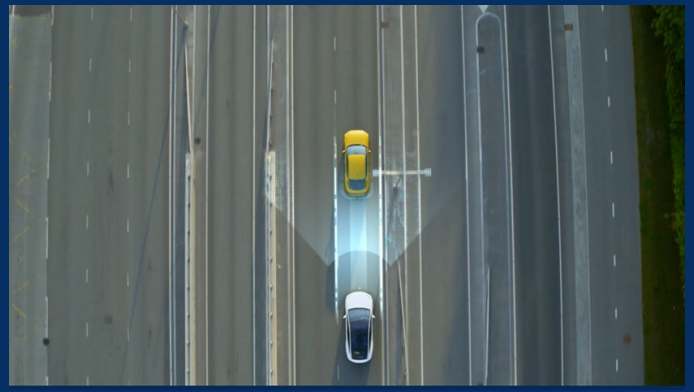
MATLAB EXPO

FRANCE

Model-Based Design for Digital Engineering: Impact and Directions

Richard Rovner

MathWorks®



Application Trends

Autonomous

Connectivity

Electrification

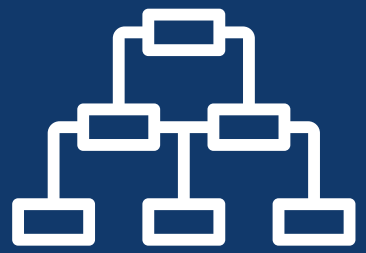
Application Trends

Autonomous

Connectivity

Electrification

Workflow Trends



Systems Engineering & Design

Modern Software Practices

AI for System Development

Application Trends

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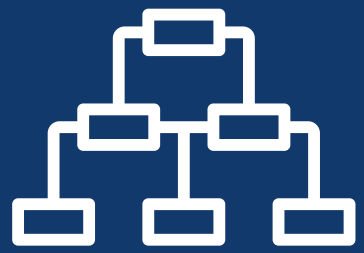

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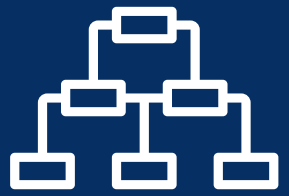
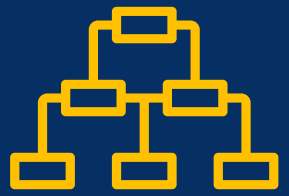


1. Automate everything
2. Scale to complex systems
3. Use automatic code generation
4. Prevent defects early

5. Apply standard software workflows
6. Design and simulate in the cloud

7. Design your system with AI

Workflow Trends



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① Automate everything

Modeling

Simulation | Analysis

+

Automation

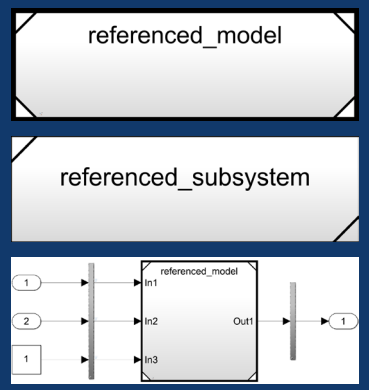
Coding | Verification

1 Automate everything

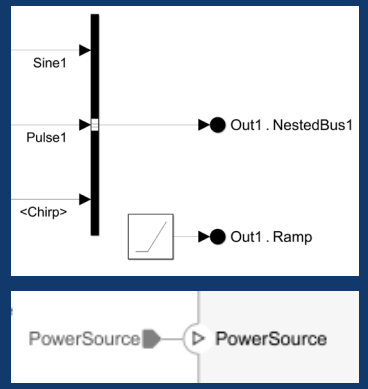
From the simulation of multi-physics to the generation of industrial codes

Rémi Fayolle and Anthony Michel, *Symbio*

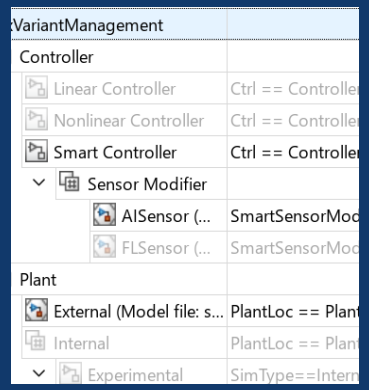
② Scale to complex systems



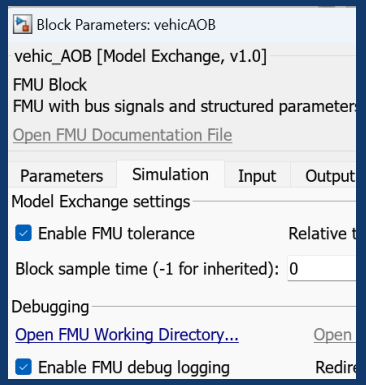
Components



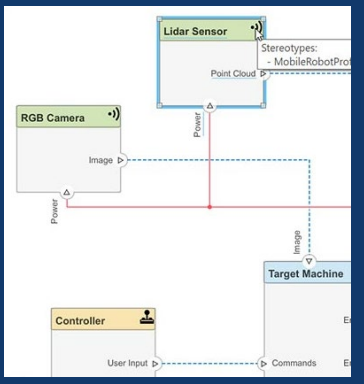
Buses, Ports, and Connectors



Variant Manager

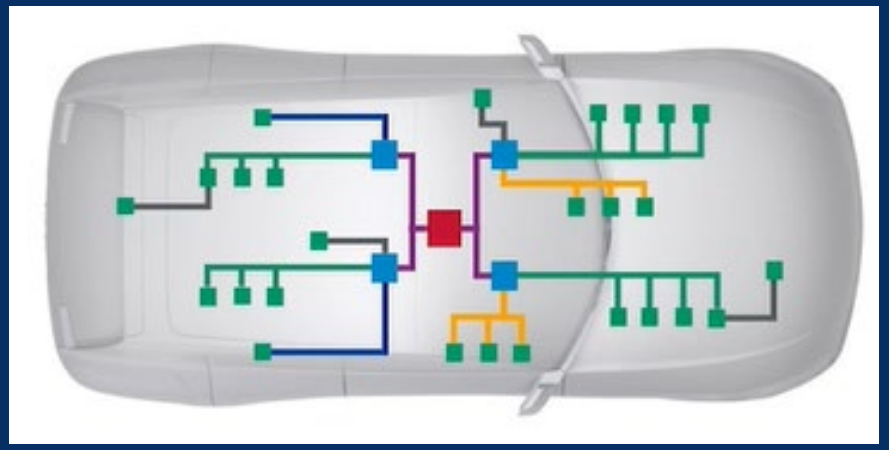


Third-Party Tool Integration

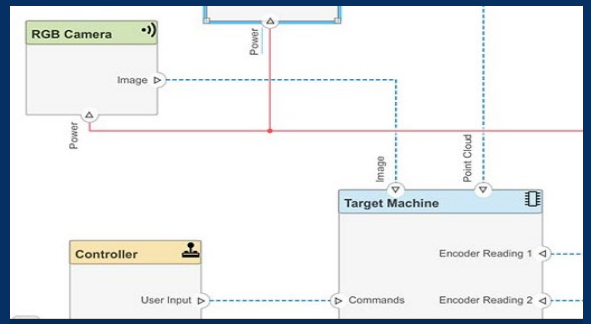


Architecture

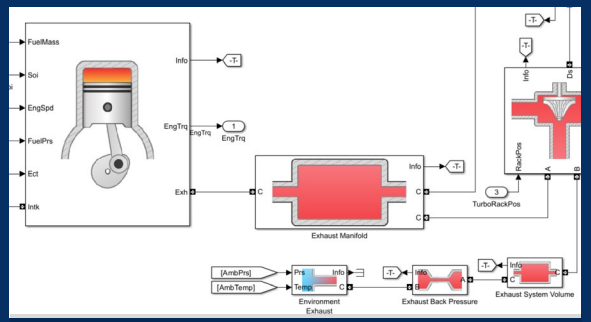
② Scale to complex systems



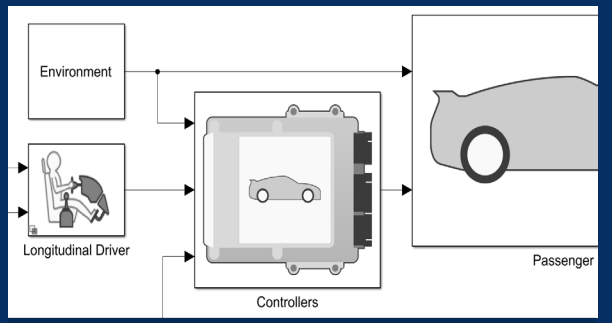
Service-Oriented Architecture



System Composer



Components

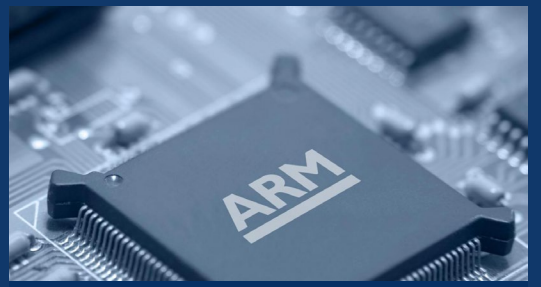


Full System

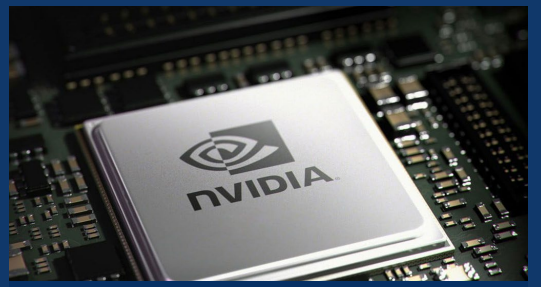
3 Use automatic code generation

3700

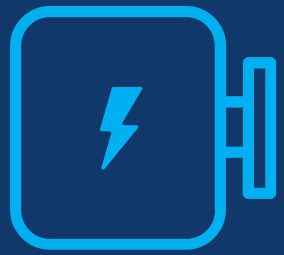
Organizations use automatic code generation

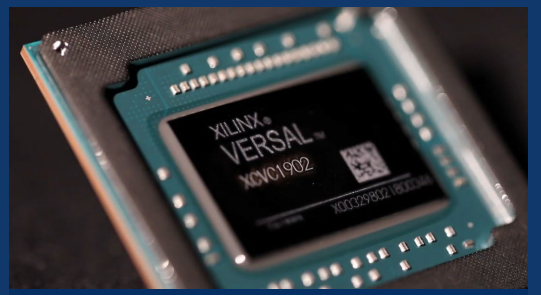


CPU



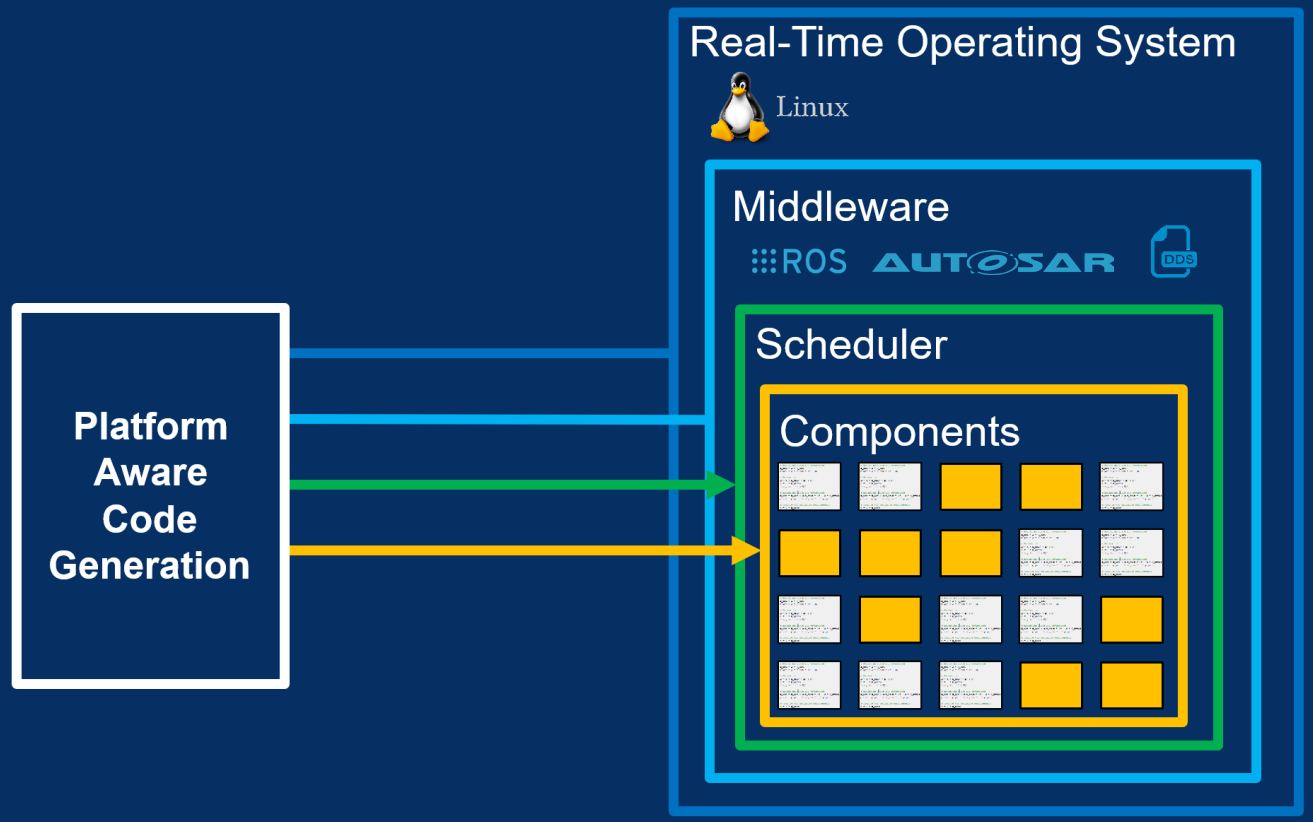
GPU

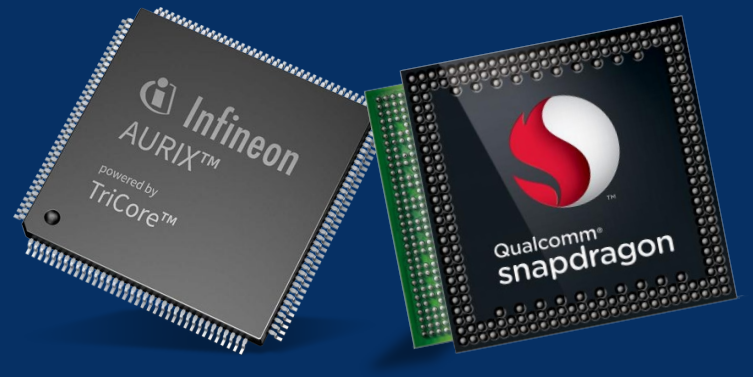




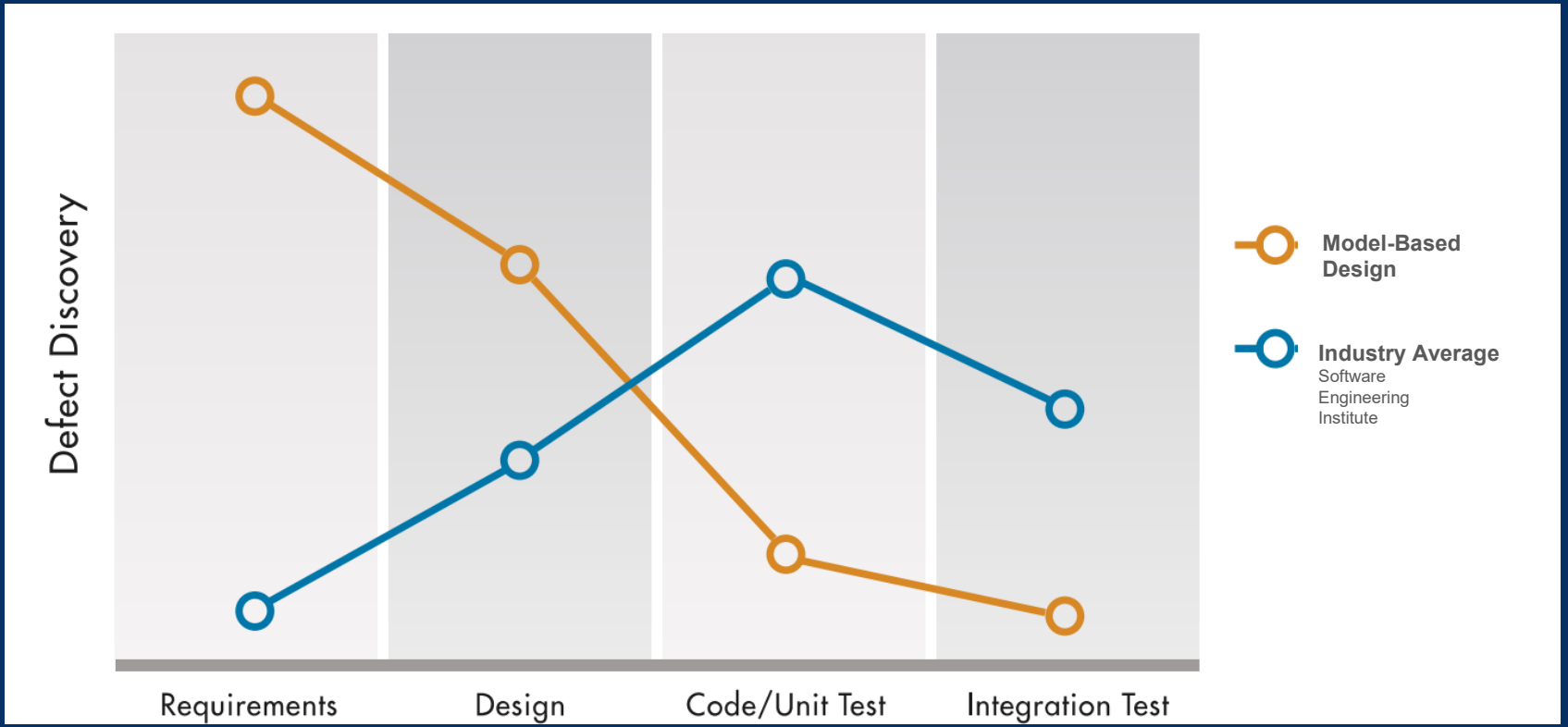
FPGA, ASIC, PLC

3 Use automatic code generation





4 Prevent defects early



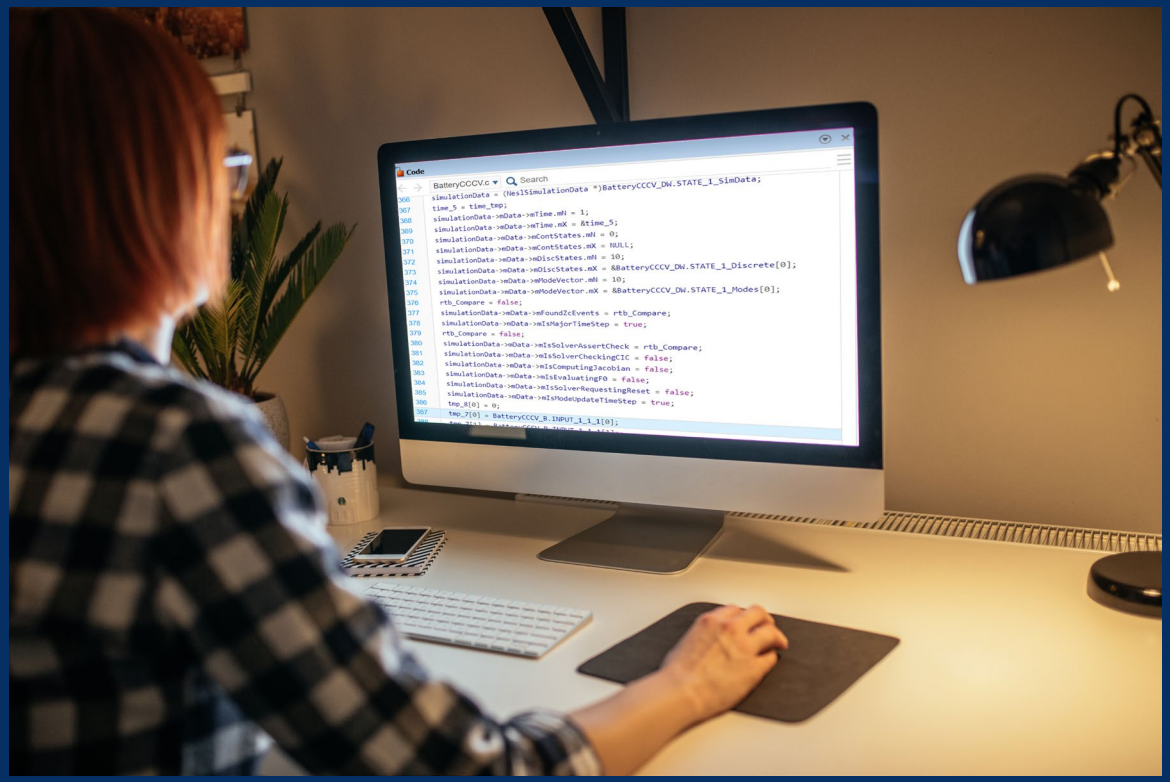
4 Prevent defects early

Find Defects Sooner

Design	Test	Code	Certify
Simulink Design Verifier	Simulink Test	Polyspace Bug Finder	DO Qualification Kit
Simulink Check	Simulink Coverage	Polyspace Code Prover	IEC Certification Kit
HDL Verifier	R2023a MATLAB Test	Polyspace Access	Simulink Code Inspector
R2023b Simulink Fault Analyzer	R2023b Polyspace Test		

UL Certification of Battery Management System Software with Model-Based Design

The Saft Flex'ion Gen2



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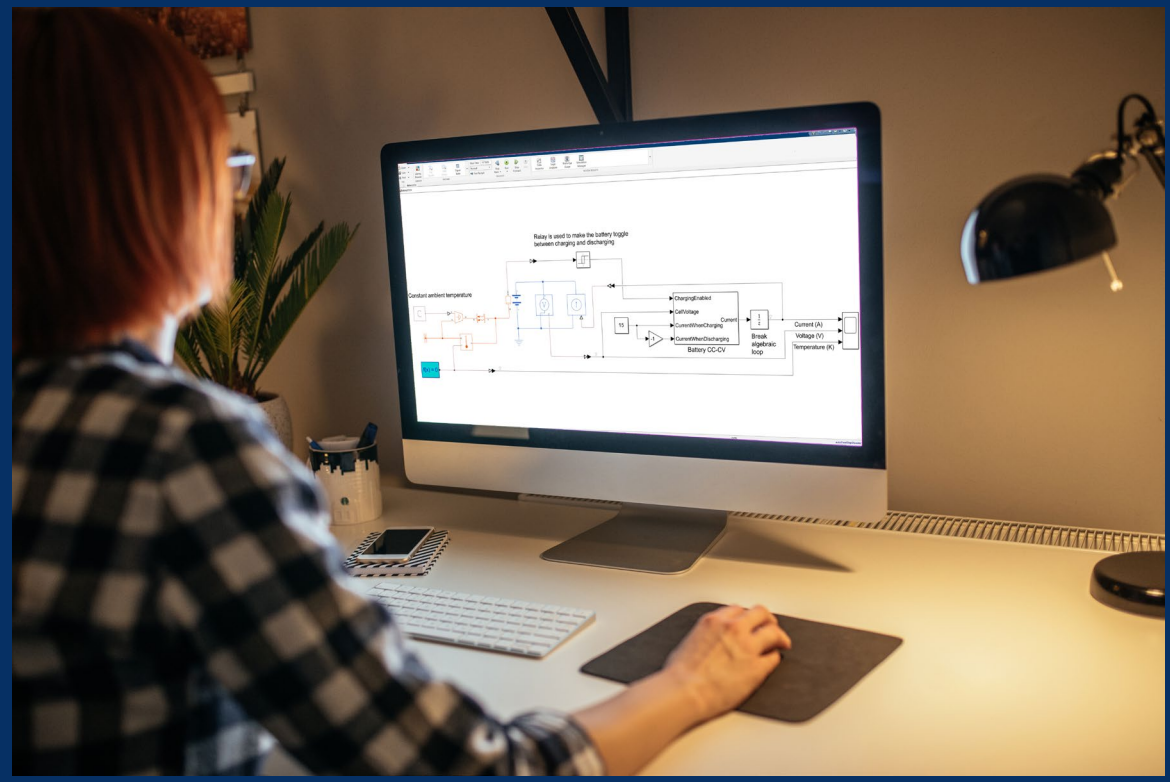

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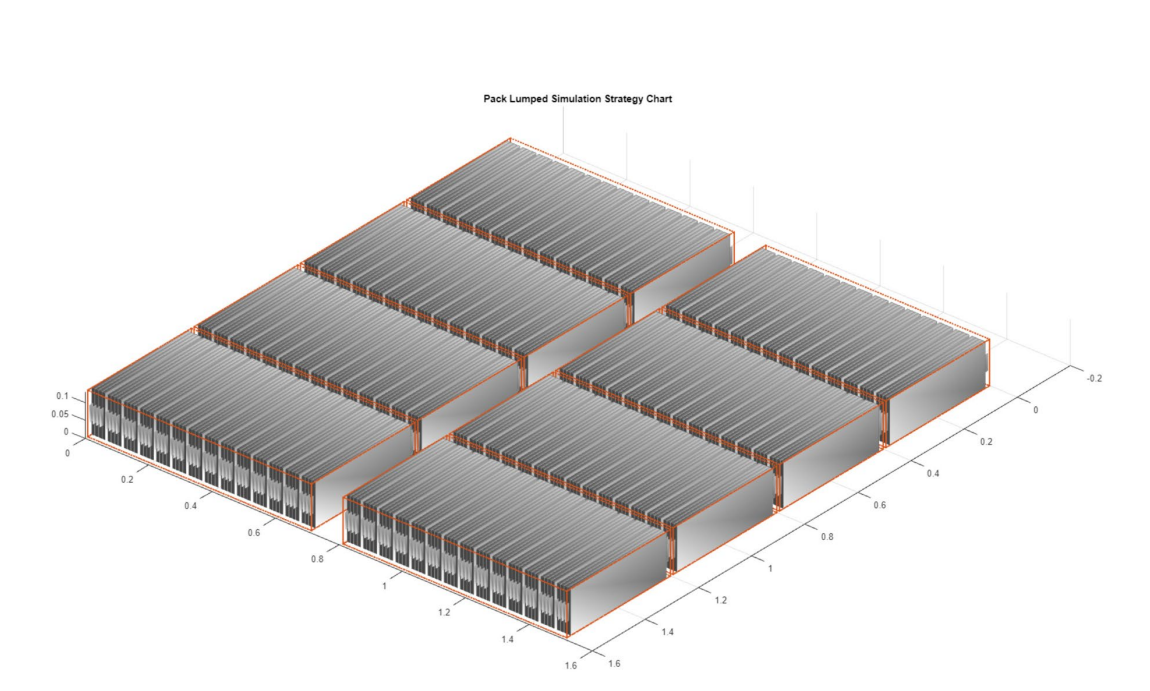

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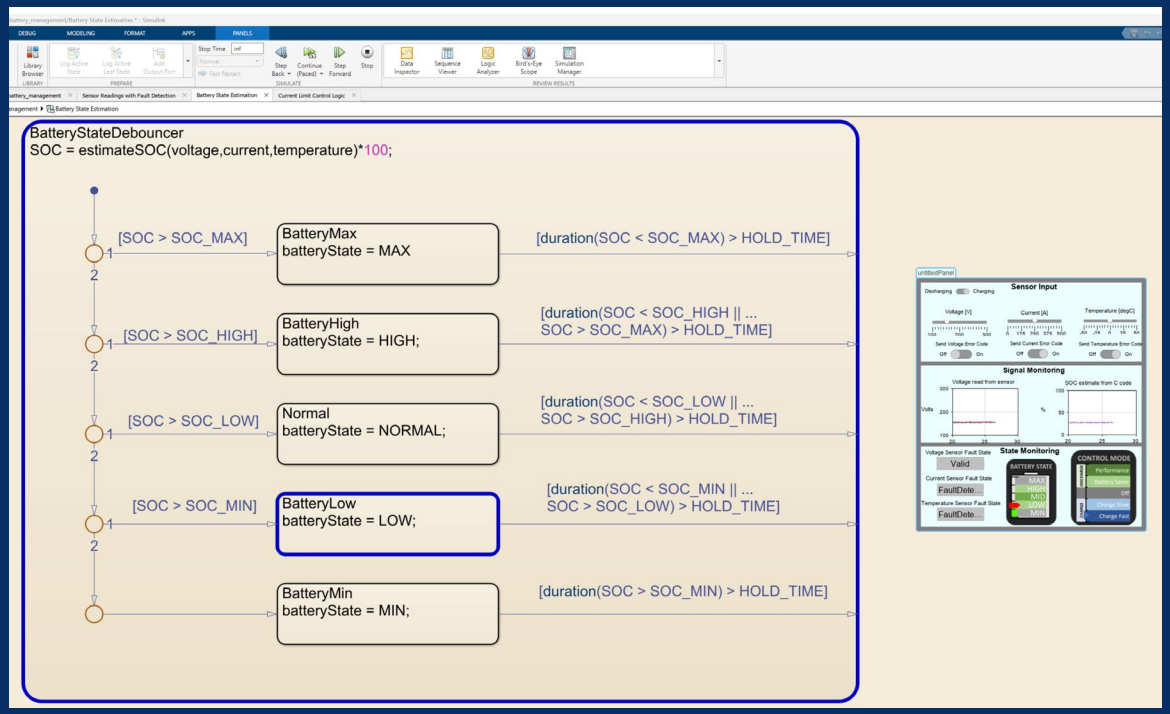

UL Certification of Battery Management System Software with Model-Based Design

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UL Certification of Battery Management System Software with Model-Based Design

The Saft Flex'ion Gen2

2X

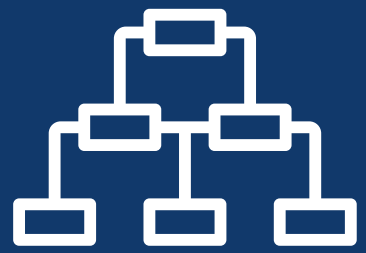
Application Trends

Autonomous

Connectivity

Electrification

Workflow Trends

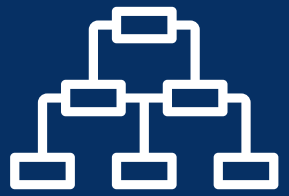


Systems Engineering & Design

Modern Software Practices

AI for System Development

Workflow Trends



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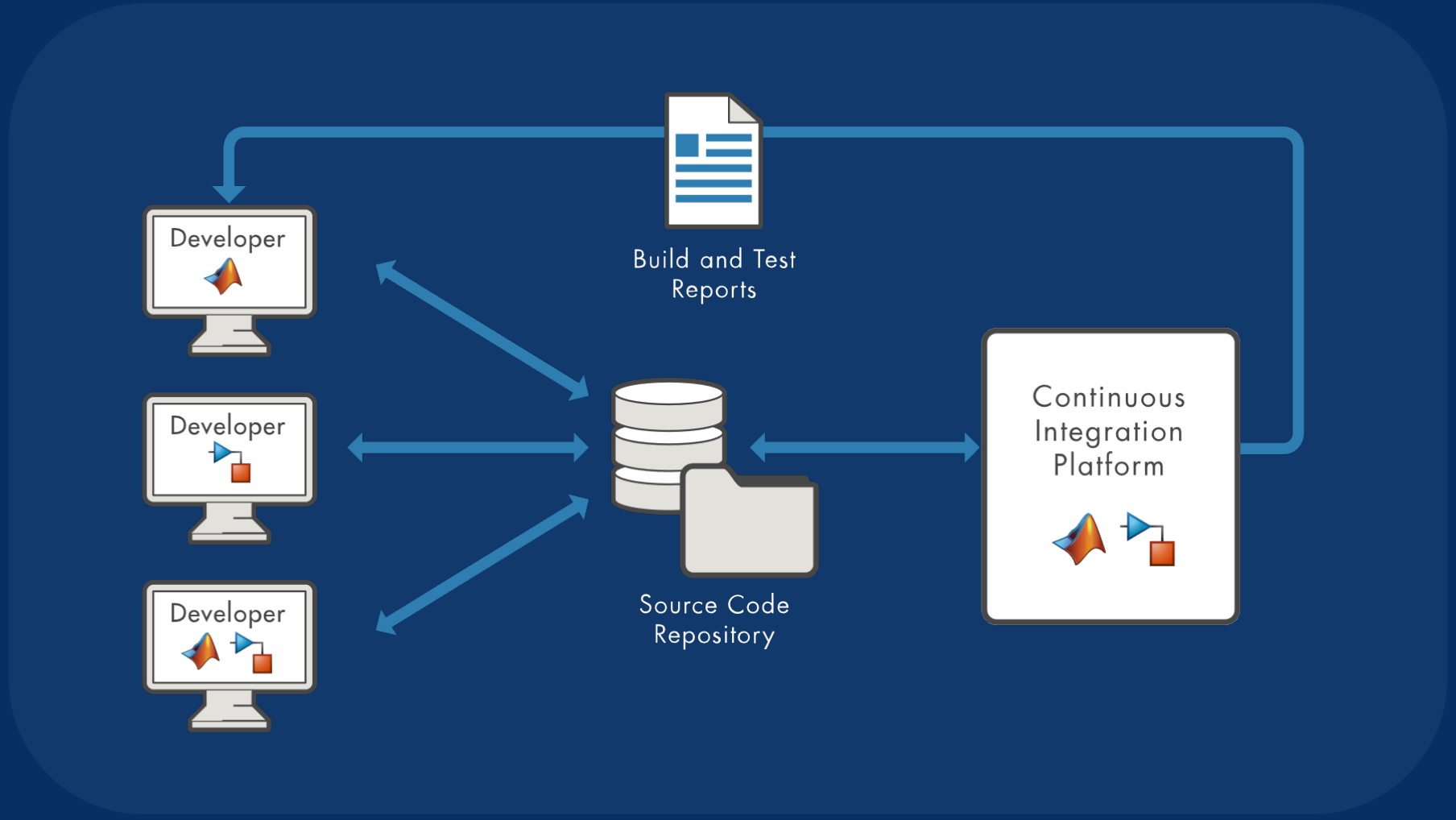
5 Apply standard software workflows

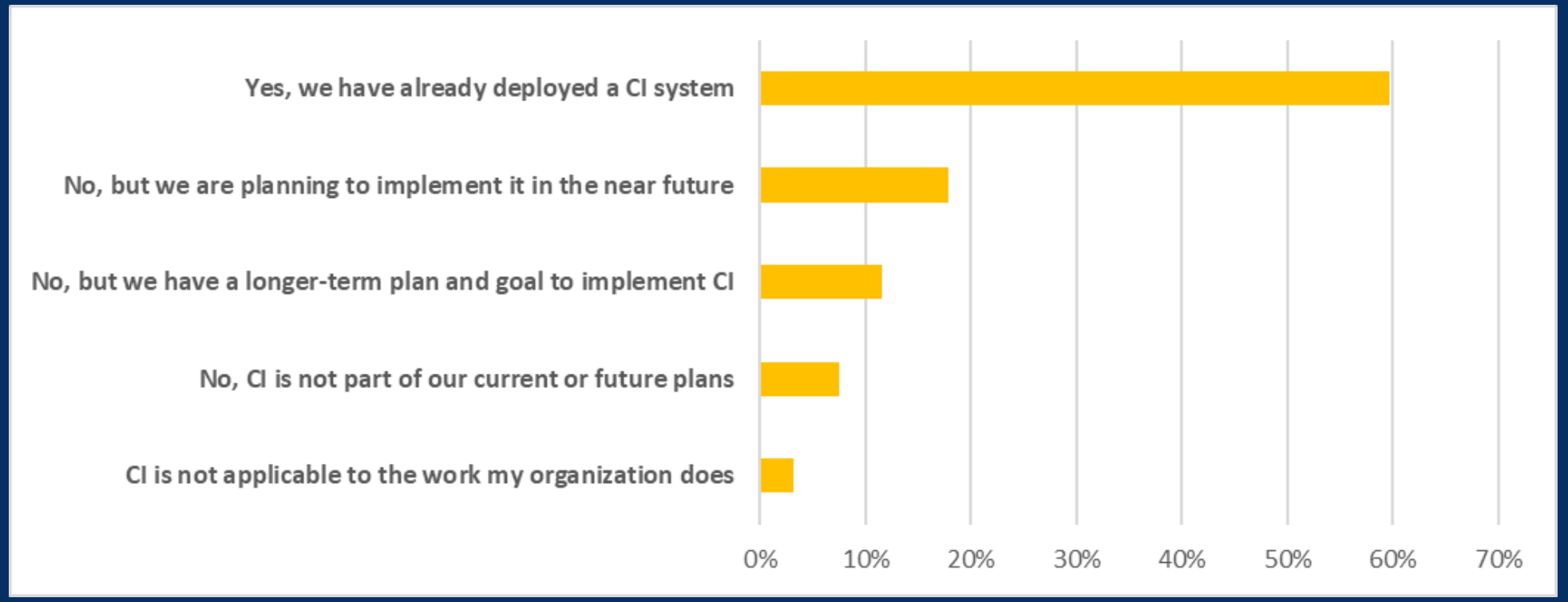
"Software is the language of automation."

- Jensen Huang, co-founder and CEO of NVIDIA

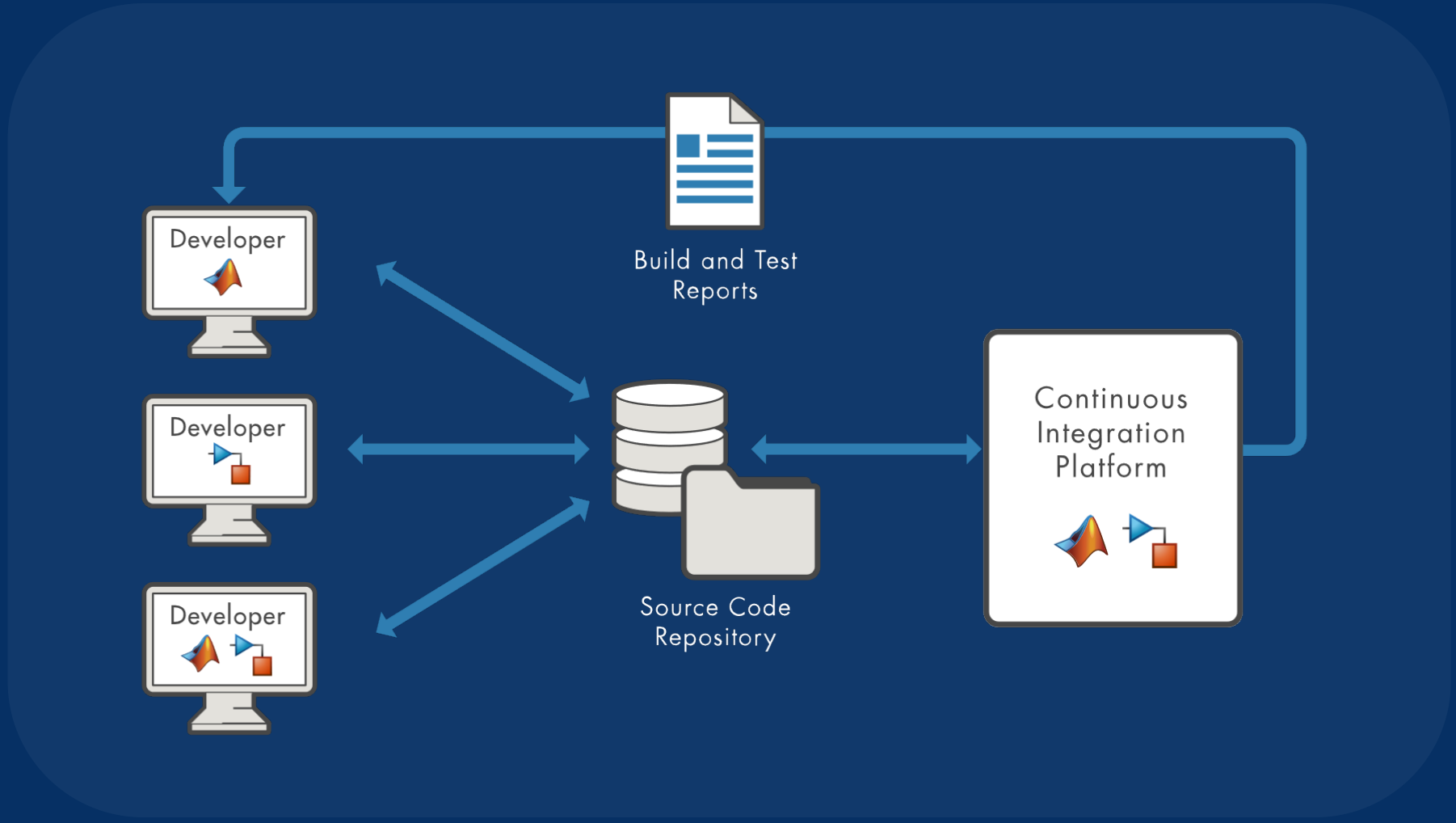
5 Apply standard software workflows



Does your organization currently use a continuous integration (CI) system? (select one)



5 Apply standard software workflows



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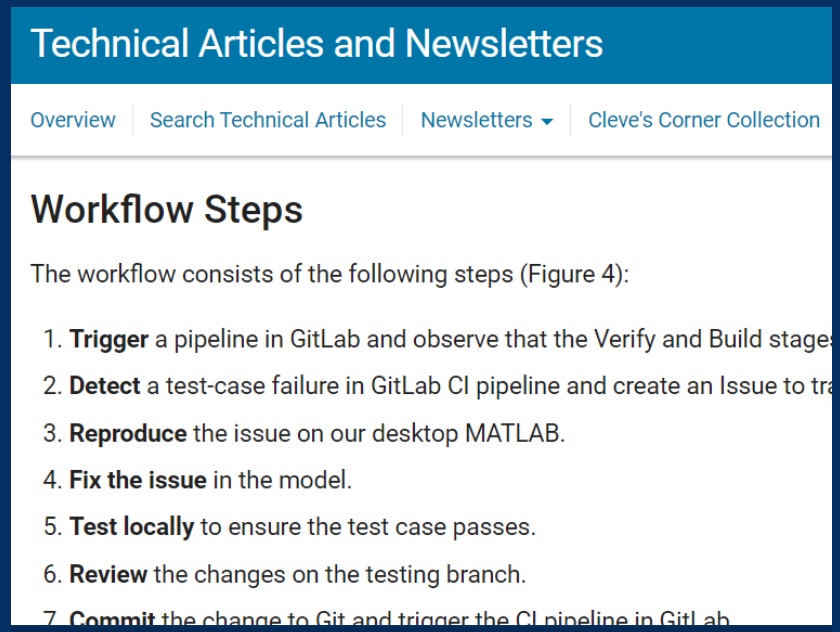
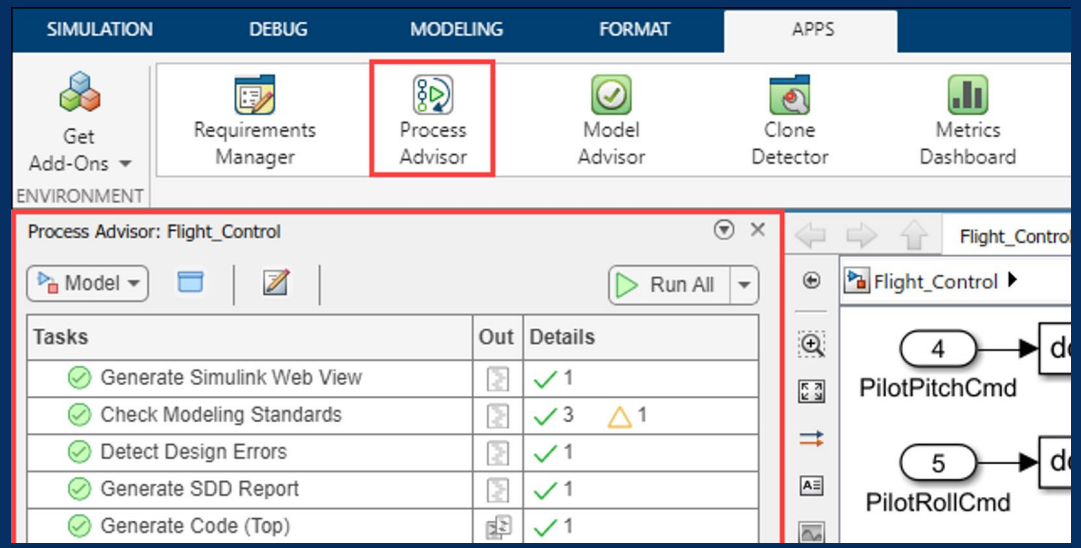


Step-by-Step Tutorials



Process Advisor

Continental

From Scripted Pipelines to Process Advisor

Continental

From Scripted Pipelines to Process Advisor

Continental

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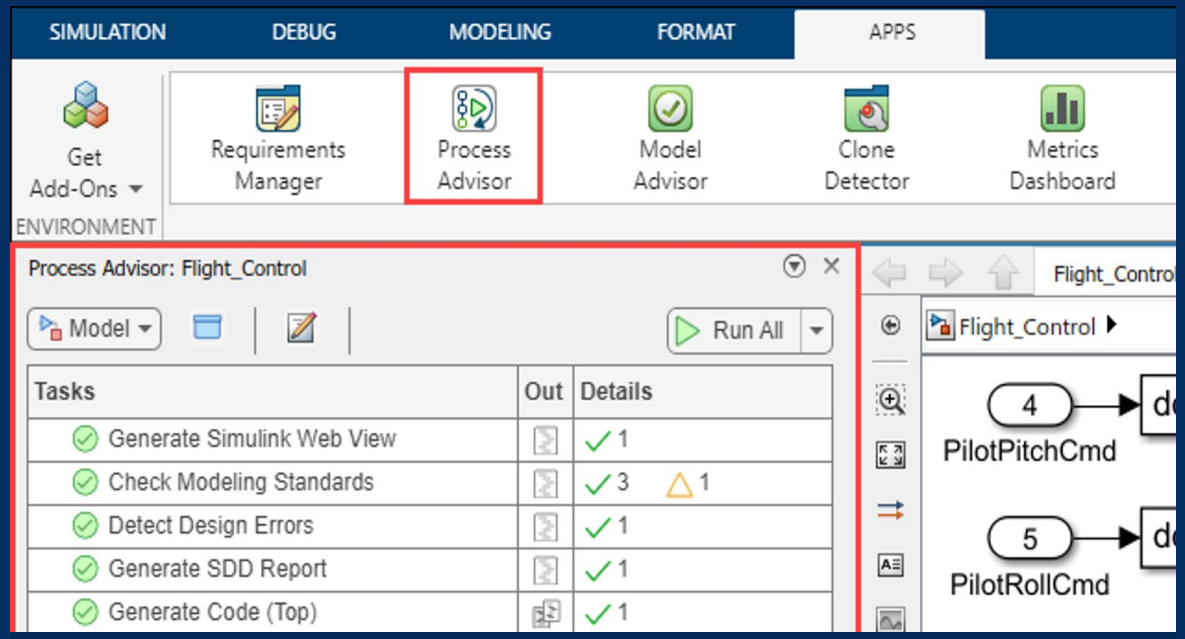
"Bring everything into MATLAB."

- Martin Römpert, Continental Automotive Technologies GmbH

Continental

From Scripted Pipelines to Process Advisor

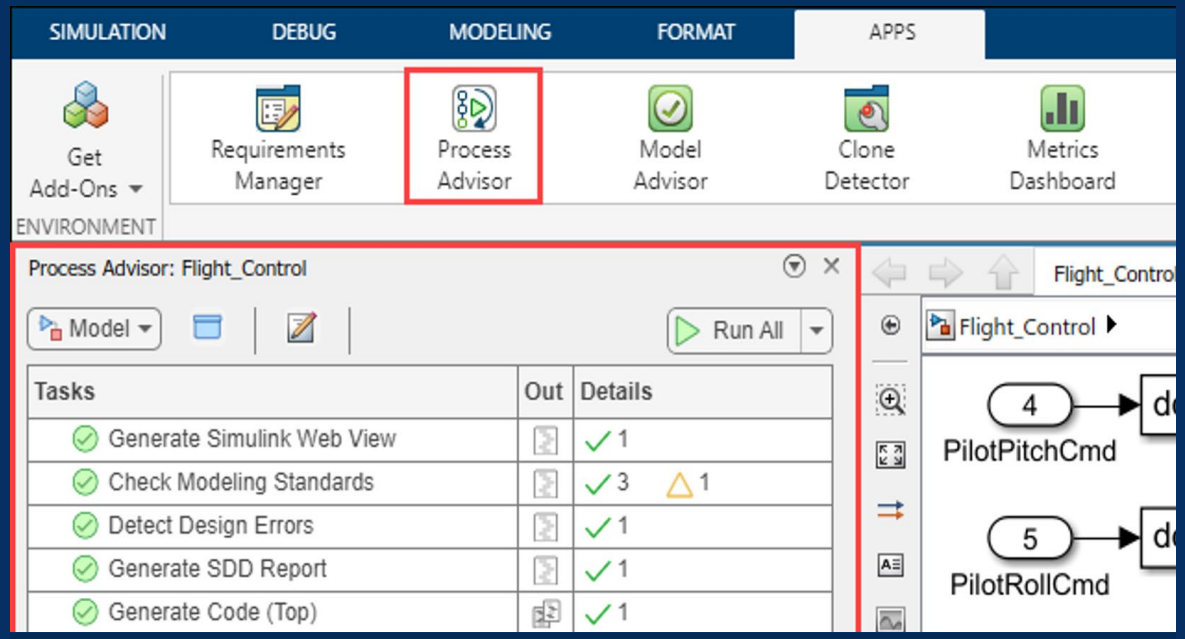


Process Advisor

- Leverage the digital thread
- Identify stale tests
- Interact with the model

Continental

From Scripted Pipelines to Process Advisor

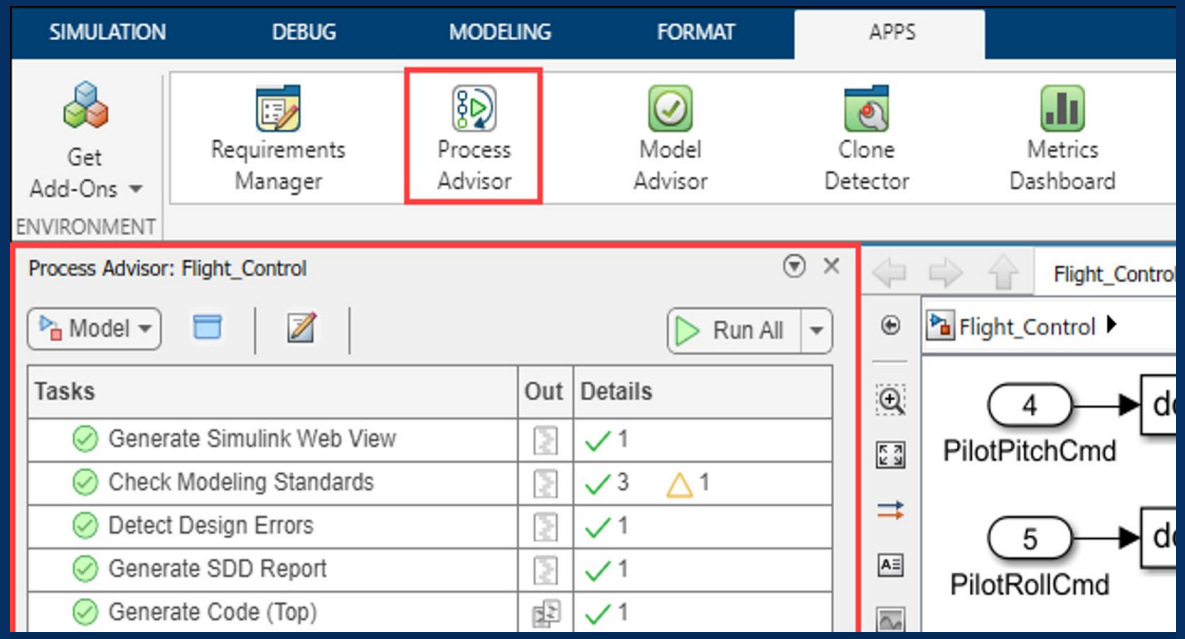


Process Advisor

2X

Continental

From Scripted Pipelines to Process Advisor



Process Advisor

500 interfaces

1,000 components

100 compositions

6 Design and simulate in the cloud

6 Design and simulate in the cloud

```
for i = 1:10000
    in(i) = Simulink.SimulationInput(my_model)
    in(i) = setVariable(my_var, i);
end
out = parsim(in);
```

Parallel Computing Toolbox

MATLAB Parallel Server

Massive simulations

6 Design and simulate in the cloud

Global Combat Air Programme

Source: Artist Rendering, Ministry of Defense website, https://www.mod.go.jp/en/article/2022/12/9f3717bac3e9bca986f2e80ba73f7822065a9f2b.html

Future Combat Air System

Source: Model of the Future Air Combat System at the Paris-Le Bourget 2019 Airshow, by Ibex73, licensed under CC-BY-SA 4.0 / background logos blurred from original

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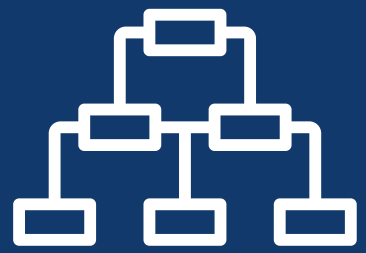
Workflow Trends



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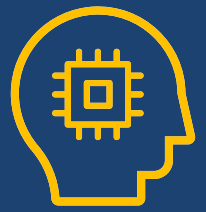
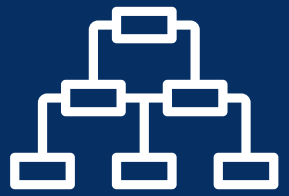


AI for System Development

Workflow Trends



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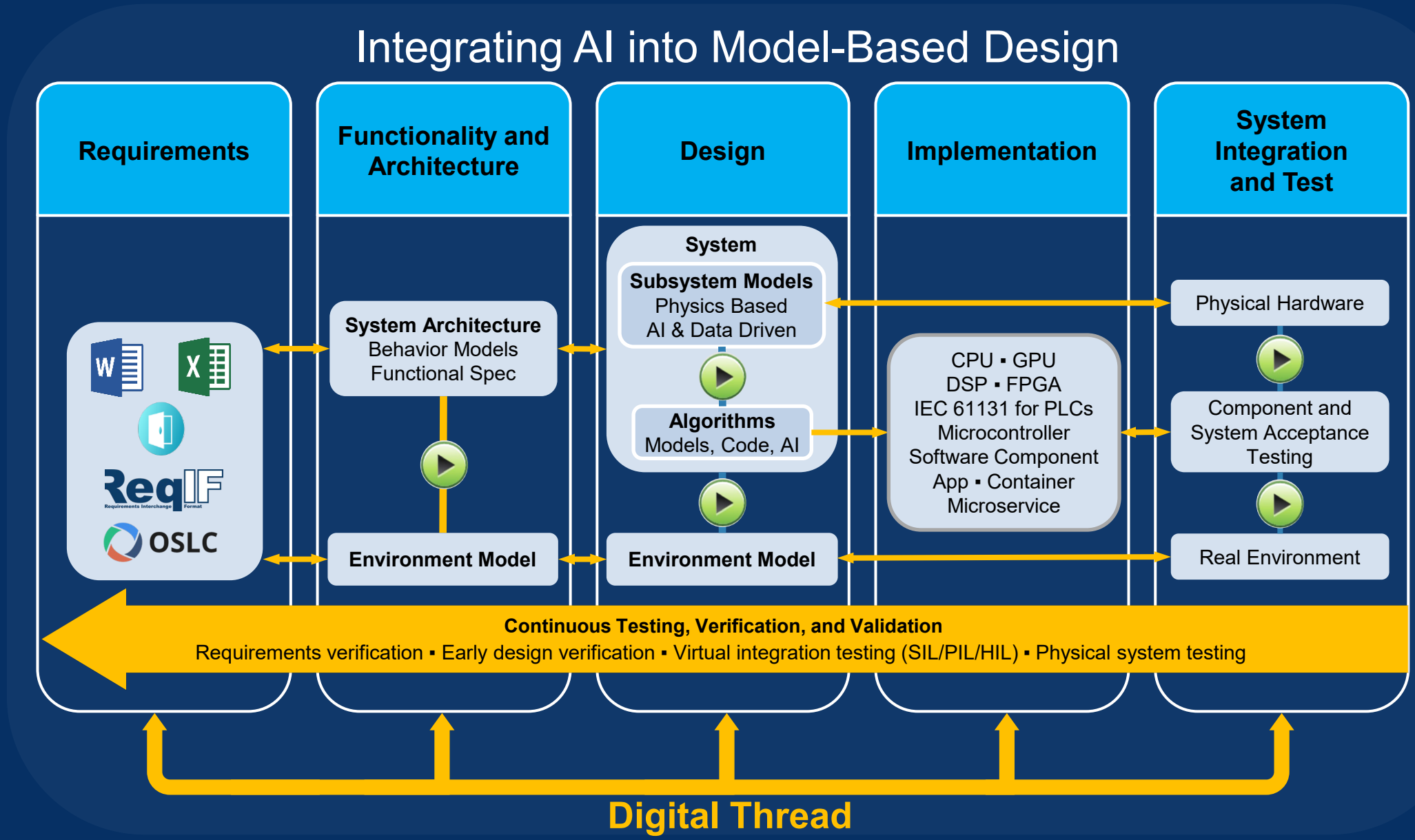
7 Design your system with AI



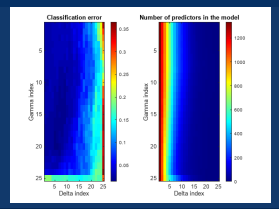
7 Design your system with AI

Masterclass: “AI and Model-Based Design”
AI at the service of systems simulation

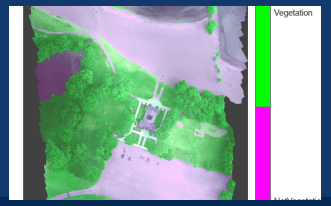
Moubarak Gado, *MathWorks*

7 Design your system with AI

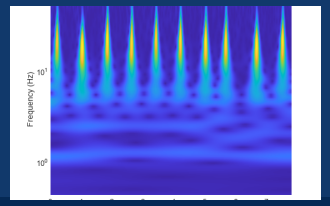
AI Reference Examples



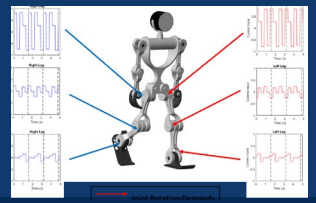
Predictive Maintenance



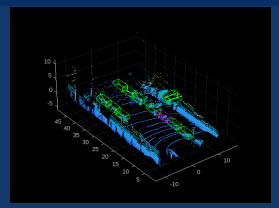
Hyperspectral Imaging



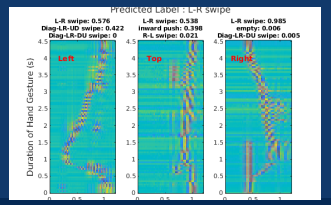
Signal Processing



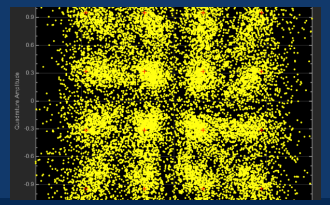
Robotic Control



Lidar Processing

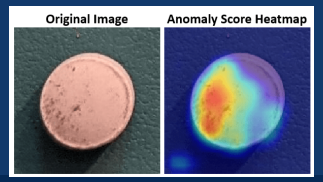


Radar Processing

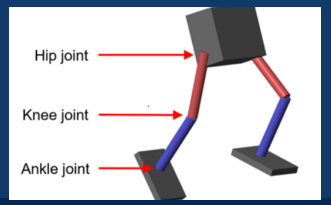


Wireless Communications

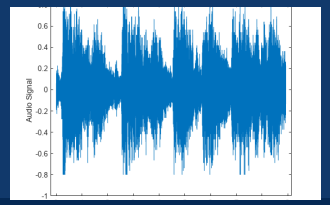
Automated Driving



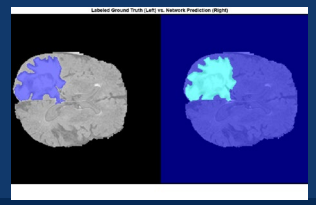
Visual Inspection



Reinforcement Learning



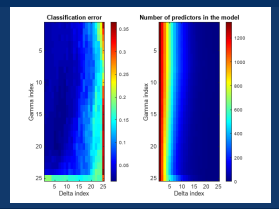
Audio



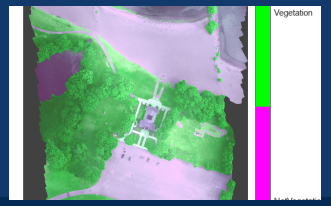
Medical Imaging

7 Design your system with AI

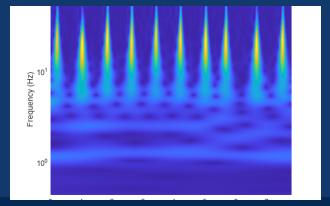
AI Reference Examples



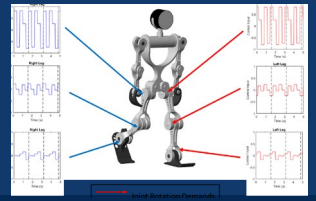
Predictive Maintenance



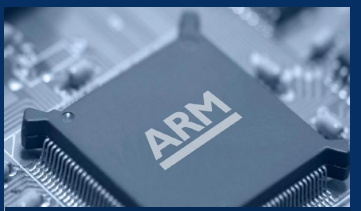
Hyperspectral Imaging



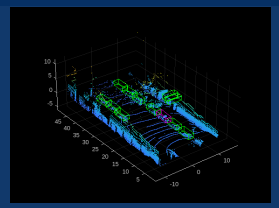
Signal Processing



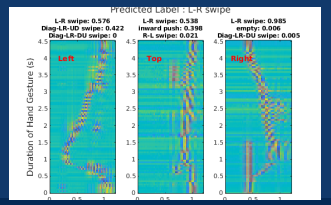
Robotic Control



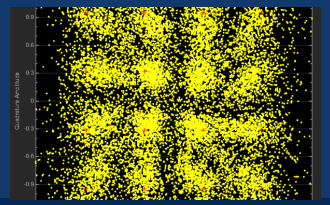
CPU



Lidar Processing

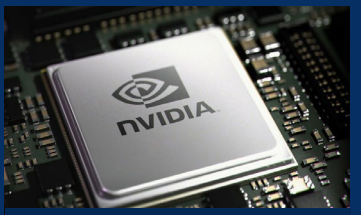


Radar Processing

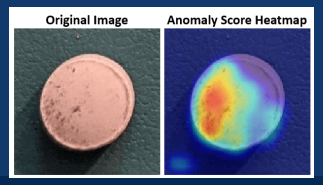


Wireless Communications

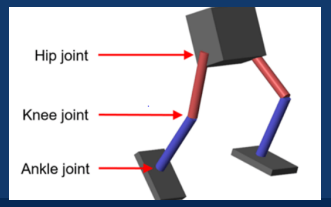
Automated Driving



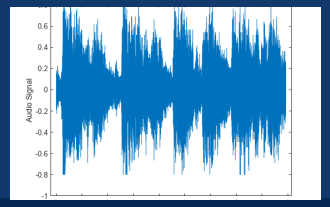
GPU



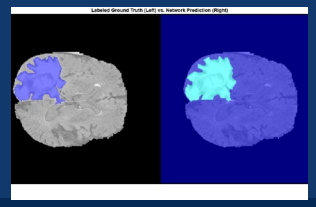
Visual Inspection



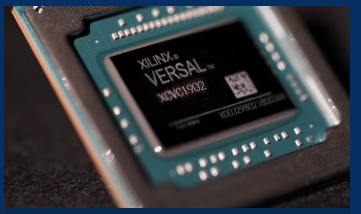
Reinforcement Learning



Audio



Medical Imaging

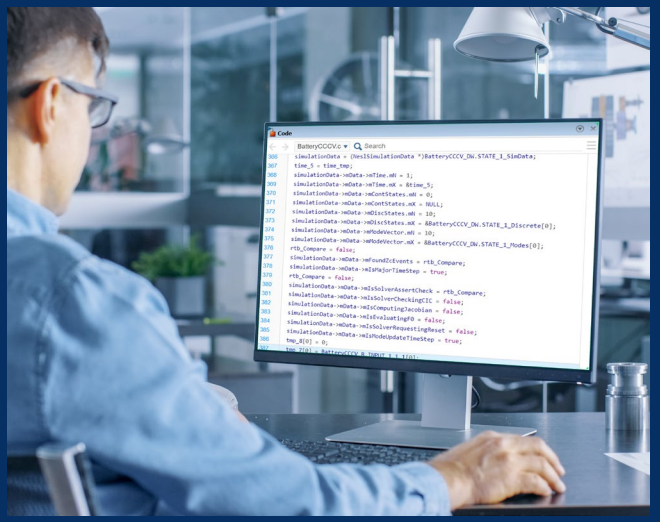


FPGA, ASIC, PLC

Mercedes-Benz

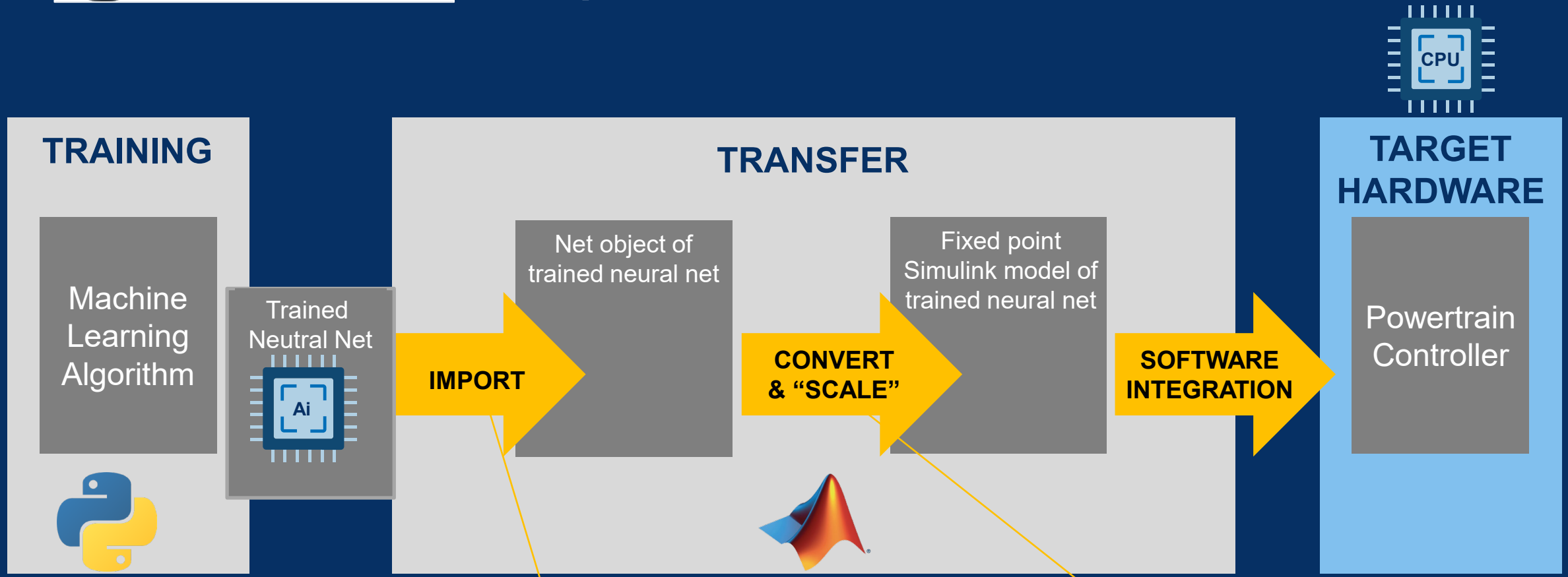
Simulates Hardware Sensors with Deep Neural Networks

QKeras



Mercedes-Benz

Simulates Hardware Sensors with Deep Neural Networks



Mercedes-Benz

Simulates Hardware Sensors with Deep Neural Networks

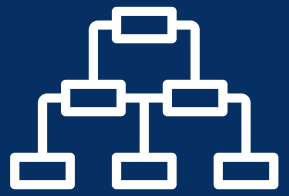
*"We are already using the **automated workflow** we created with MATLAB and Simulink for other use cases ... small adaptations to support deployment on two different powertrain controllers, and the workflow is also applicable to **other types of deep learning models** such as gated recurrent units and fully connected neural networks … we **committed fewer errors** in creating the model and the code."*

- Katja Deuschl, AI Developer, Mercedes-Benz

Simulates Hardware Sensors with Deep Neural Networks

6X

Workflow Trends

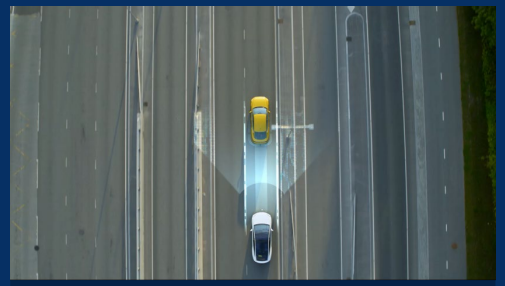


1. Automate everything
2. Scale to complex systems
3. Use automatic code generation
4. Prevent defects early

5. Apply standard software workflows
6. Design and simulate in the cloud

7. Design your system with AI

Application Trends



Autonomous

Connectivity

Electrification

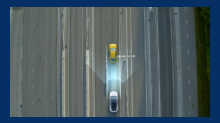
Workflow Trends

Systems Engineering & Design

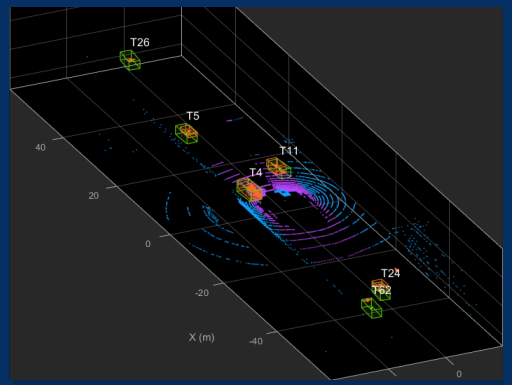
Modern Software Practices

AI for System Development

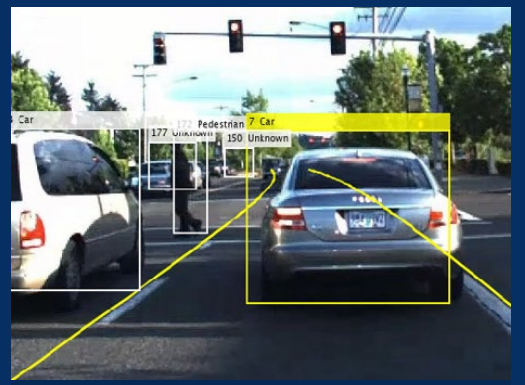
Deliver autonomous systems



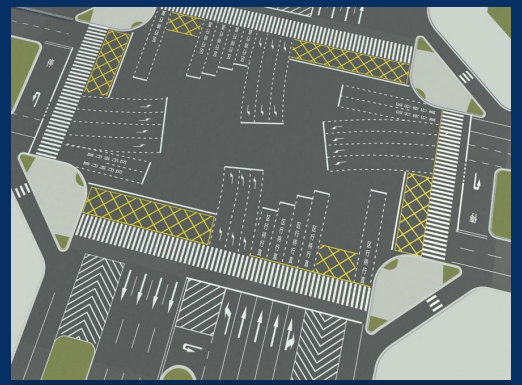
Braking and Steering



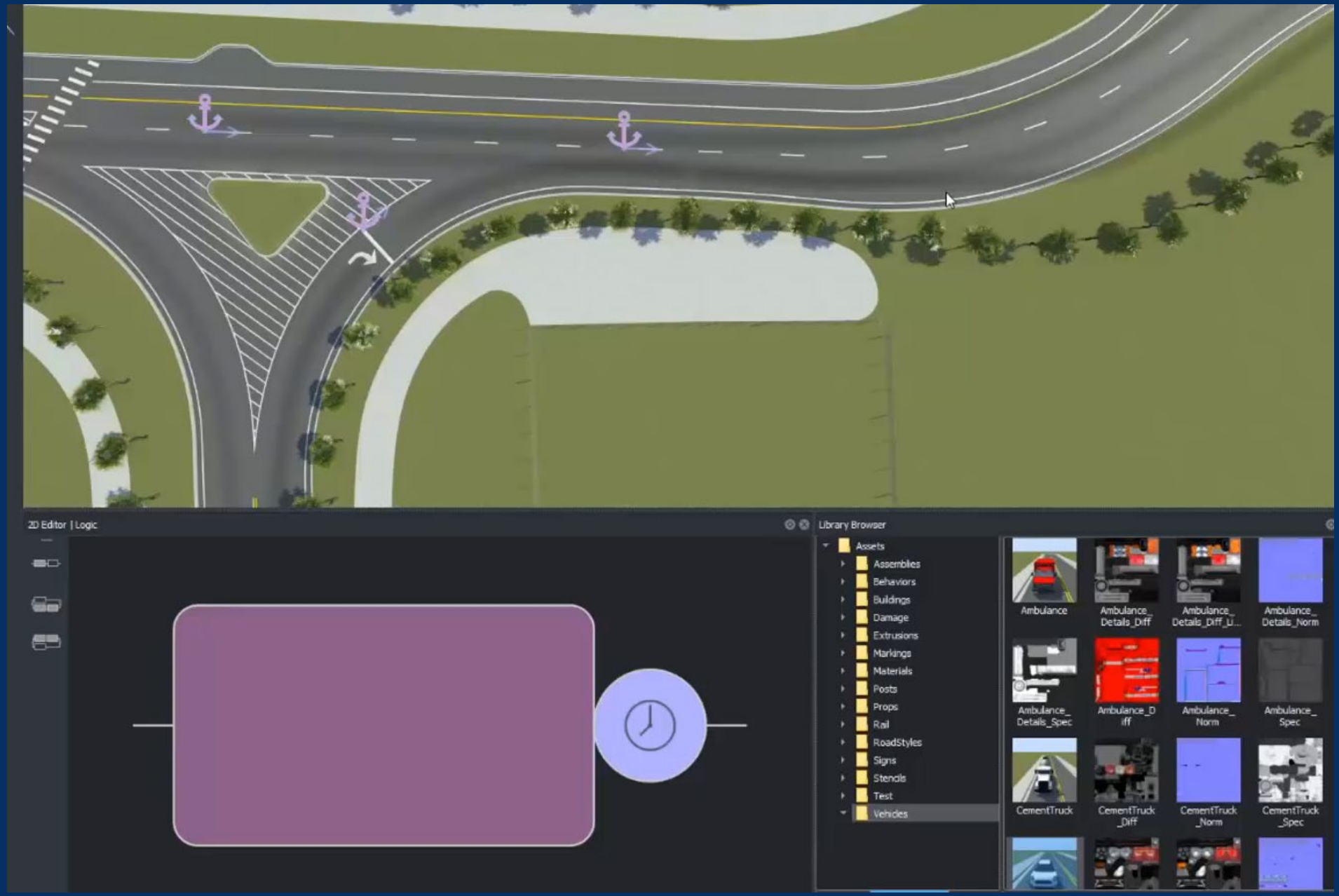
Sensor Fusion and Tracking

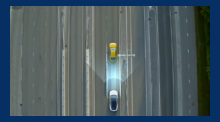


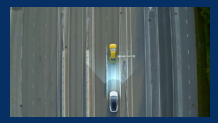
Computer Vision Radar, Lidar

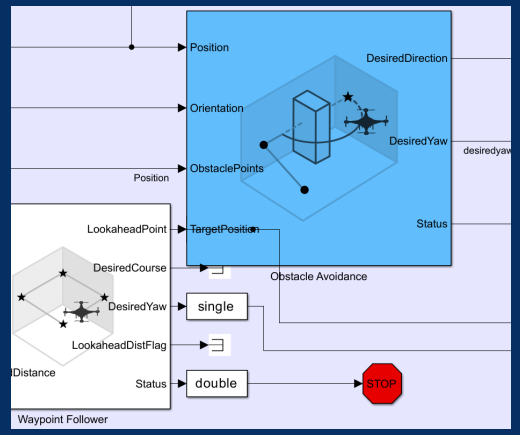


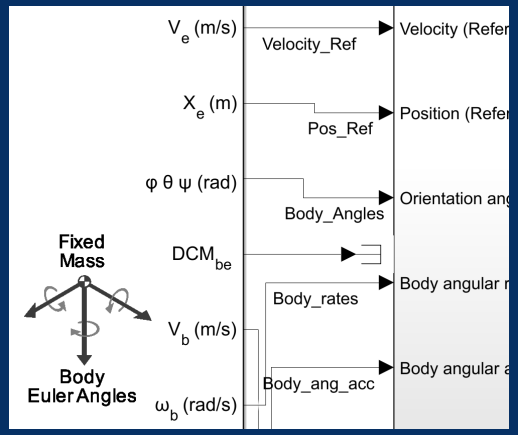
Road Network Design

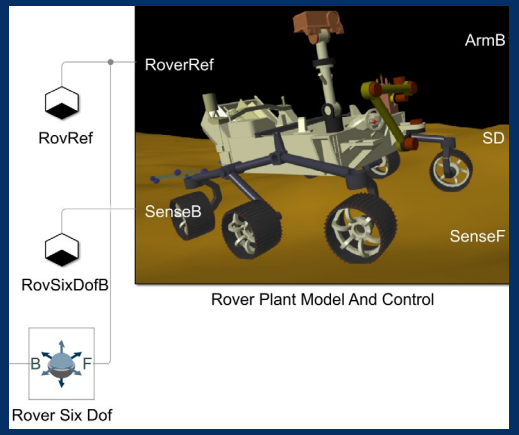

2D Editor | Logic
Library Browser
Assets
Assemblies
Behaviors
Buildings
Damage
Extrusions
Markings
Materials
Posts
Props
Rail
RoadStyles
Signs
Stencils
Test
Vehicles
Ambulance
Ambulance_ Details_Diff
Ambulance_ Details_Diff_Li...
Ambulance_ Details_Norm
Ambulance_ Details_Spec
Ambulance_D iff
Ambulance_ Norm
Ambulance_ Spec
CementTruck
CementTruck _Diff
CementTruck _Norm
CementTruck _Spec

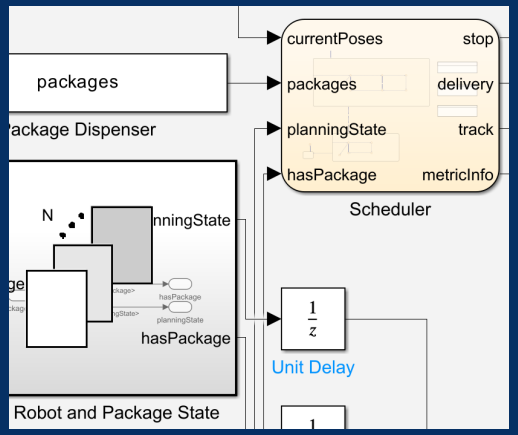




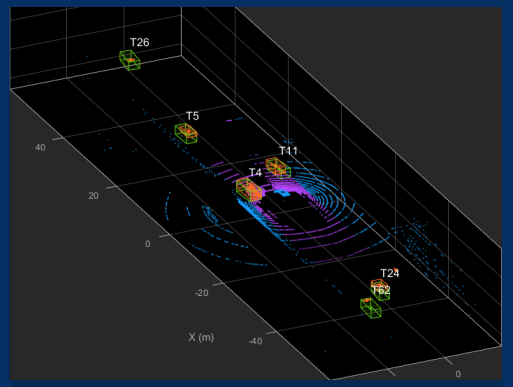








Unmanned Aerial Vehicle

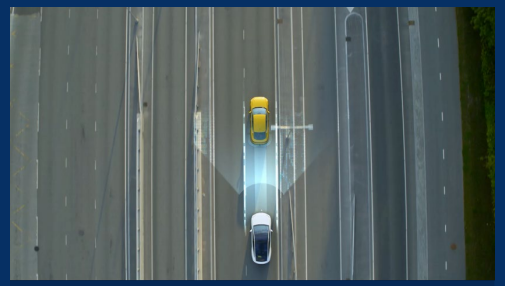


Autonomous Underwater Vehicle

Ground Robot

Industrial Robot

Application Trends



Autonomous

Connectivity

Electrification

Workflow Trends

Systems Engineering & Design

Modern Software Practices

AI for System Development

Application Trends

Autonomous

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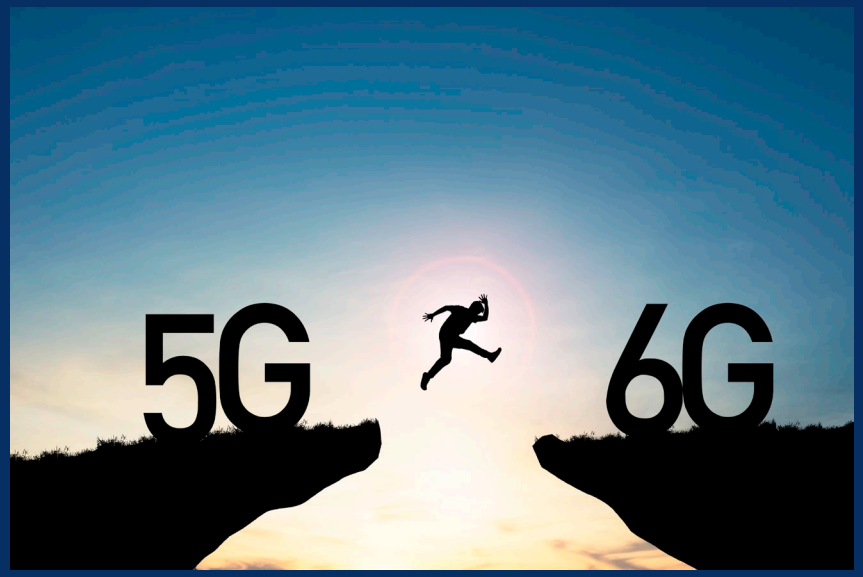
5G Standard

5G Standard

“One of MATLAB’s differentiators is its vertical products like 5G Toolbox. We use that toolbox to generate datasets for testing algorithms. We have not been able to find that capability in other software suites.”

- Christopher Brinton, Professor of Electrical and Computer Engineering, Purdue University

6G Technology Implications



- Artificial Intelligence
- Joint Communications and Sensing
- Reconfigurable Intelligent Surfaces
- Non-Terrestrial Networks (NTNs)
- Physical Layer Design
- Extreme Data Rates and Higher Frequencies

Wireless Trends – AI in Wireless

Wireless challenges

- Hard-to-model problems
- Computational infeasibility of optimal solution
- Efficient modem parameter optimization
- Dealing with non-linearity

AI-enhanced wireless communications

AI strengths

- Determining appropriate representations for hard-to-model problems
- Finding near-ideal and computationally realizable solutions
- Modeling non-linear functions

Applying AI to solve difficult wireless challenges

Deep wireless domain knowledge is required to optimally use AI capabilities

Slide courtesy of Qualcomm

Application Trends

Autonomous

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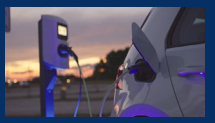
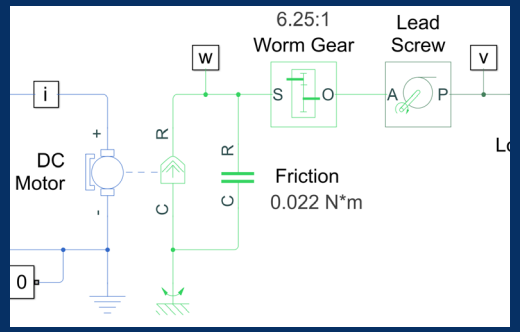
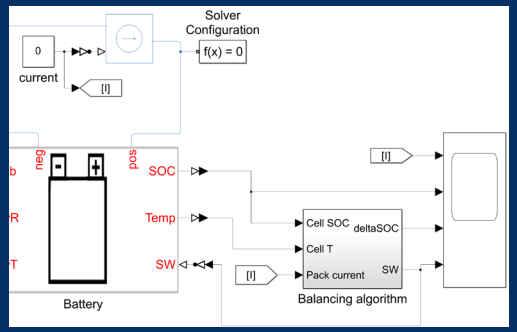
Electric Vehicles

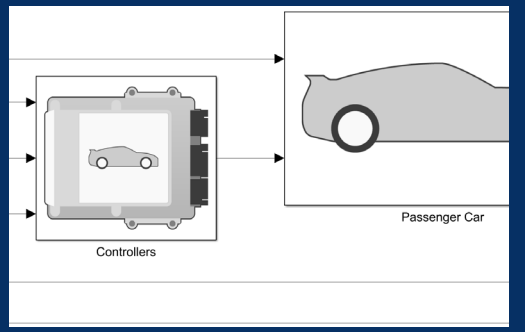


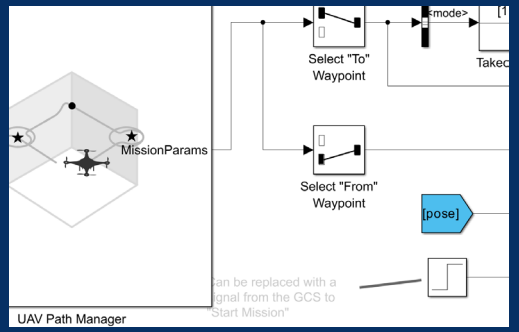
Accelerate the development and implementation of automotive BMS features

Vincent Martinez and Léa Pitault, *NXP Semiconductors*



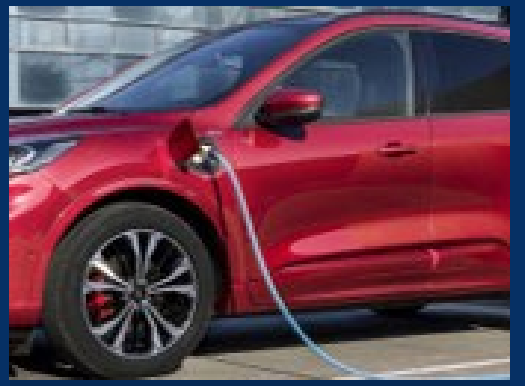






Electric Motors

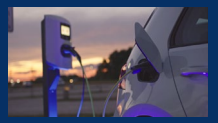
Battery Packs

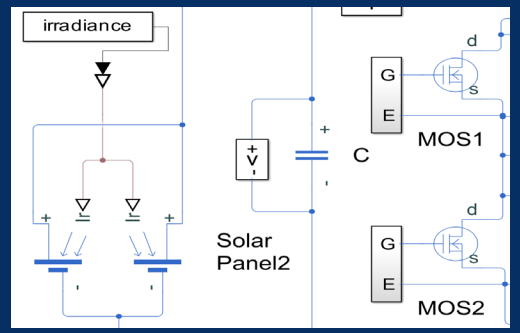


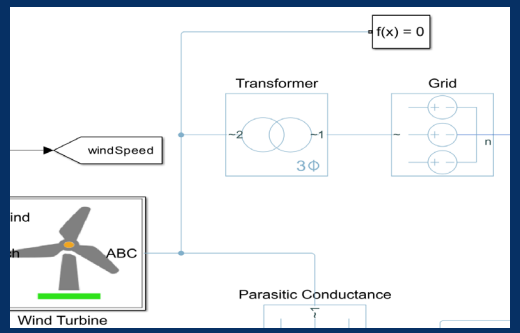
Full Vehicle Models

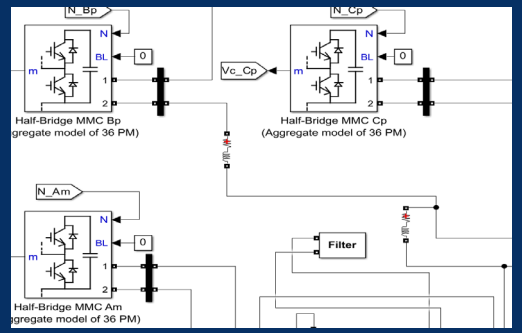
Aerial Vehicles

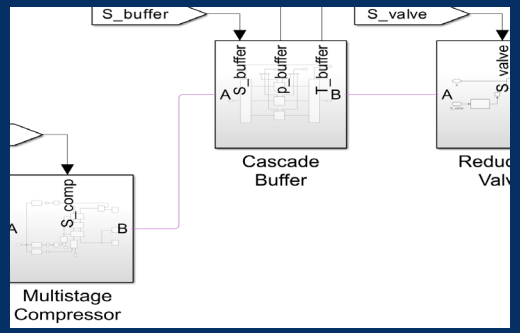
Green Energy







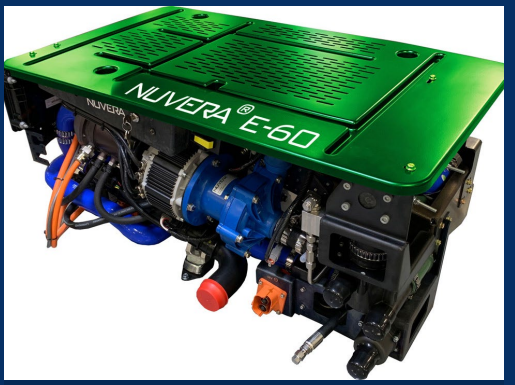




Solar

Wind

Hydroelectric



Green Hydrogen

SIEMENS energy

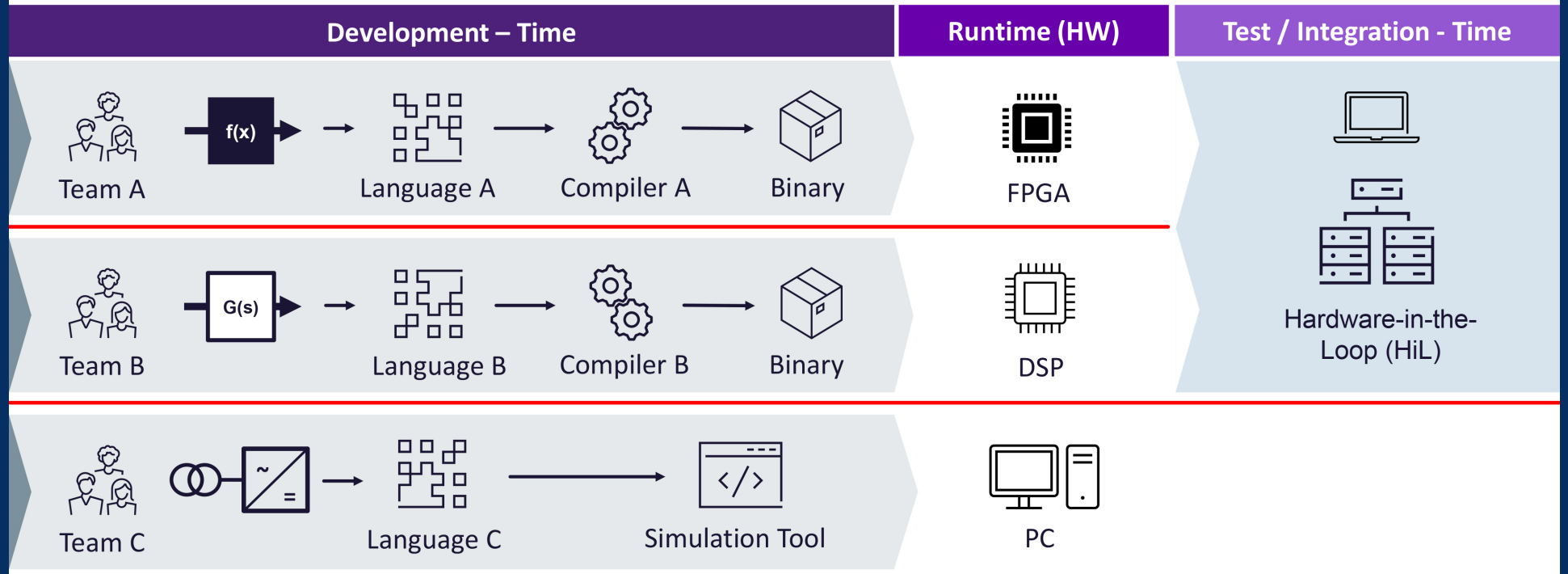
Enables the Global Energy Transition

1. Engineer solutions in solar, biomass, hydrogen, wind
2. Retrofit or upgrade infrastructure
3. Strengthen electrical grid

SIEMENS energy

Enables the Global Energy Transition

Swimlane Engineering
When the organization shapes development

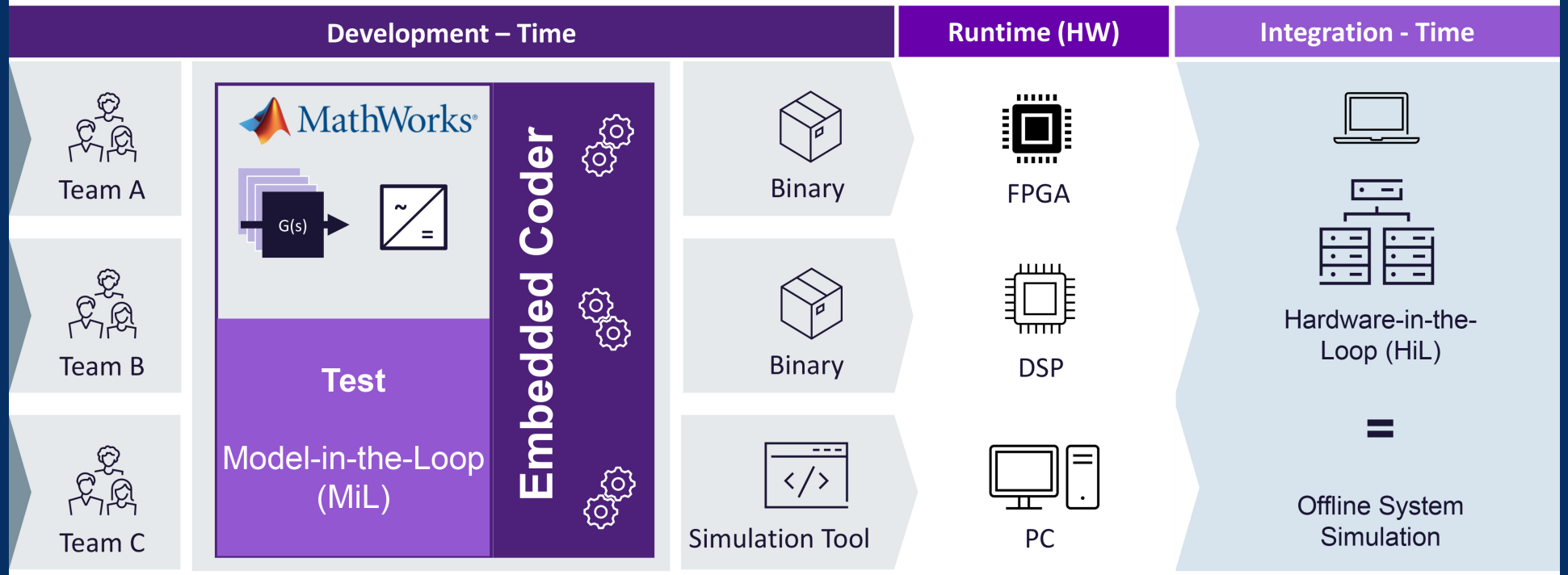


SIEMENS energy

Enables the Global Energy Transition

Centralized Engineering Ecosystem

When development extends across the organization

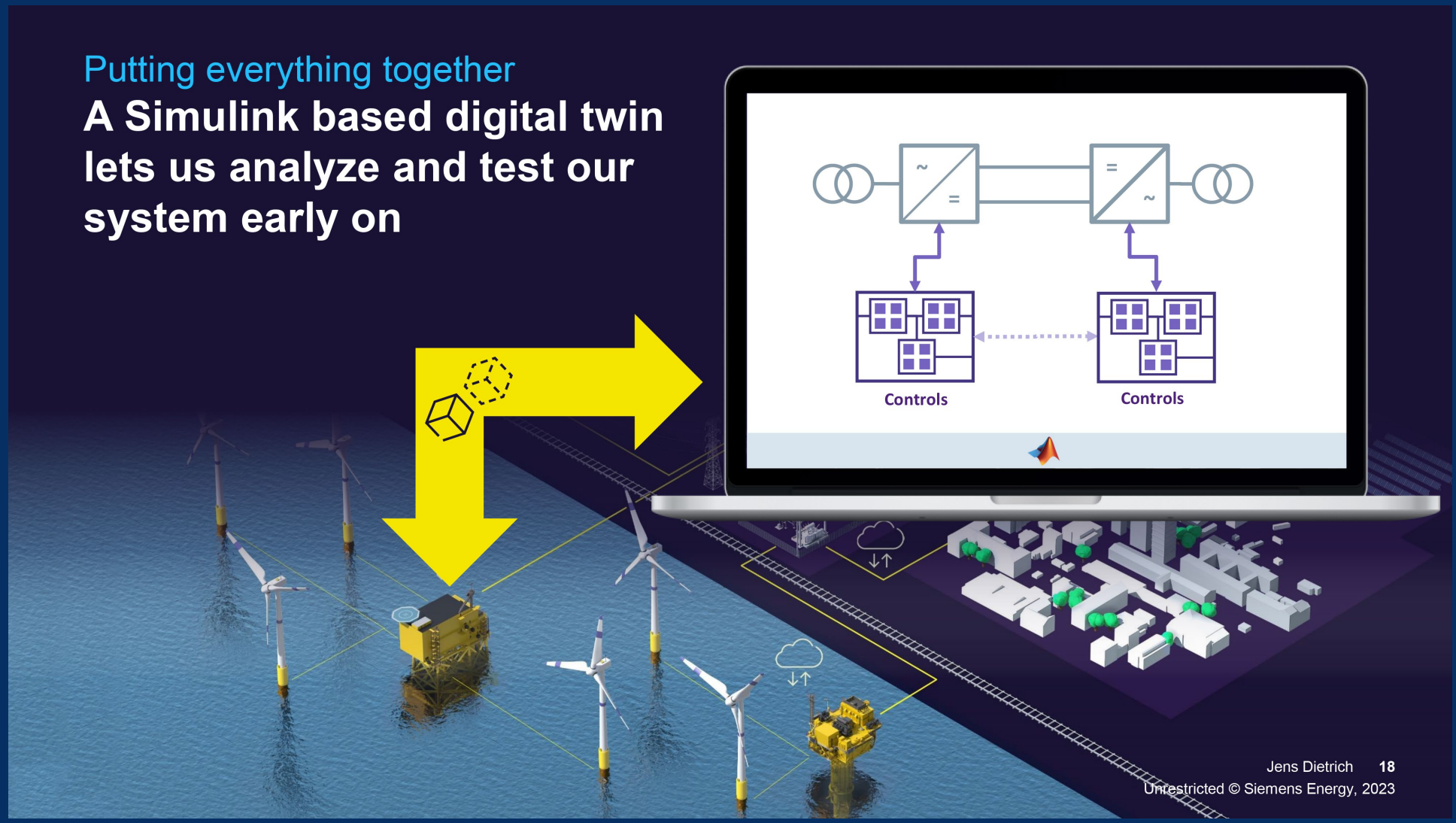


SIEMENS energy

Enables the Global Energy Transition

Putting everything together

A Simulink based digital twin lets us analyze and test our system early on

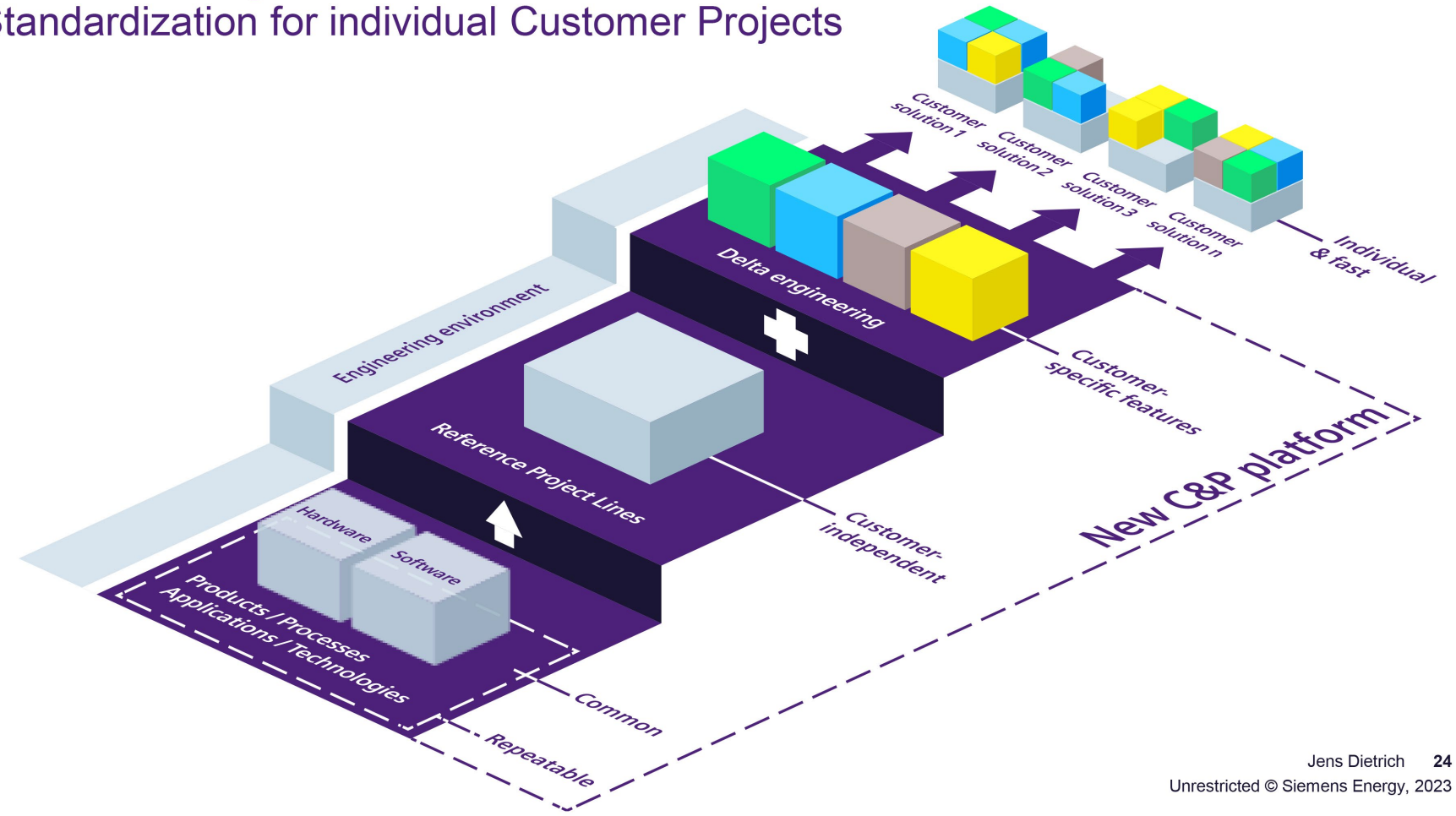


SIEMENS energy

Enables the Global Energy Transition

Reference Project Lines

Standardization for individual Customer Projects



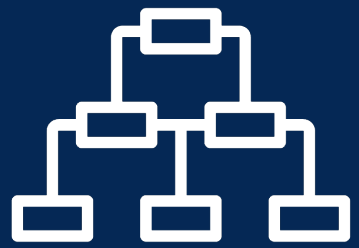
Application Trends

Autonomous

Connectivity

Electrification

Workflow Trends



Systems Engineering & Design

Modern Software Practices

AI for System Development

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7

Workflow Trends

Systems Engineering
& Design

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AI for
System Development

1. Automate everything
2. Scale to complex systems
3. Use automatic code generation
4. Prevent defects early
5. Apply standard software workflows
6. Design and simulate in the cloud
7. Design your system with AI

MATLAB EXPO

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Thank you

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