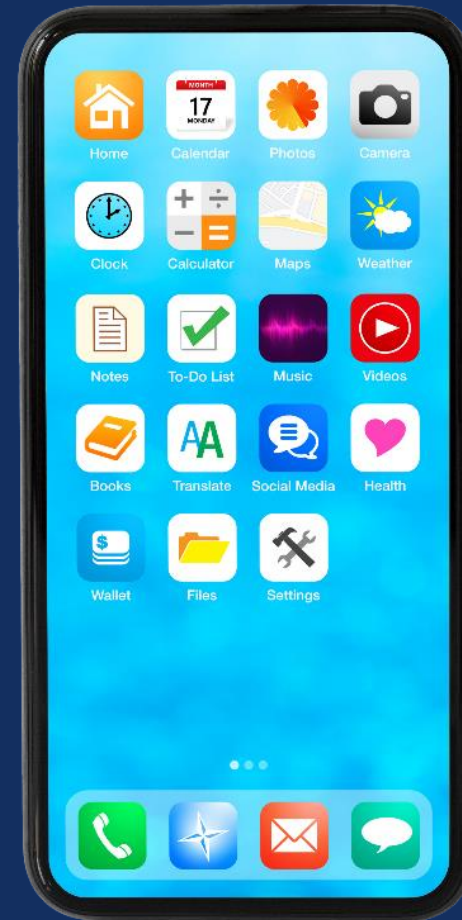


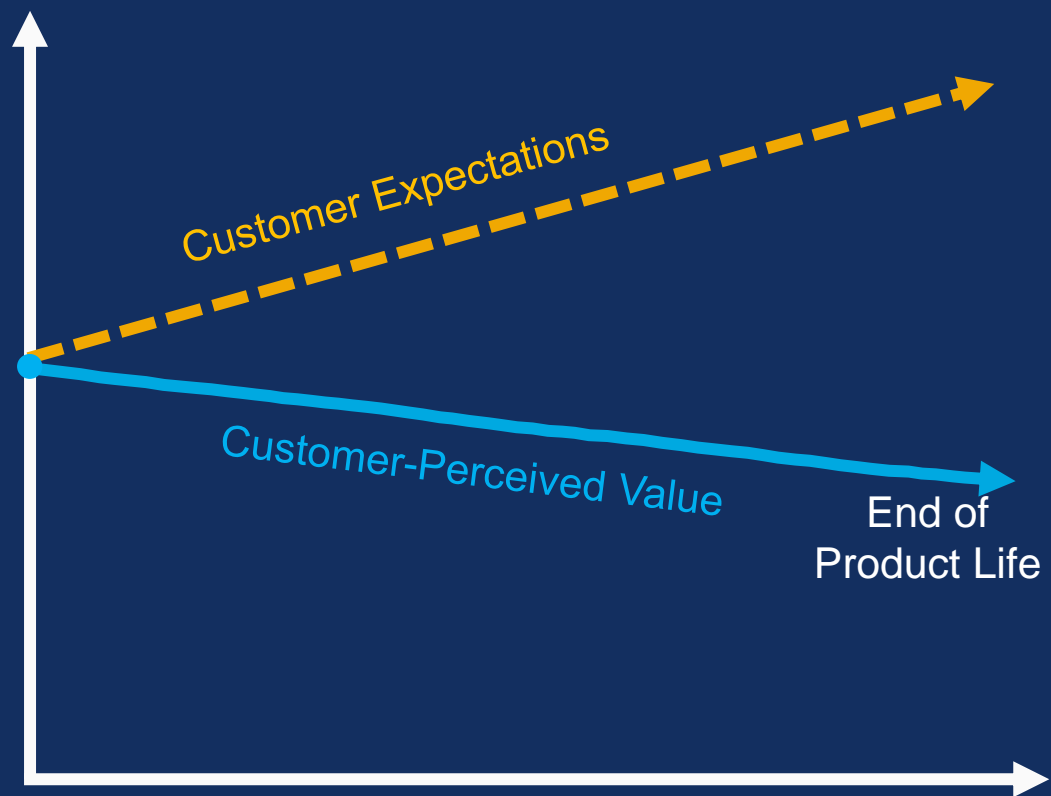
# MATLAB EXPO

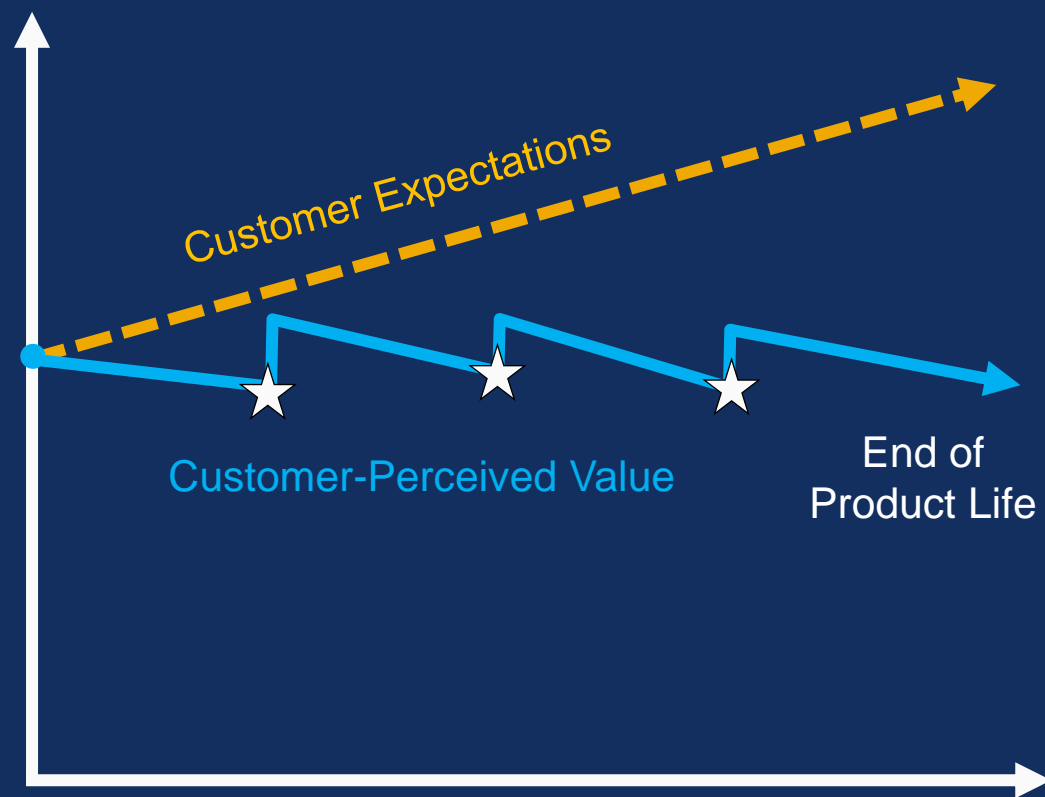
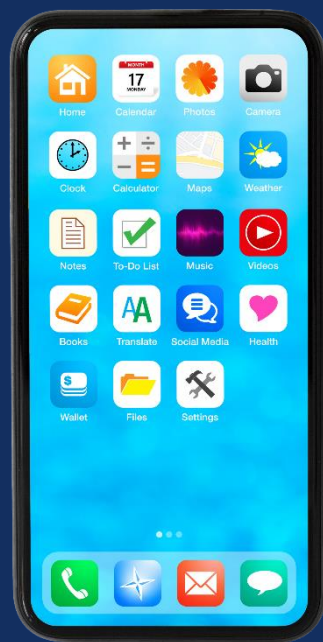
## From Embedded to Empowered: The Rise of Software-Defined Products

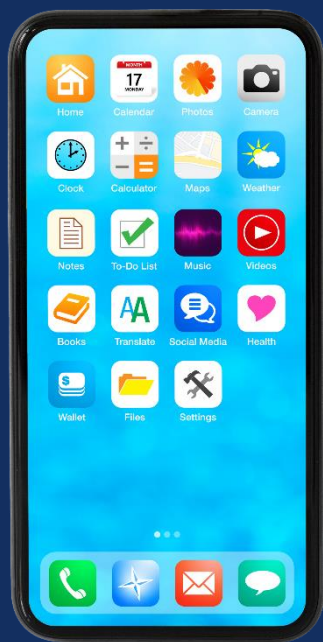
*Jim Tung*  
*MathWorks*



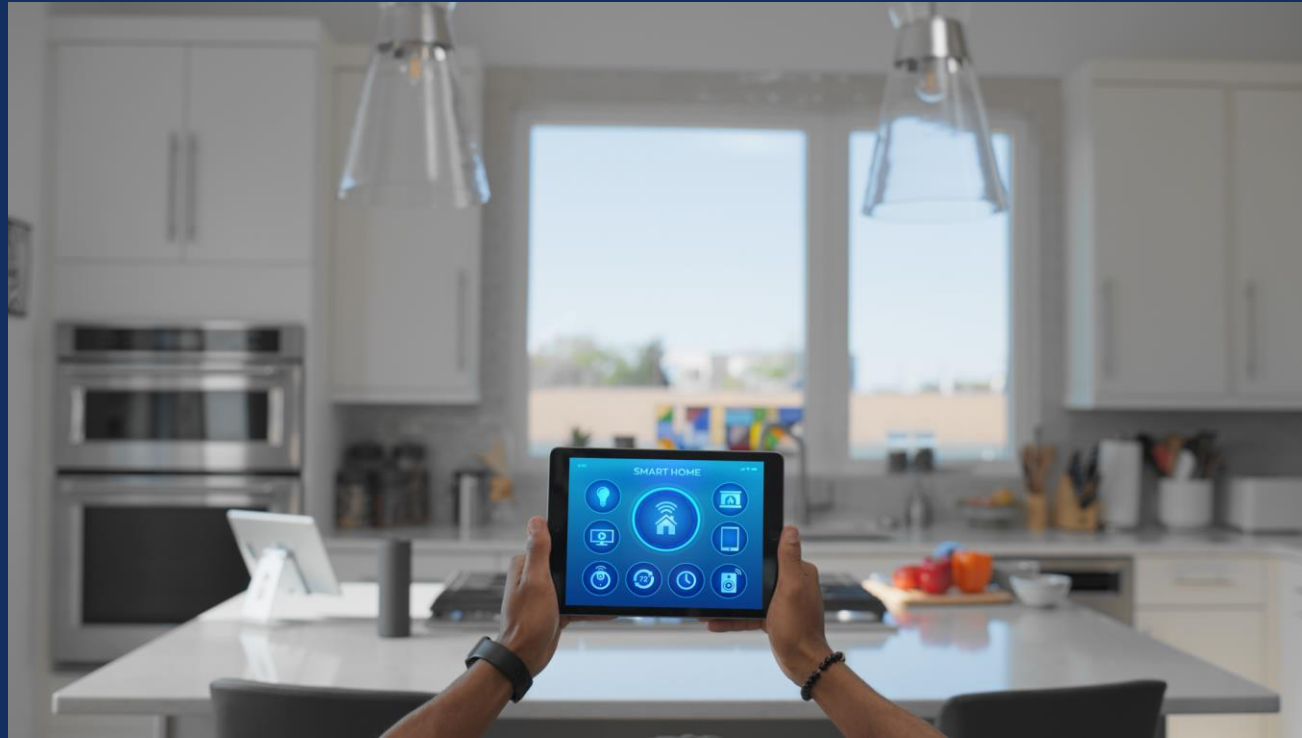








# Software-Defined Products



# Software-Defined Vehicle

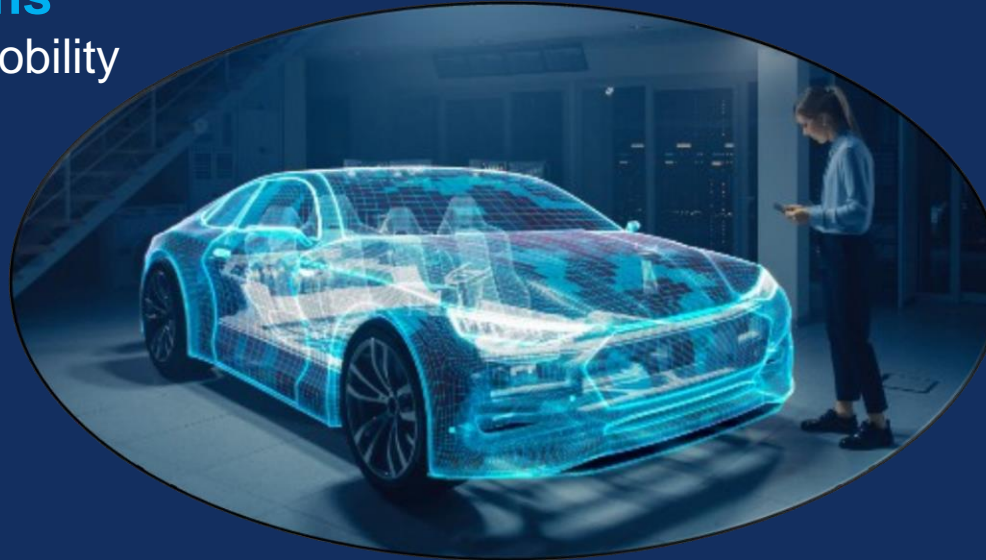
Brand-Distinctive Features and Main Customer Value Will Come From Software

## Customer expectations

- Sustainable and safe mobility
- Digital life continuity

## Technology and innovation

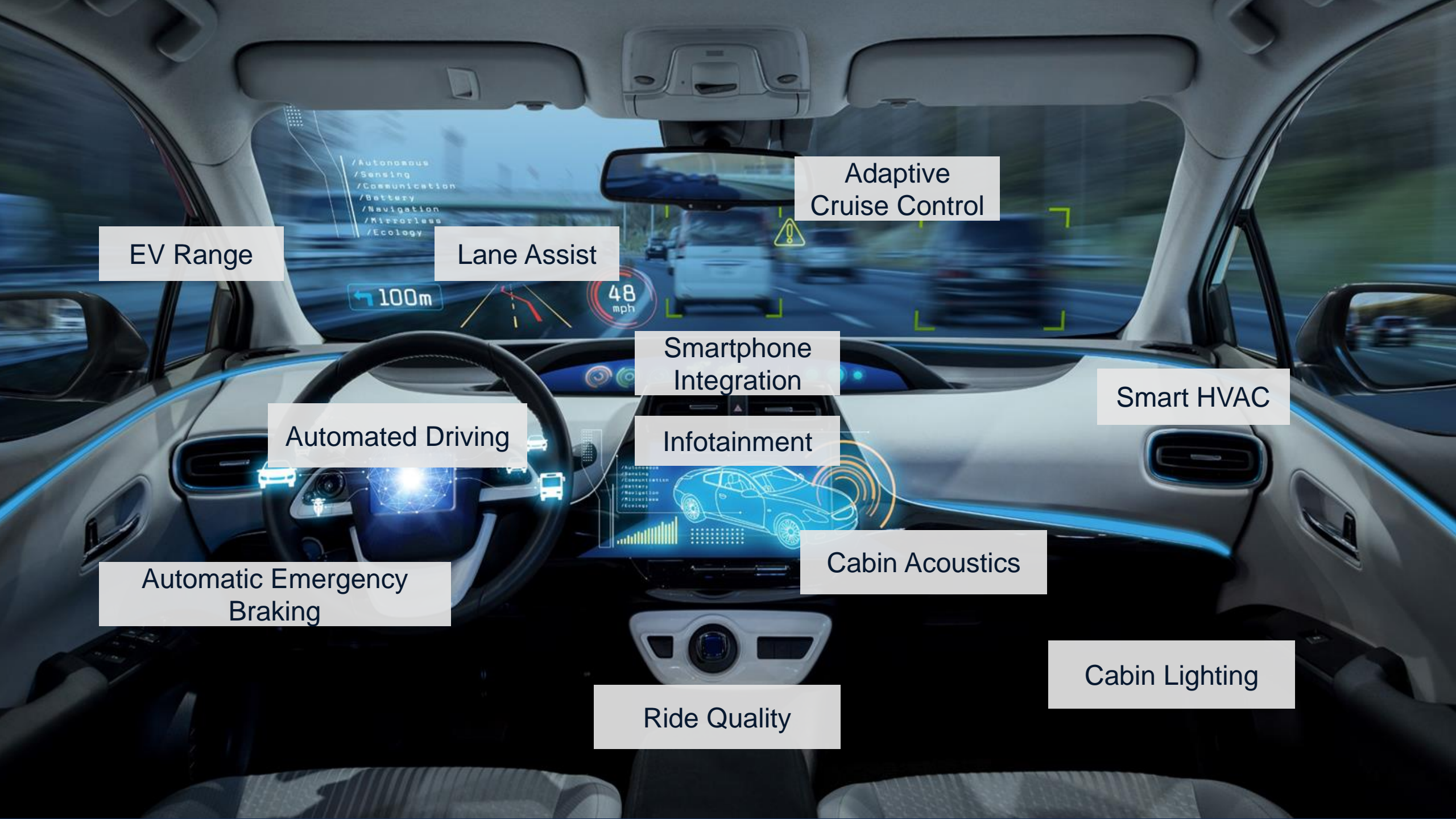
- Electrification
- Autonomy
- Connectivity



## Business opportunity

- App stores, software features on demand
- Subscription plans for software services





EV Range

Lane Assist

Adaptive  
Cruise Control

Automated Driving

Smartphone  
Integration

Smart HVAC

Infotainment

Automatic Emergency  
Braking

Cabin Acoustics

Cabin Lighting

Ride Quality



# Recycled PET Bottles are not Software-Defined



KRONES

Contiform 320



KRONES Contiform

# Machines that produce the rPET bottles are software-defined

## Goals and Challenges:

- Address material variability
- Enhance yield and efficiency
- Minimize reconfiguration time
- Achieve 100% rPET reuse



Model-Based Design and  
Reinforcement Learning

Start of production  
(SOP)

Release Train to support:

- New material
- New molds
- New bottle types

Operational Data  
via 5G/Cloud



# Software-Defined Systems

Software-Defined Vehicles



Advanced Air Mobility



Robotic Surgery Systems



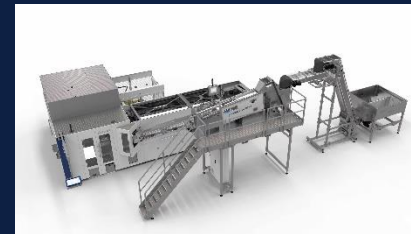
White Goods



Renewable Energy Systems



Industrial Packaging Systems





# Software-Defined



Modern Software Practices



Data-Driven Functionality



Leverages Cloud

# Systems



Reliability



Functional Safety



Physical Components

# Software-Defined Systems



Modern Software Practices



Reliability



Data-Driven Functionality



Functional Safety



Leverages Cloud



Physical Components

# Software-Defined Systems



Modern Software Practices



Reliability



Data-Driven Functionality



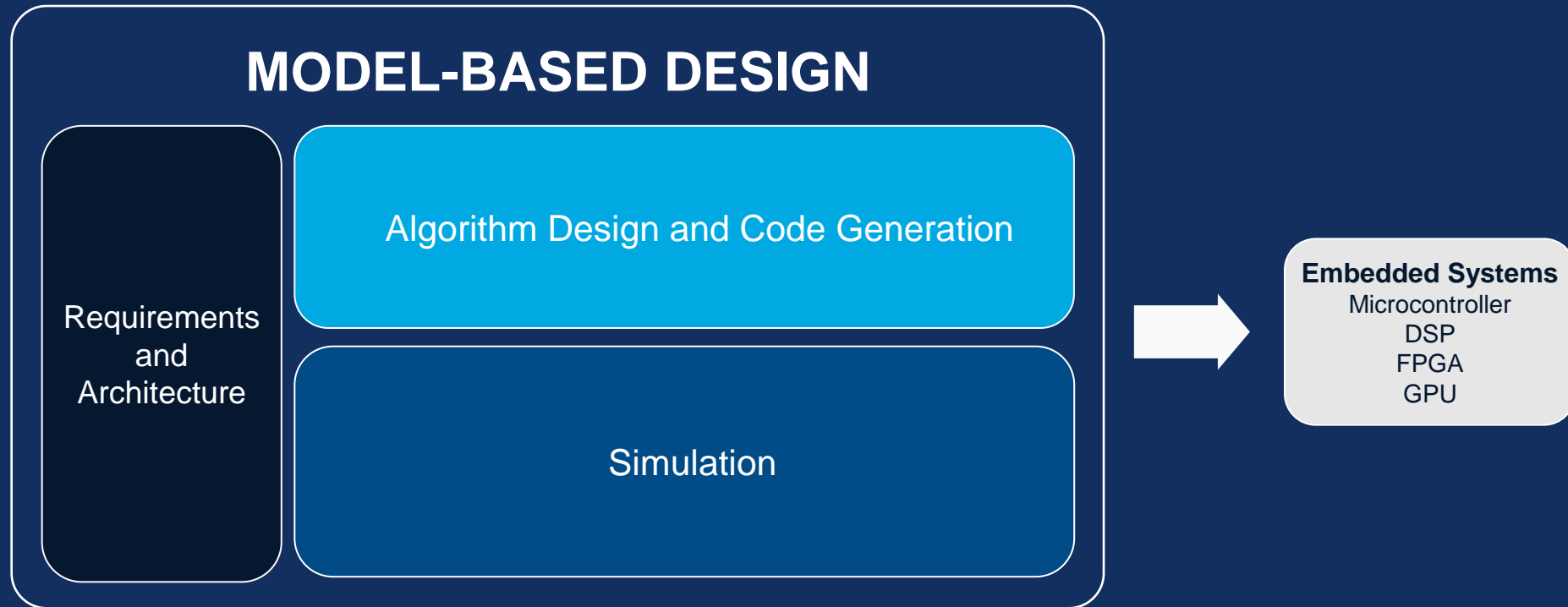
Functional Safety



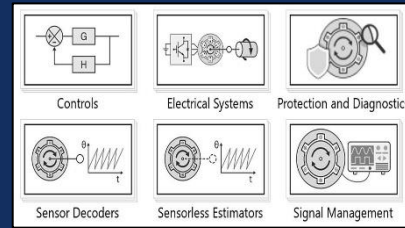
Leverages Cloud



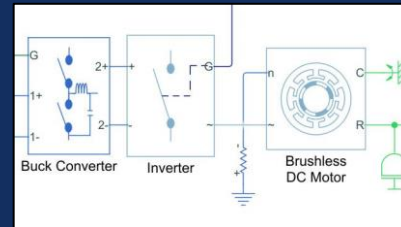
Physical Components



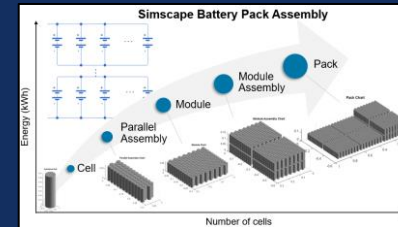
MATLAB®  
& SIMULINK®



Motor Control Blockset



Simscape Electrical



Simscape Battery



Embedded Coder  
HDL Coder

## MODEL-BASED DESIGN

Requirements  
and  
Architecture

Algorithm Design and Code Generation

Simulation



Full System



Components



**Embedded Systems**

Microcontroller  
DSP  
FPGA  
GPU



MATLAB®  
& SIMULINK®



## MODEL-BASED DESIGN

Requirements  
and  
Architecture

Algorithm Design and Code Generation

Simulation



Full System



Components



### Embedded Systems

Microcontroller  
DSP  
FPGA  
GPU



**Infineon**

AURIX™ microcontroller



**Qualcomm®**

Hexagon™ NPU for Snapdragon

## MODEL-BASED DESIGN

Requirements  
and  
Architecture

Algorithm Design and Code Generation

Simulation



Full System



Components



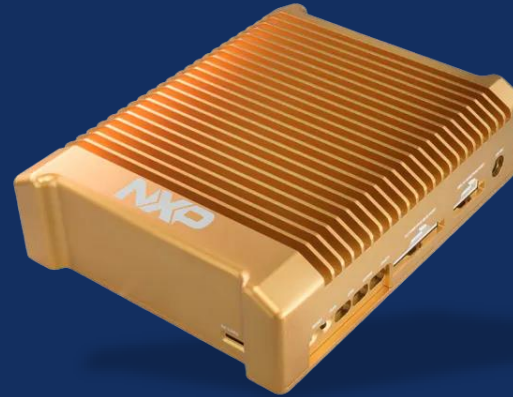
**Embedded Systems**

Microcontroller  
DSP  
FPGA  
GPU



**Infineon**

AURIX™ microcontroller



**NXP®**

GoldBox for in-vehicle HPC



**Qualcomm®**

Hexagon™ NPU for Snapdragon

## MODEL-BASED DESIGN

Requirements  
and  
Architecture

Algorithm Design and Code Generation

Simulation



Full System



Components



**On-board HPC**  
Microprocessor

**Embedded Systems**  
Microcontroller  
DSP  
FPGA  
GPU



RoadRunner Scenario



Satellite to aircraft comms



Construction site



## MODEL-BASED DESIGN

Requirements  
and  
Architecture

Algorithm Design and Code Generation

Simulation



Full System



Components

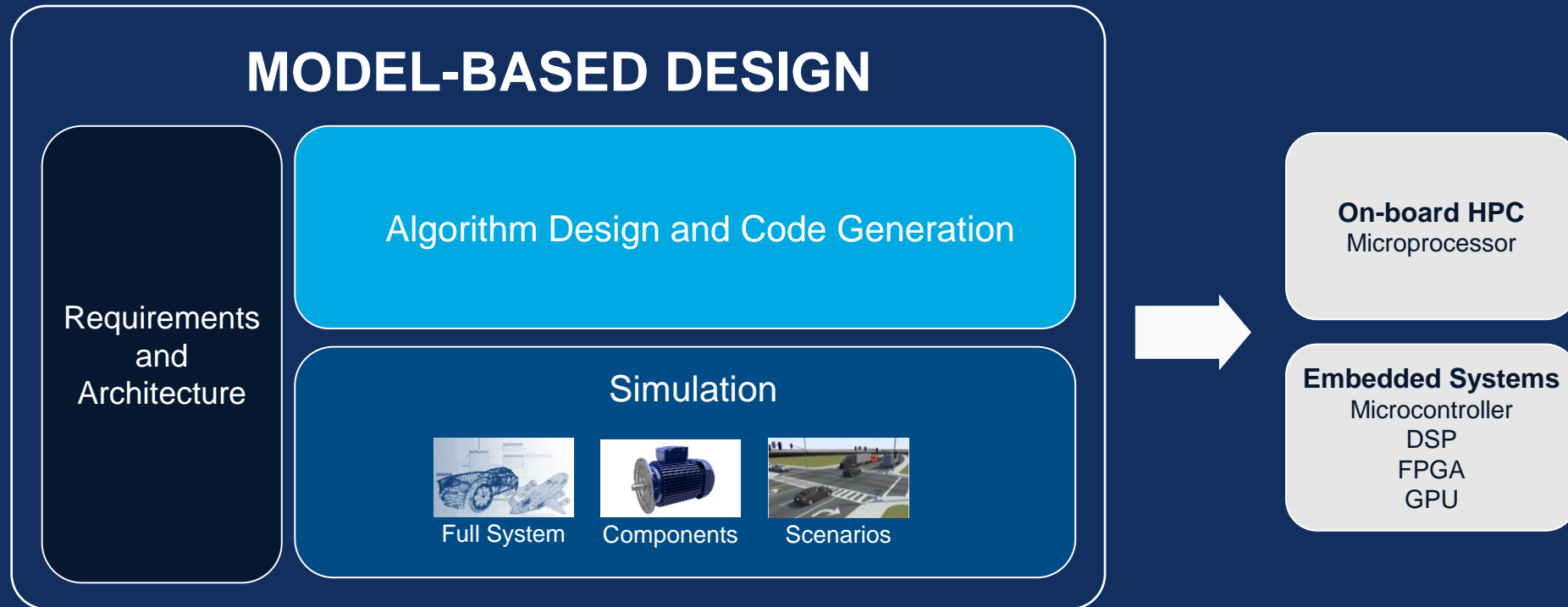


Scenarios



**On-board HPC**  
Microprocessor

**Embedded Systems**  
Microcontroller  
DSP  
FPGA  
GPU







Systems

**FIND OUT MORE**



**Master Class : analyse précoce et continue de la  
sûreté de fonctionnement**

Magnus Nord et Daniel Martins, MathWorks



**Master Class : Accélérez la mise en service des  
systèmes grâce au jumeau numérique**

Kévin Roblet et Morgan Fremovici, MathWorks

# Software-Defined Systems



Modern Software Practices



Reliability



Data-Driven Functionality



Functional Safety



Leverages Cloud



Physical Components

# Software-Defined Systems



## Modern Software Practices

- Fast development
- Frequent releases
- High automation



## Data-Driven Functionality



## Leverages Cloud



## Reliability



## Functional Safety



## Physical Components



## SOFTWARE FACTORY

Code-Based Development

DevOps and CI Platforms

## MODEL-BASED DESIGN

Requirements  
and  
Architecture

Algorithm Design  
and Code Generation

Simulation



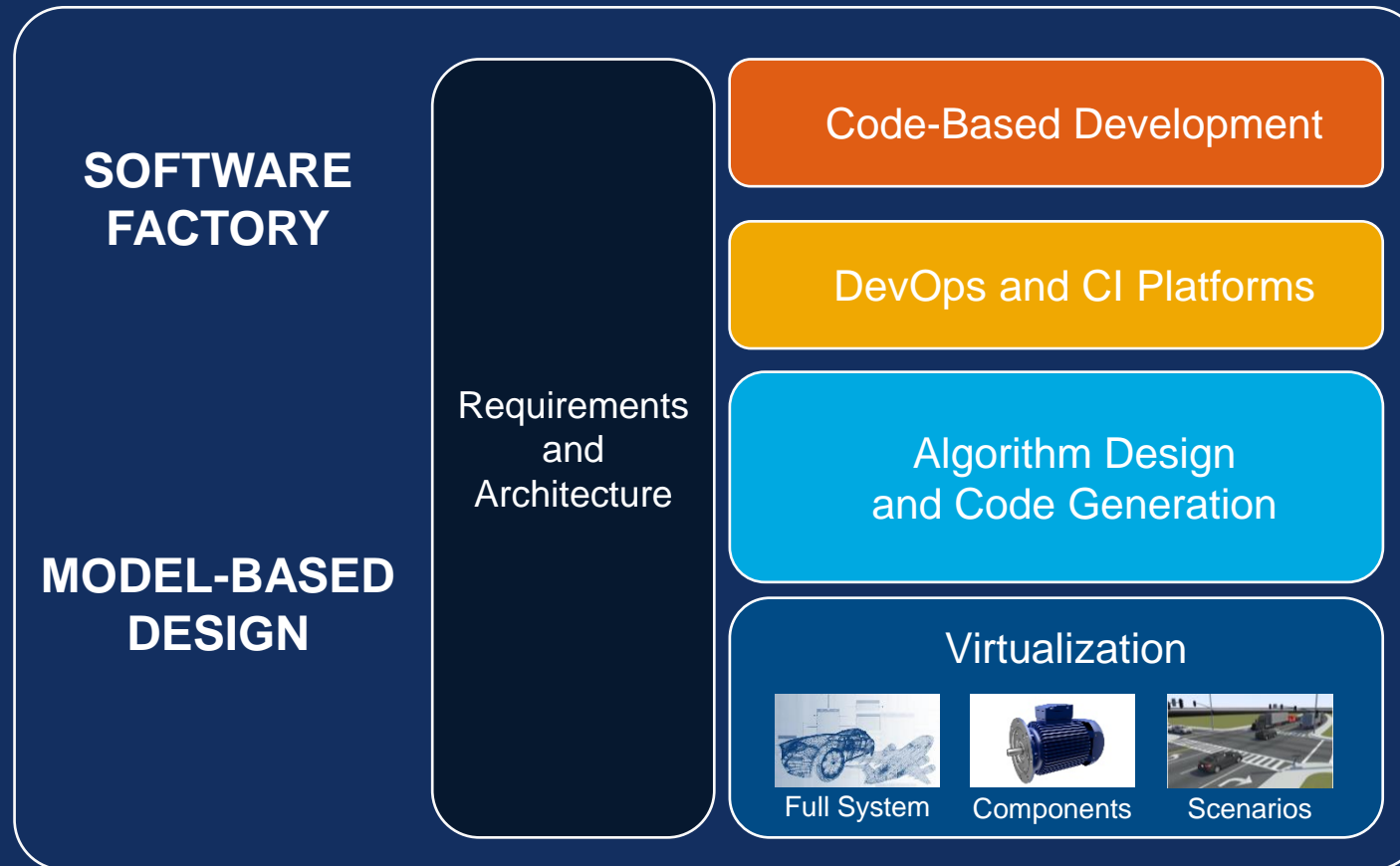
Full System



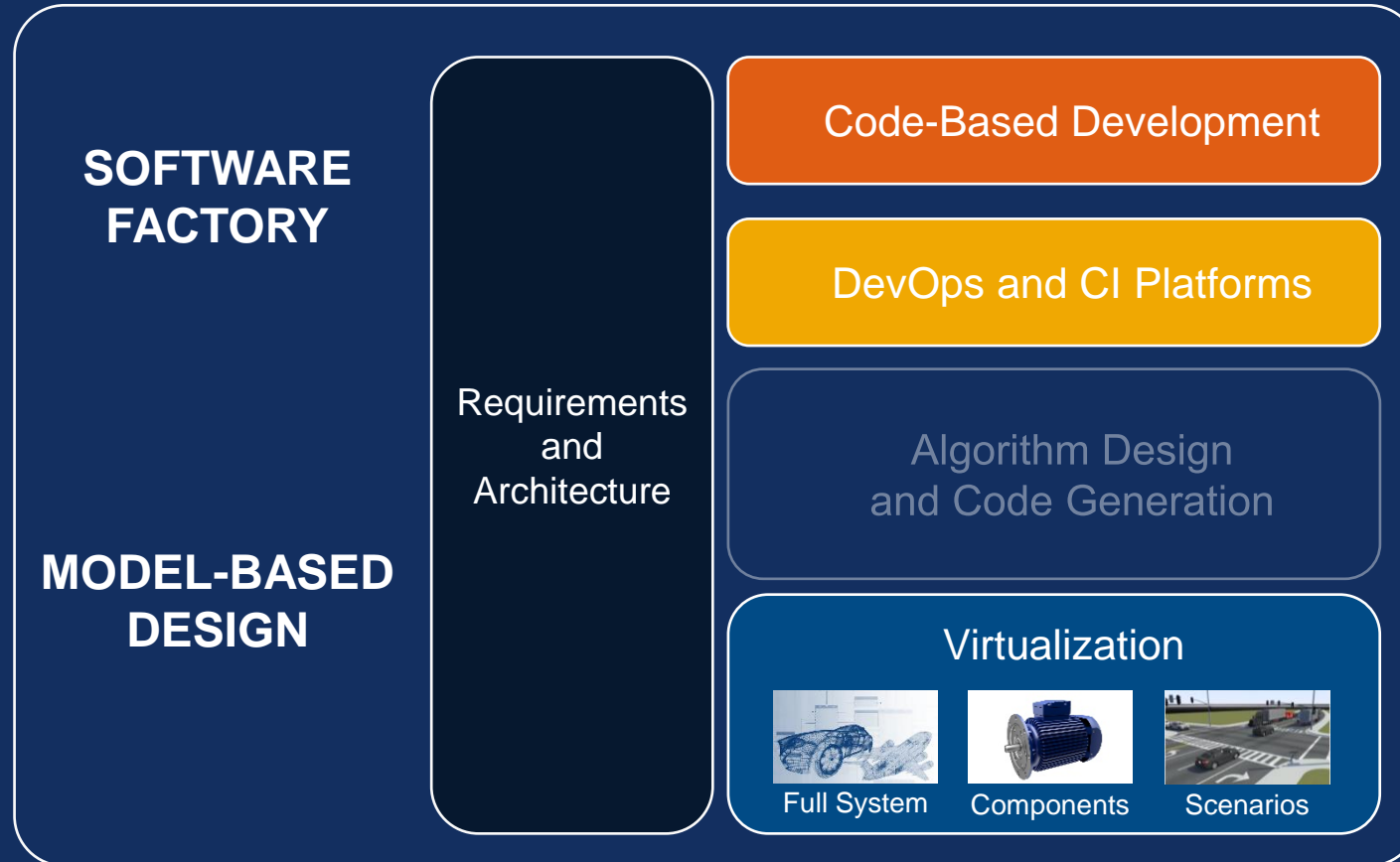
Components



Scenarios









## Modern Software Practices

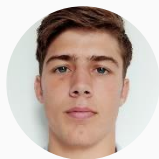
### FIND OUT MORE

#### **Automatisation des tests back-to-back MIL-SIL et MIL-PIL sur serveur Jenkins**

Vivien-Junior Obanda et Stéphane Louvet, Robert Bosch France

#### **Simulation multi-domaines pour le management thermique des véhicules**

Camille Brunon et Patrick Fayard, Hutchinson



#### **Master Class: Usine logicielle, industrialisez vos développements avec MATLAB et Simulink**

Michelle Valente et Maxime François, MathWorks

# Software-Defined Systems



Modern Software Practices



Reliability



Data-Driven Functionality



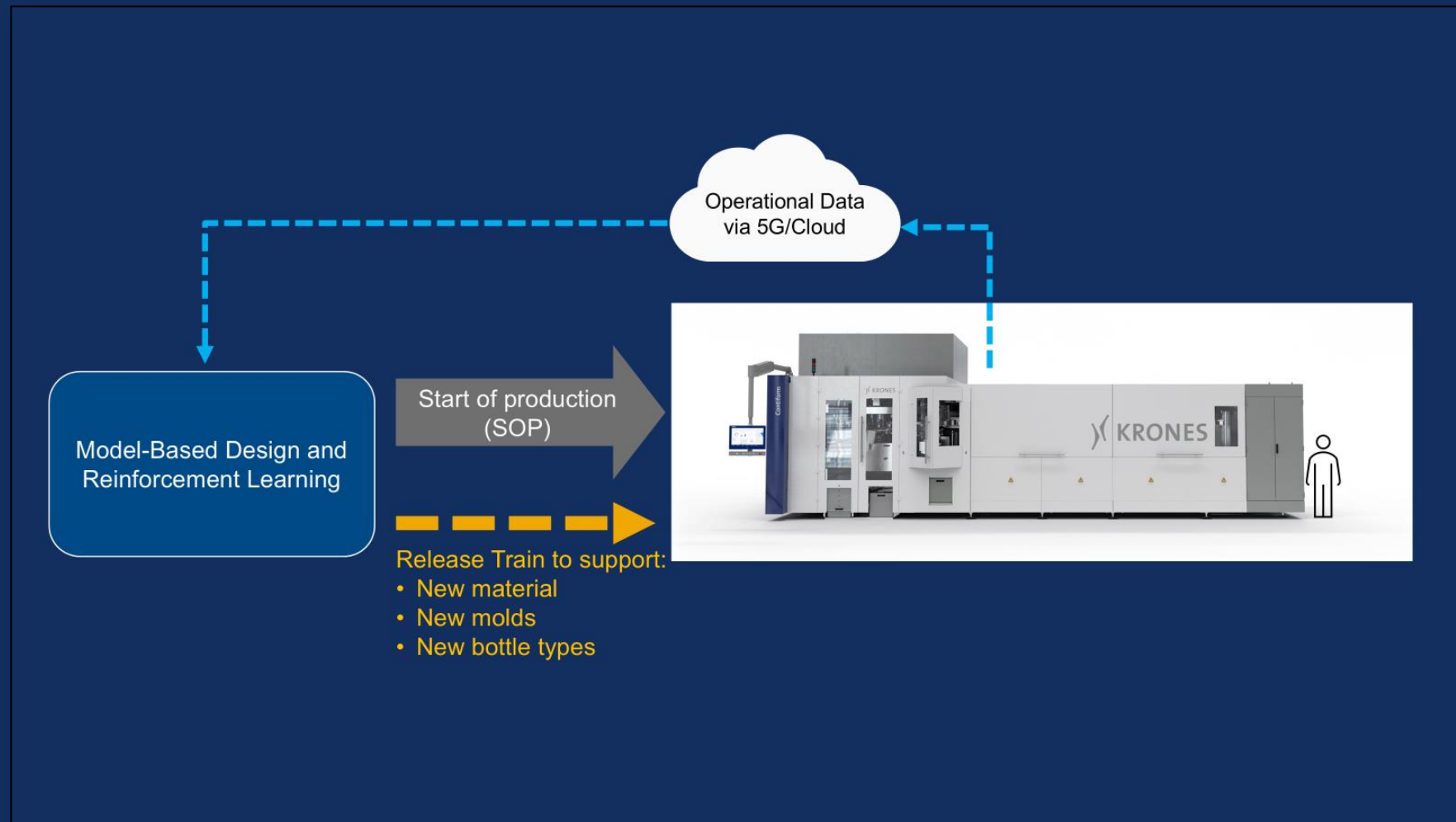
Functional Safety



Leverages Cloud



Physical Components



# Design your system with AI

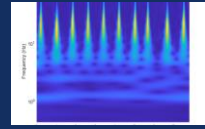
## AI Reference Examples



Predictive Maintenance



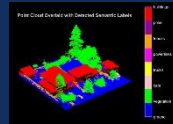
Hyperspectral Imaging



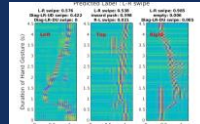
Signal Processing



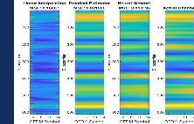
Robotic Control



Lidar Processing



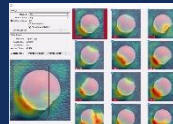
Radar Processing



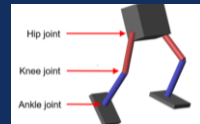
Wireless Communications



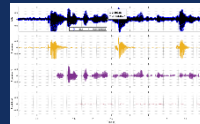
Automated Driving



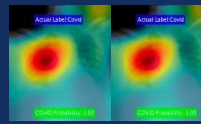
Visual Inspection



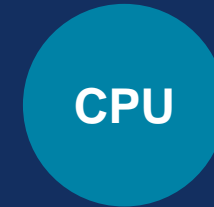
Reinforcement Learning



Audio

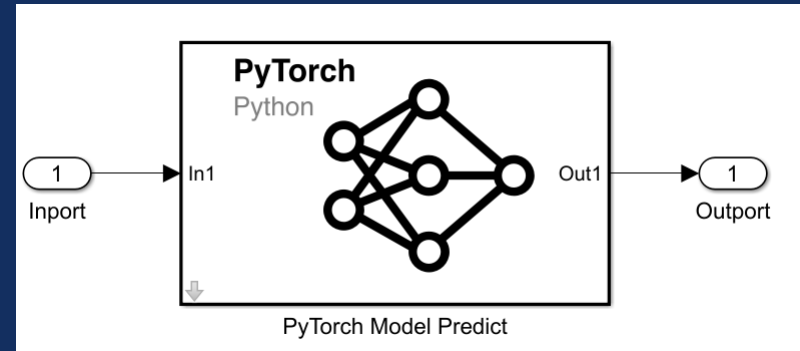


Medical Imaging



If your AI model is done with PyTorch,  
integrate it into MATLAB and Simulink

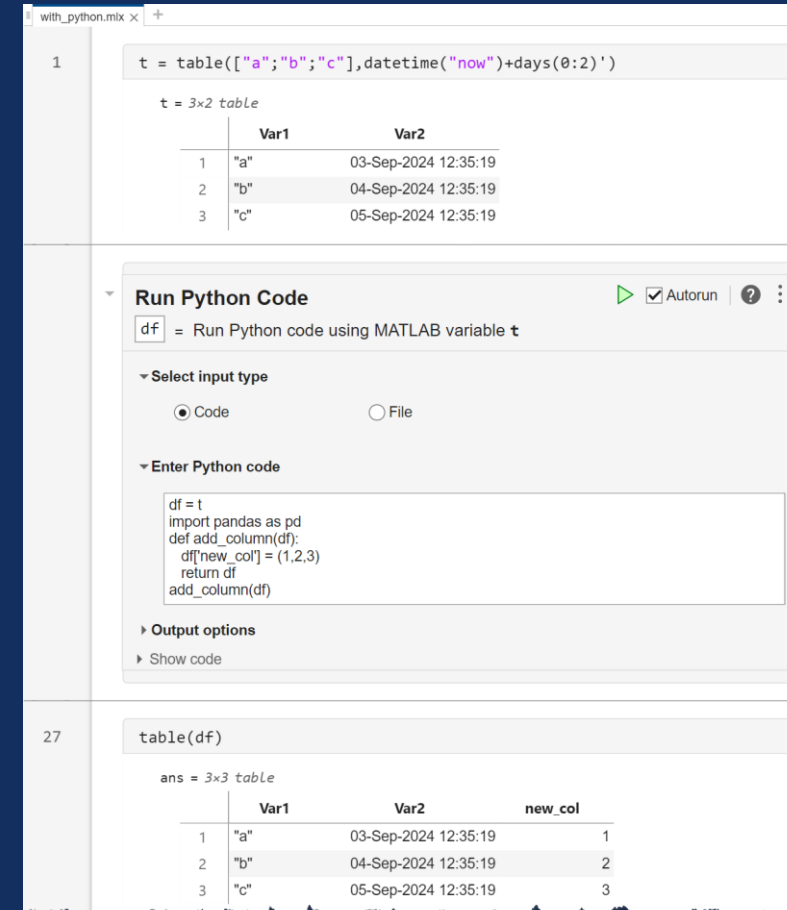
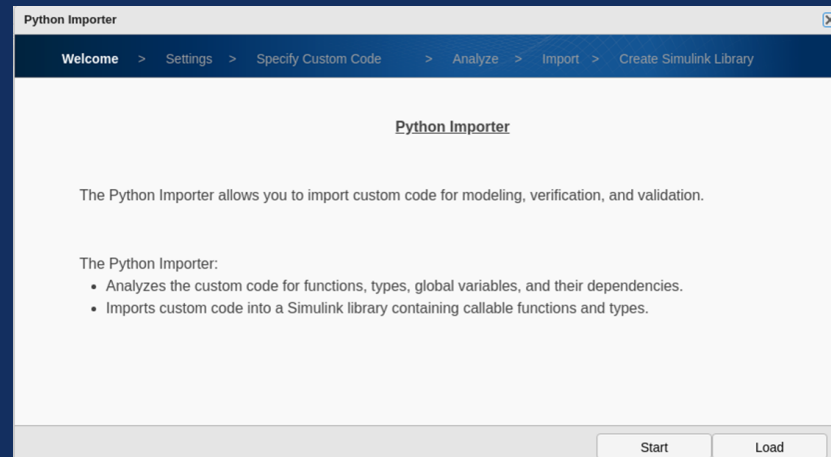
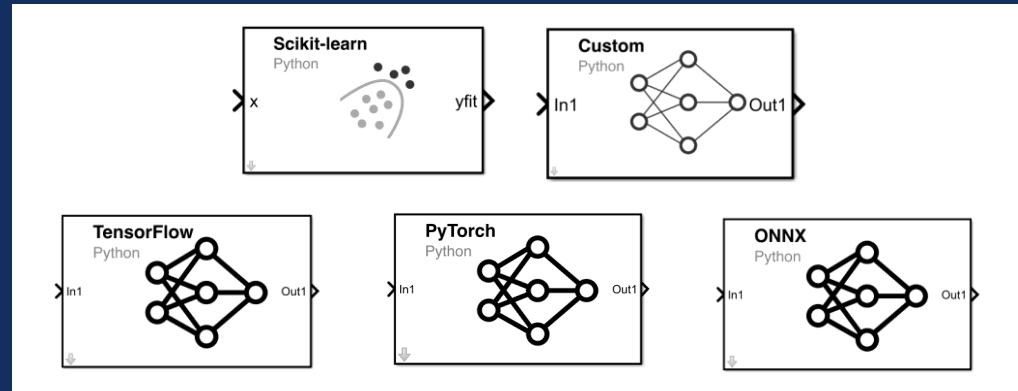
Starting in  
**R2024a**



MATLAB works with TensorFlow and PyTorch:

- Co-execution
- Model converters
- MATLAB Deep Learning Model Hub

# Enabling collaboration across engineering, data science and IT teams using Python, MATLAB and Simulink







## AI and Data-Driven Functionality

**FIND OUT MORE**



**Master Class : IA de confiance pour les systèmes critiques**  
Moubarak Gado, MathWorks



# Generative AI for MATLAB AI Chat Playground

The screenshot shows the MATLAB AI Chat Playground interface. At the top, the MathWorks logo is on the left, and navigation links for Products, Solutions, Academia, Support, Community, and Events are in the center. On the right, there are buttons for MATLAB, SD, and a grid icon. Below this, a blue navigation bar contains links for MATLAB Answers, File Exchange, Cody, AI Chat Playground (which is highlighted), Discussions, Contests, Blogs, and a More dropdown. The main content area has a 'New' button with a plus icon. On the right side of this area are 'Copy' and 'Download' buttons. The chat interface on the left shows a welcome message from 'AI' and a disclaimer box. Below the disclaimer are three example prompts, each preceded by a star icon. A 'Shuffle' button is located below the prompts. At the bottom of the chat area is a text input field labeled 'Enter prompt here' with a send button. On the right side of the interface is a code editor with tabs for 'CODE' and 'RUN', and a large area for the output or code execution results.

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MATLAB SD

MATLAB Answers File Exchange Cody AI Chat Playground Discussions Contests Blogs More ▾

+ New ▾

Copy Download

AI

Hello! Whether you're checking out MATLAB for the first time or have been using it for years, I'm here to answer your questions and provide coding tips.

Please keep in mind that AI sometimes writes code and text that seems accurate, but isn't. AI does not yet have knowledge of features delivered after June 2021 and only limited knowledge of Simulink and specialized toolboxes. This is a space for experimentation. Try it, verify any resulting code, and kindly give or on the results to help improve the responses.

- ✦ Roll two six-sided dice 1000 times and plot the sum of each roll
- ✦ Solve the linear equations with coefficients  $A = [2, 4; 1, 3]$  and constants  $B = [8; 5]$  and display the results
- ✦ Load Fisher's iris data set, use the petal lengths and widths as predictors, cluster data using k-means clustering, and then plot the cluster regions

Shuffle

Enter prompt here

Generated code and text might be inaccurate. Validate before use. [About](#) [Discuss](#)



# Generative AI for MATLAB    MATLAB GPT for ChatGPT

Available

MathWorks Products Solutions Academia Store

MATLAB Answers File Exchange Code Central MATLAB Central

New

```
% Roll two six-sided dice 1000 times
rolls = randi(6, 1000, 2);

% Calculate the sum of each roll
sums = sum(rolls, 2);

% Plot the sum of each roll
histogram(sums, 'binned', 'linestyle', 'none');
xlabel('Sum of Rolls');
ylabel('Frequency');
title('Sum of Two Dice Rolls');
```

This code uses the `randi` function to generate random integers for two dice. The `sum` function is then used to calculate the sum of each roll. The `histogram` function is used to plot the frequency of each sum.

How can I change the number of rolls or the number of dice?

Can I customize the appearance of the histogram?

Is there a way to calculate the probabilities of each sum?

Enter prompt here

Generated code and text might not accurately reflect MATLAB code. ©2023 MathWorks

AI Chat

chatgpt.com

MATLAB

By mathworks.com

Discover MATLAB® with the official MATLAB GPT by MathWorks. Learn about valuable resources, save time building with MATLAB, get answers, and stay up to date with the latest features.

🧠 Explain k-means clustering with an example

📁 What are the latest features of MATLAB?

📊 Smooth a noisy dataset

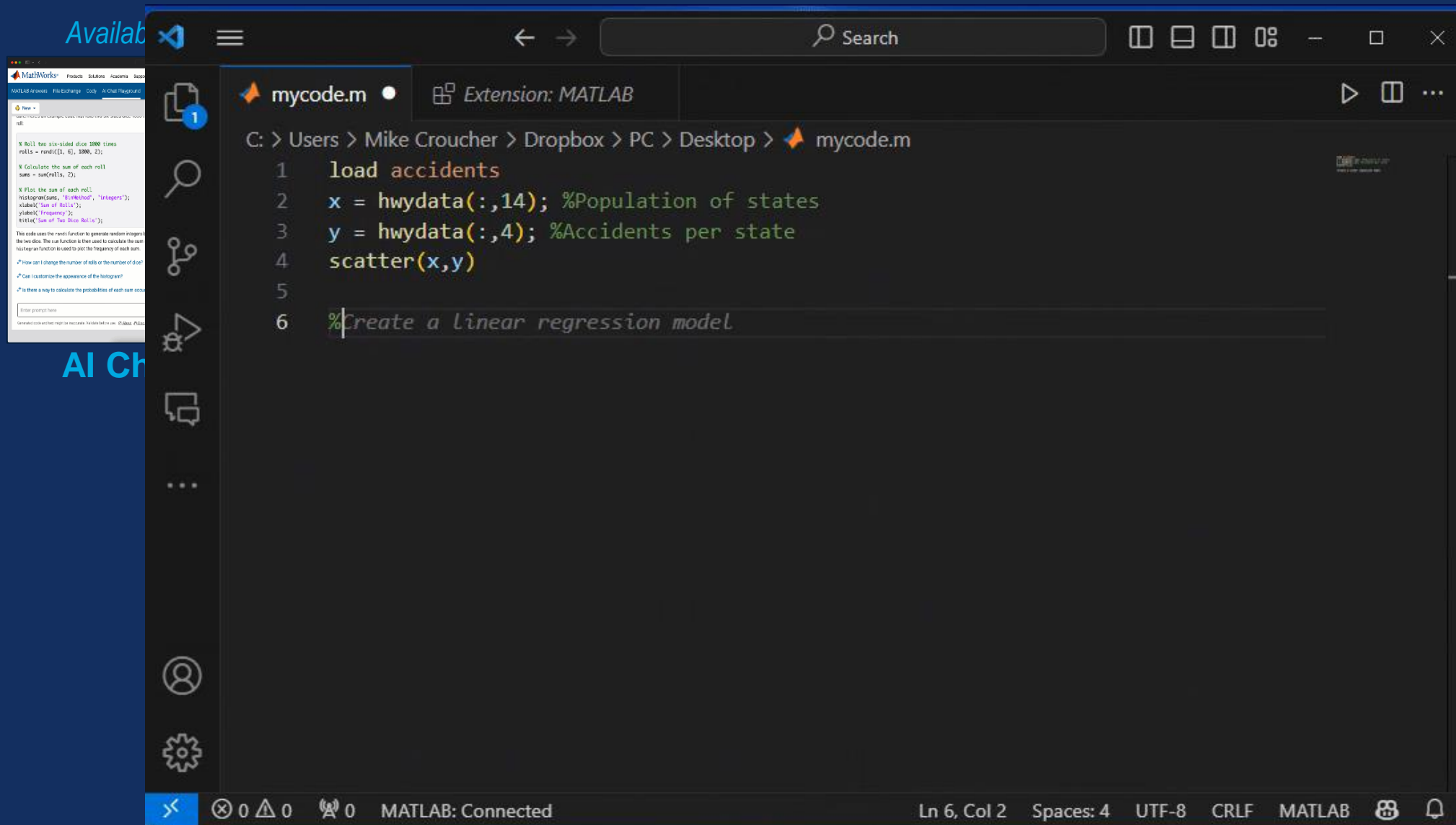
➔ How do I get MATLAB?

Message MATLAB

MathWorks workspace chats aren't used to train our models. ChatGPT can make mistakes.

# Generative AI for MATLAB

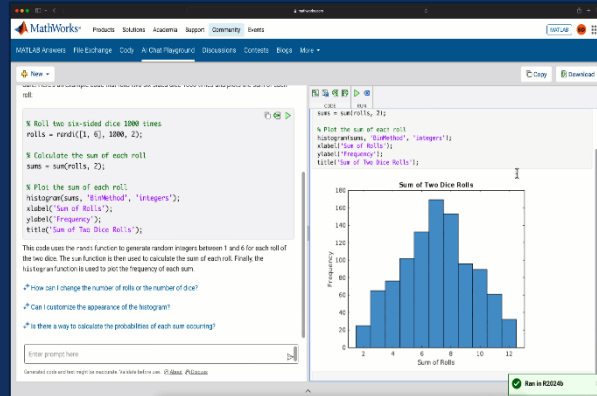
## MATLAB Extension for Visual Studio Code





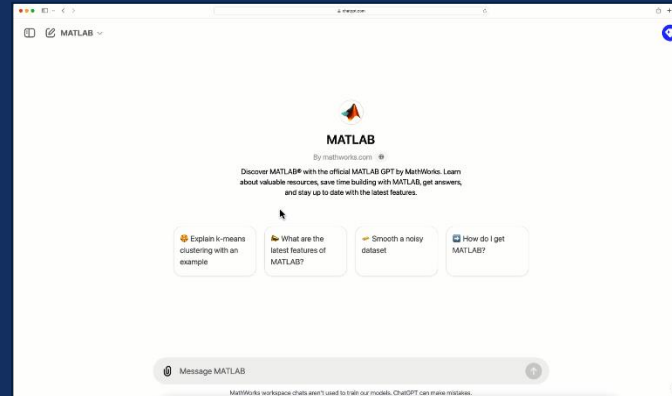
# Generative AI for MATLAB

Available at [mathworks.com](https://mathworks.com)



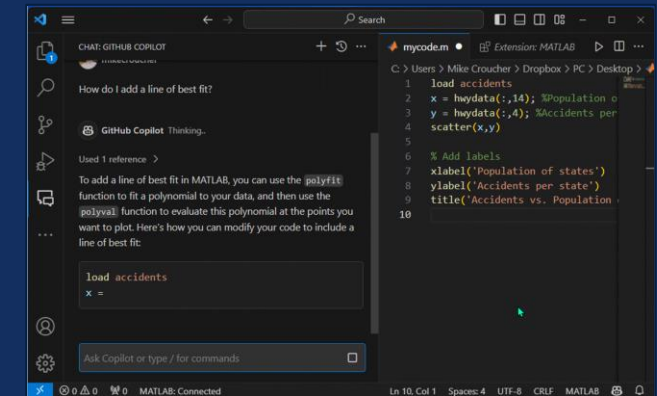
AI Chat Playground

Available at OpenAI GPT Store



MATLAB GPT for ChatGPT

Available at Visual Studio Marketplace



MATLAB Extension for VS Code



# Generative AI for MATLAB, Simulink, and Polyspace

In development:  
**MATLAB Copilot**

*Planned 2025*

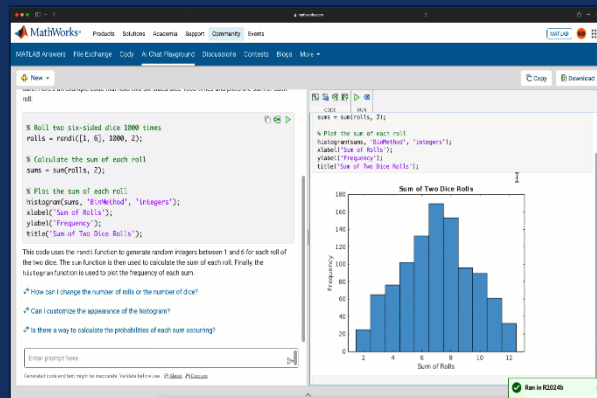
In development:  
**Simulink Copilot**

*Planned 2025*

In development:  
**Polyspace Copilot**

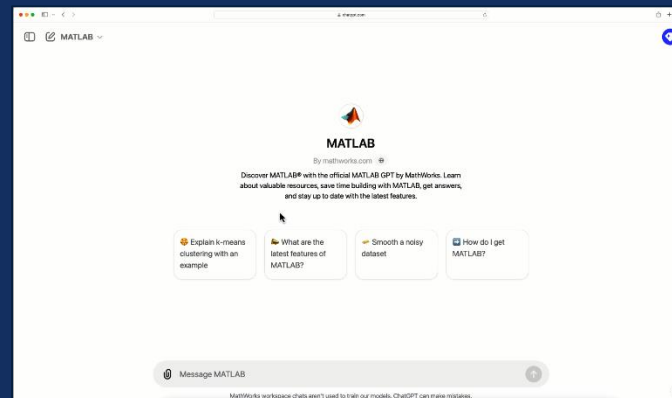
*Planned 2025*

Available at [mathworks.com](https://mathworks.com)



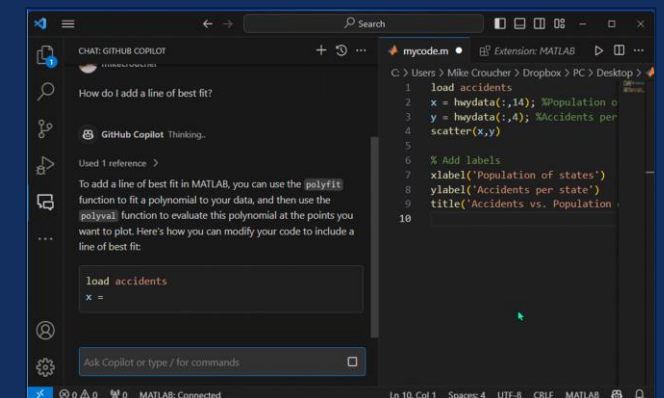
AI Chat Playground

Available at OpenAI GPT Store



MATLAB GPT for ChatGPT

Available at Visual Studio Marketplace



MATLAB Extension for VS Code

# Software-Defined Systems



Modern Software Practices



Reliability



Data-Driven Functionality



Functional Safety



Leverages Cloud



Physical Components

In my Software-Defined System, can we release a major feature with no hardware changes, leveraging the cloud?

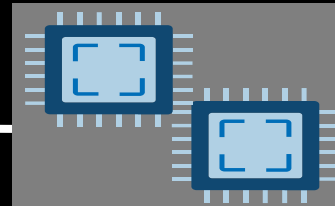
### “Sport+” Mode

▲ Reduce 0-60mph time

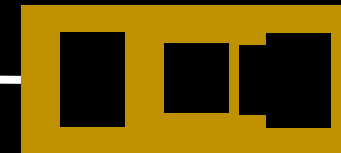
↔ Minimum Range Change



Infotainment System (IVI)  
QM



Vehicle Control Unit (HPC)  
ASIL-B



Battery Management  
(Embedded Edge)  
ASIL-D





## Automotive Software Development in the Cloud

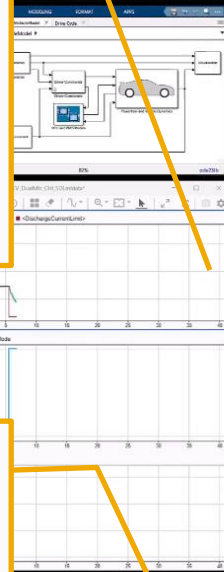
aws FOR AUTOMOTIVE

- Run parallel simulations
- Automate model checks, simulations, report generation in CI pipelines

- Automatically generate code, interactively or in CI pipeline

MathWorks

Simulation II: MATLAB & Simulink



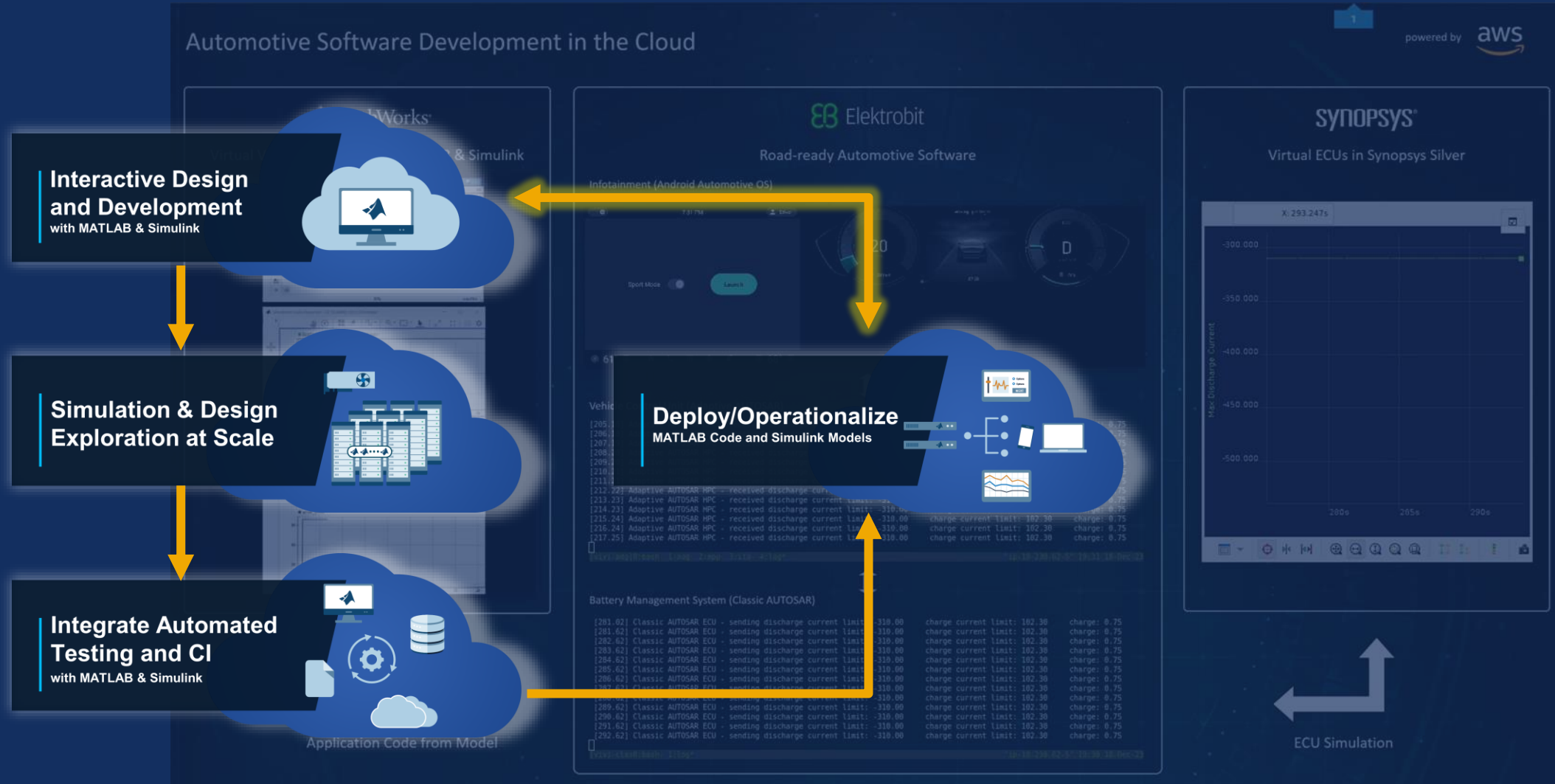
Elektrobit

- Invoke function from instrument cluster

- Integrate application code with production middleware

SYNOPSYS

- Integrate with detailed virtual ECU

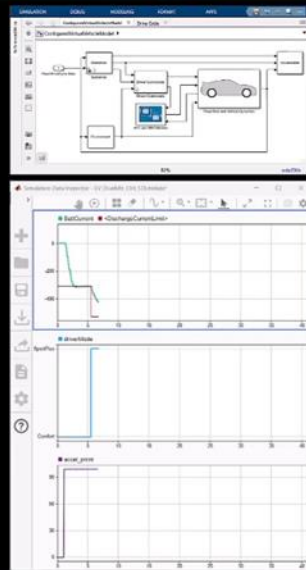


# Automotive Software Development in the Cloud

powered by **aws**



## Virtual Vehicle Simulation in MATLAB & Simulink

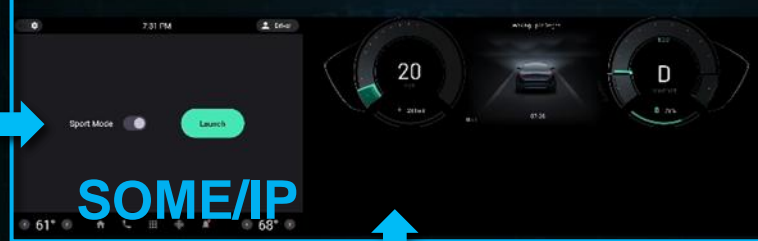


Application Code from Model



## Road-ready Automotive Software

### Infotainment (Android Automotive OS)

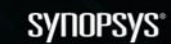


### Vehicle Control Unit (Adaptive AUTOSAR)

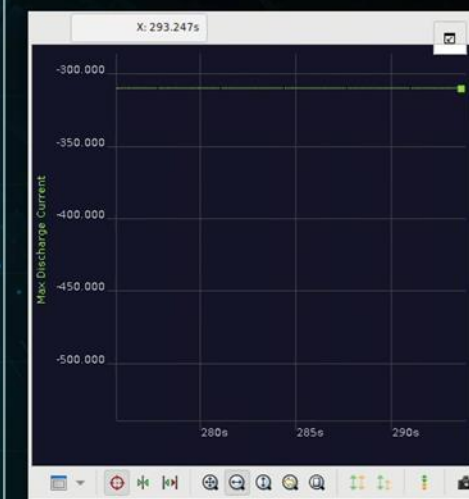
```
[205.18] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[206.18] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[207.19] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[208.20] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[209.20] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[210.21] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[211.21] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[212.22] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[213.23] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[214.23] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[215.24] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[216.24] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[217.25] Adaptive AUTOSAR HPC - received discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
```

### Battery Management System (Classic AUTOSAR)

```
[281.02] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[281.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[282.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[283.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[284.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[285.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[286.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[287.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[288.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[289.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[290.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[291.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
[292.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00 charge current limit: 102.30 charge: 0.75
```



## Virtual ECUs in Synopsys Silver

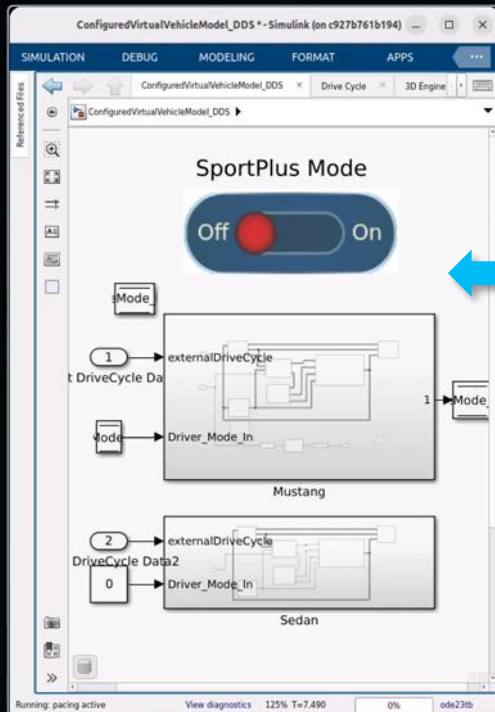


ECU Simulation

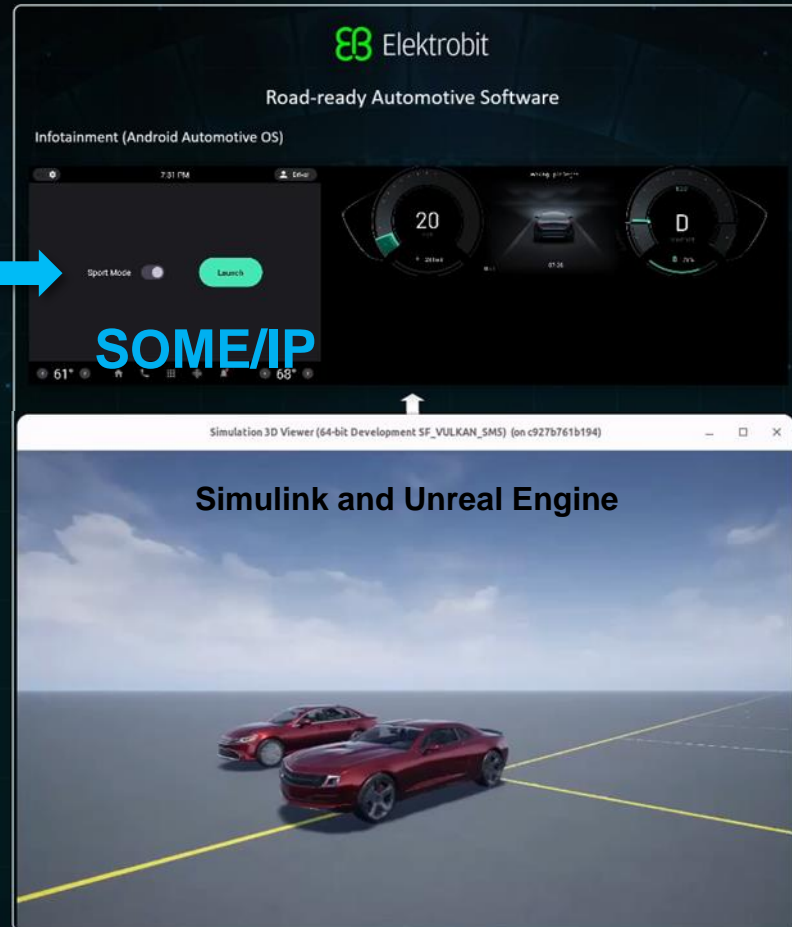
# Automotive Software Development in the Cloud

1

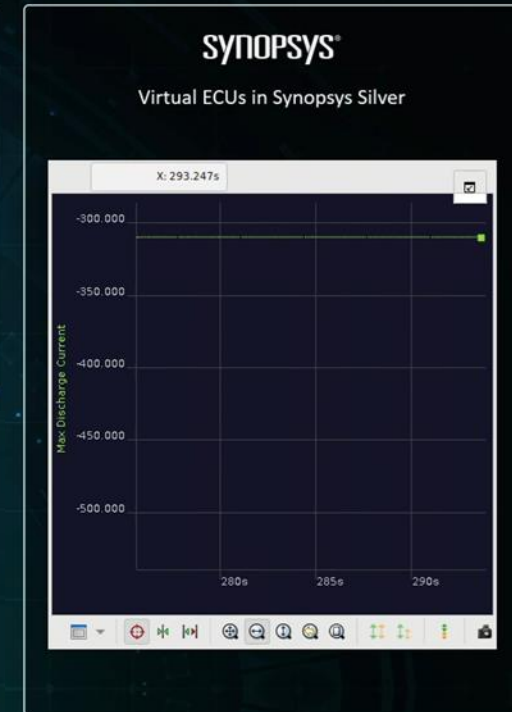
powered by 



Application Code from Model



SOME/IP

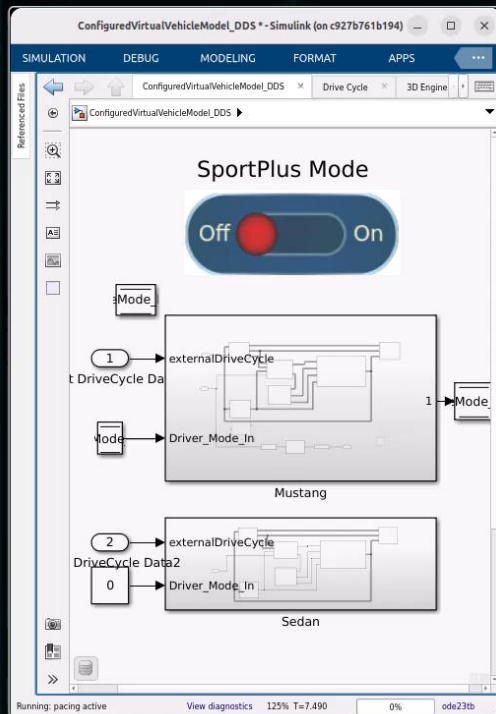


ECU Simulation

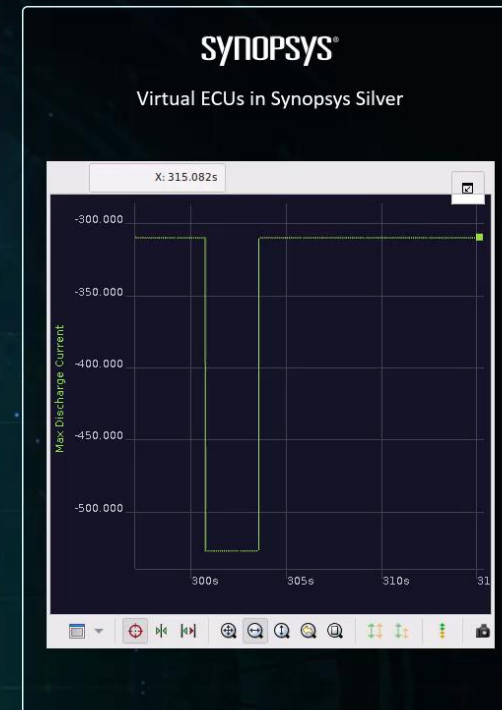
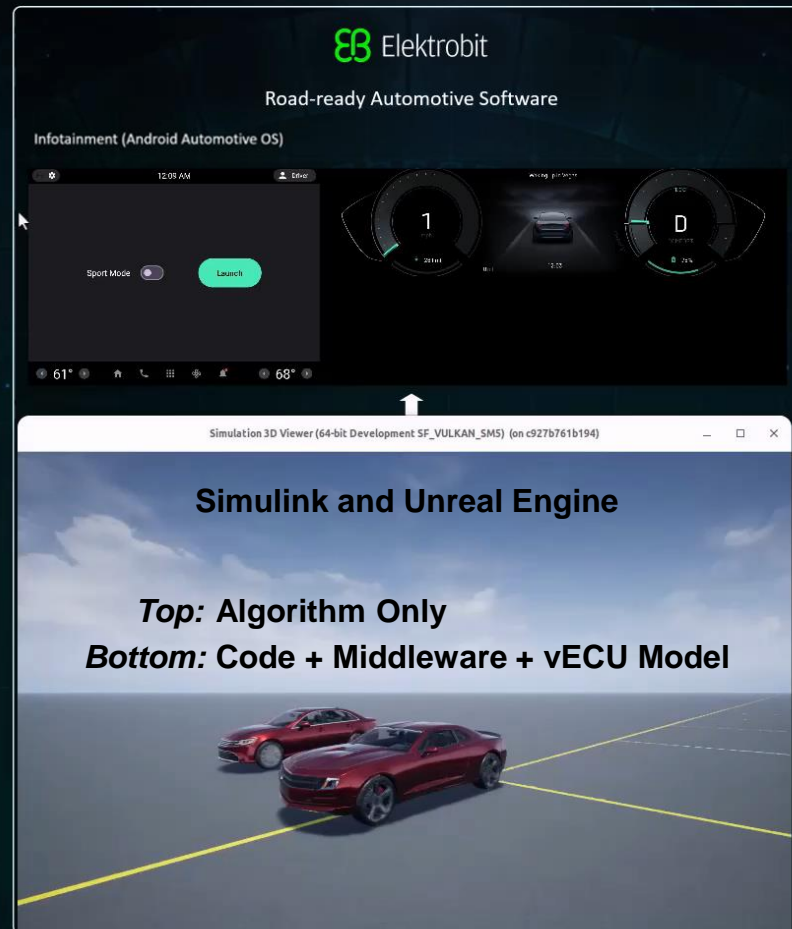


## Automotive Software Development in the Cloud

powered by 



  
Application Code from Model



  
ECU Simulation



**SOFTWARE  
FACTORY**

**MODEL-BASED  
DESIGN**

Requirements  
and  
Architecture

Code-Based Development

DevOps and CI Platforms

Algorithm Design  
and Code Generation

Virtualization



Full System



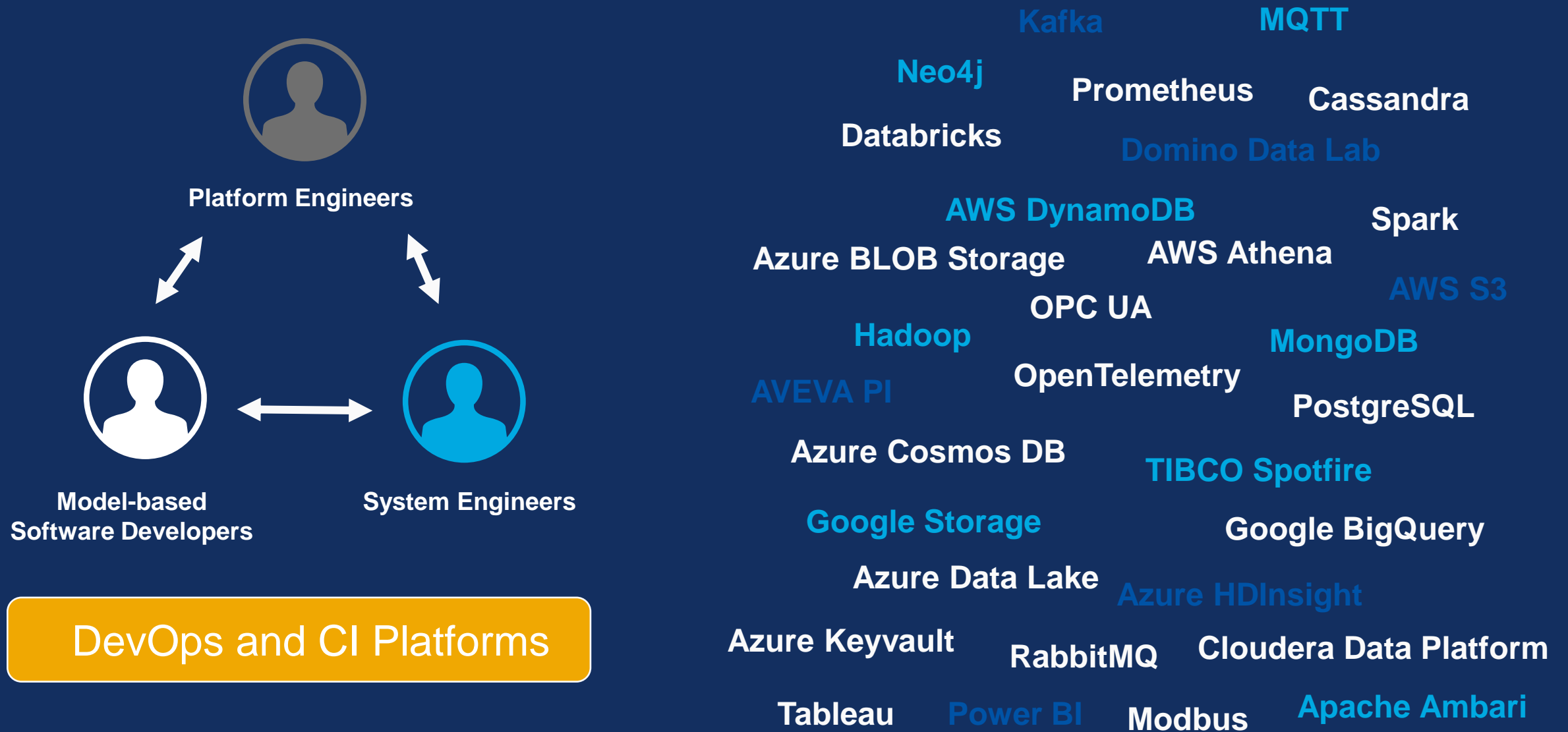
Components



Scenarios

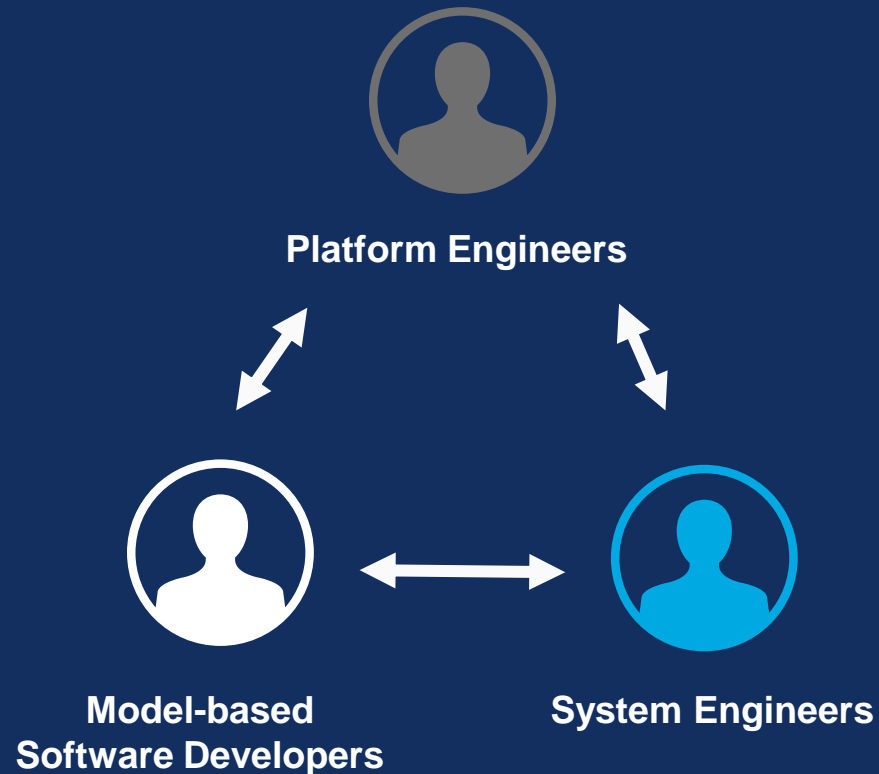


# Integrations to Leverage Data and Cloud

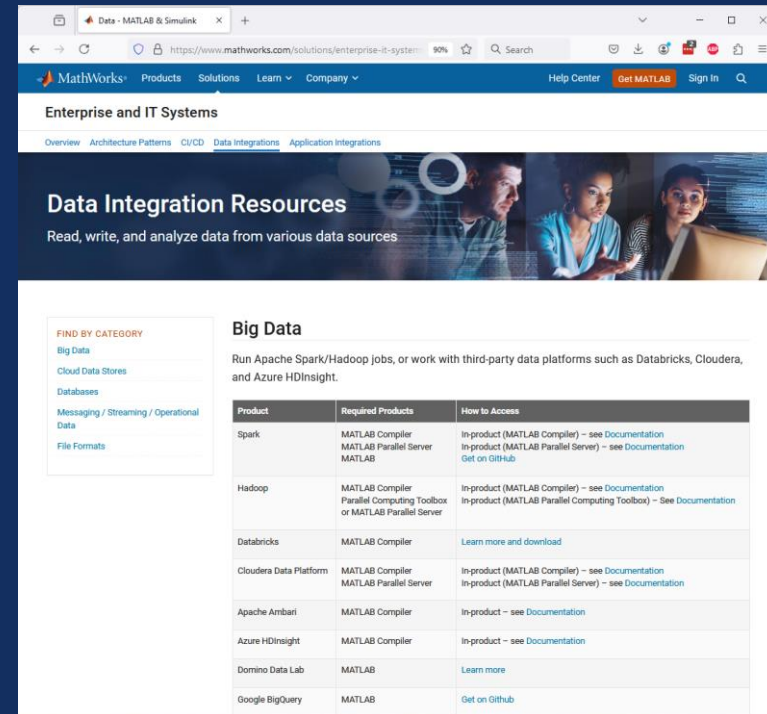




# Integrations to Leverage Data and Cloud

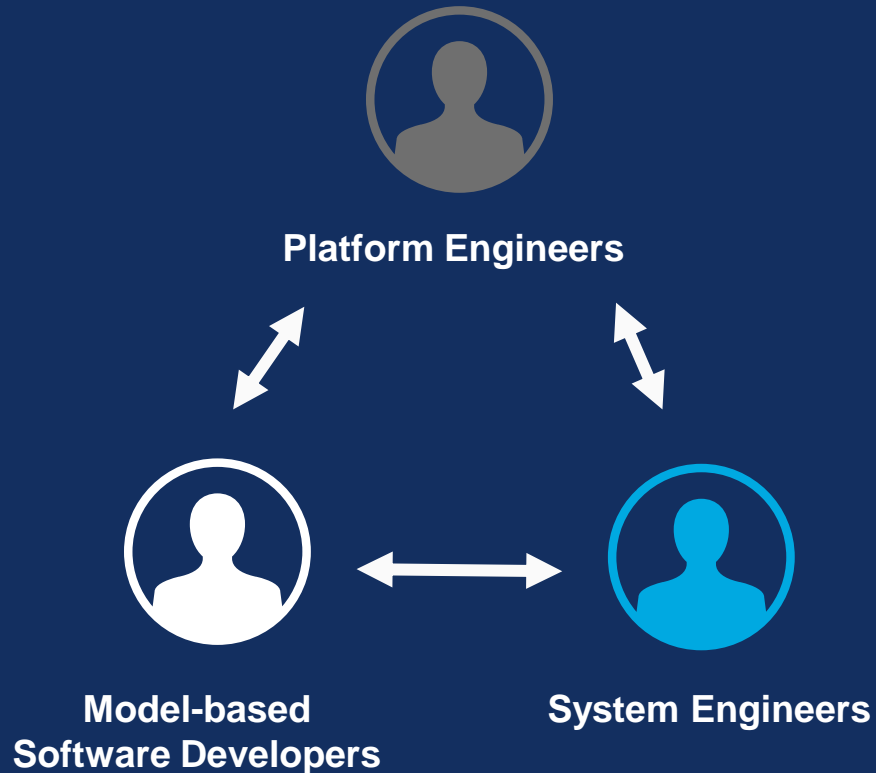


DevOps and CI Platforms



Search for “mathworks enterprise integration”

# Empowering Platform Engineers: Accelerating MATLAB Startup with Custom Cloud Images



DevOps and CI Platforms

**MATLAB Cold-Start in Cloud: ~~12 minutes~~**

1 minute → 25 seconds

Point platform engineers to MathWorks  
Reference Architectures on GitHub

Search “**matlab github packer**”



# Software-Defined Systems



Modern Software Practices



Reliability



Data-Driven Functionality



Functional Safety



Leverages Cloud



Physical Components

**SOFTWARE  
FACTORY**

**MODEL-BASED  
DESIGN**

Requirements  
and  
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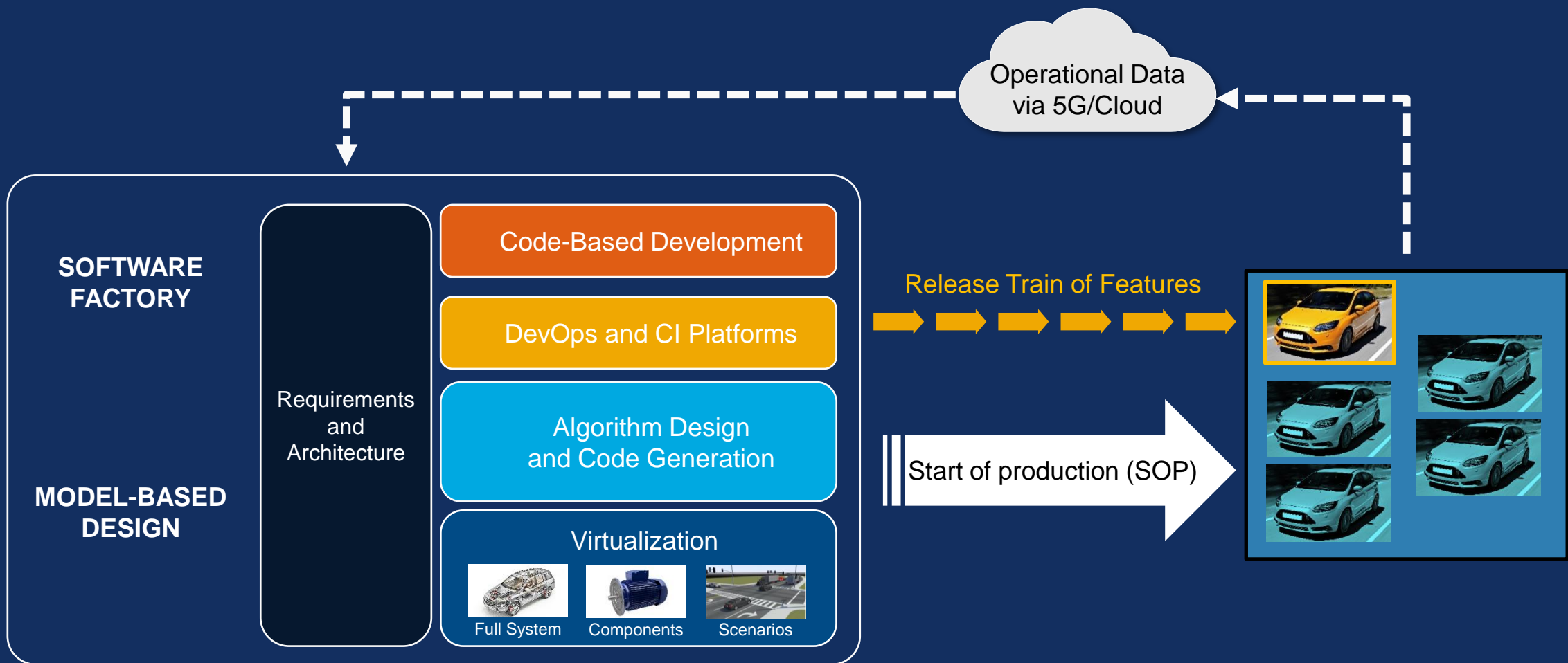
Full System

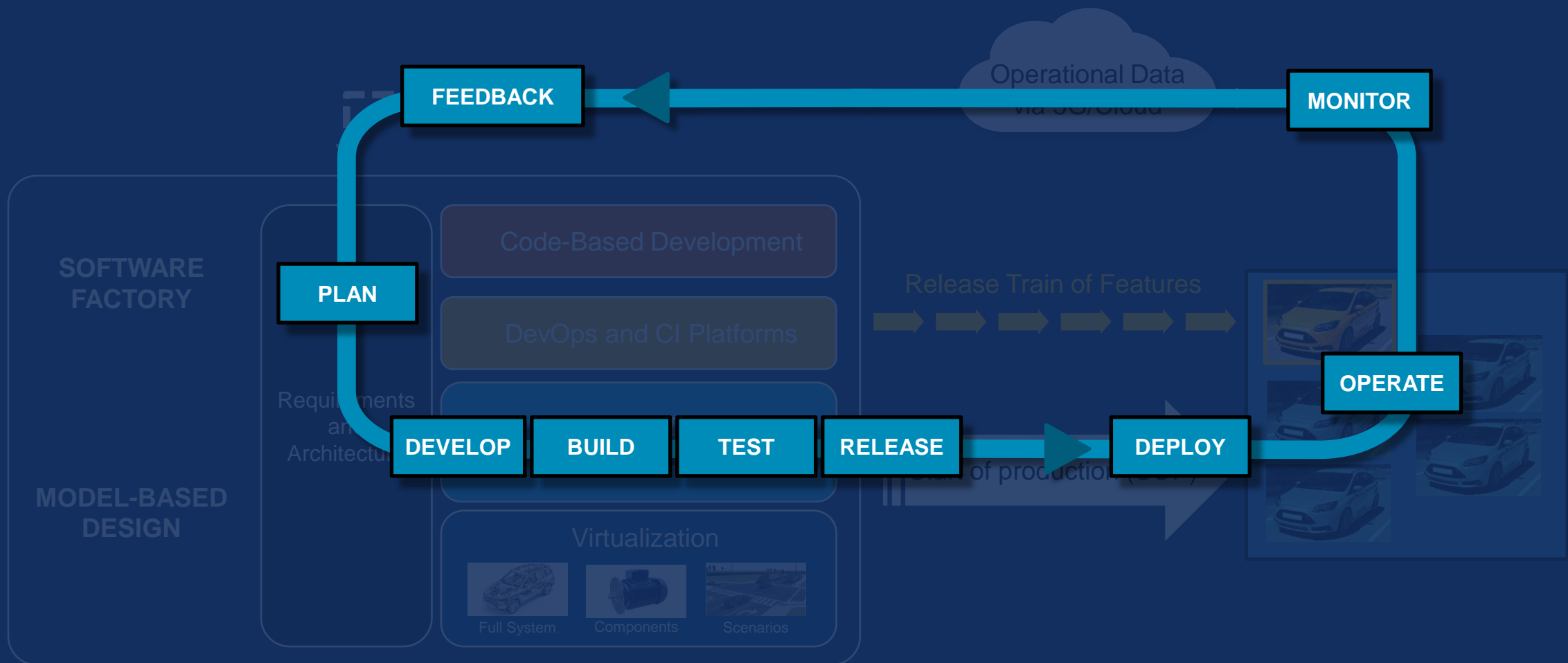


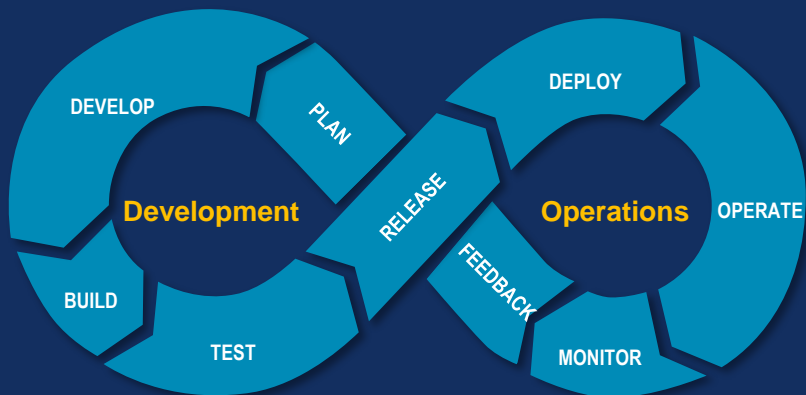
Components



Scenarios







## DevOps Research and Assessment (DORA) metrics



Deployment frequency



Lead time for changes

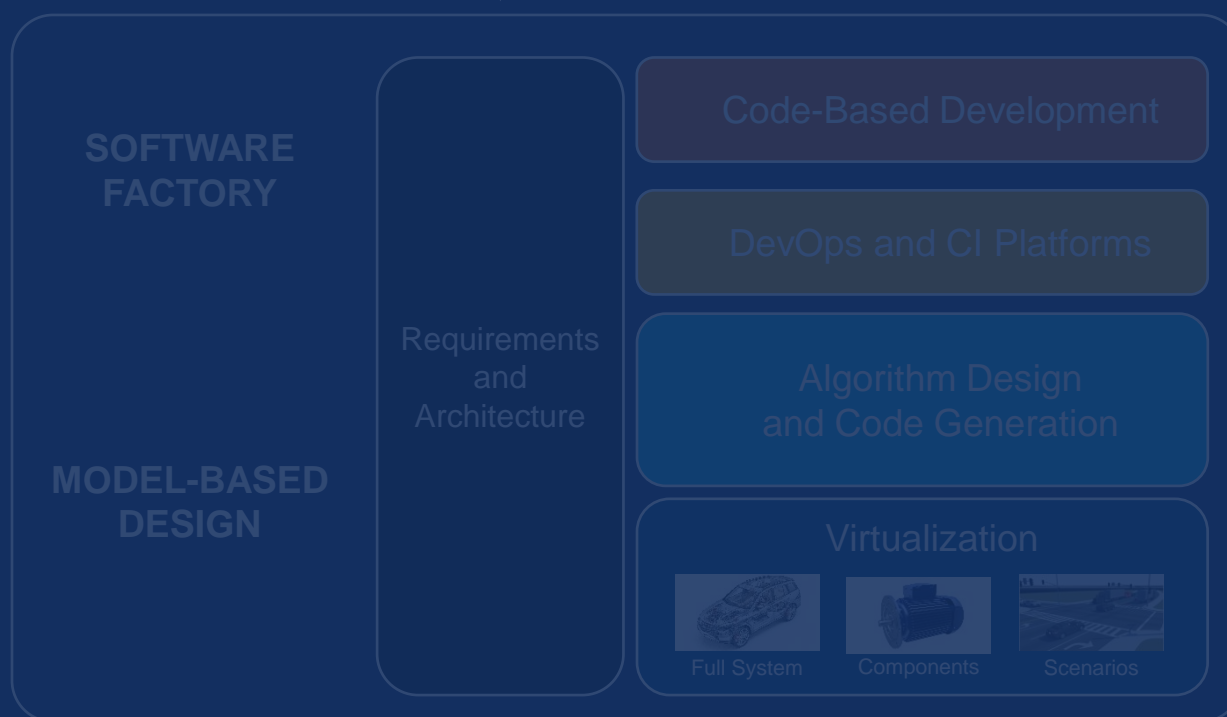


Change failure rate



Mean time to recovery

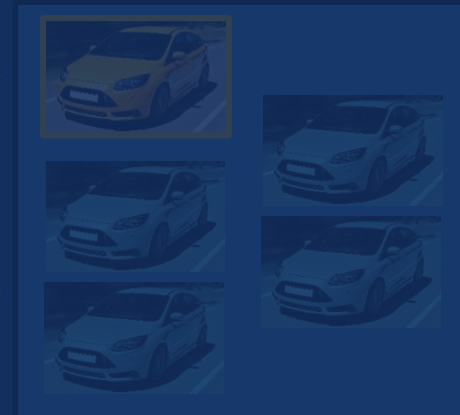
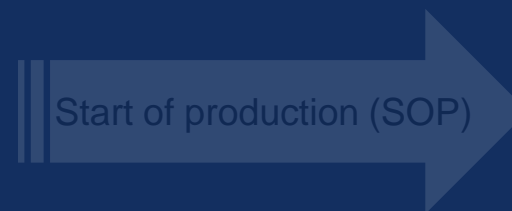
Operational Data  
via 5G/Cloud



Release Train of Features



Start of production (SOP)



# Software-Defined Products



## Software-Defined Systems



# Software-Defined Systems

Software-Defined Vehicles



Advanced Air Mobility



Robotic Surgery Systems



White Goods



Renewable Energy Systems



Industrial Packaging Systems



# Software-Defined Systems



Value creation thanks  
to continuous updates



Systems and software-defined  
mindsets together as enablers



It's an opportunity and  
a challenge, and we  
are here to support you

# MATLAB EXPO

## Thank you



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