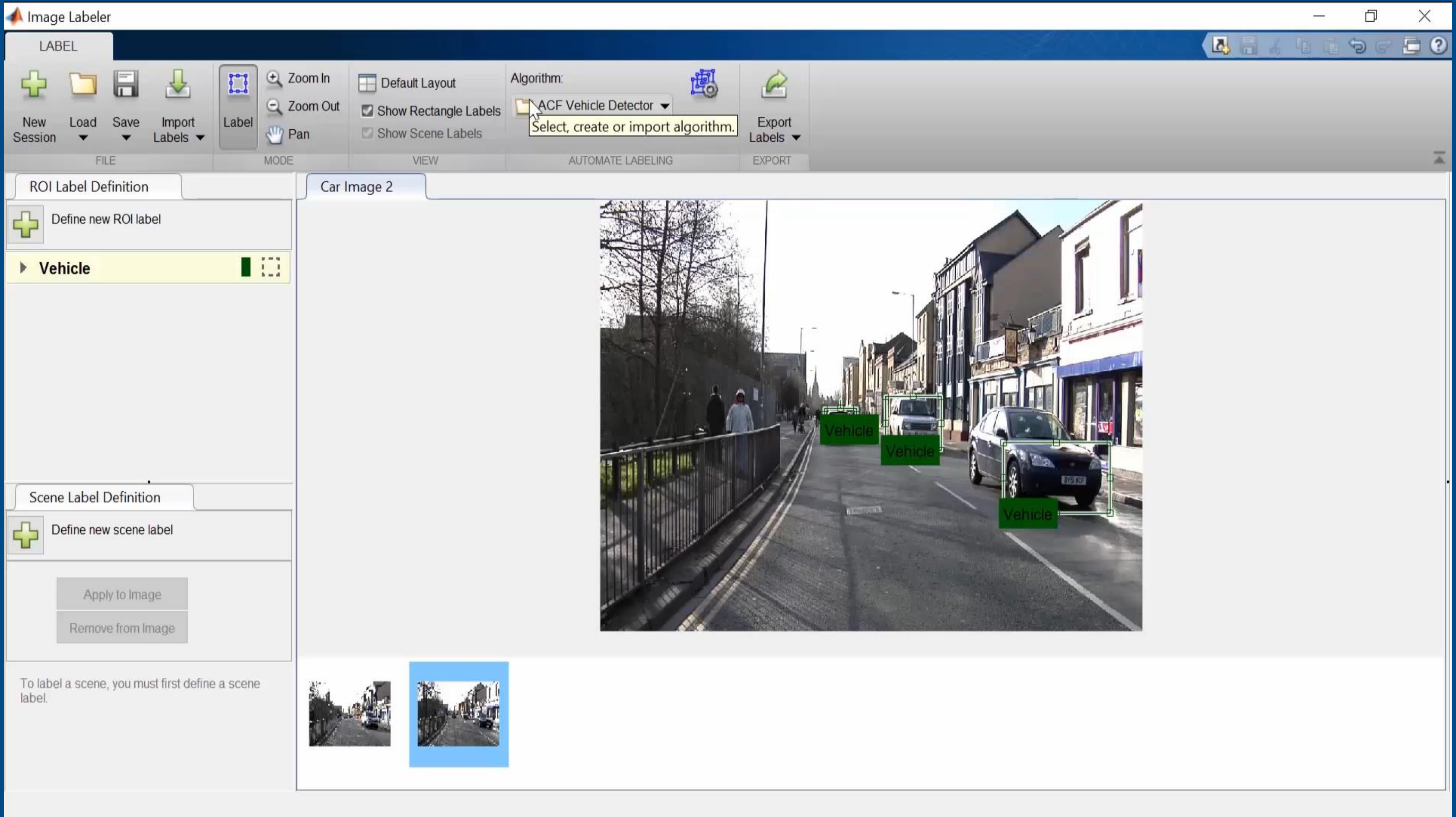
# Using MATLAB & Simulink to Build **Machine Learning Models**



MATLAB® & SIMULINK®

# Using Apps for Ground Truth Labeling

## Image and Video Data



☑ Show Rectangle Labels

☑ Show Scene Labels

Algorithm: ACF Vehicle Detector

Select, create or import algorithm.

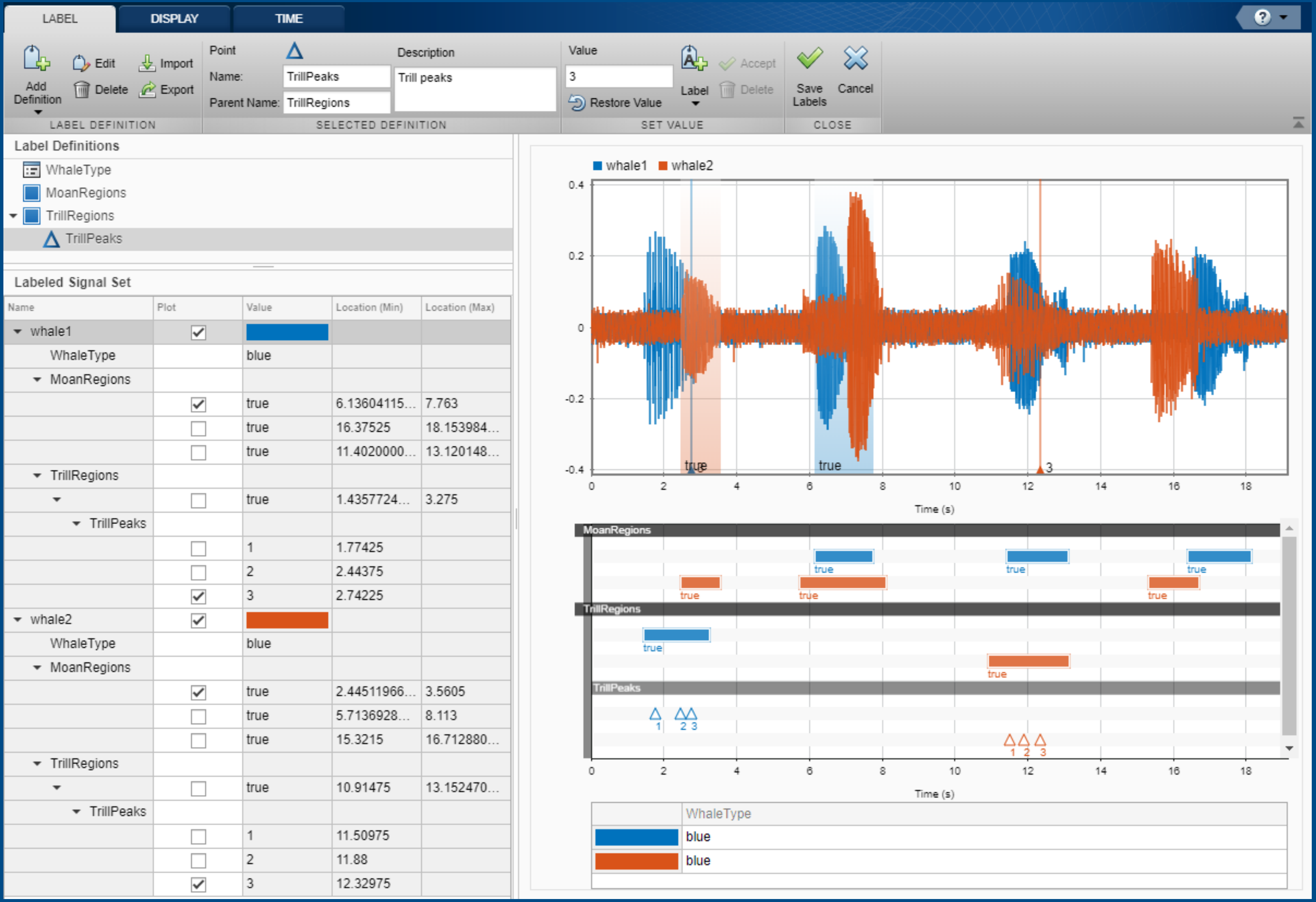
To label a scene, you must first define a scene label.

**Computer Vision Toolbox**

Input

# Using Apps for Ground Truth Labeling

## Signal Data



Point

Name: TrillPeaks

Parent Name: TrillRegions

Description: Trill peaks

Value: 3

Label Definitions

- WhaleType
- MoanRegions
- TrillRegions
  - TrillPeaks

Labeled Signal Set

| Name | Plot | Value | Location (Min) | Location (Max) |
|---|---|---|---|---|
| whale1 | ☑ | 🟦 | | |
| WhaleType | | blue | | |
| MoanRegions | | | | |
| | ☑ | true | 6.13604115... | 7.763 |
| | □ | true | 16.37525 | 18.153984... |
| | □ | true | 11.4020000... | 13.120148... |
| TrillRegions | | | | |
| | □ | true | 1.4357724... | 3.275 |
| TrillPeaks | | | | |
| | □ | 1 | 1.77425 | |
| | □ | 2 | 2.44375 | |
| | ☑ | 3 | 2.74225 | |
| whale2 | ☑ | 🟧 | | |
| WhaleType | | blue | | |
| MoanRegions | | | | |
| | ☑ | true | 2.44511966... | 3.5605 |
| | □ | true | 5.7136928... | 8.113 |
| | □ | true | 15.3215 | 16.712880... |
| TrillRegions | | | | |
| | □ | true | 10.91475 | 13.152470... |
| TrillPeaks | | | | |
| | □ | 1 | 11.50975 | |
| | □ | 2 | 11.88 | |
| | ☑ | 3 | 12.32975 | |

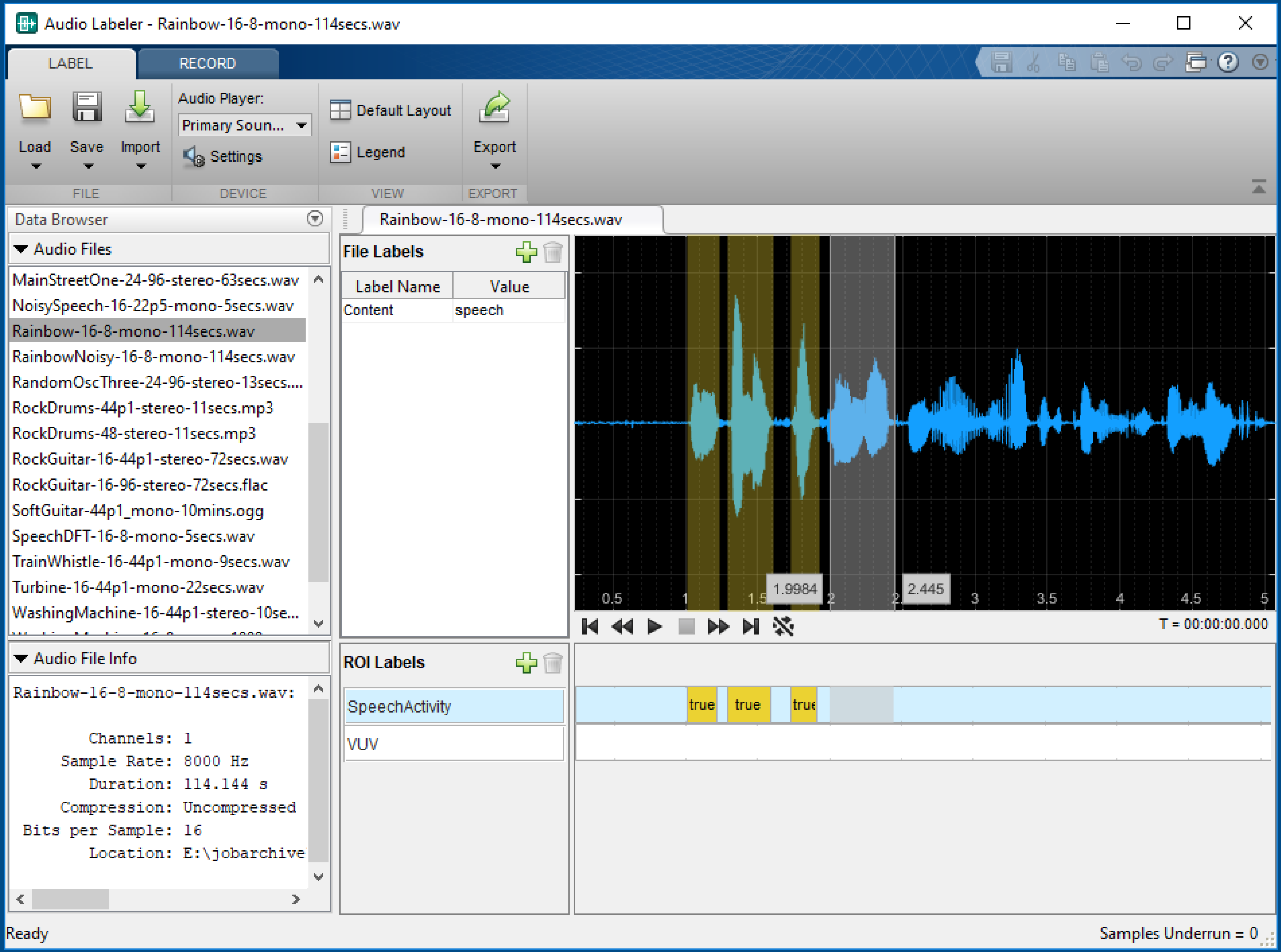
| | WhaleType |
|---|---|
| 🟦 | blue |
| 🟧 | blue |

Signal Processing Toolbox

# Using Apps for Ground Truth Labeling

## Audio Data

Input



MainStreetOne-24-96-stereo-63secs.wav
NoisySpeech-16-22p5-mono-5secs.wav
Rainbow-16-8-mono-114secs.wav
RainbowNoisy-16-8-mono-114secs.wav
RandomOscThree-24-96-stereo-13secs....
RockDrums-44p1-stereo-11secs.mp3
RockDrums-48-stereo-11secs.mp3
RockGuitar-16-44p1-stereo-72secs.wav
RockGuitar-16-96-stereo-72secs.flac
SoftGuitar-44p1_mono-10mins.ogg
SpeechDFT-16-8-mono-5secs.wav
TrainWhistle-16-44p1-mono-9secs.wav
Turbine-16-44p1-mono-22secs.wav
WashingMachine-16-44p1-stereo-10se....

Audio File Info

```
Rainbow-16-8-mono-114secs.wav:

        Channels: 1
     Sample Rate: 8000 Hz
        Duration: 114.144 s
     Compression: Uncompressed
 Bits per Sample: 16
        Location: E:\jobarchive
```

Rainbow-16-8-mono-114secs.wav

File Labels

| Label Name | Value |
|---|---|
| Content | speech |

ROI Labels

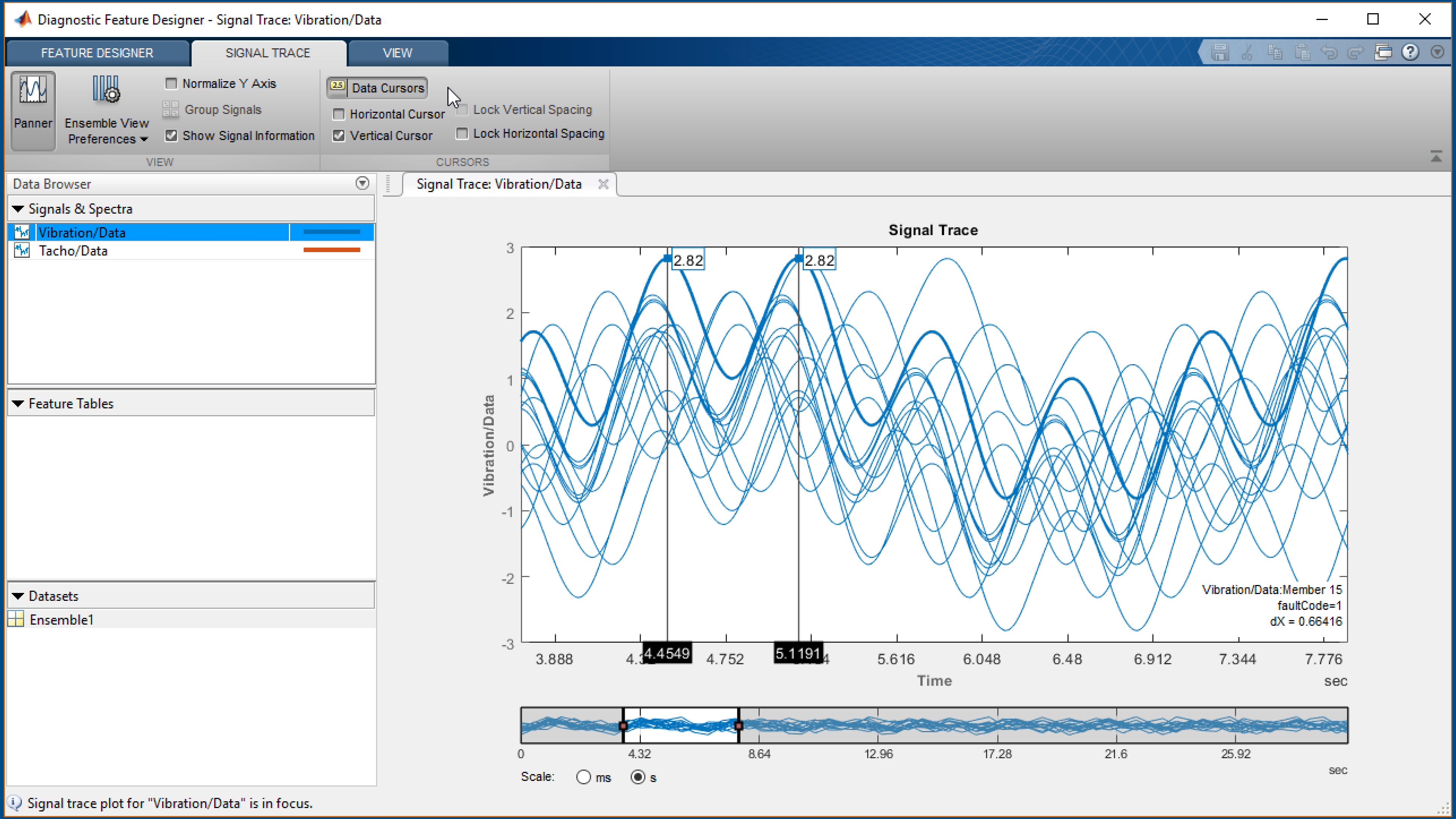
SpeechActivity
VUV

Ready

Samples Underrun = 0

Audio Toolbox

# Identifying the Useful Data



Diagnostic Feature Designer - Signal Trace: Vibration/Data

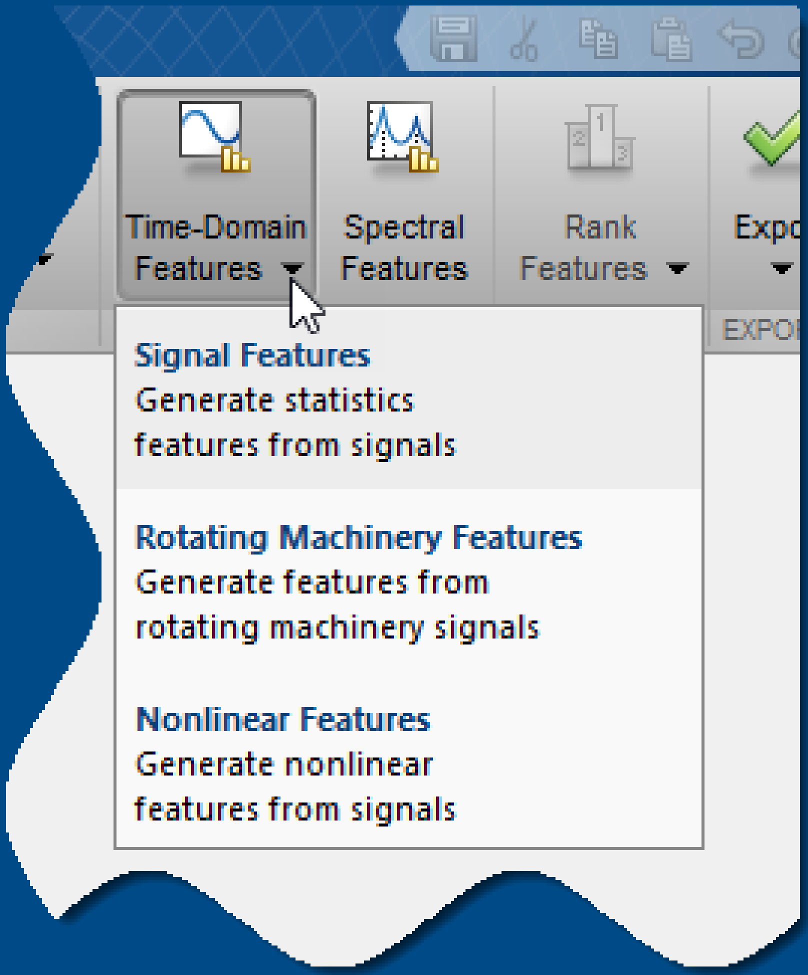
- ☐ Normalize Y Axis
- ☐ Group Signals
- ☑ Show Signal Information
- Data Cursors
- ☐ Horizontal Cursor
- ☑ Vertical Cursor
- ☐ Lock Vertical Spacing
- ☐ Lock Horizontal Spacing

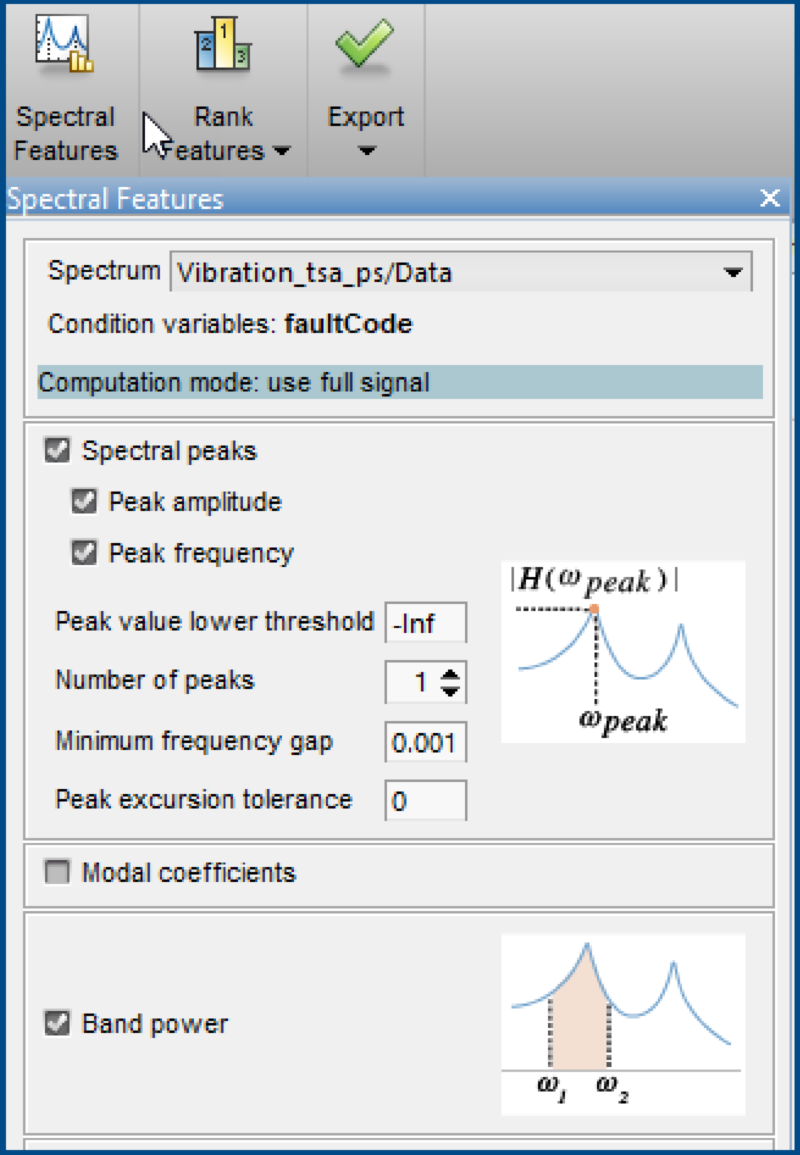
Vibration/Data:Member 15
faultCode=1
dX = 0.66416

Scale: ○ ms ● s

Signal trace plot for "Vibration/Data" is in focus.

# Identifying the Useful Data


Time-Domain Features
Spectral Features
Rank Features
Expo
EXPOI
Signal Features
Generate statistics features from signals
Rotating Machinery Features
Generate features from rotating machinery signals
Nonlinear Features
Generate nonlinear features from signals



Spectrum Vibration_tsa_ps/Data

Condition variables: **faultCode**

Computation mode: use full signal

☑ Spectral peaks

☑ Peak amplitude

☑ Peak frequency

Peak value lower threshold -Inf

Number of peaks 1

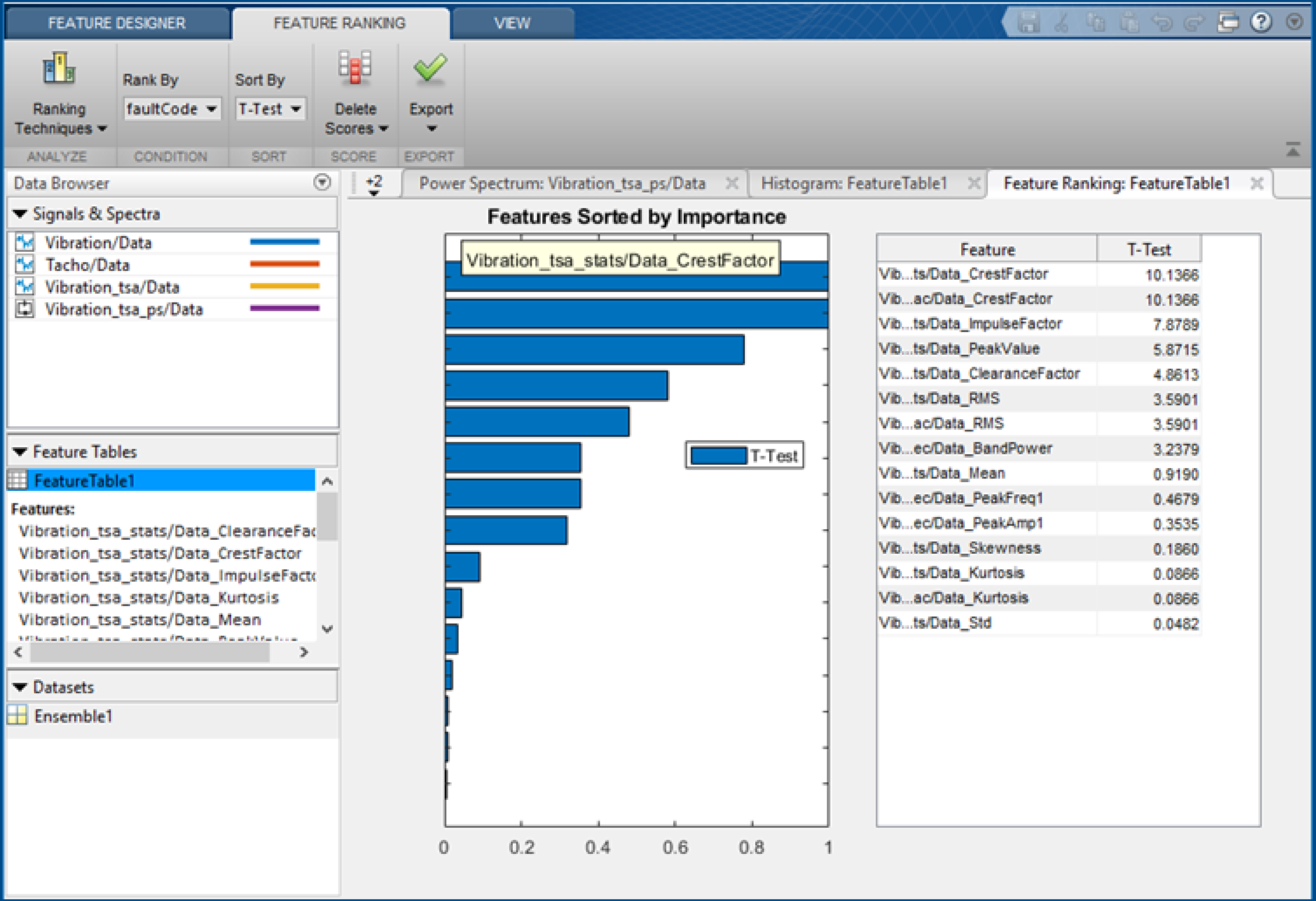
Minimum frequency gap 0.001

Peak excursion tolerance 0

□ Modal coefficients

☑ Band power

# Identifying the Useful Data



Rank By: faultCode

Sort By: T-Test

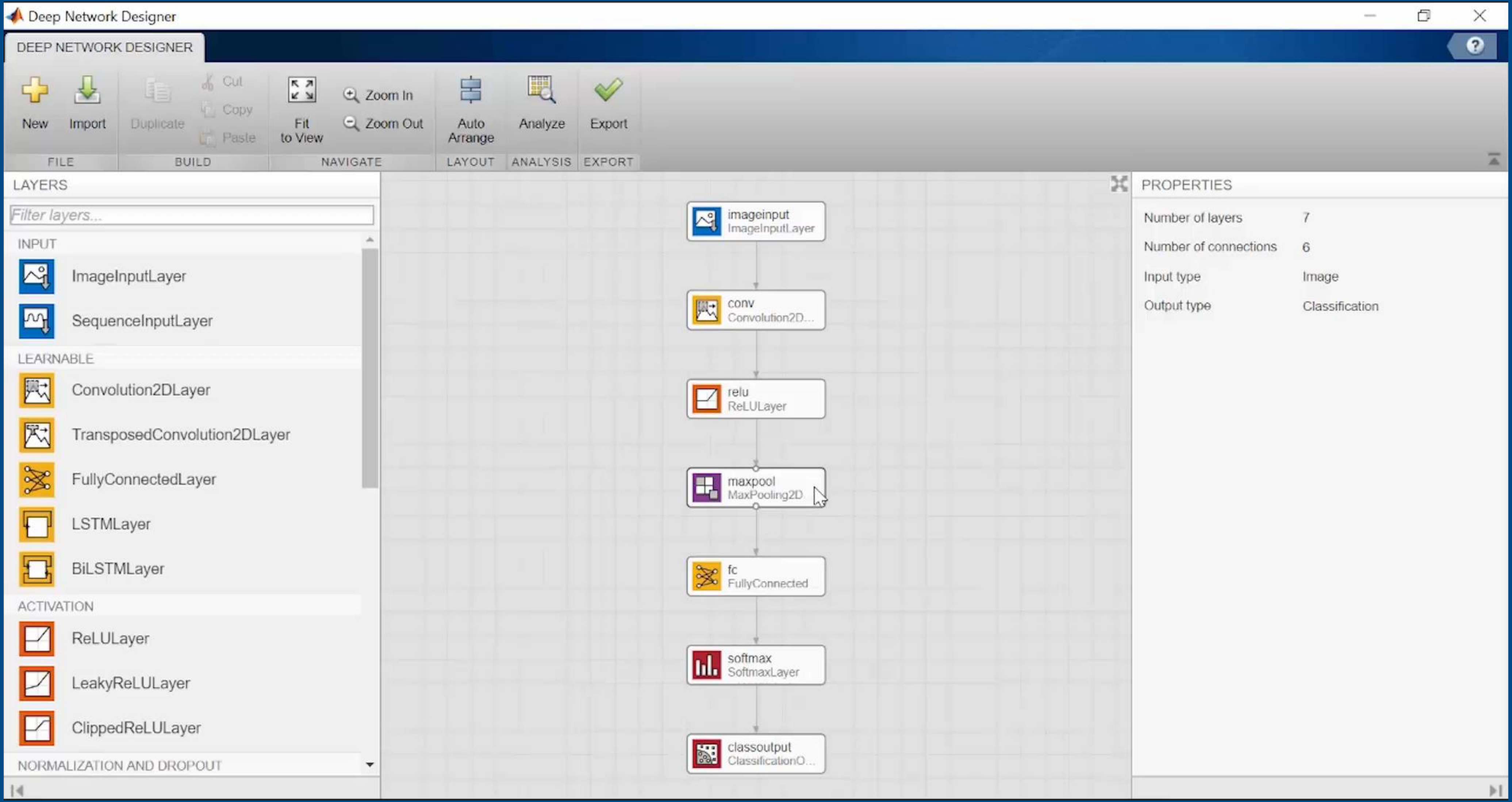
Features:
Vibration_tsa_stats/Data_ClearanceFac
Vibration_tsa_stats/Data_CrestFactor
Vibration_tsa_stats/Data_ImpulseFacto
Vibration_tsa_stats/Data_Kurtosis
Vibration_tsa_stats/Data_Mean

| Feature | T-Test |
|---|---|
| Vib...ts/Data_CrestFactor | 10.1366 |
| Vib...ac/Data_CrestFactor | 10.1366 |
| Vib...ts/Data_ImpulseFactor | 7.8789 |
| Vib...ts/Data_PeakValue | 5.8715 |
| Vib...ts/Data_ClearanceFactor | 4.8613 |
| Vib...ts/Data_RMS | 3.5901 |
| Vib...ac/Data_RMS | 3.5901 |
| Vib...ec/Data_BandPower | 3.2379 |
| Vib...ts/Data_Mean | 0.9190 |
| Vib...ec/Data_PeakFreq1 | 0.4679 |
| Vib...ec/Data_PeakAmp1 | 0.3535 |
| Vib...ts/Data_Skewness | 0.1860 |
| Vib...ts/Data_Kurtosis | 0.0866 |
| Vib...ac/Data_Kurtosis | 0.0866 |
| Vib...ts/Data_Std | 0.0482 |

Predictive Maintenance Toolbox

# Using Apps for Designing Deep Learning Networks

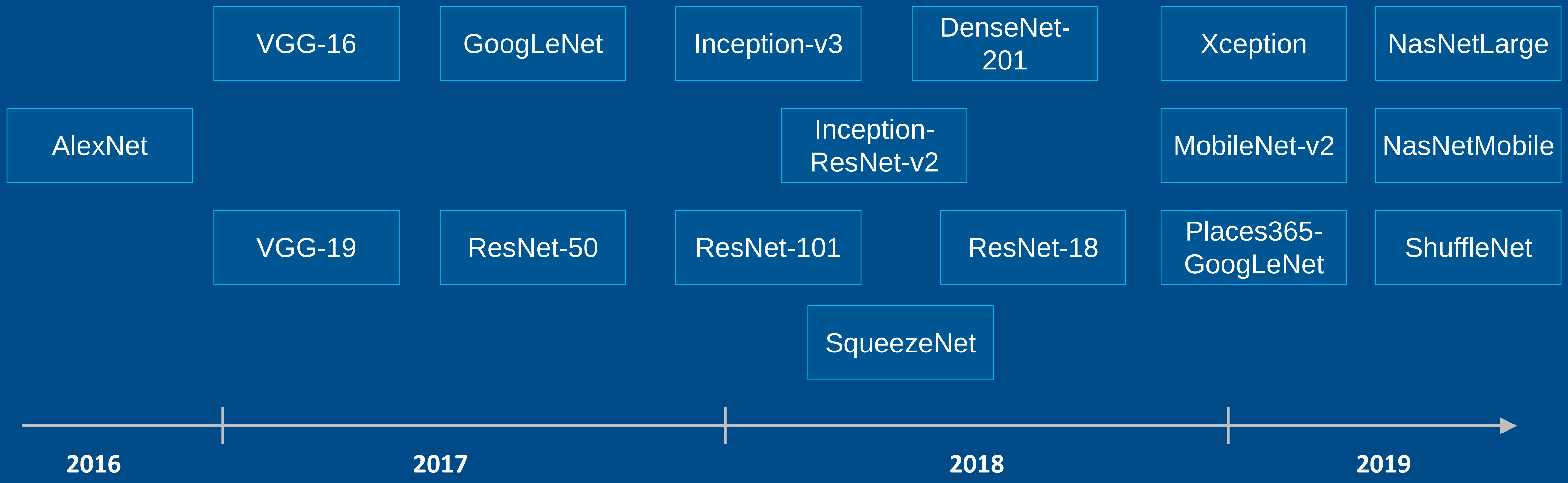
Design



| | |
|---|---|
| Number of layers | 7 |
| Number of connections | 6 |
| Input type | Image |
| Output type | Classification |

Deep Learning Toolbox

# Using Transfer Learning with Pre-trained Models



AlexNet

VGG-16

VGG-19

GoogLeNet

ResNet-50

Inception-v3

ResNet-101

Inception-ResNet-v2

SqueezeNet

DenseNet-201

ResNet-18

Xception

MobileNet-v2

Places365-GoogLeNet

NasNetLarge

NasNetMobile

ShuffleNet

2016

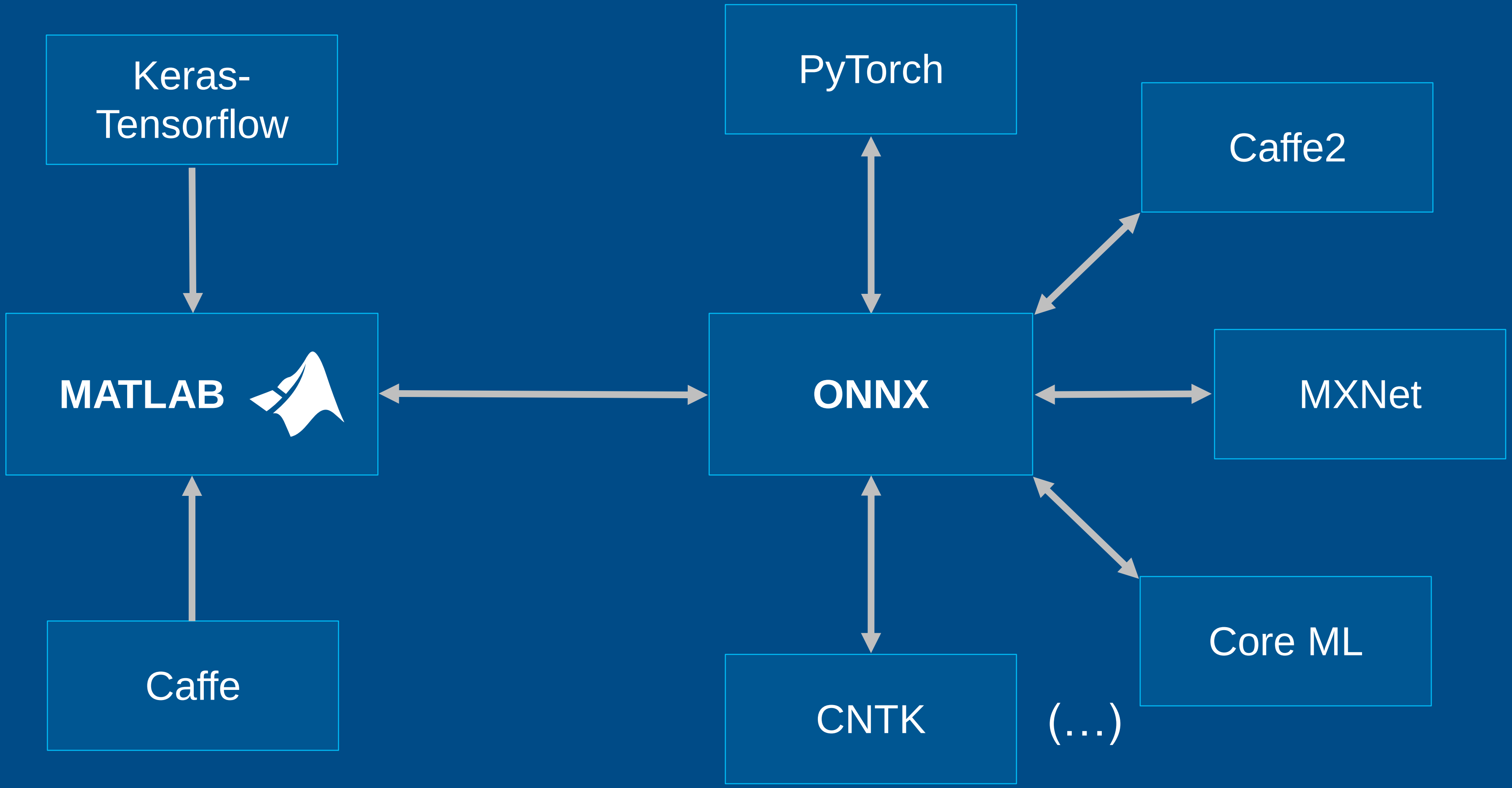
2017

2018

2019

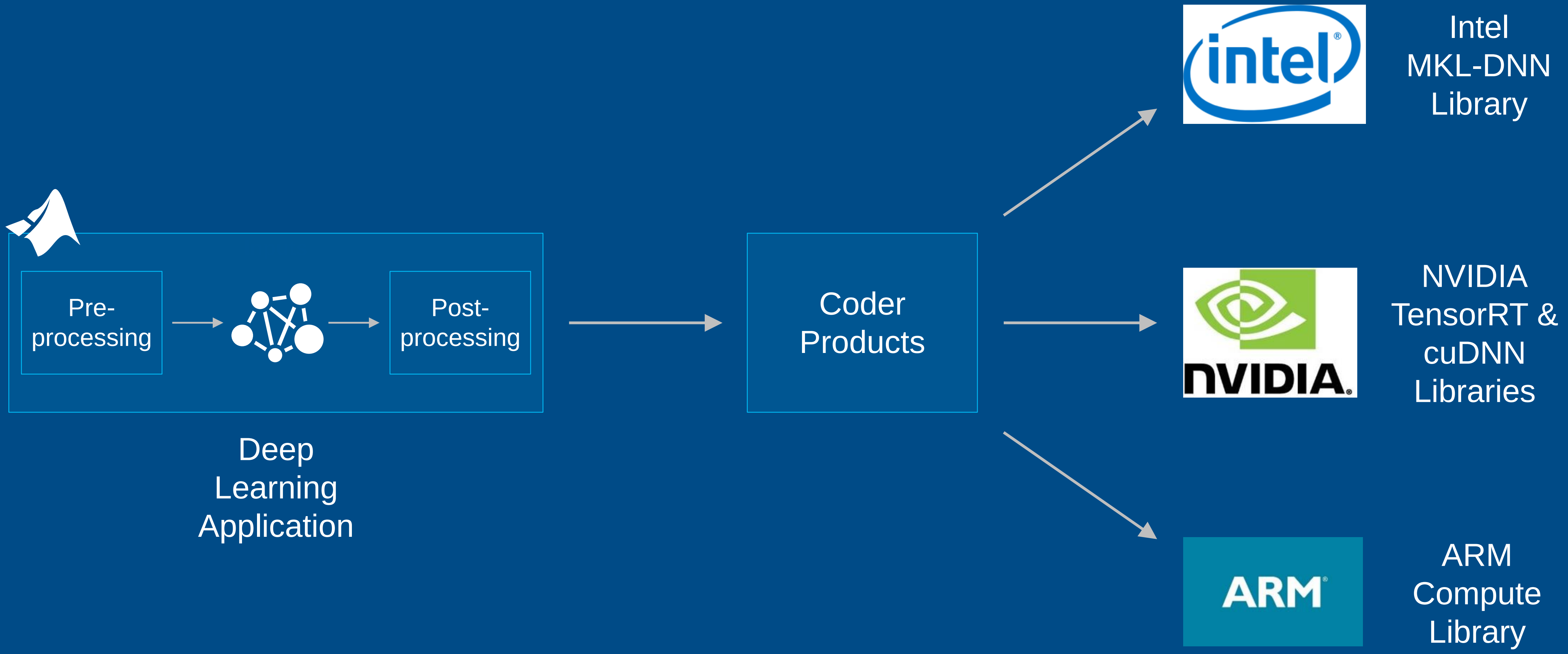
# Using Models from Other Frameworks

Design



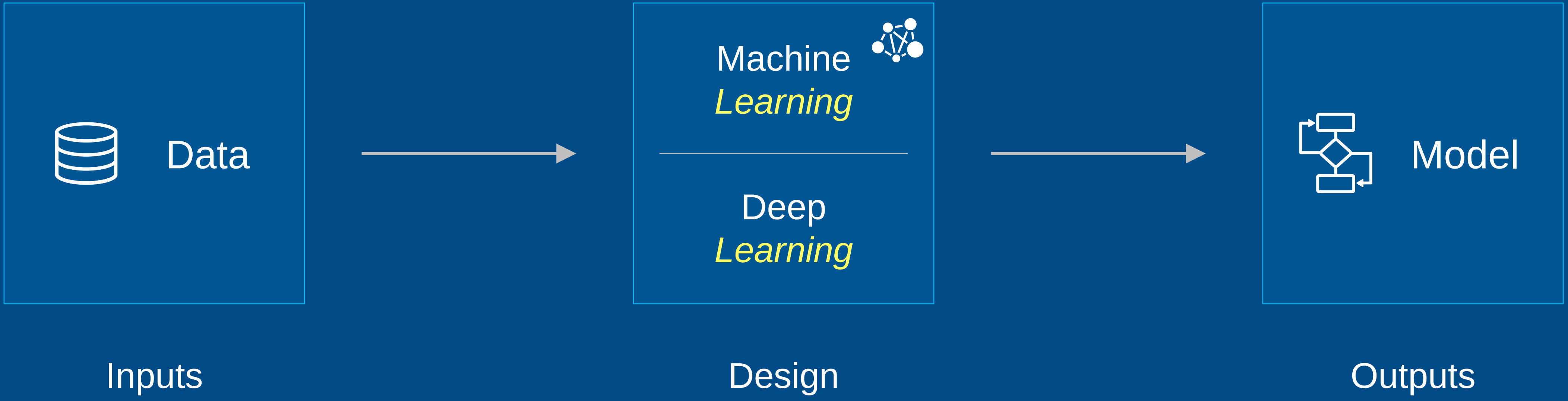
Deep Learning Toolbox

# Deploying Deep Learning Applications



**MATLAB Coder**
**GPU Coder**

# Using MATLAB and Simulink for Reinforcement Learning



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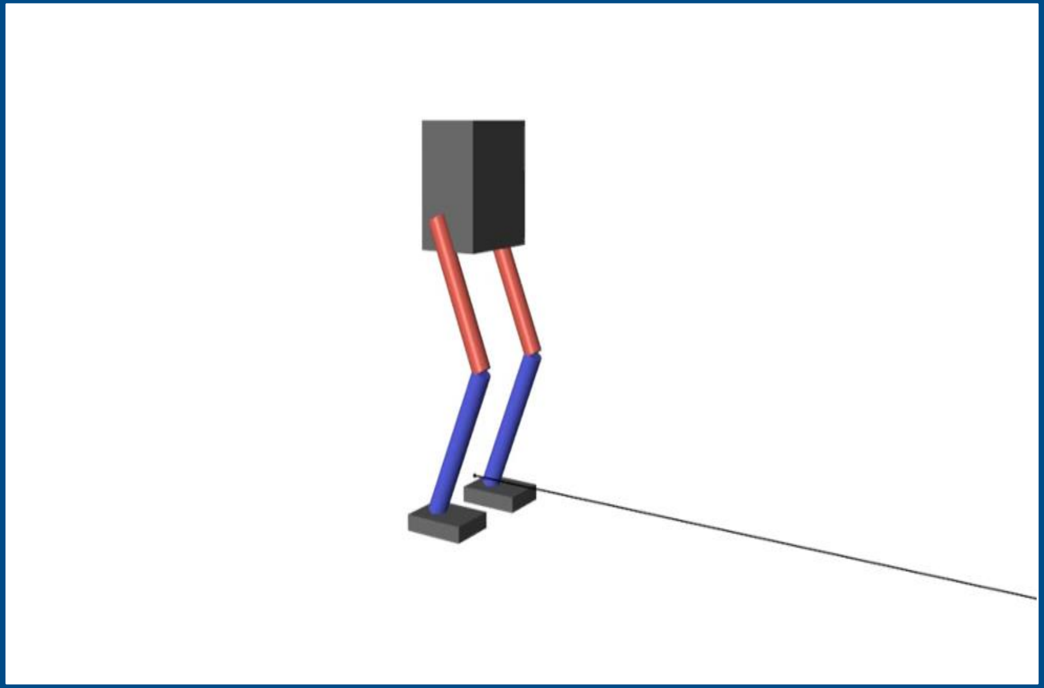
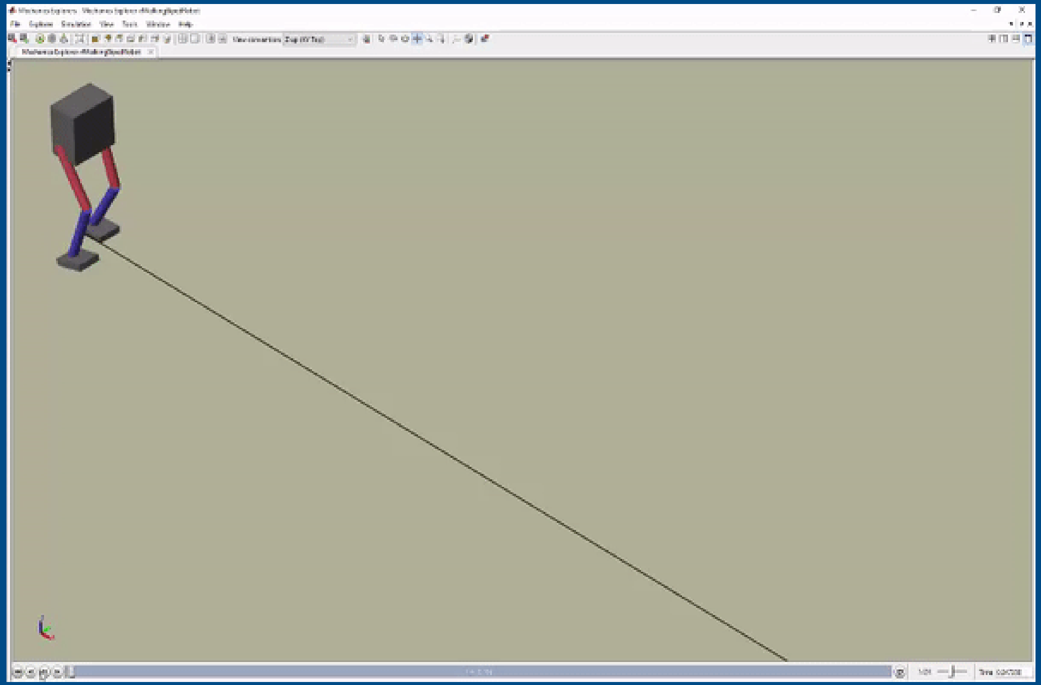
# Using MATLAB and Simulink for Reinforcement Learning





Reinforcement Learning Toolbox

# Using MATLAB and Simulink for Reinforcement Learning

Genera

Scena

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data g

odel

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ts

## Find out more:

**2:30 PM: Deep Learning and Reinforcement Learning Workflows in A.I.**

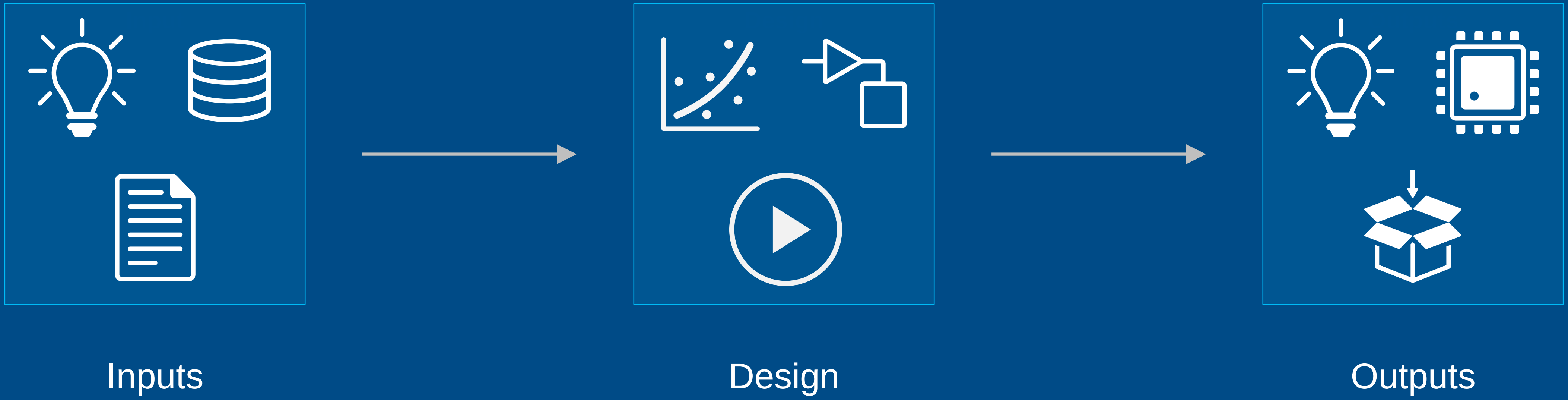
**3:30 PM: AI Techniques in MATLAB for Signal, Time-Series, and Text Data**

**4:30 PM: Deploying Deep Neural Networks to Embedded GPUs and CPUs**

MATLAB&SIMULINK

Simulink
Reinforcement Learning Toolbox

# Using MATLAB & Simulink to Build Algorithms in Everything



MATLAB® & SIMULINK®

# Working with Data

Input

## Business and Transactional Data

### Repositories

- Databases (SQL/NoSQL)
- Hadoop

### File I/O

- Text
- Spreadsheet

### Web Sources

- RESTful/SOAP
- JSON
- HTML/XML
- Mapping
- Financial datafeeds
- FTP

## Recent Additions

### File I/O

- PDF
- Microsoft Word
- Parquet
- Vector BLF
- STL (Stereolithography)

### Web Sources

- Amazon Web Services
- Azure Blob Storage

### Internet of Things (IOT)

- ThingSpeak

## Engineering, Scientific and Field Data

### File I/O

- CDF/HDF
- Audio/Image/ Video
- Geospatial
- Microarrays
- CAD Models
- MDF

### Communication Protocols

- CAN (Controller Area Network)
- DDS (Data Distribution Service)
- OPC (OLE for Process Control) (e.g. PI)
- XCP (eXplicit Control Protocol)
- TCP/IP
- Serial/Bluetooth/USB

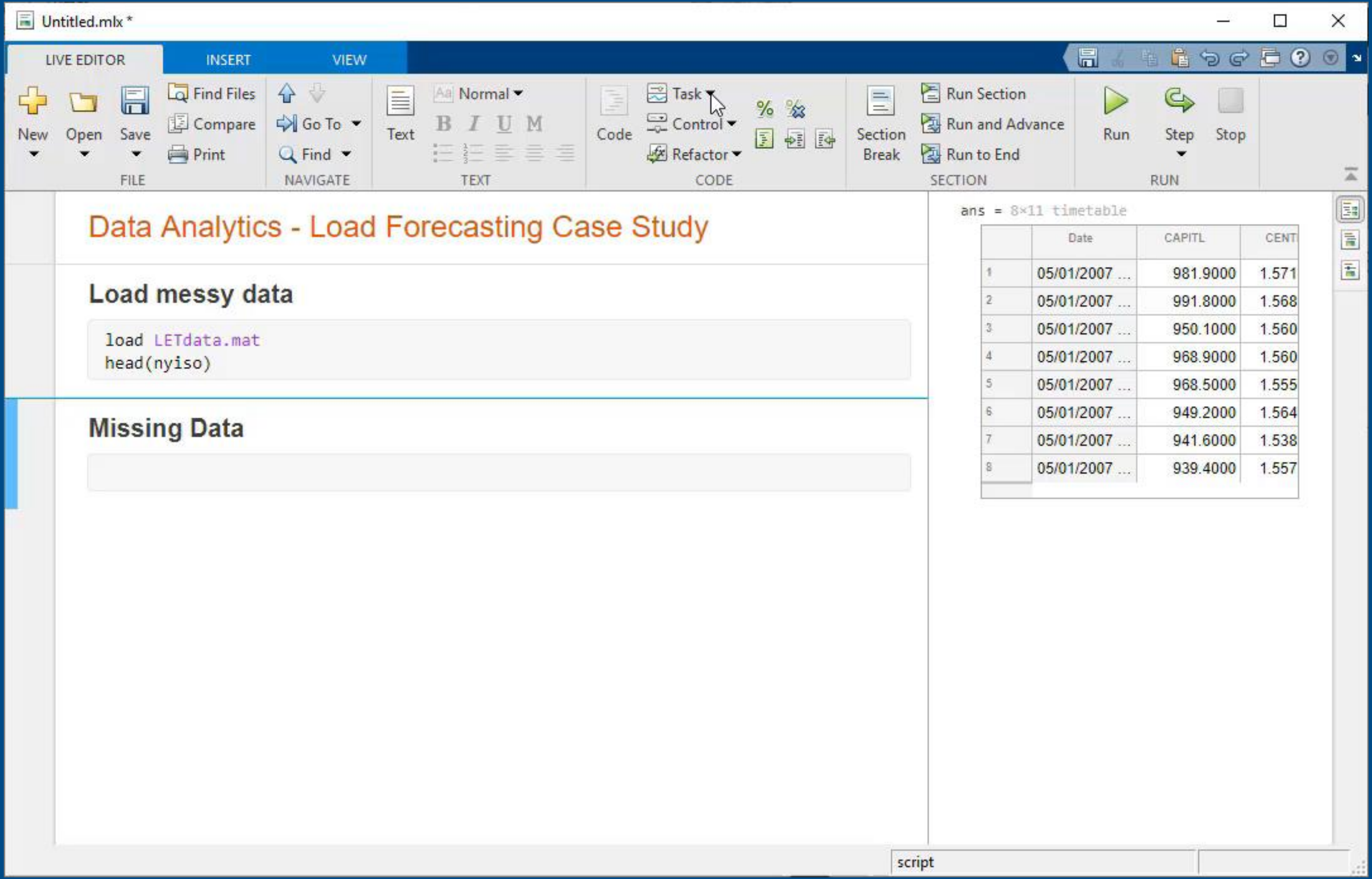
### Real-Time Sources

- Sensors/Instrumentation/Cameras
- GPS
- Communication systems
- Machines (embedded systems)
- Robot Operating System (ROS)

The above list is not all-inclusive, but is intended for guidance only

# Live Editor Tasks

Design



## Data Analytics - Load Forecasting Case Study

### Load messy data

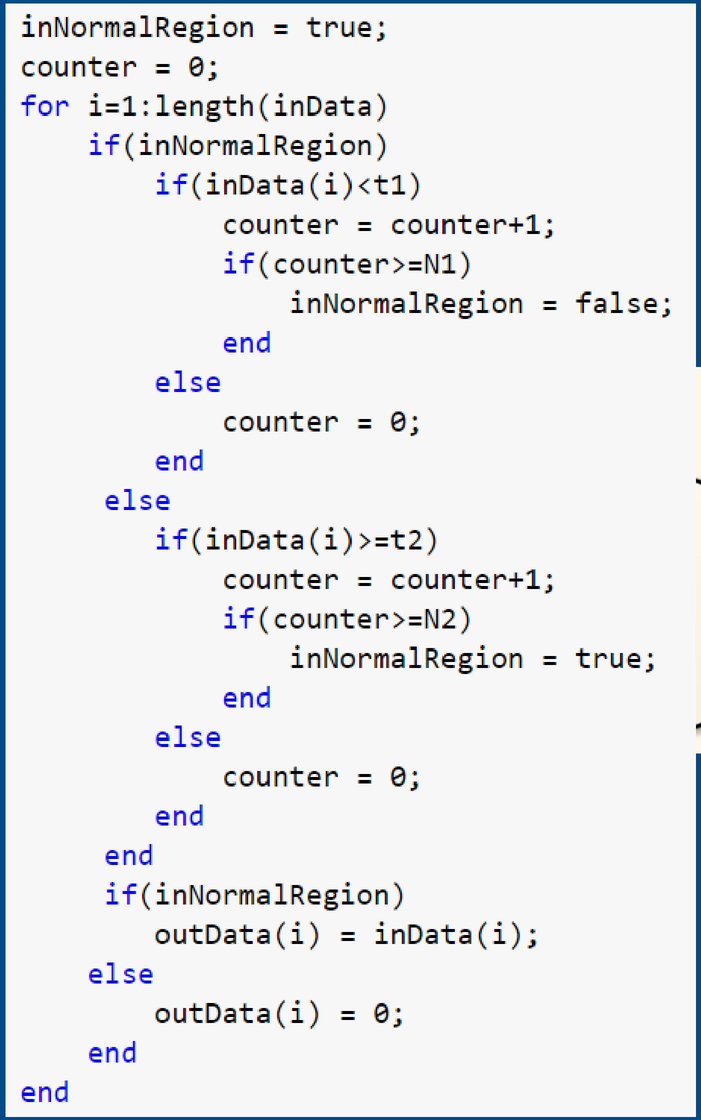
```
load LETdata.mat
head(nyiso)
```

### Missing Data

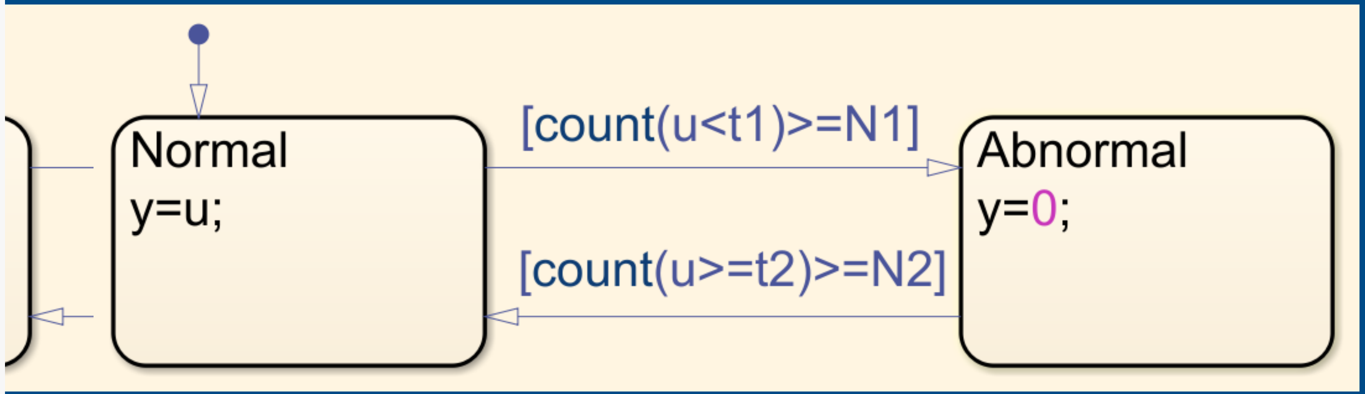
```
ans = 8×11 timetable
```

| | Date | CAPITL | CENT |
|---|---|---|---|
| 1 | 05/01/2007 ... | 981.9000 | 1.571 |
| 2 | 05/01/2007 ... | 991.8000 | 1.568 |
| 3 | 05/01/2007 ... | 950.1000 | 1.560 |
| 4 | 05/01/2007 ... | 968.9000 | 1.560 |
| 5 | 05/01/2007 ... | 968.5000 | 1.555 |
| 6 | 05/01/2007 ... | 949.2000 | 1.564 |
| 7 | 05/01/2007 ... | 941.6000 | 1.538 |
| 8 | 05/01/2007 ... | 939.4000 | 1.557 |

# Designing Decision Logic with Stateflow

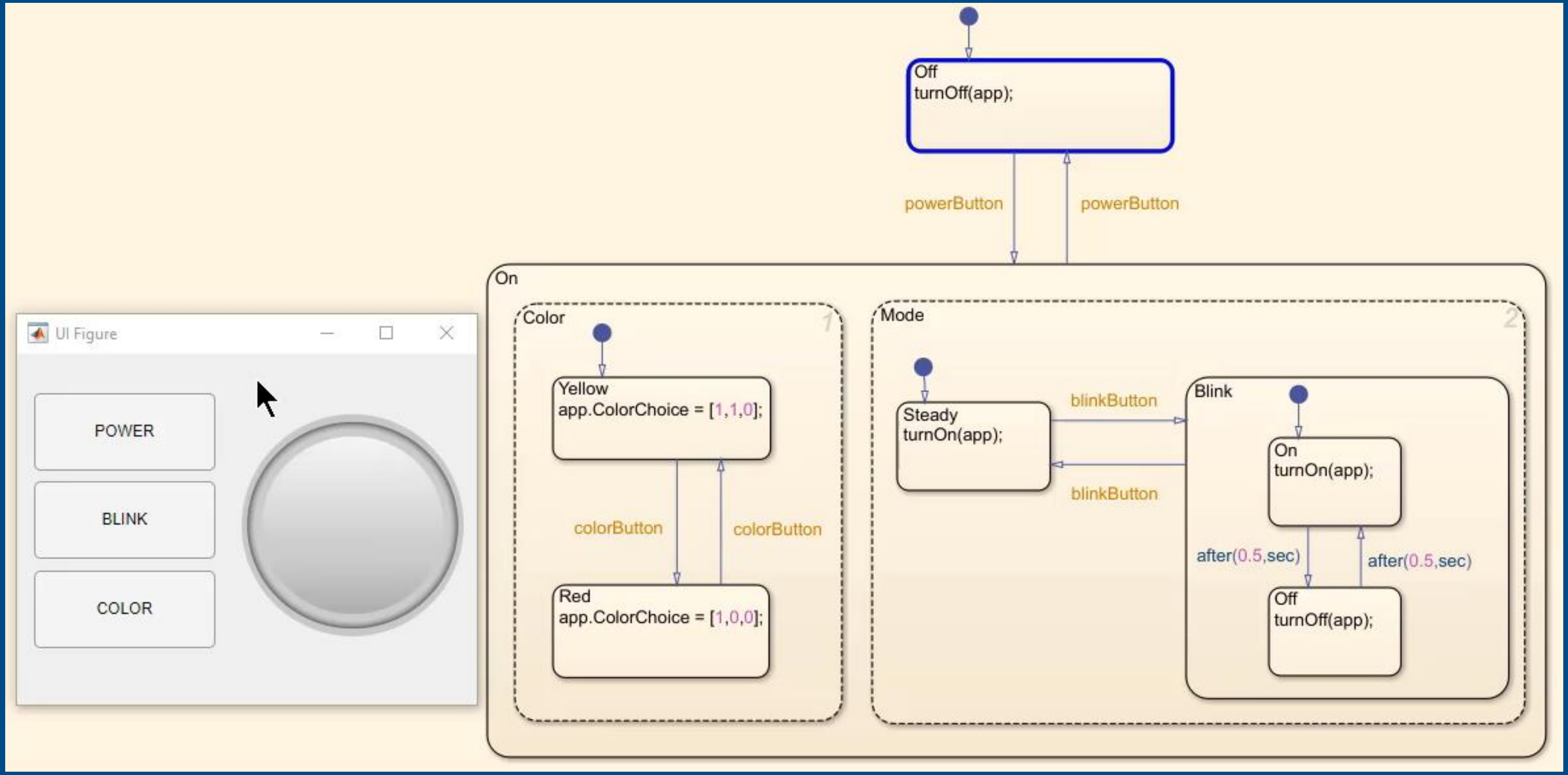


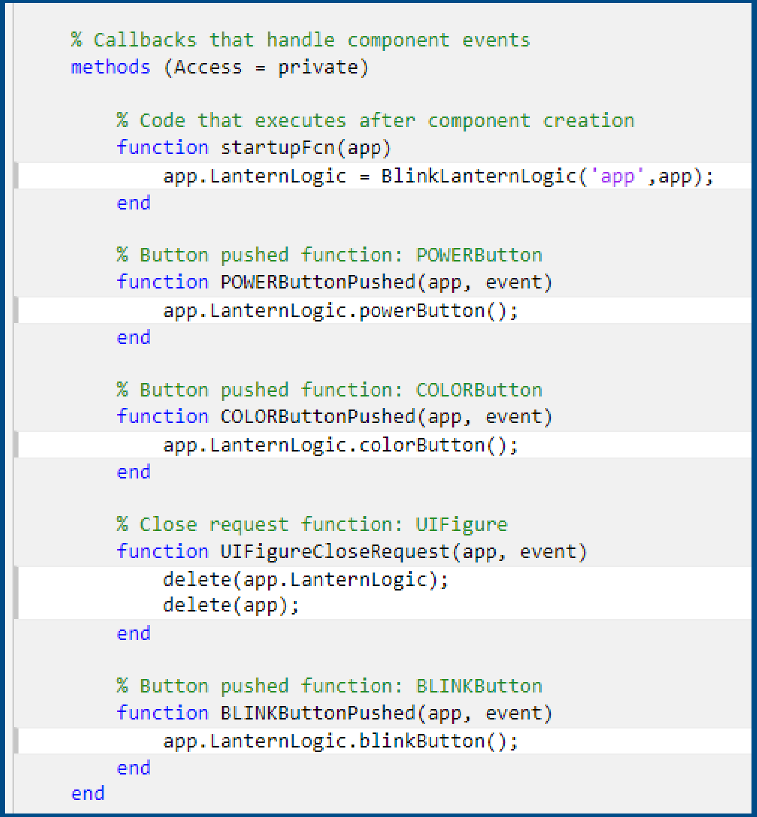
```
inNormalRegion = true;
counter = 0;
for i=1:length(inData)
    if(inNormalRegion)
        if(inData(i)<t1)
            counter = counter+1;
            if(counter>=N1)
                inNormalRegion = false;
            end
        else
            counter = 0;
        end
     else
        if(inData(i)>=t2)
            counter = counter+1;
            if(counter>=N2)
                inNormalRegion = true;
            end
        else
            counter = 0;
        end
     end
     if(inNormalRegion)
        outData(i) = inData(i);
    else
        outData(i) = 0;
    end
end
```



**Stateflow**
**MATLAB**

# Using Stateflow in MATLAB



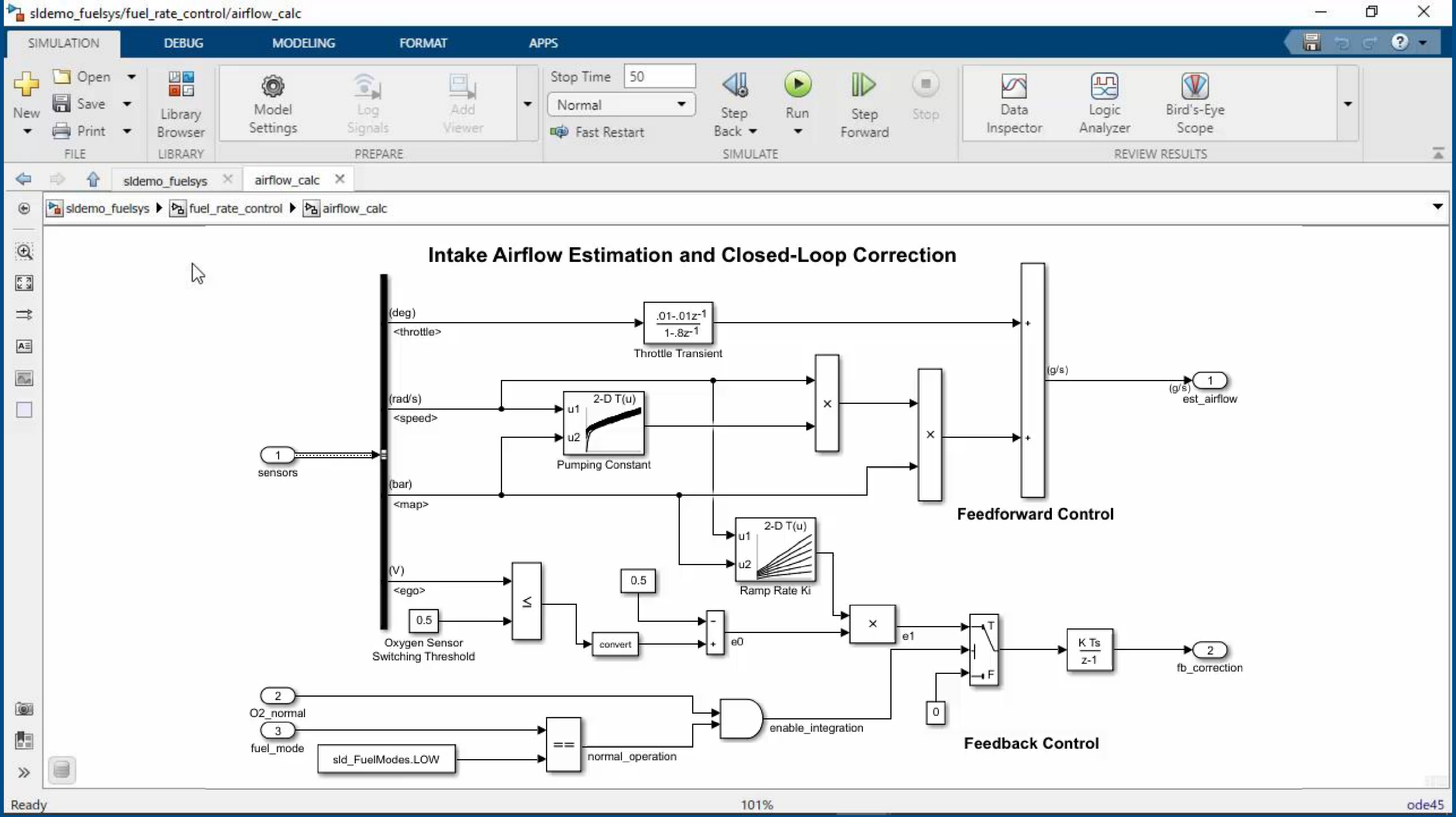


```
% Callbacks that handle component events
methods (Access = private)

    % Code that executes after component creation
    function startupFcn(app)
        app.LanternLogic = BlinkLanternLogic('app',app);
    end

    % Button pushed function: POWERButton
    function POWERButtonPushed(app, event)
        app.LanternLogic.powerButton();
    end

    % Button pushed function: COLORButton
    function COLORButtonPushed(app, event)
        app.LanternLogic.colorButton();
    end

    % Close request function: UIFigure
    function UIFigureCloseRequest(app, event)
        delete(app.LanternLogic);
        delete(app);
    end

    % Button pushed function: BLINKButton
    function BLINKButtonPushed(app, event)
        app.LanternLogic.blinkButton();
    end
end
```

**Stateflow**
**MATLAB**

# Editing at the Speed of Thought

Design

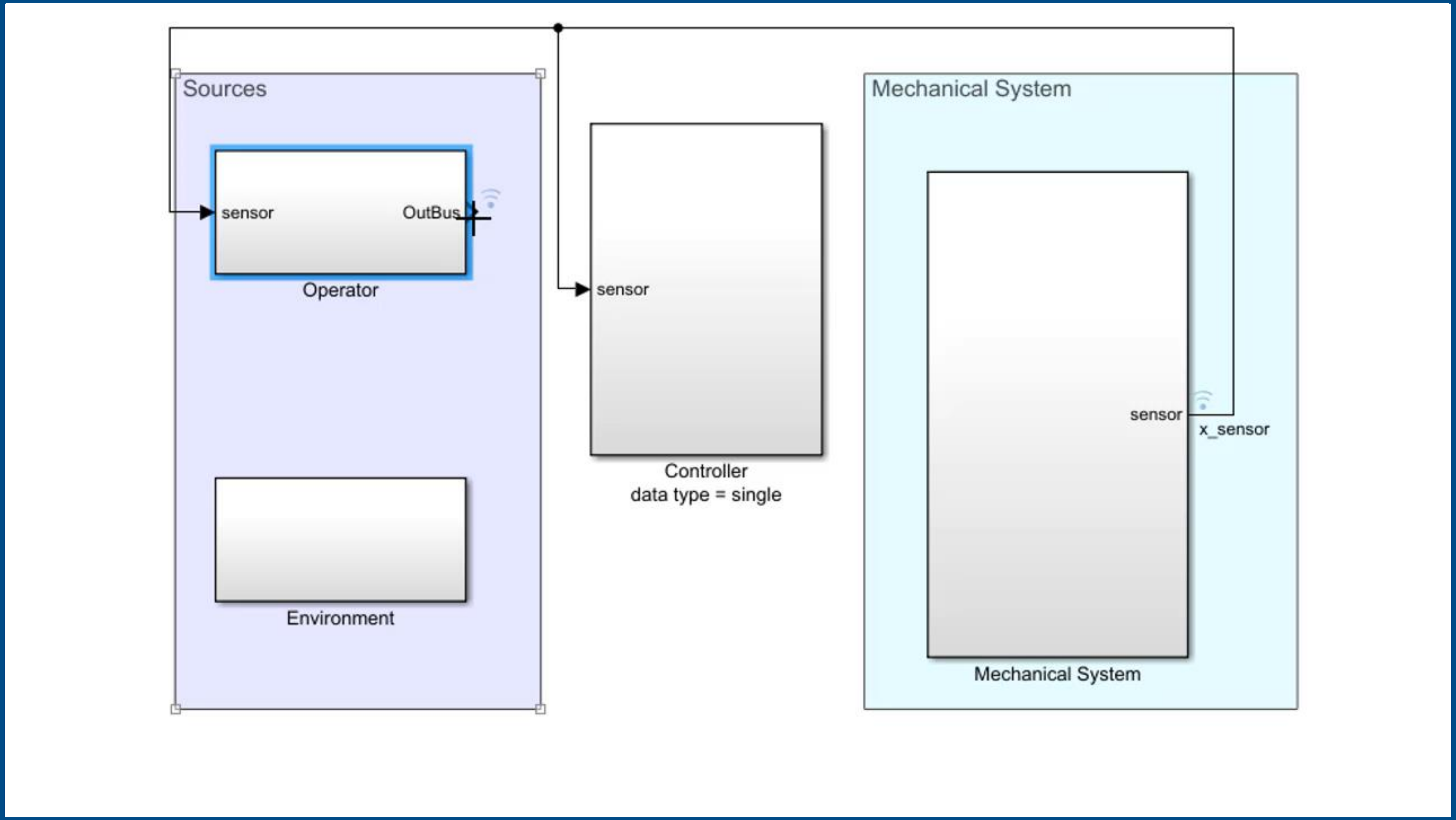


Simulink

# Editing at the Speed of Thought

Design

- Automatic Port Creation
- Edit on Block Icon
- Block Parameter Autocomplete
- Predictive Quick Insert

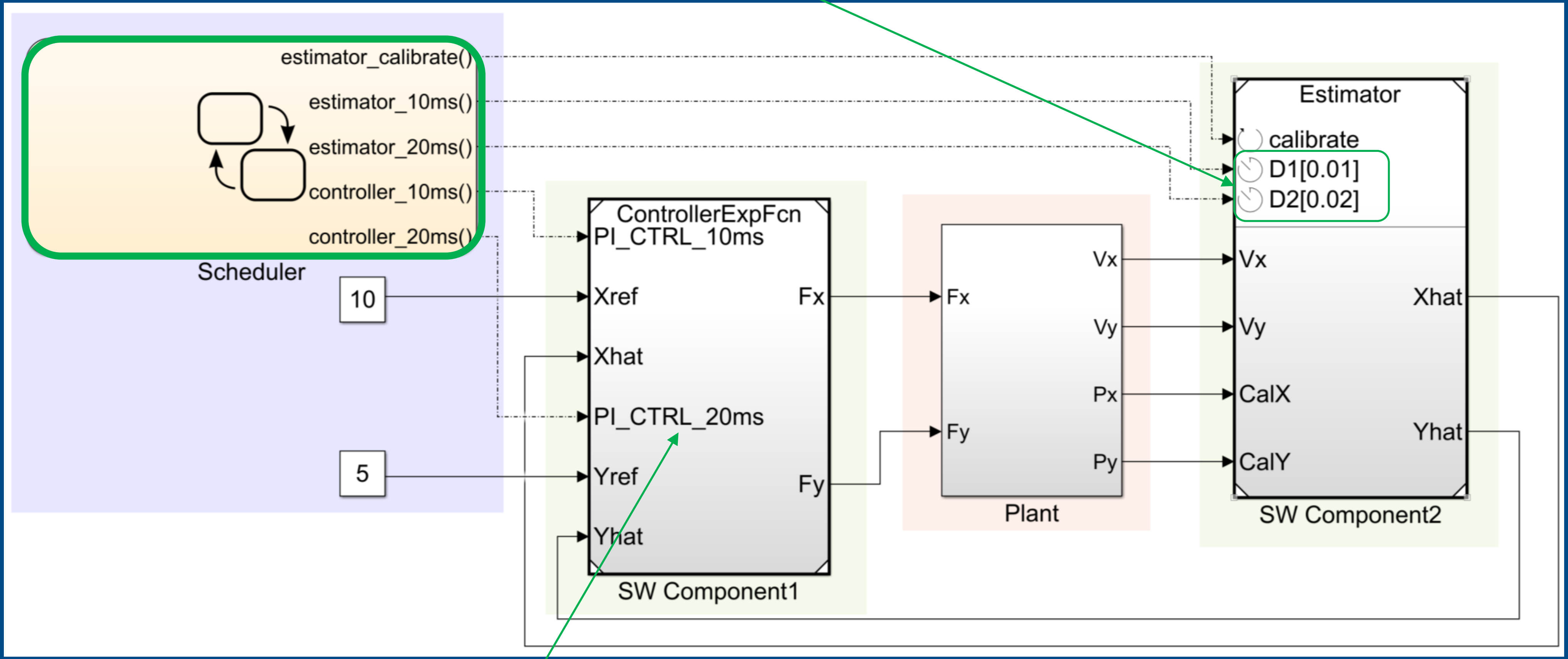


Simulink

# Controlling the Execution of Model Components

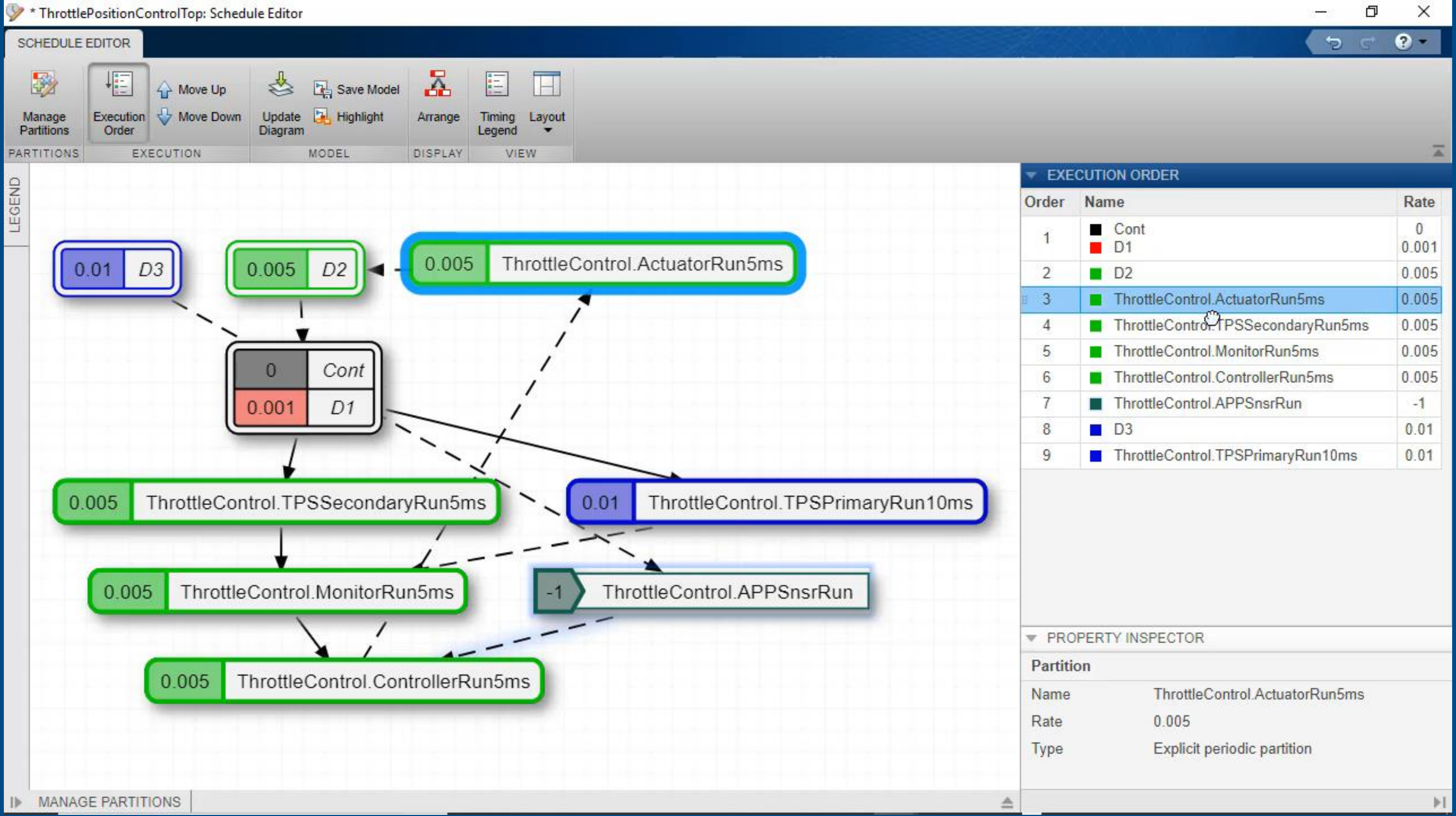
Design

Schedulable Rate-Based Model



Export Function Model

# Controlling the Execution of Model Components



* ThrottlePositionControlTop: Schedule Editor
SCHEDULE EDITOR
Manage Partitions
Execution Order
Move Up
Move Down
Update Diagram
Save Model
Highlight
Arrange
Timing Legend
Layout
PARTITIONS
EXECUTION
MODEL
DISPLAY
VIEW
LEGEND
0.01 D3
0.005 D2
0.005 ThrottleControl.ActuatorRun5ms
0 Cont
0.001 D1
0.005 ThrottleControl.TPSSecondaryRun5ms
0.01 ThrottleControl.TPSPrimaryRun10ms
0.005 ThrottleControl.MonitorRun5ms
-1 ThrottleControl.APPSnsrRun
0.005 ThrottleControl.ControllerRun5ms
MANAGE PARTITIONS

EXECUTION ORDER

| Order | Name | Rate |
|---|---|---|
| 1 | ⬛ Cont<br>🟥 D1 | 0<br>0.001 |
| 2 | 🟩 D2 | 0.005 |
| 3 | 🟩 ThrottleControl.ActuatorRun5ms | 0.005 |
| 4 | 🟩 ThrottleControl.TPSSecondaryRun5ms | 0.005 |
| 5 | 🟩 ThrottleControl.MonitorRun5ms | 0.005 |
| 6 | 🟩 ThrottleControl.ControllerRun5ms | 0.005 |
| 7 | ⬛ ThrottleControl.APPSnsrRun | -1 |
| 8 | 🟦 D3 | 0.01 |
| 9 | 🟦 ThrottleControl.TPSPrimaryRun10ms | 0.01 |

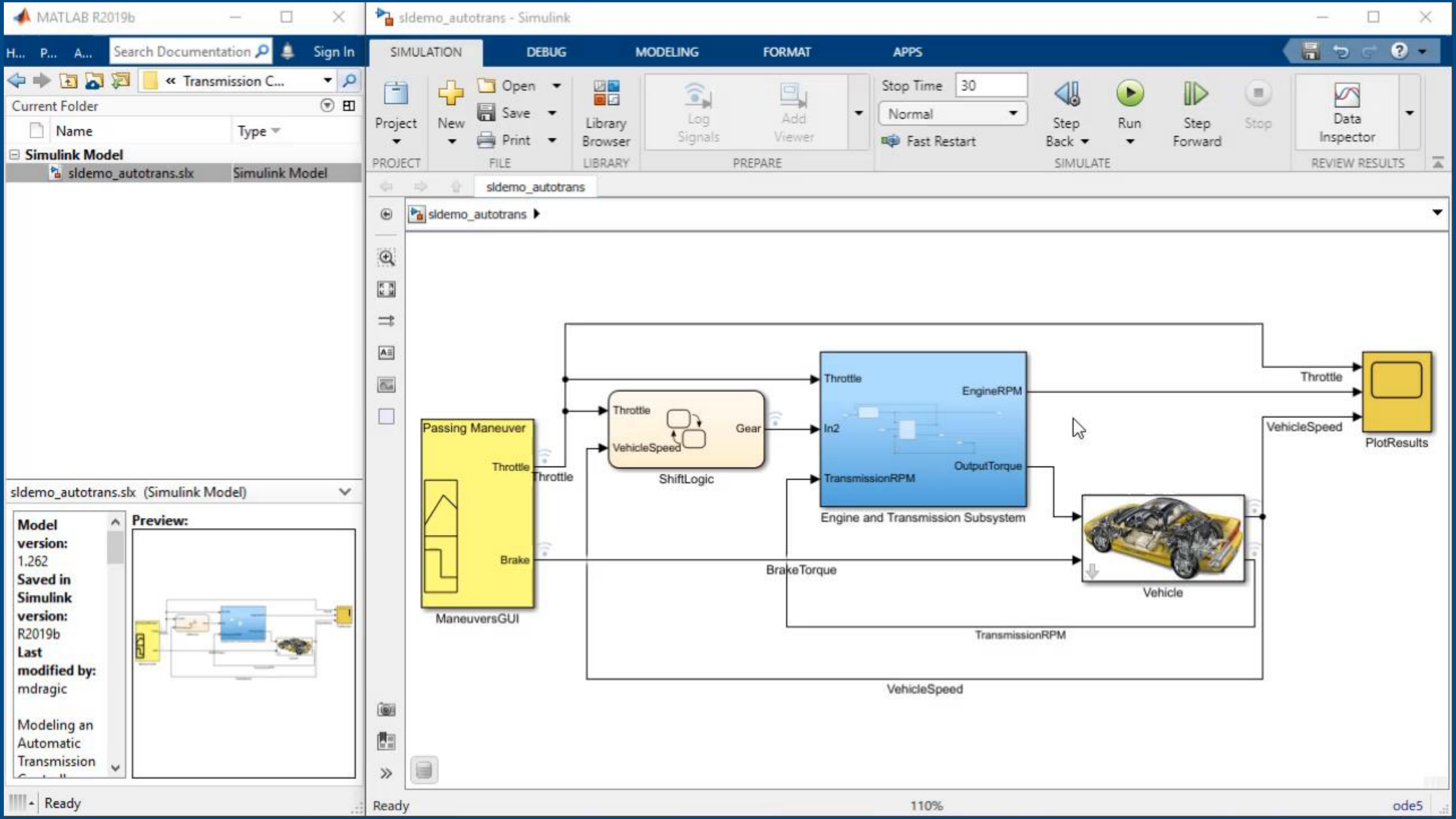
PROPERTY INSPECTOR

Partition

| | |
|---|---|
| Name | ThrottleControl.ActuatorRun5ms |
| Rate | 0.005 |
| Type | Explicit periodic partition |

Simulink

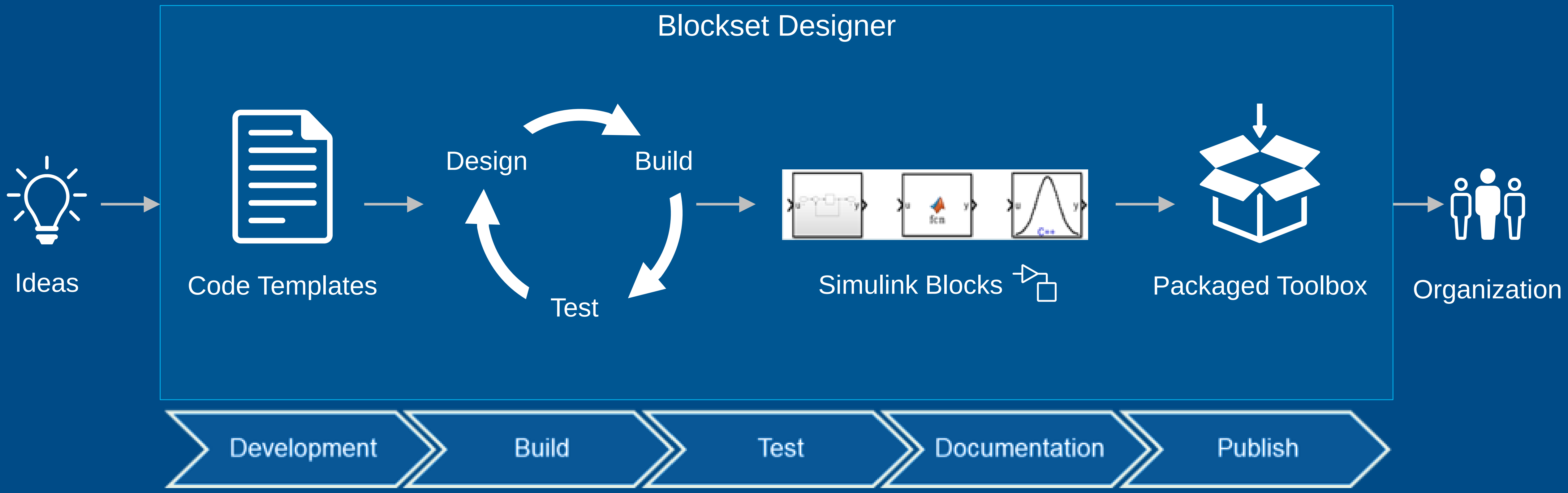
# More Ways to Componentize Your Design



Simulink

# Simplifying Blockset Creation and Sharing

Output



Blockset Designer

Ideas

Code Templates

Design

Build

Test

Simulink Blocks

Packaged Toolbox

Organization

Development

Build

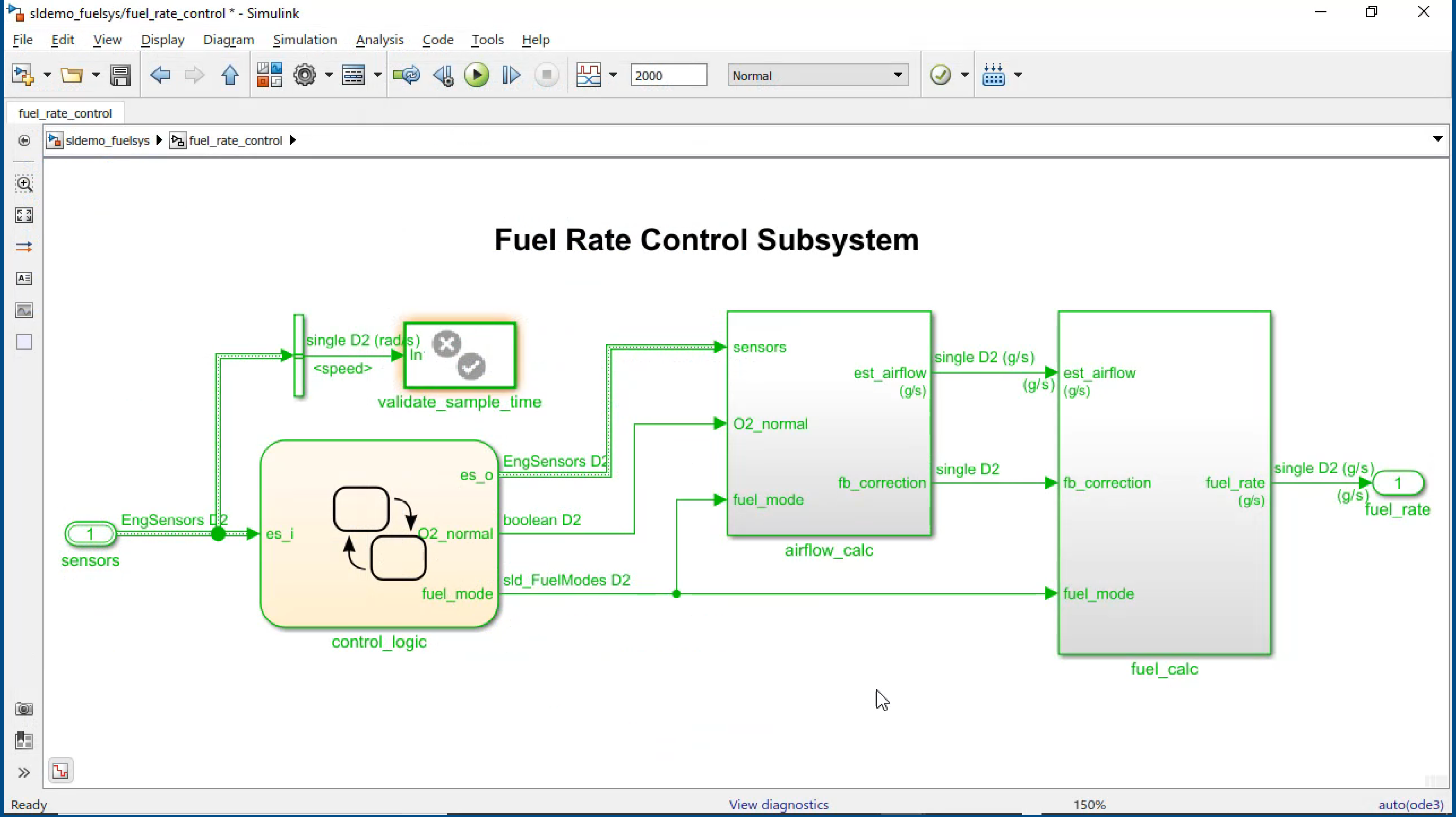
Test

Documentation

Publish

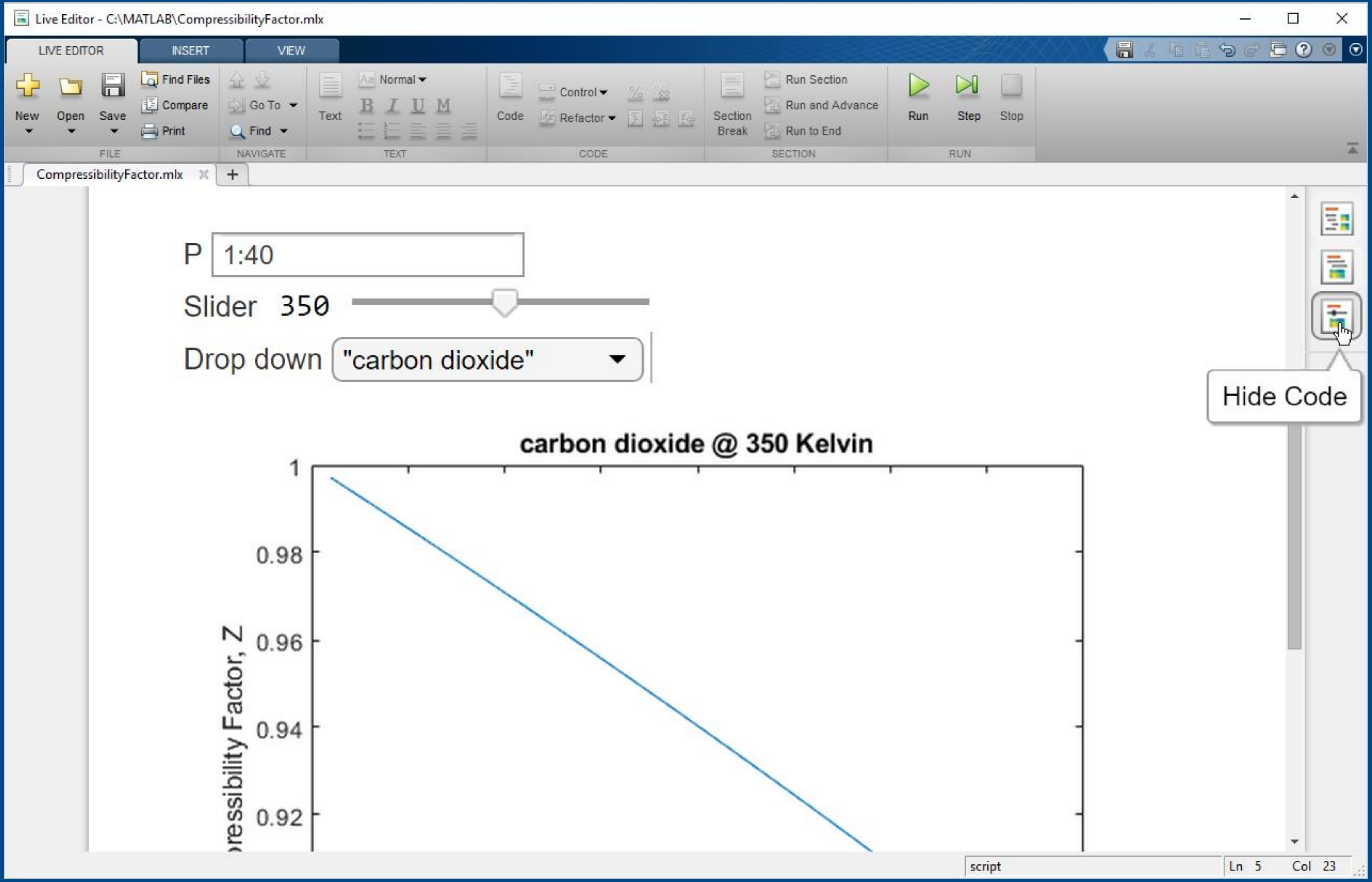
# Viewing Generated Code Alongside the Model

Output



Embedded Coder

# Sharing Live Scripts



P 1:40

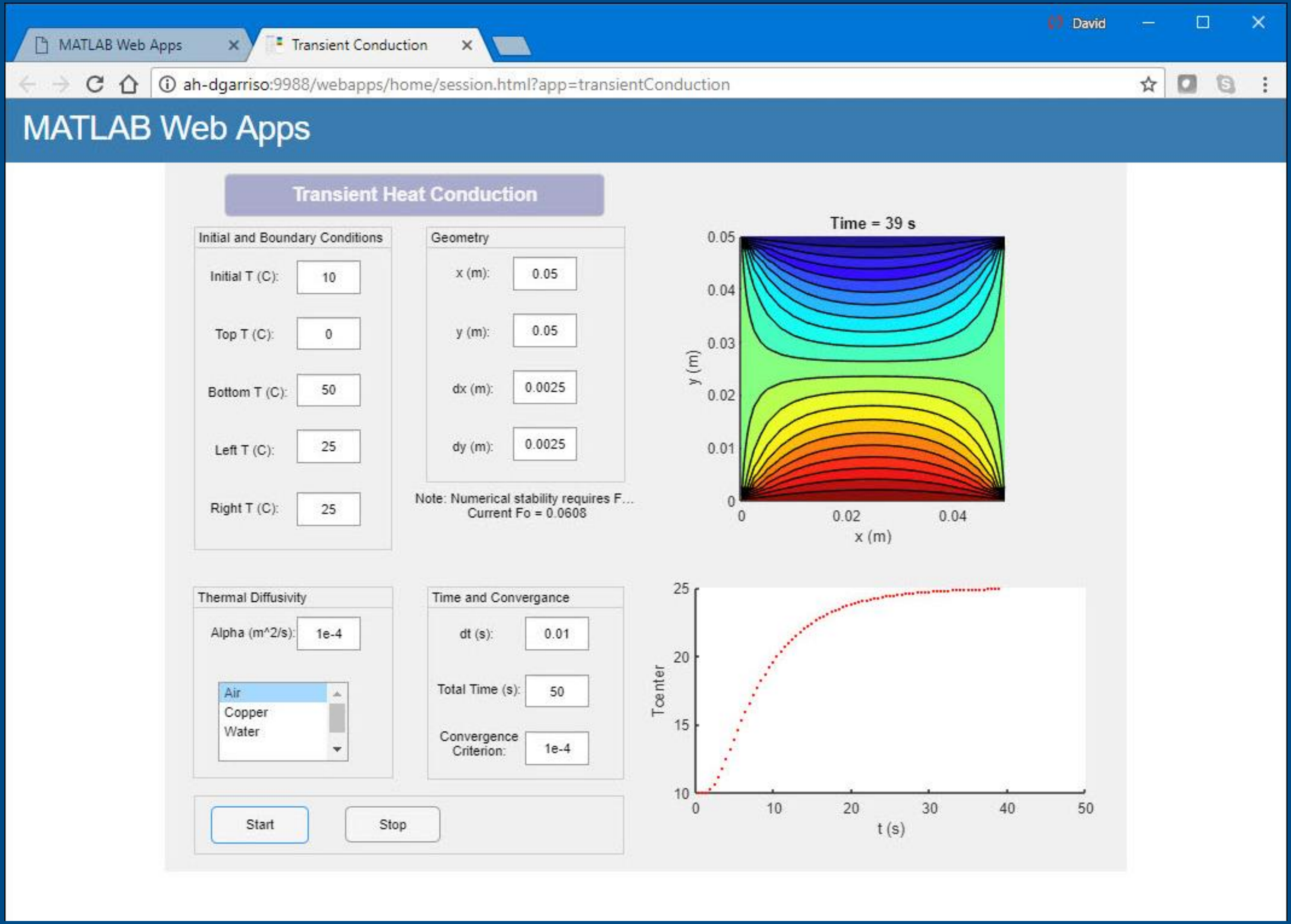
Slider 350

Drop down "carbon dioxide"

Output

Output

# Deploying Web Apps



MATLAB Web Apps

Transient Heat Conduction

Initial and Boundary Conditions

Initial T (C): 10

Top T (C): 0

Bottom T (C): 50

Left T (C): 25

Right T (C): 25

Geometry

x (m): 0.05

y (m): 0.05

dx (m): 0.0025

dy (m): 0.0025

Note: Numerical stability requires F...
Current Fo = 0.0608

Thermal Diffusivity

Alpha (m^2/s): 1e-4

Air
Copper
Water

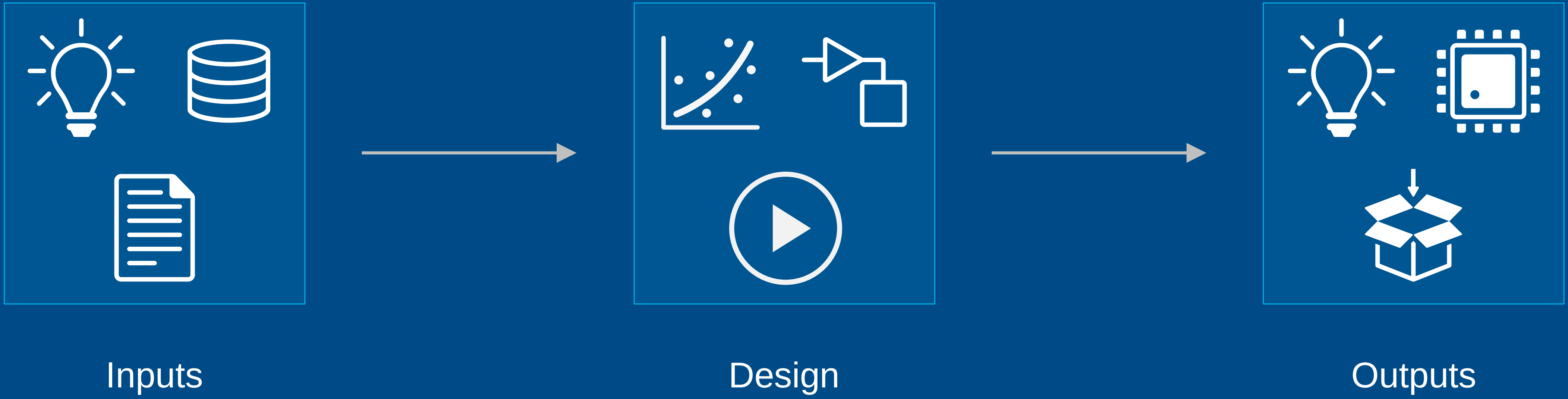
Time and Convergance

dt (s): 0.01

Total Time (s): 50

Convergence Criterion: 1e-4

# Using MATLAB & Simulink to Build Algorithms in Everything



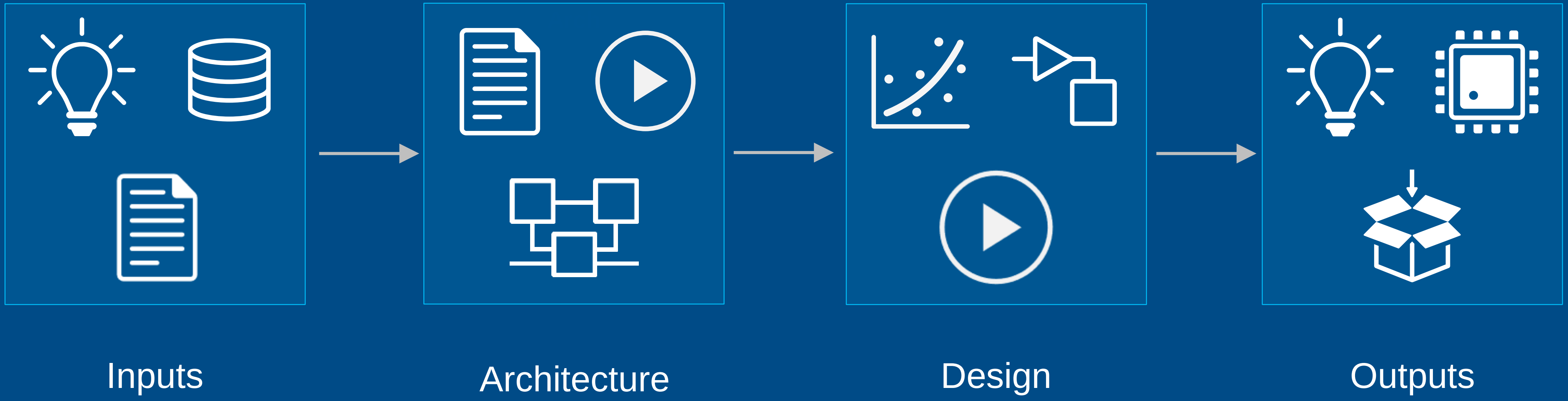
Inputs

Design

Outputs

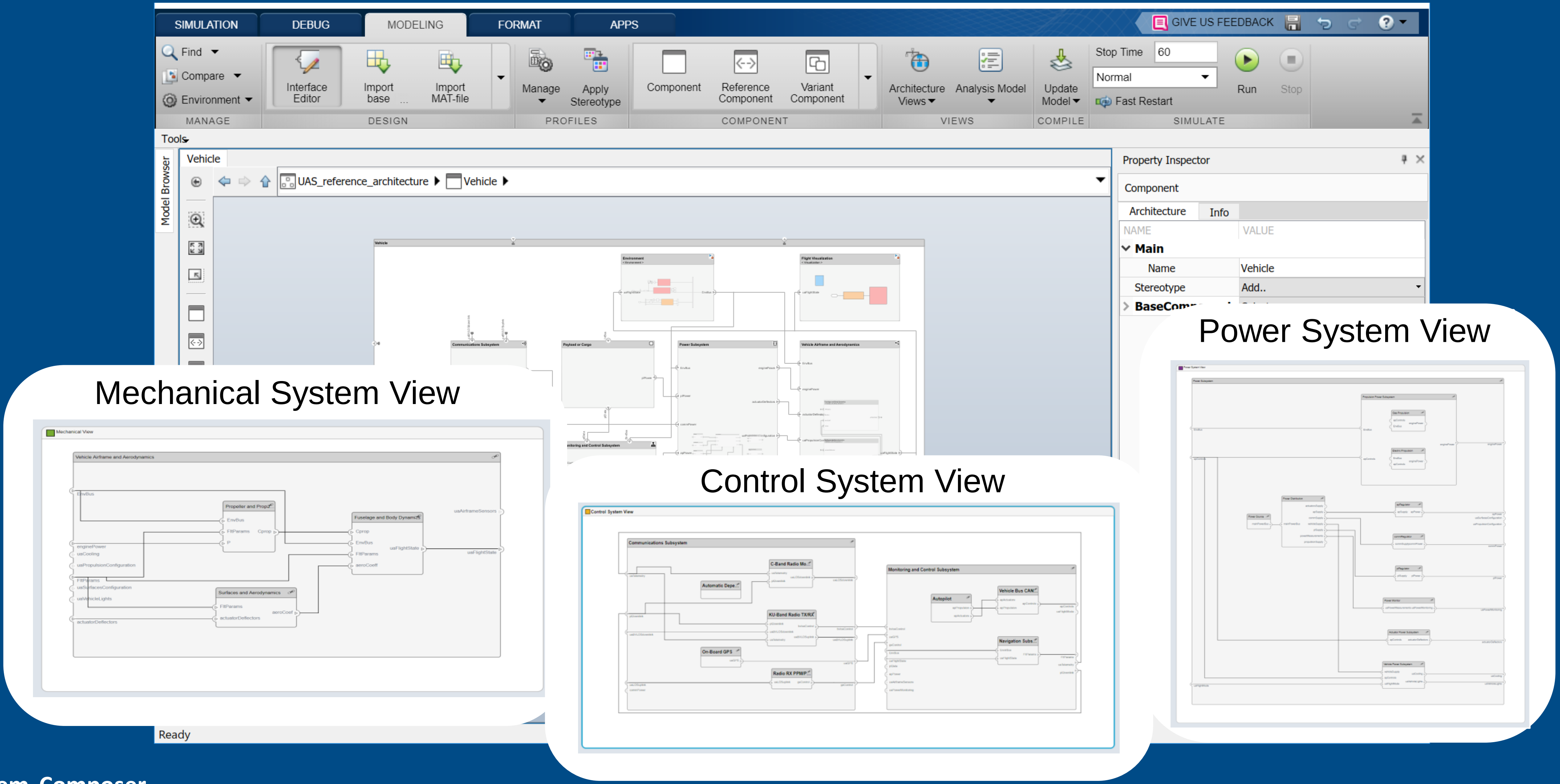
MATLAB®&SIMULINK®

# Evaluating Architectures



MATLAB & SIMULINK

# Designing System and Software Architectures



Stop Time: 60
Normal

| Name | Vehicle |
|---|---|
| Stereotype | Add.. |

Mechanical System View

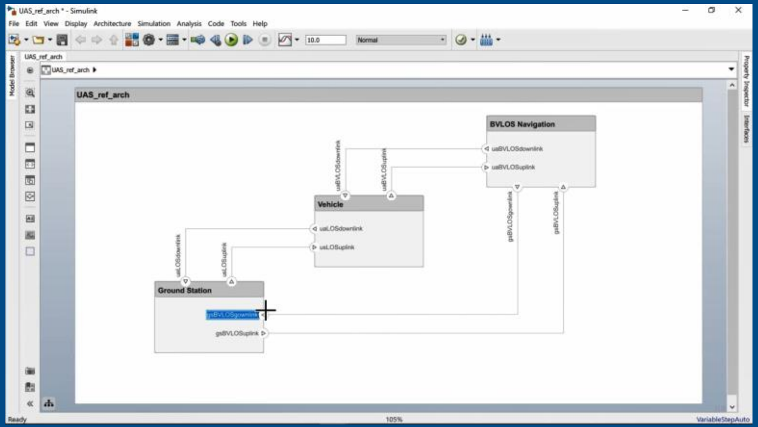
Control System View

Power System View

# Designing Beyond System and Software Architectures

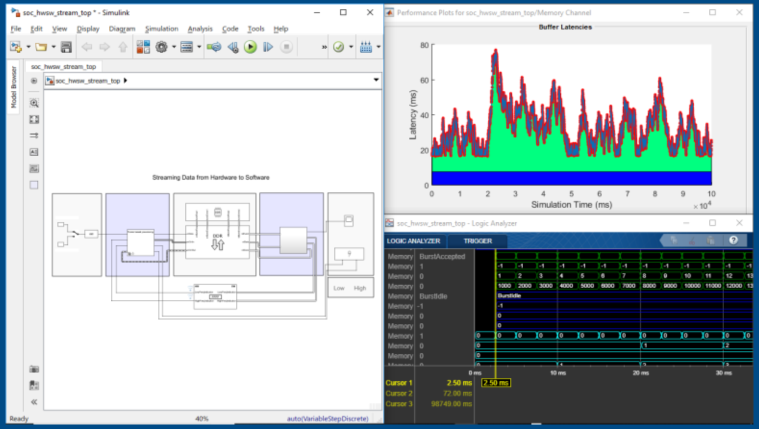
Arch

## Systems and Software



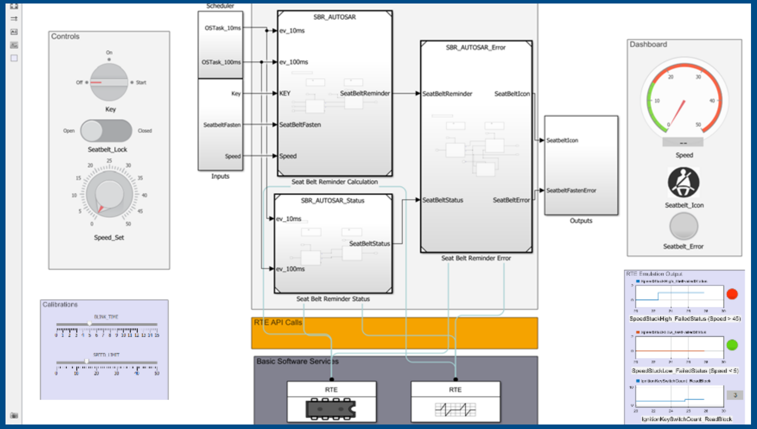
System Composer

## SoC Hardware and Software


soc_hwsw_stream_top * - Simulink
Streaming Data from Hardware to Software
Buffer Latencies
Latency (ms)
Simulation Time (ms)
LOGIC ANALYZER
TRIGGER

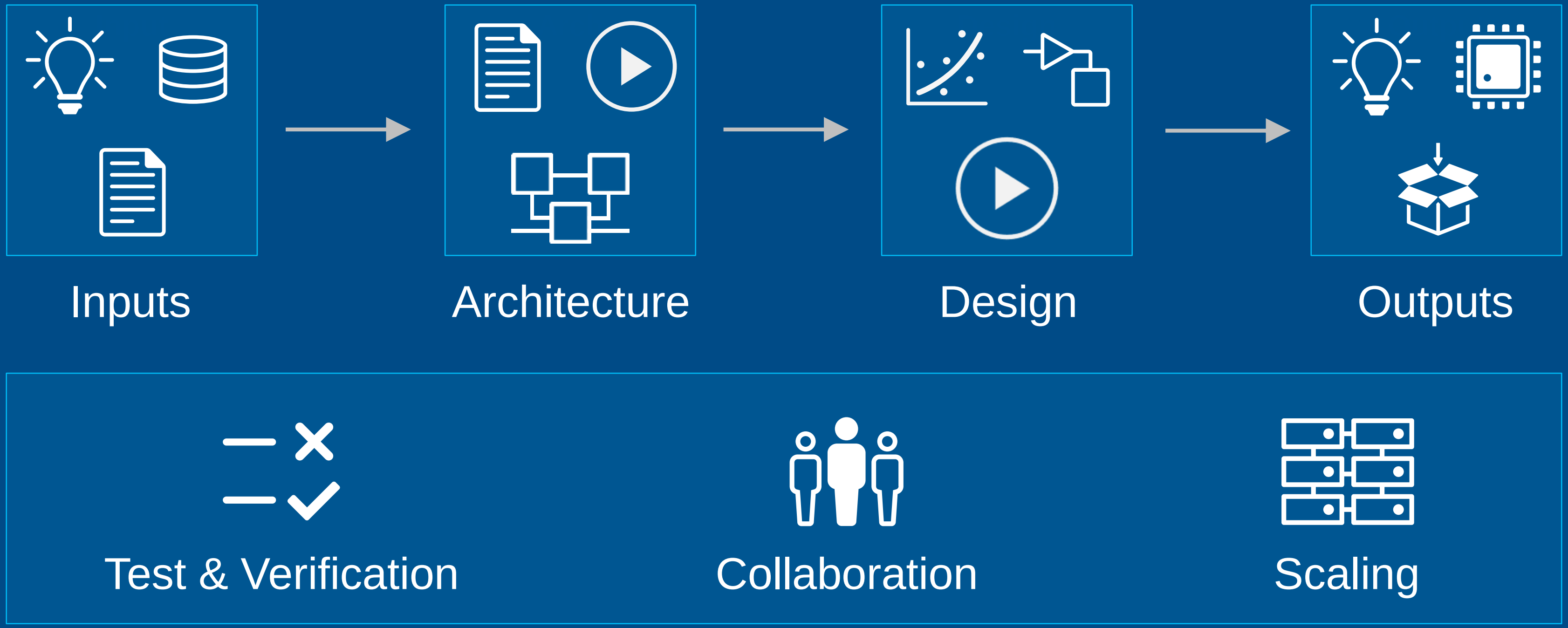
SoC Blockset

## AUTOSAR Software



AUTOSAR Blockset

# Using MATLAB & Simulink to Build Algorithms in Everything



Inputs

Architecture

Design

Outputs

Test & Verification

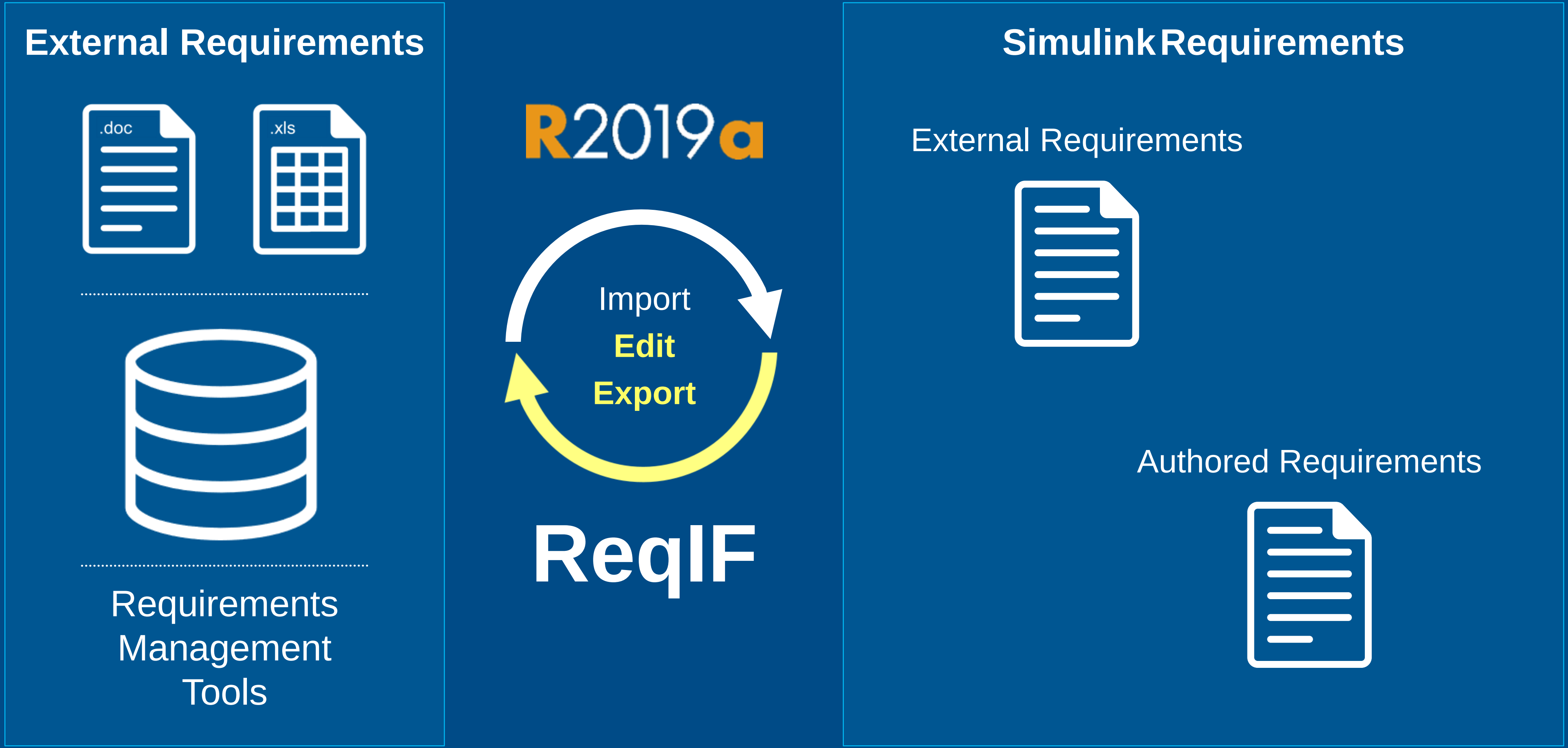
Collaboration

Scaling

MATLAB®&SIMULINK®

# Integrating with Third-party Requirements Tools

Test & Verification



## External Requirements

Requirements Management Tools

R2019a

Import
Edit
Export

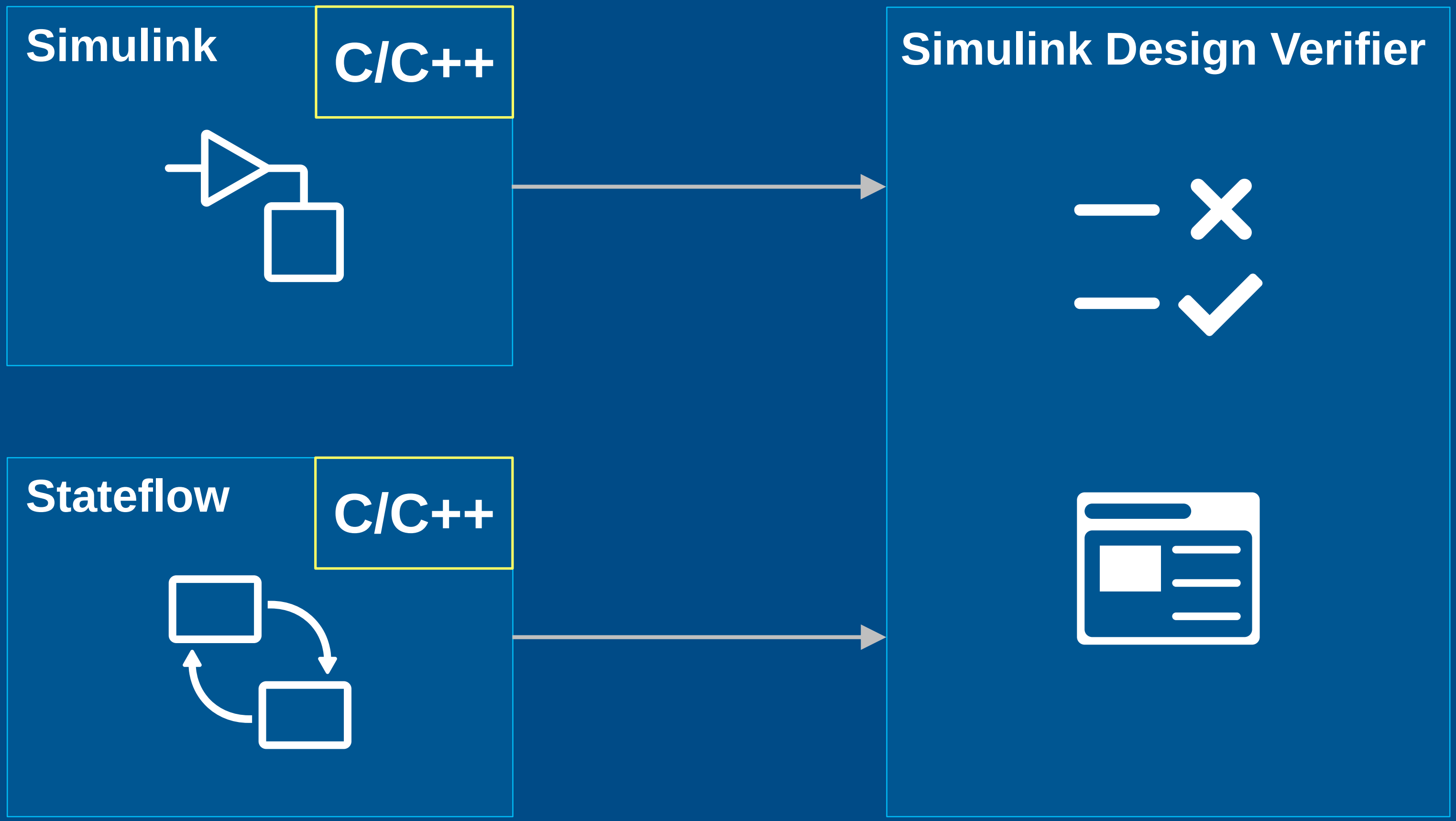
ReqIF

## Simulink Requirements

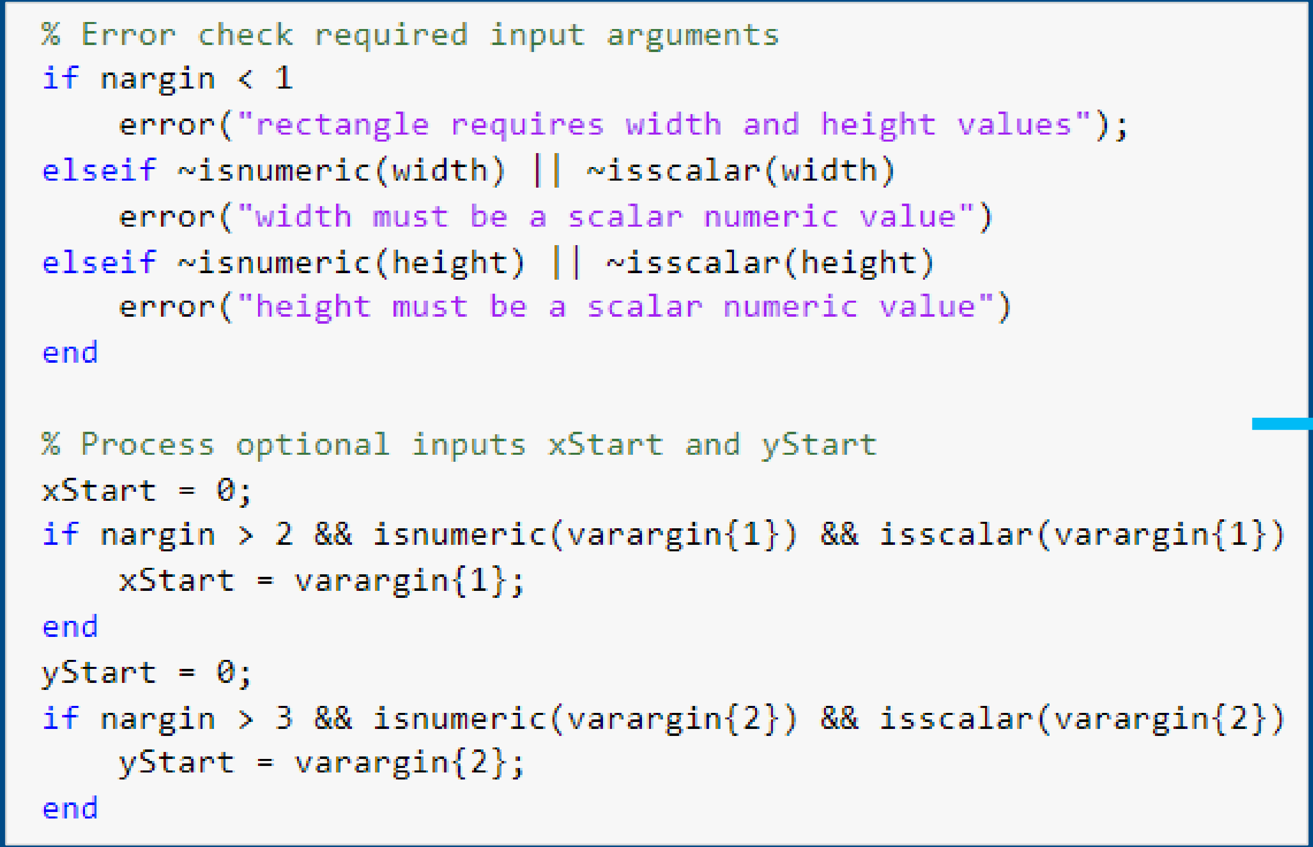
External Requirements

Authored Requirements

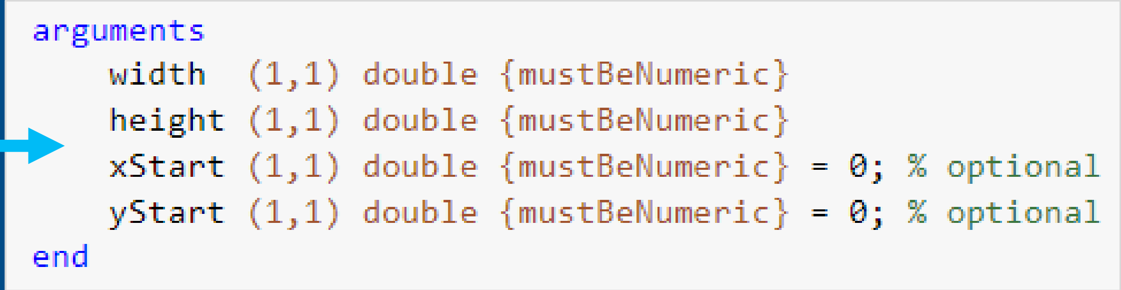
# Include Custom Code in Test & Verification



# Validating Function Arguments



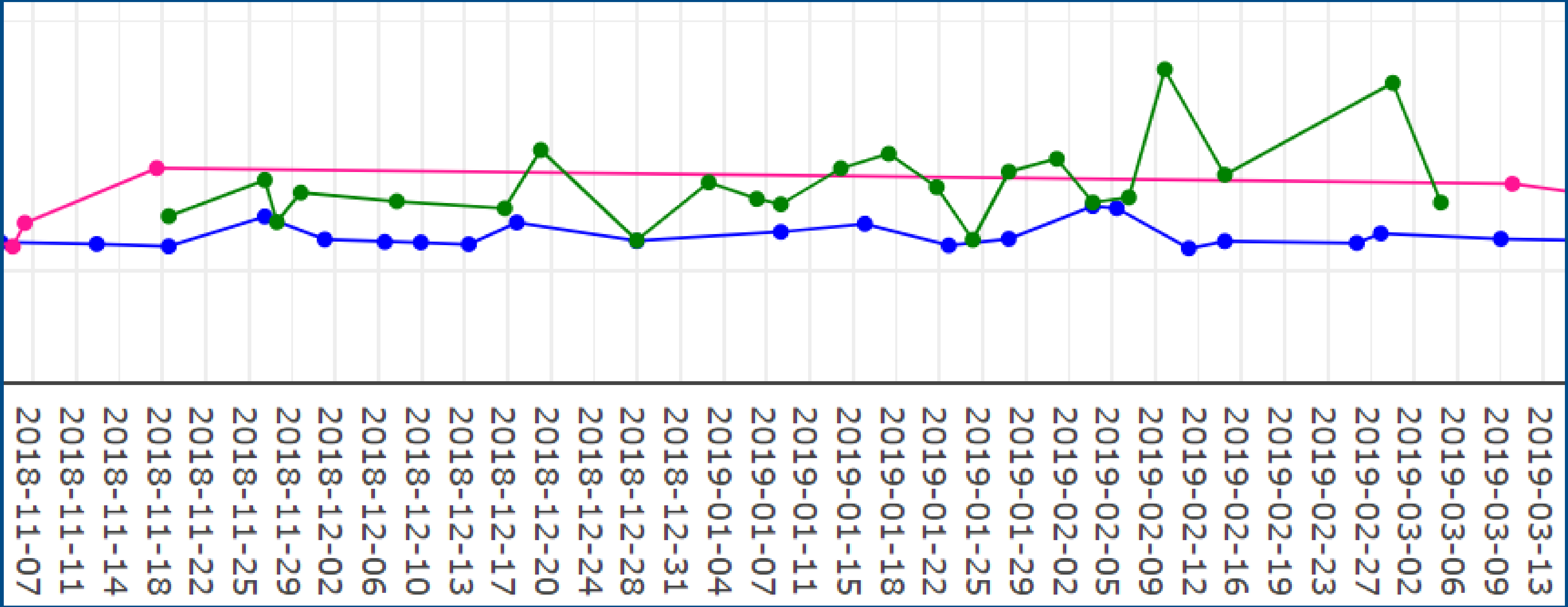
```
% Error check required input arguments
if nargin < 1
    error("rectangle requires width and height values");
elseif ~isnumeric(width) || ~isscalar(width)
    error("width must be a scalar numeric value")
elseif ~isnumeric(height) || ~isscalar(height)
    error("height must be a scalar numeric value")
end

% Process optional inputs xStart and yStart
xStart = 0;
if nargin > 2 && isnumeric(varargin{1}) && isscalar(varargin{1})
    xStart = varargin{1};
end
yStart = 0;
if nargin > 3 && isnumeric(varargin{2}) && isscalar(varargin{2})
    yStart = varargin{2};
end
```



```
arguments
    width  (1,1) double {mustBeNumeric}
    height (1,1) double {mustBeNumeric}
    xStart (1,1) double {mustBeNumeric} = 0; % optional
    yStart (1,1) double {mustBeNumeric} = 0; % optional
end
```

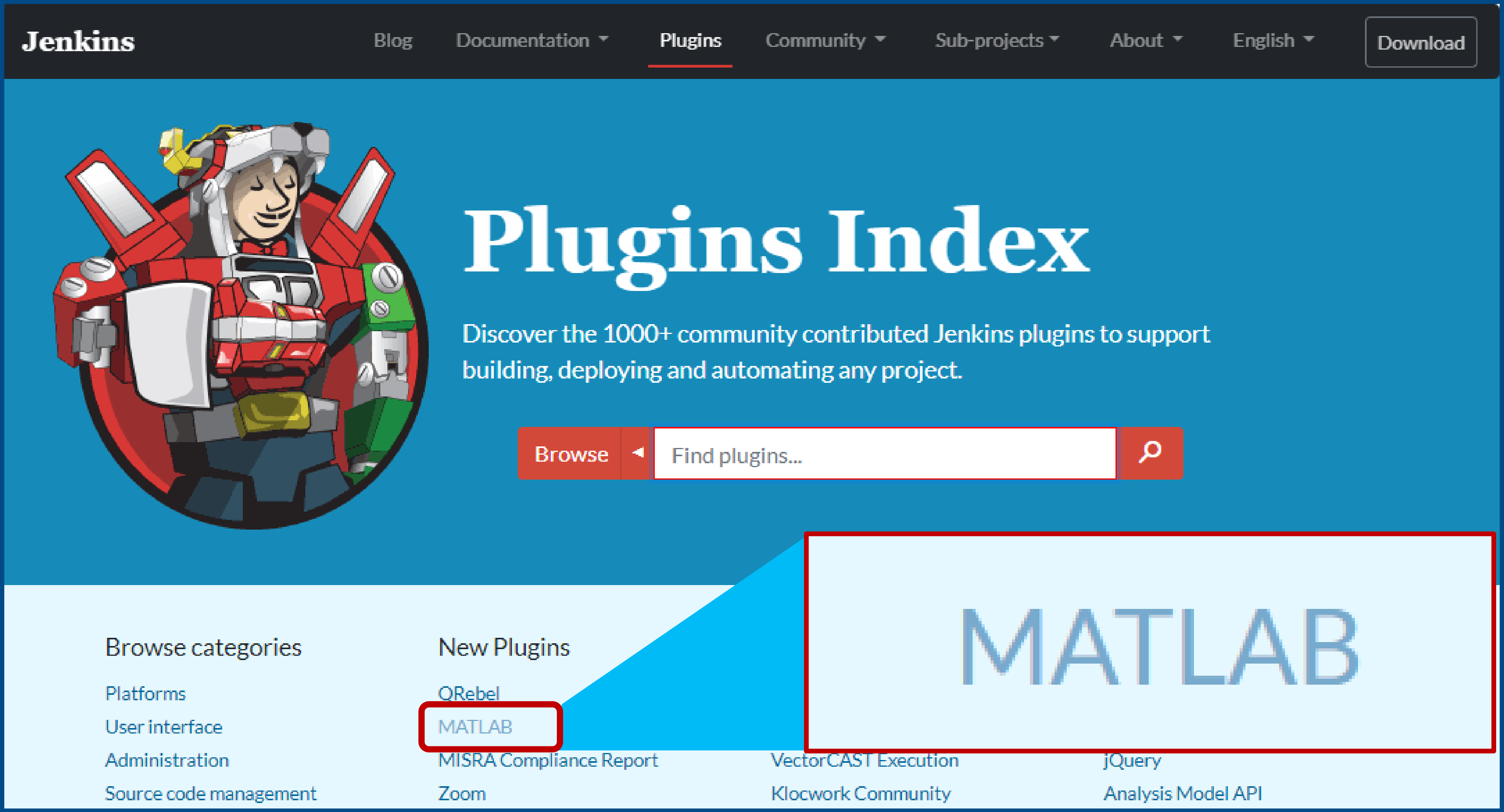
# Using the MATLAB Performance Testing Framework

Test & Verification



# Using Continuous Integration

Test & Verification



## Plugins Index

Discover the 1000+ community contributed Jenkins plugins to support building, deploying and automating any project.

### Browse categories

- Platforms
- User interface
- Administration
- Source code management

### New Plugins

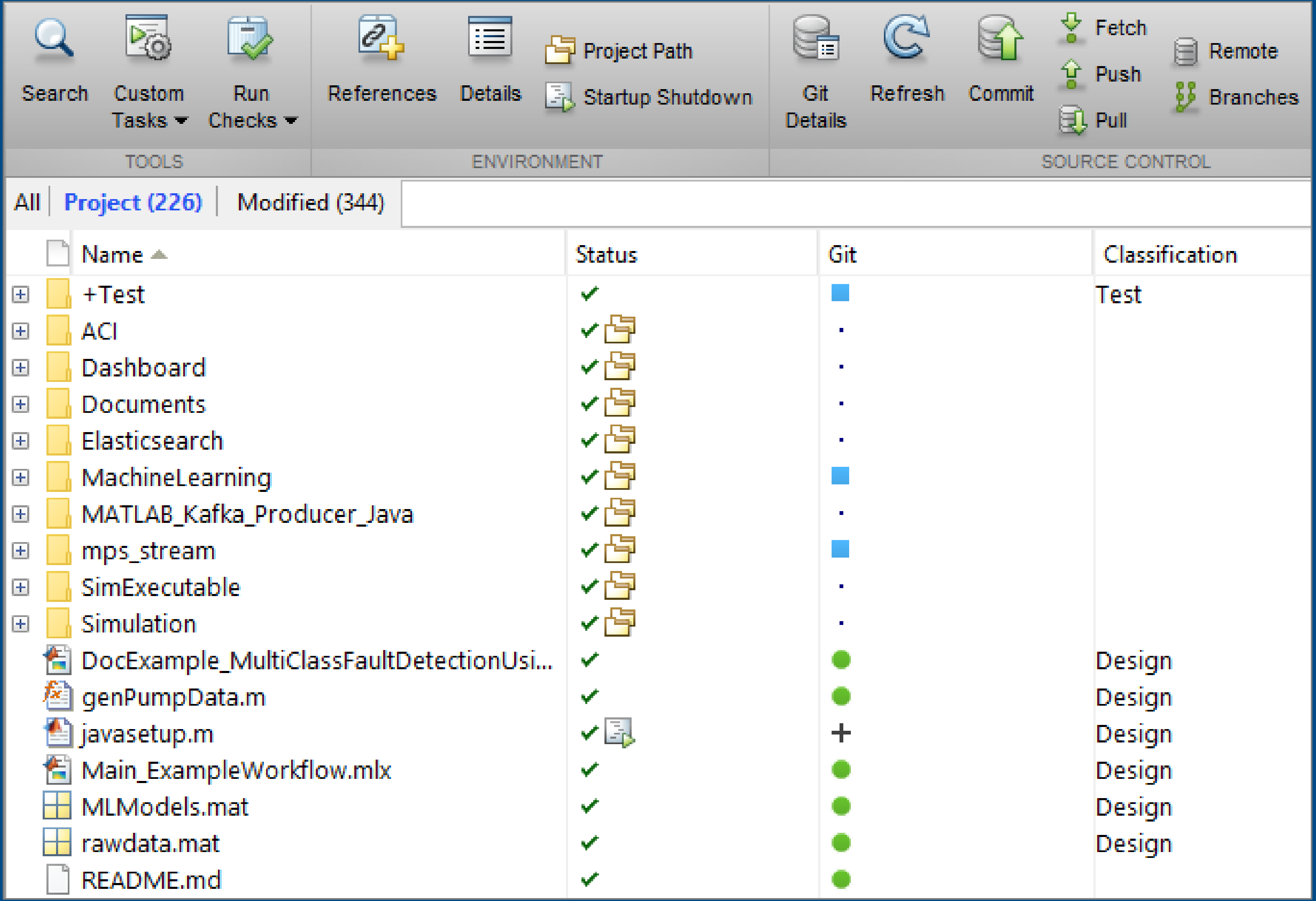
- QRebel
- MATLAB
- MISRA Compliance Report
- Zoom
- VectorCAST Execution
- Klocwork Community
- jQuery
- Analysis Model API

https://plugins.jenkins.io/

MathWorks

# Using Projects in MATLAB

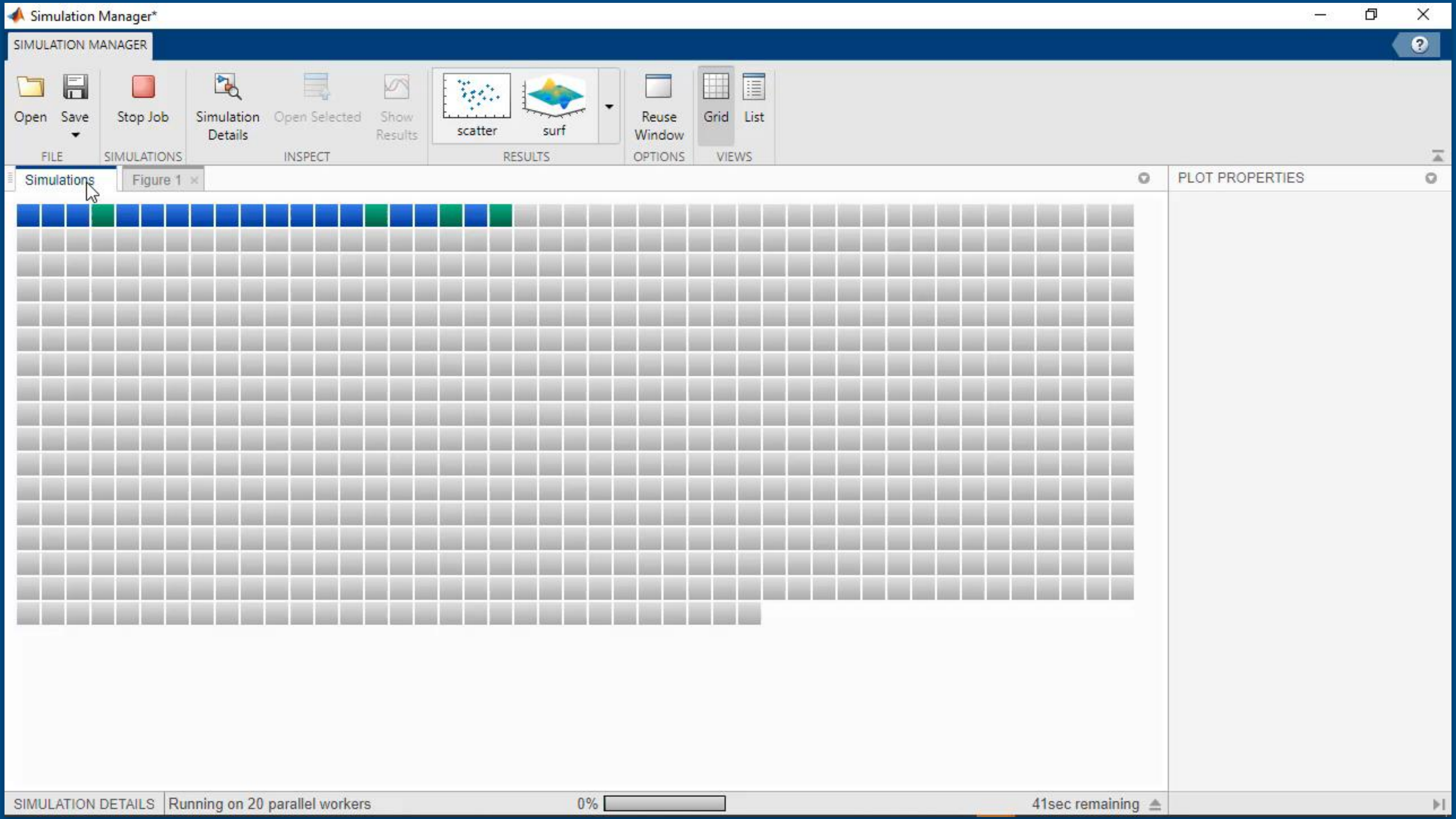
Collaboration



| Name | Status | Git | Classification |
|---|---|---|---|
| +Test | ✓ | ■ | Test |
| ACI | ✓ | · | |
| Dashboard | ✓ | · | |
| Documents | ✓ | · | |
| Elasticsearch | ✓ | · | |
| MachineLearning | ✓ | ■ | |
| MATLAB_Kafka_Producer_Java | ✓ | · | |
| mps_stream | ✓ | ■ | |
| SimExecutable | ✓ | · | |
| Simulation | ✓ | · | |
| DocExample_MultiClassFaultDetectionUsi... | ✓ | ● | Design |
| genPumpData.m | ✓ | ● | Design |
| javasetup.m | ✓ | + | Design |
| Main_ExampleWorkflow.mlx | ✓ | ● | Design |
| MLModels.mat | ✓ | ● | Design |
| rawdata.mat | ✓ | ● | Design |
| README.md | ✓ | ● | |

# Parallel Simulations in Simulink

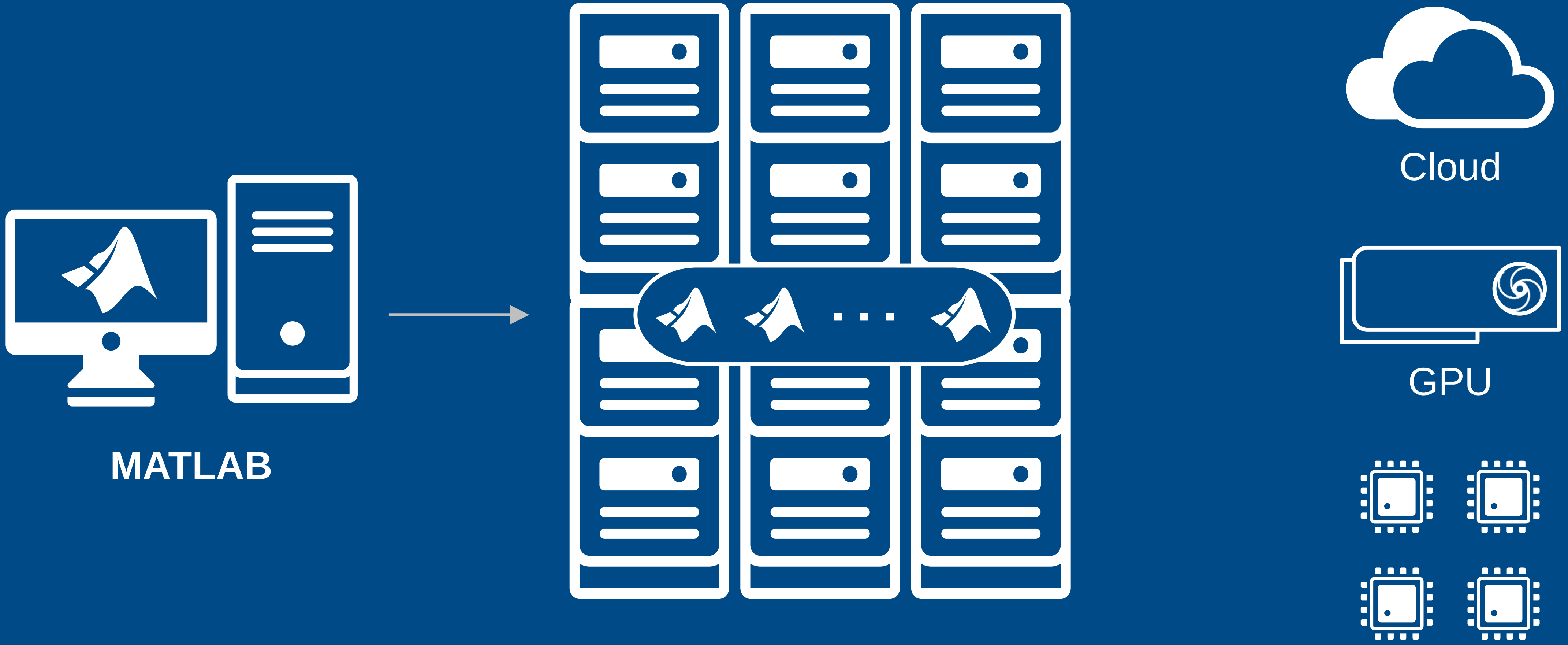
Scaling



SIMULATION DETAILS | Running on 20 parallel workers | 0% | 41sec remaining

**Simulink**
**Parallel Computing Toolbox**

# Scaling Computations on Clusters and Clouds



MATLAB

Cloud

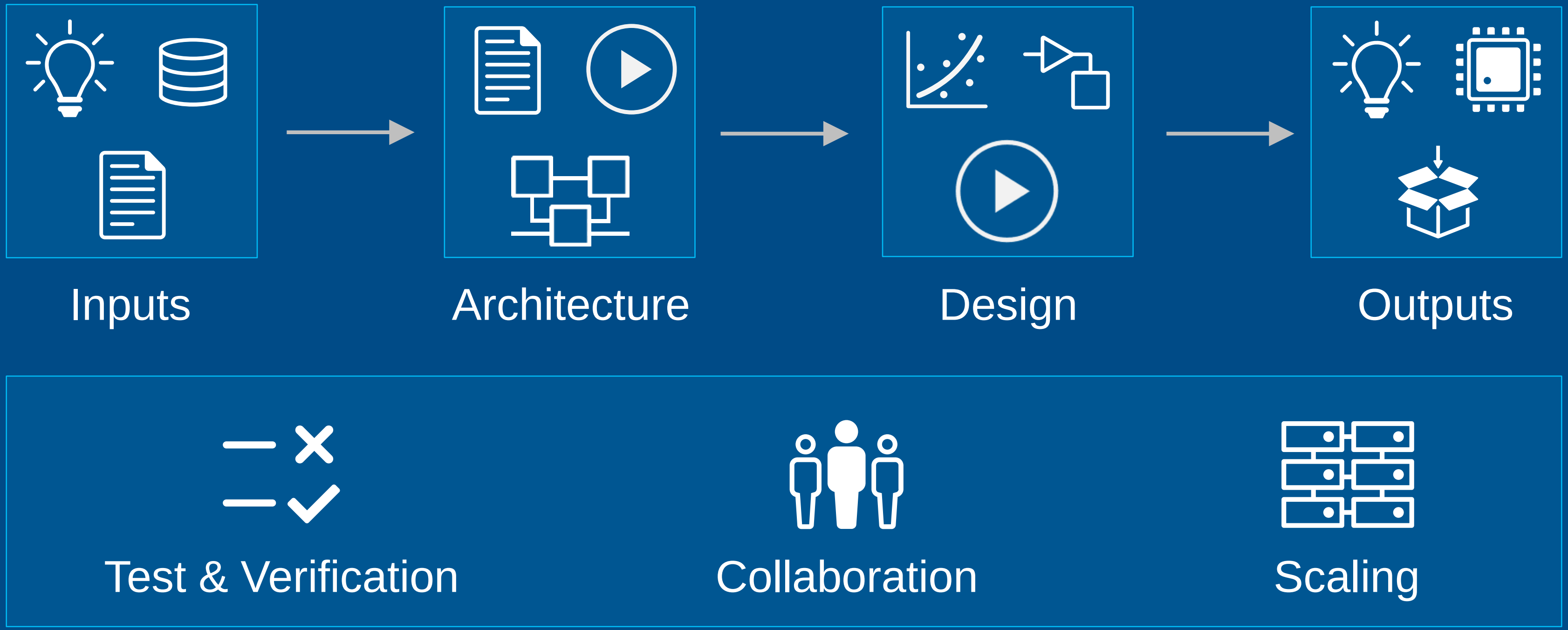
GPU

Parallel Computing Toolbox

MATLAB Parallel Server

Multi-core CPU

# Using MATLAB & Simulink to Build Algorithms in Everything



Inputs

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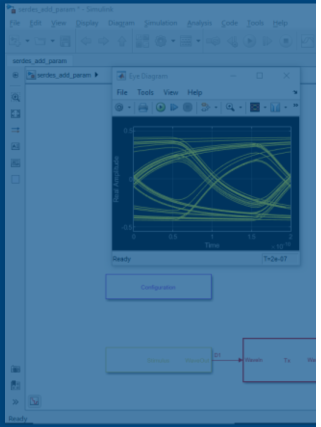
Scaling

MATLAB® & SIMULINK®

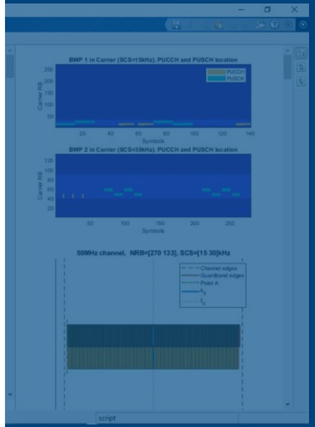
# Specialized Tools for Building Algorithms in Everything

Physical

ations



Ser



x

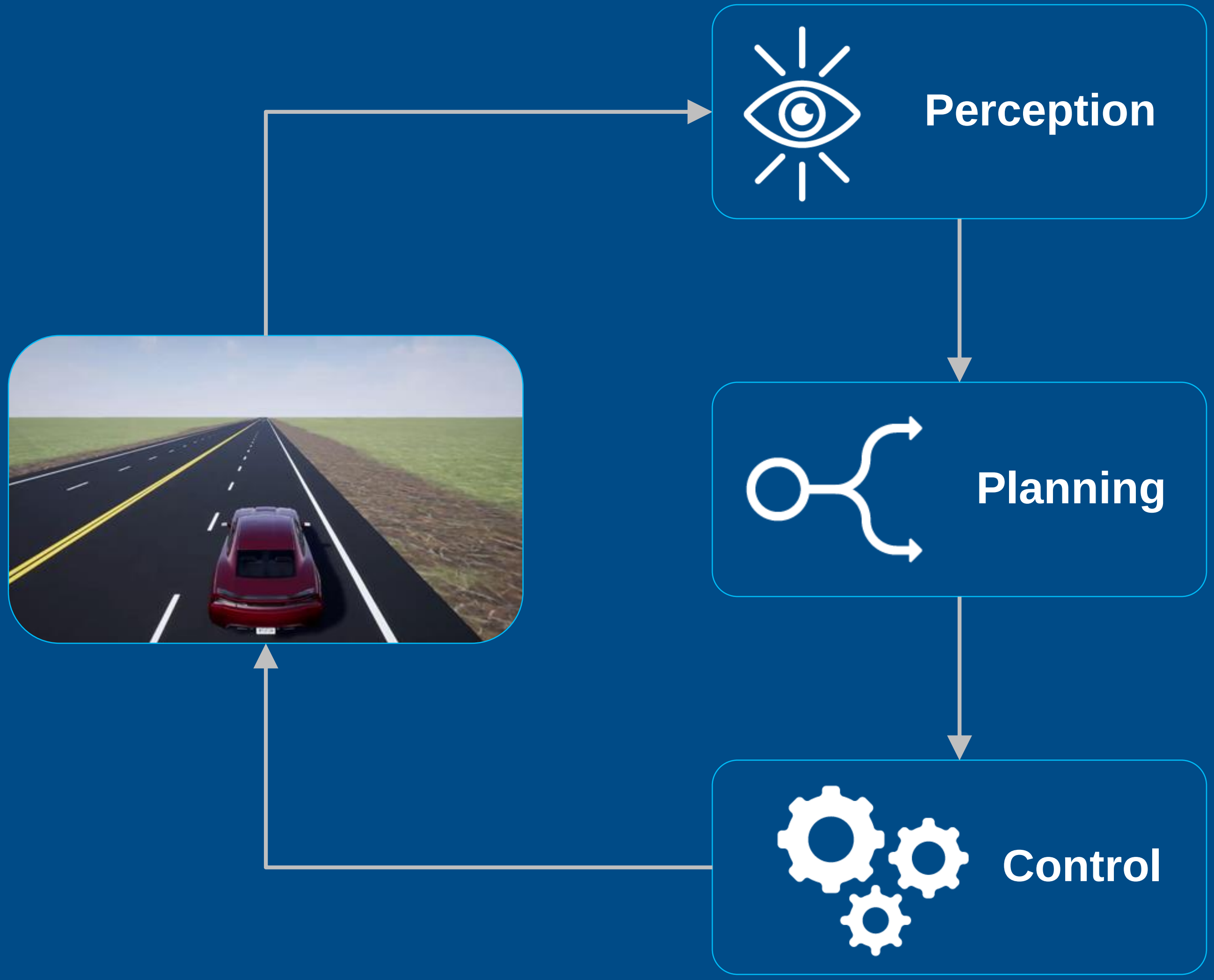
## Find out more:

**2:30 PM: Wired Communications Systems Modeling and Analysis.**

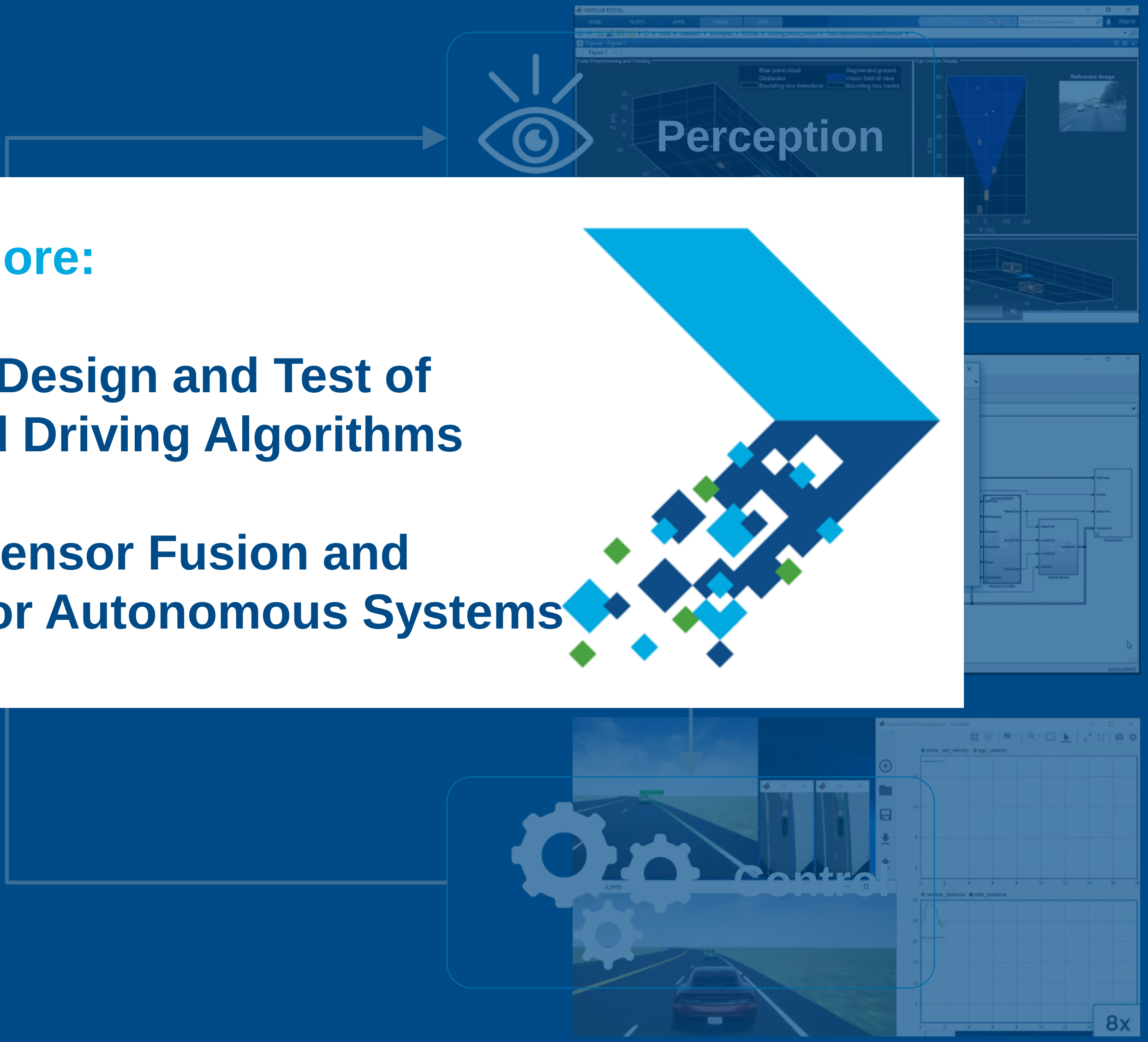
**3:30 PM: Top-Down Modeling and Analysis of Analog Mixed-Signal Systems**

**4:30 PM: Understanding and Modeling the 5G NR Physical Layer**

# Developing Autonomous Systems



# Developing Autonomous Systems



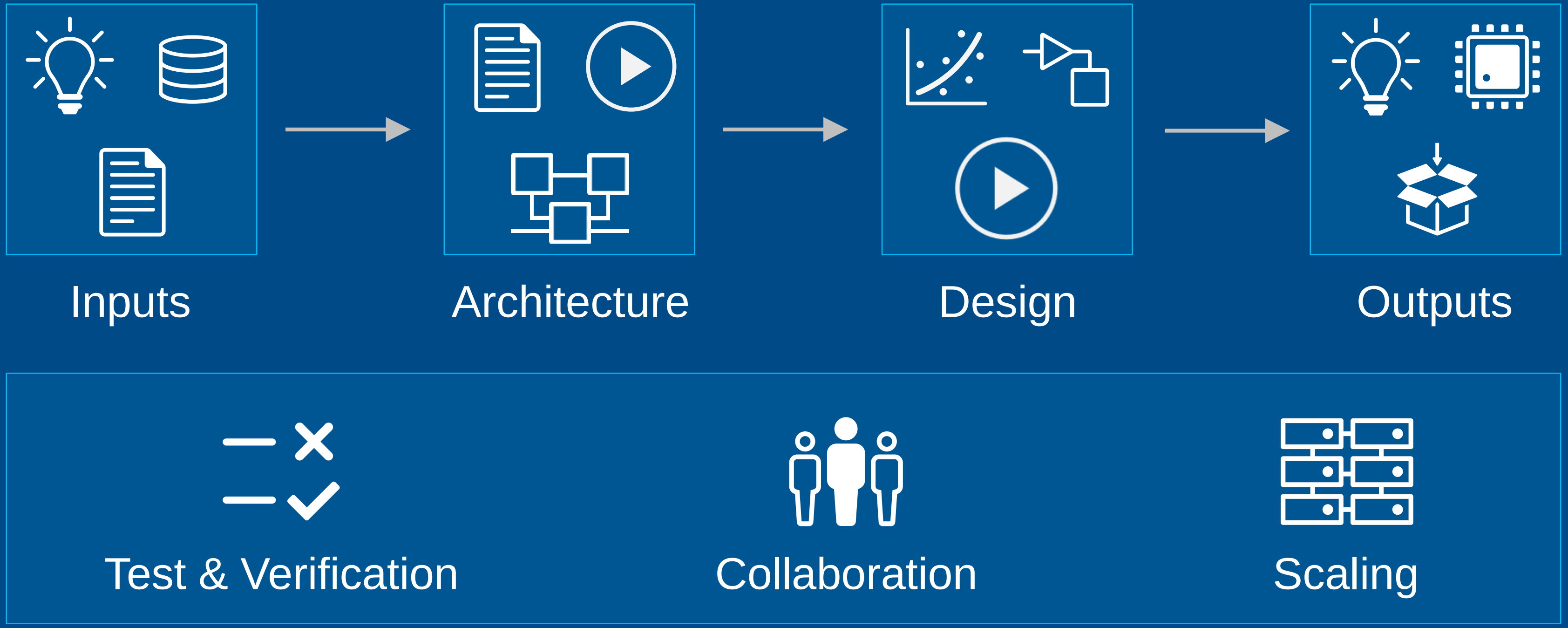
## Find out more:

**12:00 PM: Design and Test of Automated Driving Algorithms**

**4:00 PM: Sensor Fusion and Tracking for Autonomous Systems**

Sensor Fusion and Tracking Toolbox
Automated Driving Toolbox
Model Predictive Control Toolbox

# Using MATLAB & Simulink to Build Algorithms in Everything



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Design

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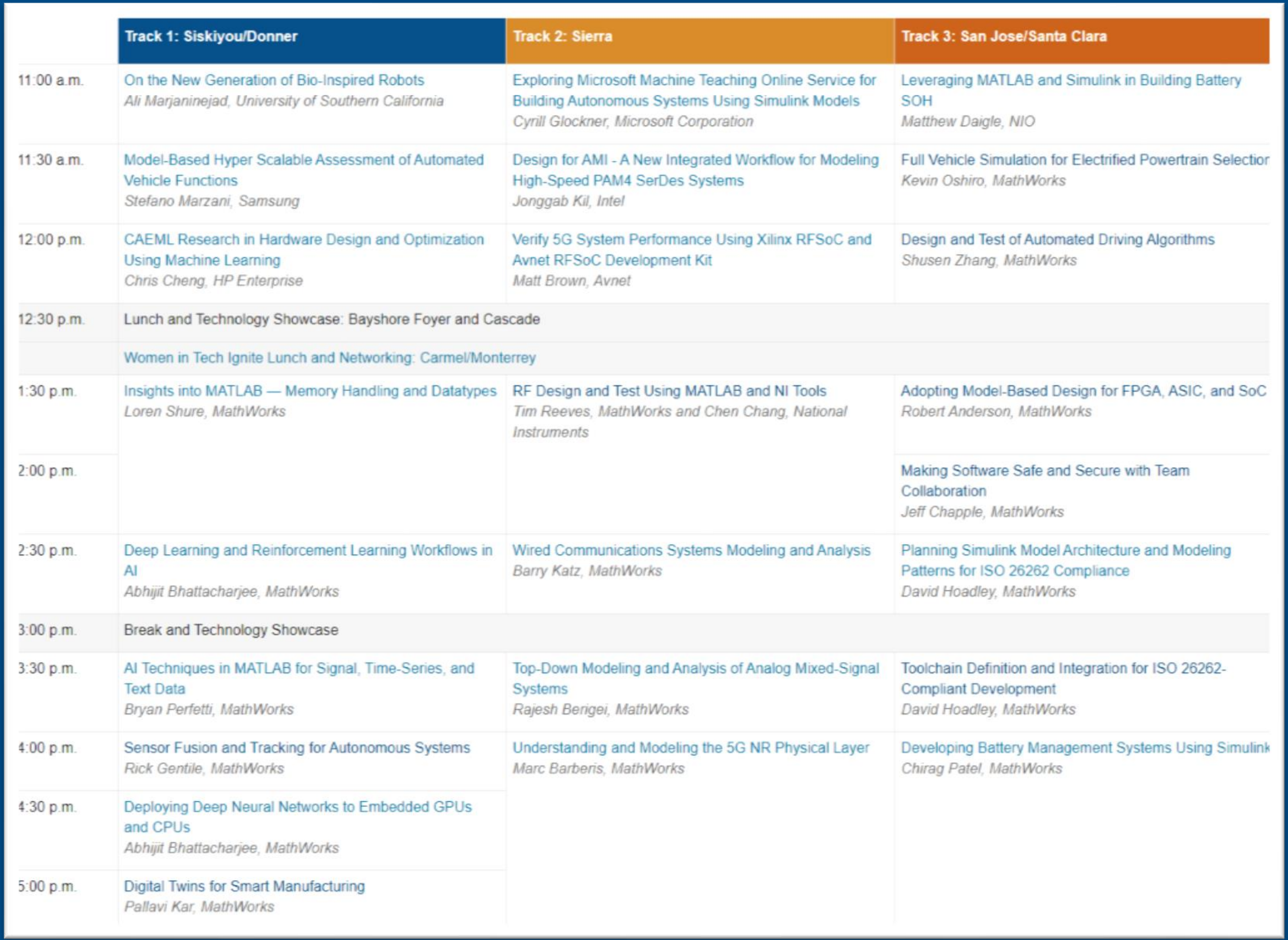
Collaboration

Scaling

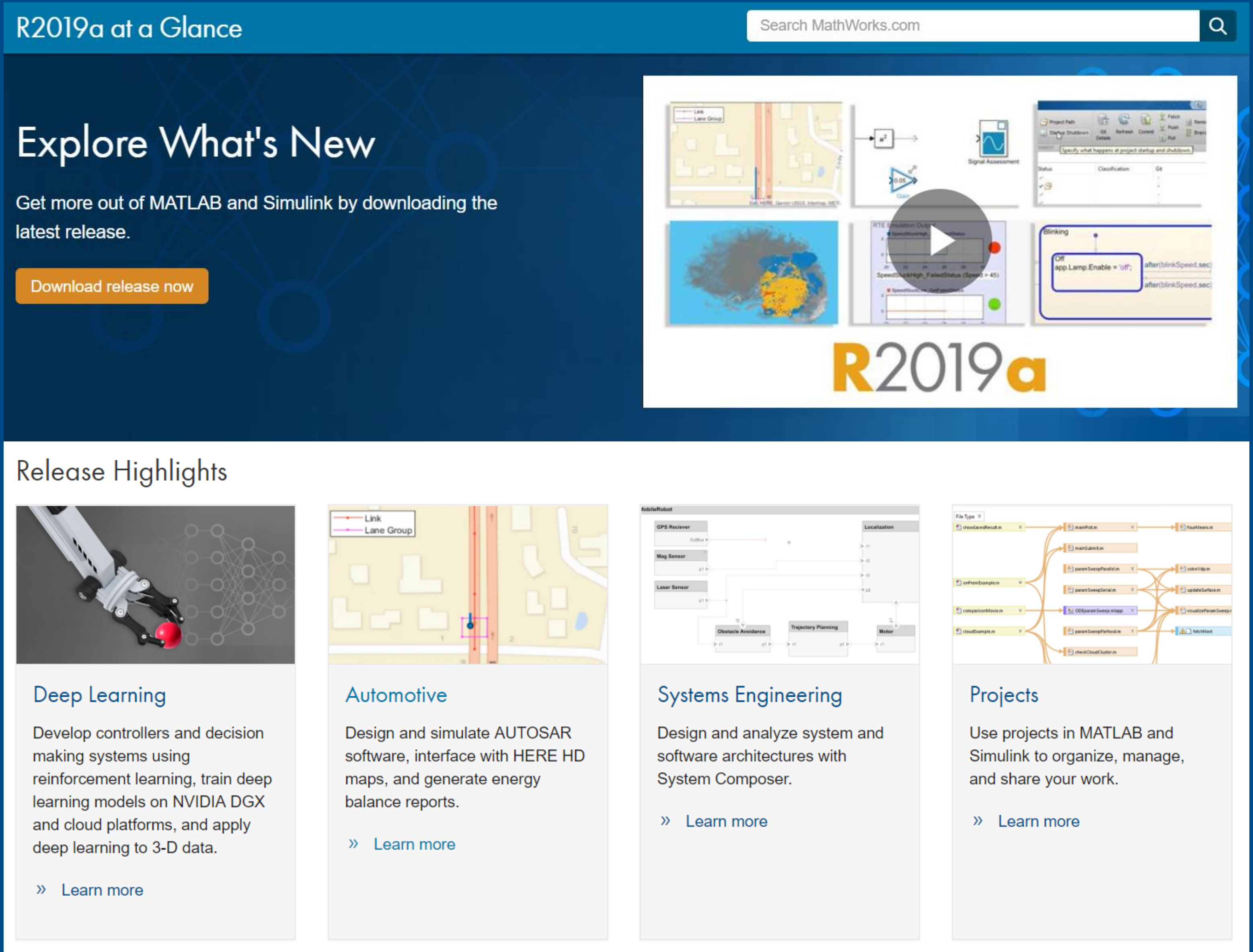
MATLAB® & SIMULINK®

# Attend Sessions this Afternoon



| | Track 1: Siskiyou/Donner | Track 2: Sierra | Track 3: San Jose/Santa Clara |
|---|---|---|---|
| 11:00 a.m. | On the New Generation of Bio-Inspired Robots<br>*Ali Marjaninejad, University of Southern California* | Exploring Microsoft Machine Teaching Online Service for Building Autonomous Systems Using Simulink Models<br>*Cyrill Glockner, Microsoft Corporation* | Leveraging MATLAB and Simulink in Building Battery SOH<br>*Matthew Daigle, NIO* |
| 11:30 a.m. | Model-Based Hyper Scalable Assessment of Automated Vehicle Functions<br>*Stefano Marzani, Samsung* | Design for AMI - A New Integrated Workflow for Modeling High-Speed PAM4 SerDes Systems<br>*Jonggab Kil, Intel* | Full Vehicle Simulation for Electrified Powertrain Selectior<br>*Kevin Oshiro, MathWorks* |
| 12:00 p.m. | CAEML Research in Hardware Design and Optimization Using Machine Learning<br>*Chris Cheng, HP Enterprise* | Verify 5G System Performance Using Xilinx RFSoC and Avnet RFSoC Development Kit<br>*Matt Brown, Avnet* | Design and Test of Automated Driving Algorithms<br>*Shusen Zhang, MathWorks* |
| 12:30 p.m. | Lunch and Technology Showcase: Bayshore Foyer and Cascade | | |
| | Women in Tech Ignite Lunch and Networking: Carmel/Monterrey | | |
| 1:30 p.m. | Insights into MATLAB — Memory Handling and Datatypes<br>*Loren Shure, MathWorks* | RF Design and Test Using MATLAB and NI Tools<br>*Tim Reeves, MathWorks and Chen Chang, National Instruments* | Adopting Model-Based Design for FPGA, ASIC, and SoC<br>*Robert Anderson, MathWorks* |
| 2:00 p.m. | | | Making Software Safe and Secure with Team Collaboration<br>*Jeff Chapple, MathWorks* |
| 2:30 p.m. | Deep Learning and Reinforcement Learning Workflows in AI<br>*Abhijit Bhattacharjee, MathWorks* | Wired Communications Systems Modeling and Analysis<br>*Barry Katz, MathWorks* | Planning Simulink Model Architecture and Modeling Patterns for ISO 26262 Compliance<br>*David Hoadley, MathWorks* |
| 3:00 p.m. | Break and Technology Showcase | | |
| 3:30 p.m. | AI Techniques in MATLAB for Signal, Time-Series, and Text Data<br>*Bryan Perfetti, MathWorks* | Top-Down Modeling and Analysis of Analog Mixed-Signal Systems<br>*Rajesh Berigei, MathWorks* | Toolchain Definition and Integration for ISO 26262-Compliant Development<br>*David Hoadley, MathWorks* |
| 4:00 p.m. | Sensor Fusion and Tracking for Autonomous Systems<br>*Rick Gentile, MathWorks* | Understanding and Modeling the 5G NR Physical Layer<br>*Marc Barberis, MathWorks* | Developing Battery Management Systems Using Simulink<br>*Chirag Patel, MathWorks* |
| 4:30 p.m. | Deploying Deep Neural Networks to Embedded GPUs and CPUs<br>*Abhijit Bhattacharjee, MathWorks* | | |
| 5:00 p.m. | Digital Twins for Smart Manufacturing<br>*Pallavi Kar, MathWorks* | | |

# Read the Release Notes



R2019a at a Glance

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## Explore What's New

Get more out of MATLAB and Simulink by downloading the latest release.

Download release now

## Release Highlights

### Deep Learning

Develop controllers and decision making systems using reinforcement learning, train deep learning models on NVIDIA DGX and cloud platforms, and apply deep learning to 3-D data.

» Learn more

### Automotive

Design and simulate AUTOSAR software, interface with HERE HD maps, and generate energy balance reports.

» Learn more

### Systems Engineering

Design and analyze system and software architectures with System Composer.

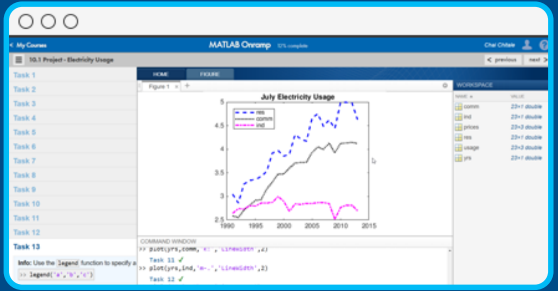
» Learn more

### Projects

Use projects in MATLAB and Simulink to organize, manage, and share your work.

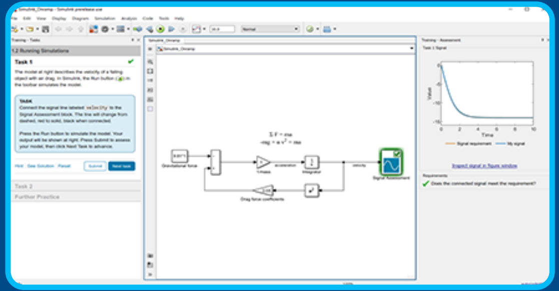
» Learn more

# Get Started



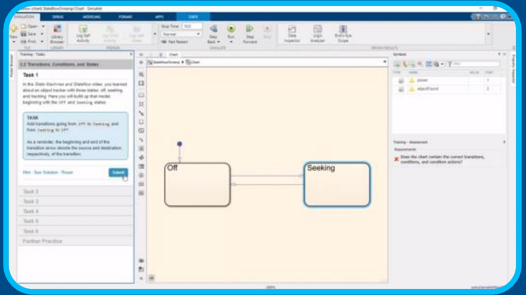
## MATLAB Onramp

Quickly learn the essentials of MATLAB.



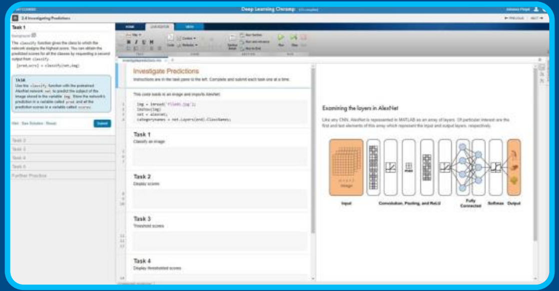
## Simulink Onramp

Learn to create, edit, and simulate Simulink models.



## Stateflow Onramp

Learn to create, edit, and simulate state machines.



## Deep Learning Onramp

Learn to use deep learning techniques in MATLAB.

# MATLAB EXPO 2019