

MATLAB EXPO

UNITED KINGDOM

Model-Based Design for Digital Engineering: Impact and Directions

Richard Rovner





Application Trends



Autonomous



Connectivity



Electrification

Application Trends



Autonomous

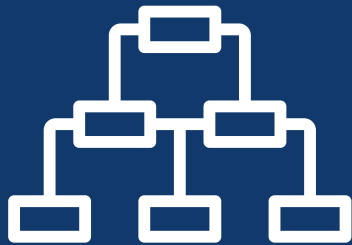


Connectivity



Electrification

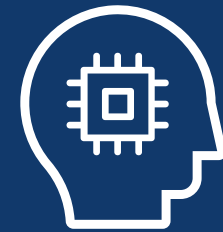
Workflow Trends



**Systems Engineering
& Design**



**Modern
Software Practices**



**AI for
System Development**

Application Trends



Autonomous

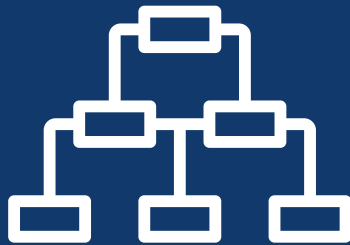


Connectivity



Electrification

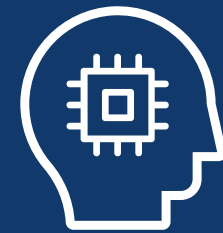
Workflow Trends



Systems Engineering
& Design

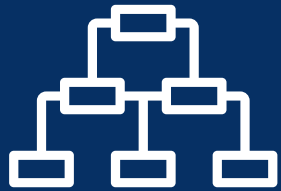


Modern
Software Practices



AI for
System Development

Workflow Trends



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

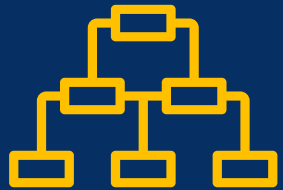


5. Apply standard software workflows
6. Design and simulate in the cloud



7. Design your system with AI

Workflow Trends



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



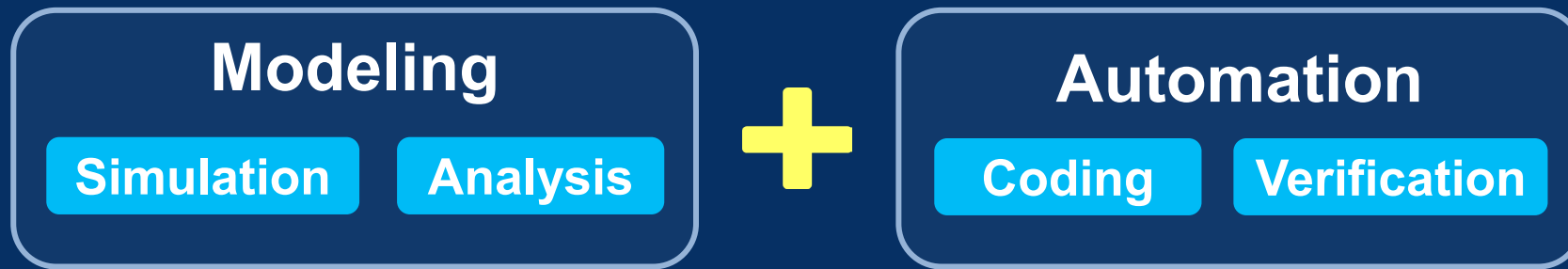
5. Apply standard software workflows
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7. Design your system with AI

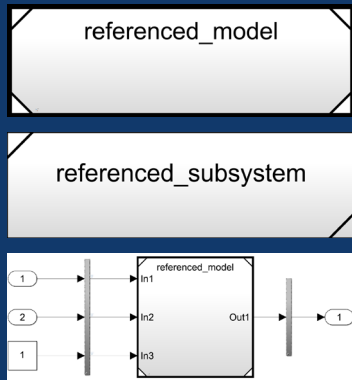


① Automate everything

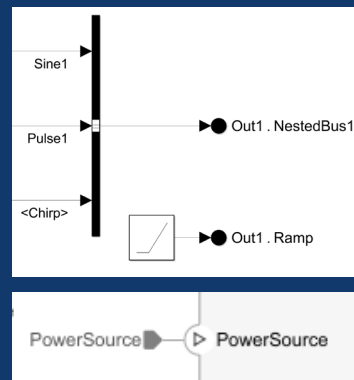




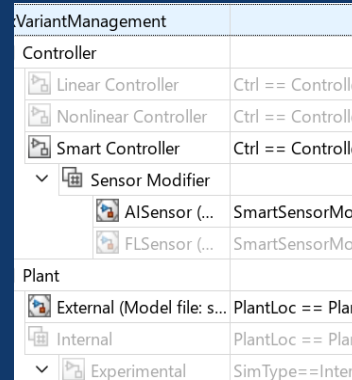
2 Scale to complex systems



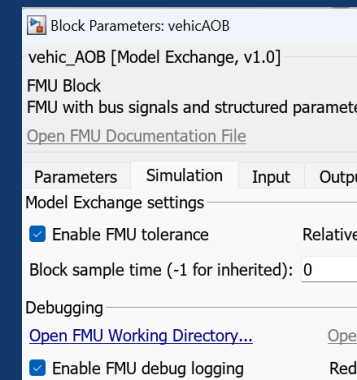
Components



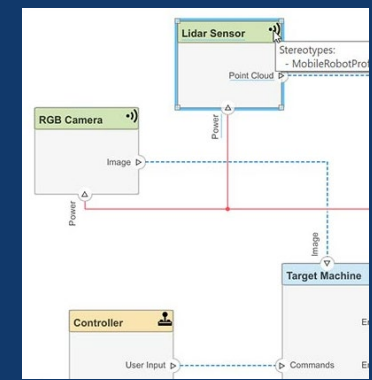
Buses, Ports, and Connectors



Variant Manager



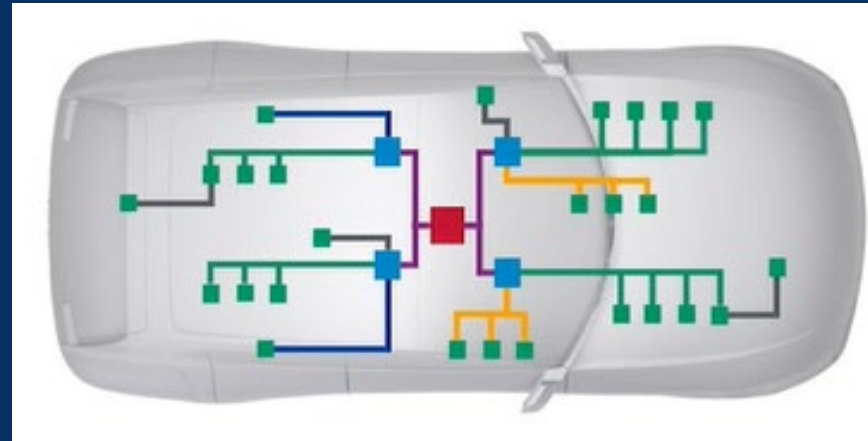
Third-Party Tool Integration



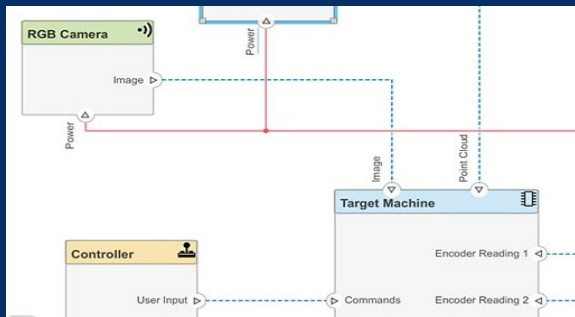
Architecture



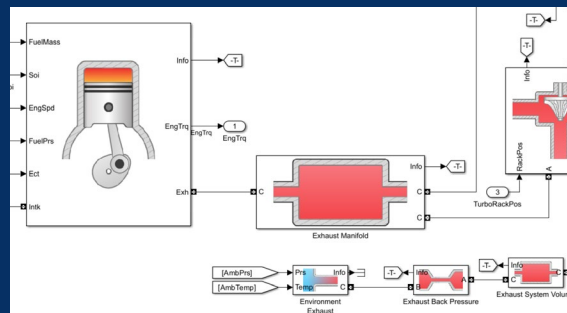
2 Scale to complex systems



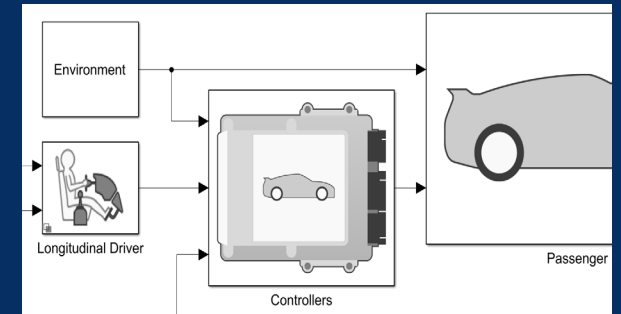
Service-Oriented Architecture



System Composer



Components



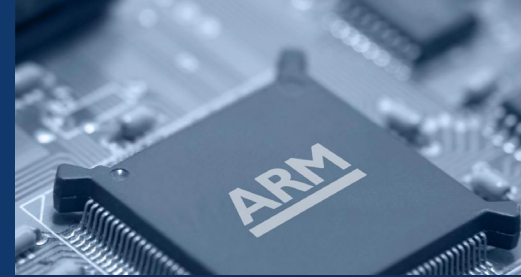
Full System



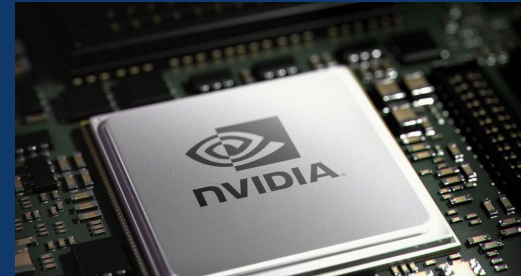
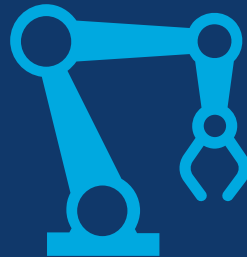
③ Use automatic code generation

3700

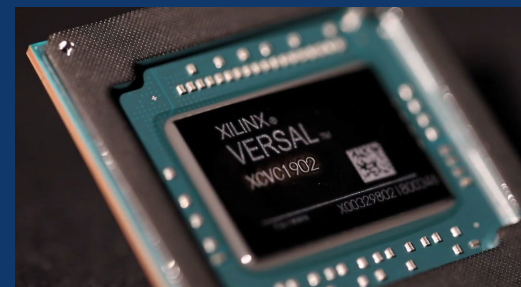
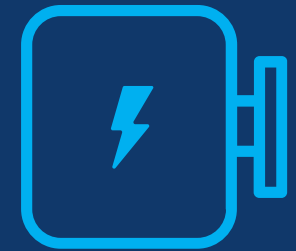
Organizations use
automatic code generation



CPU



GPU

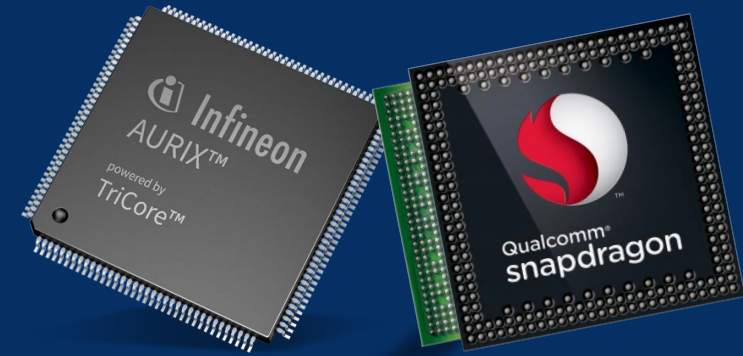
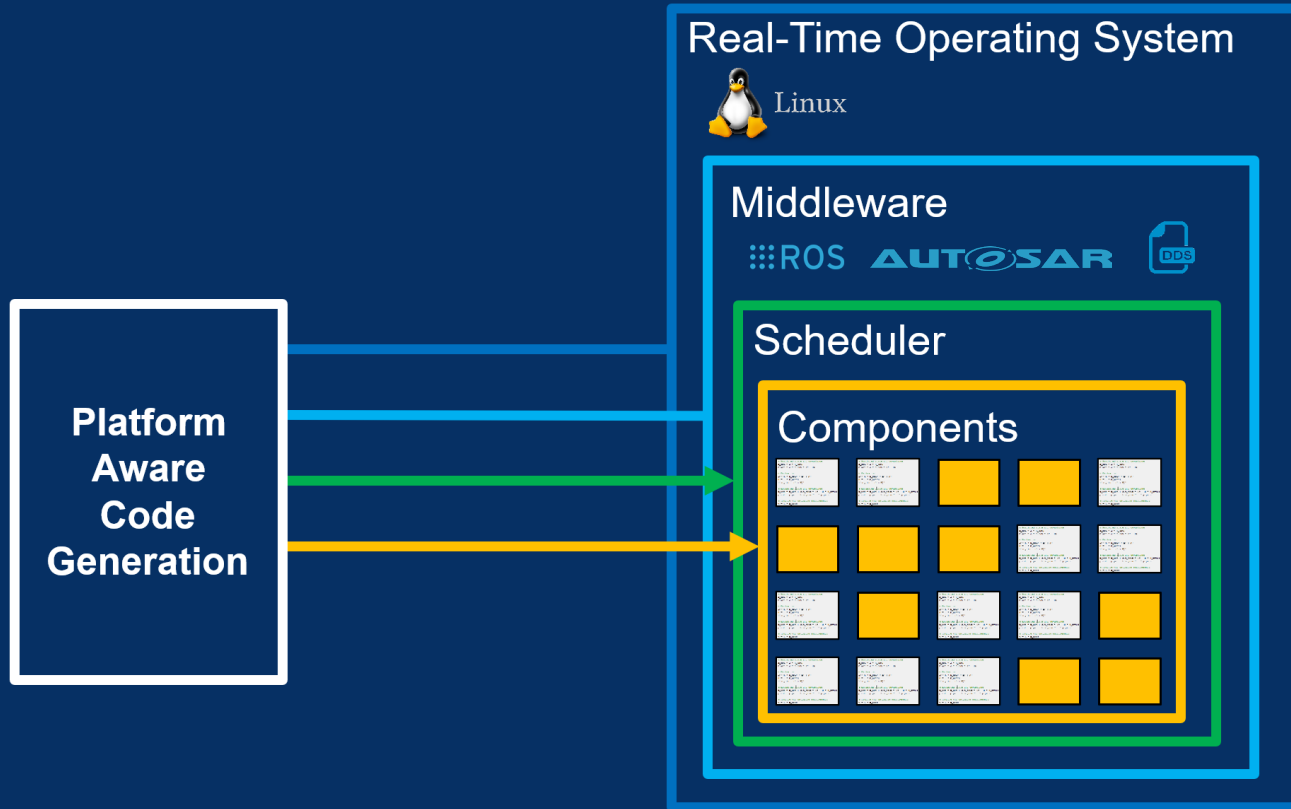


FPGA, ASIC, PLC





3 Use automatic code generation

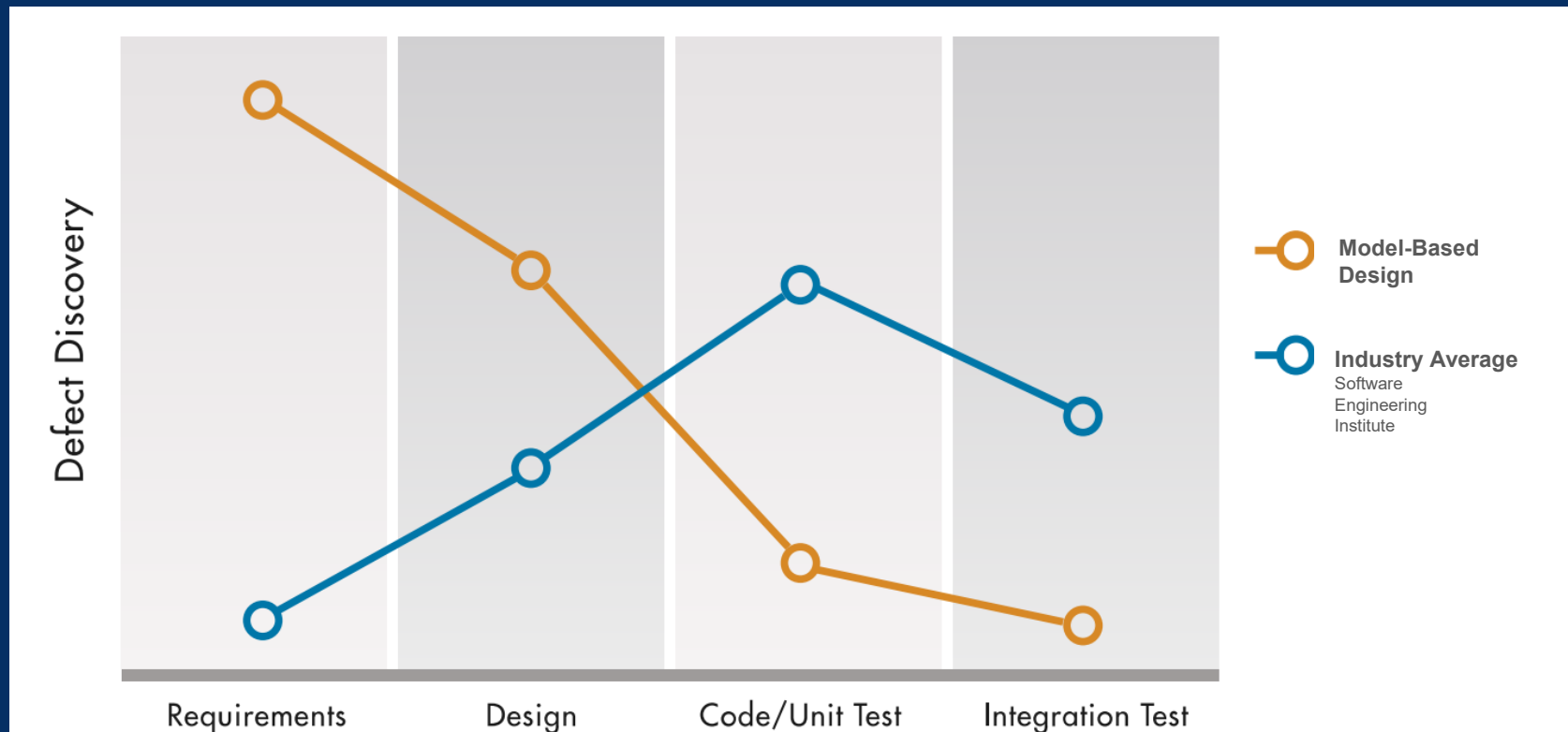




4 Prevent defects early



Keynote: The Pursuit of Zero-Defect Development
Jason Casey, BAE Systems





④ Prevent defects early



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		

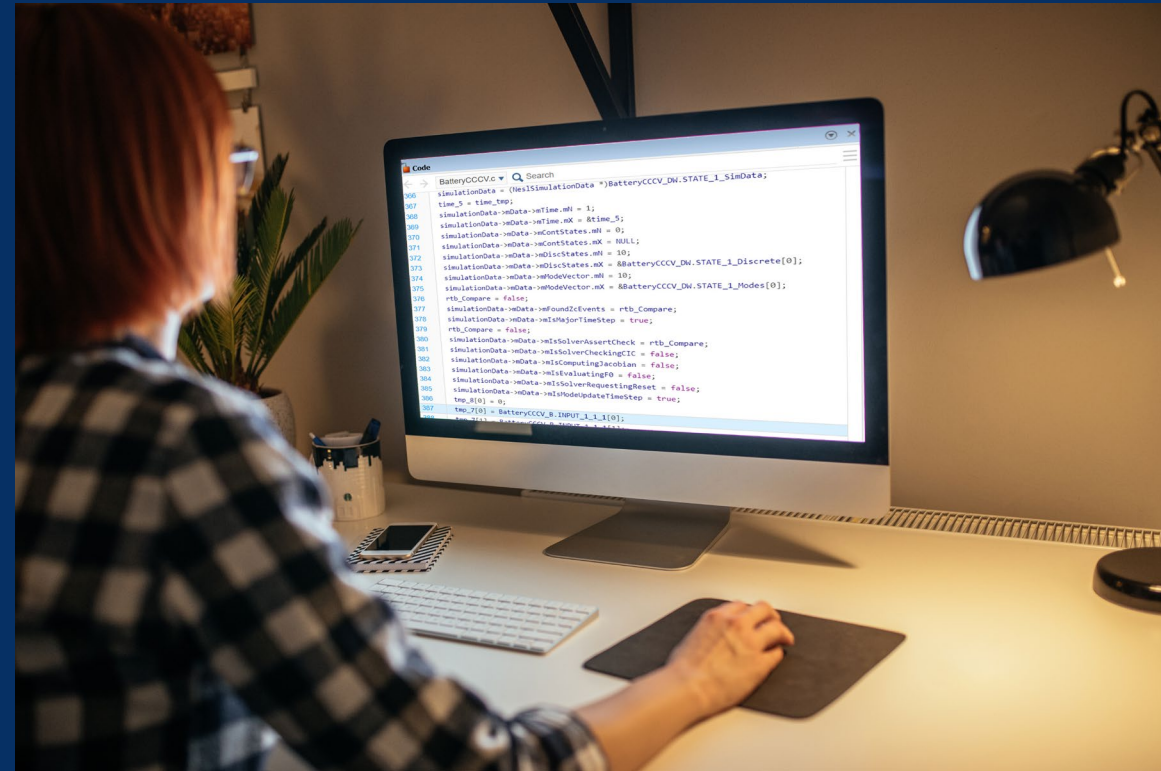


SAFT

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



The Saft Flex'ion Gen2



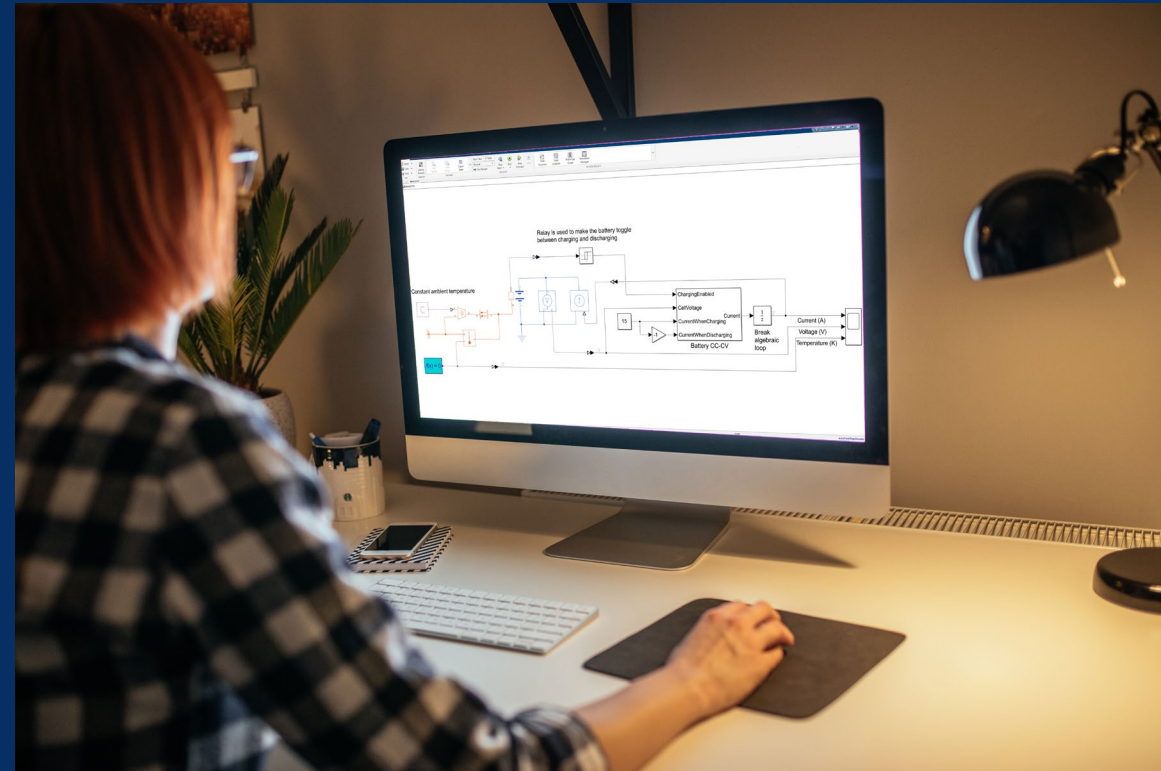


SAFT

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



The Saft Flex'ion Gen2



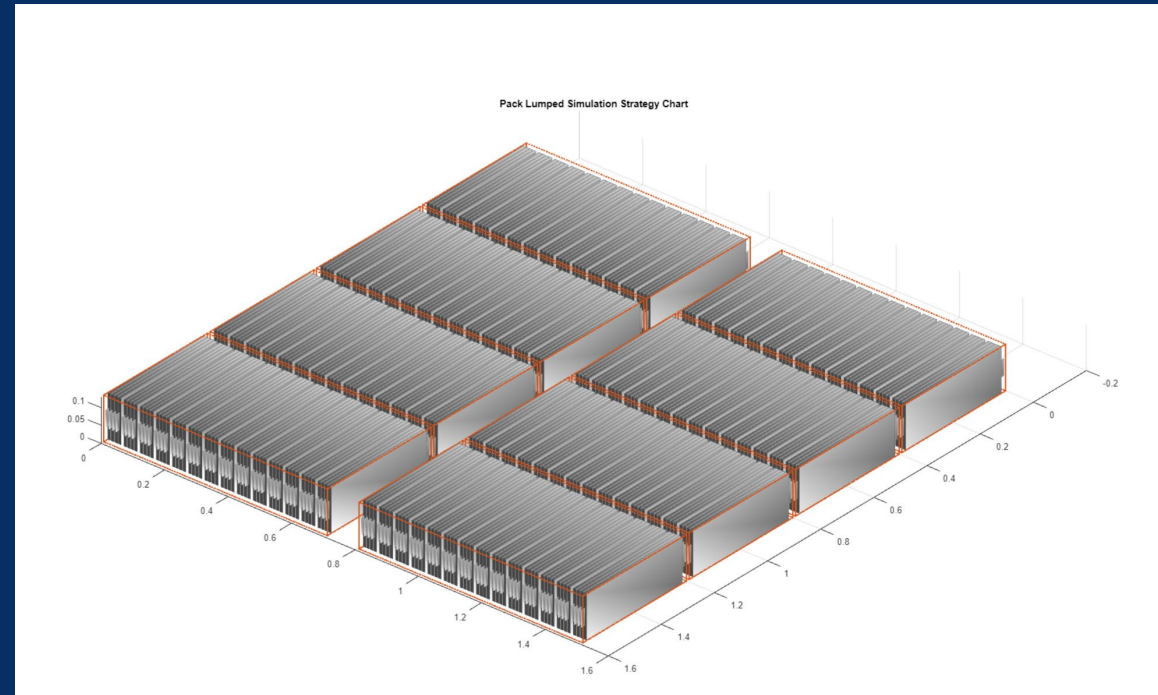


SAFT

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The Saft Flex'ion Gen2



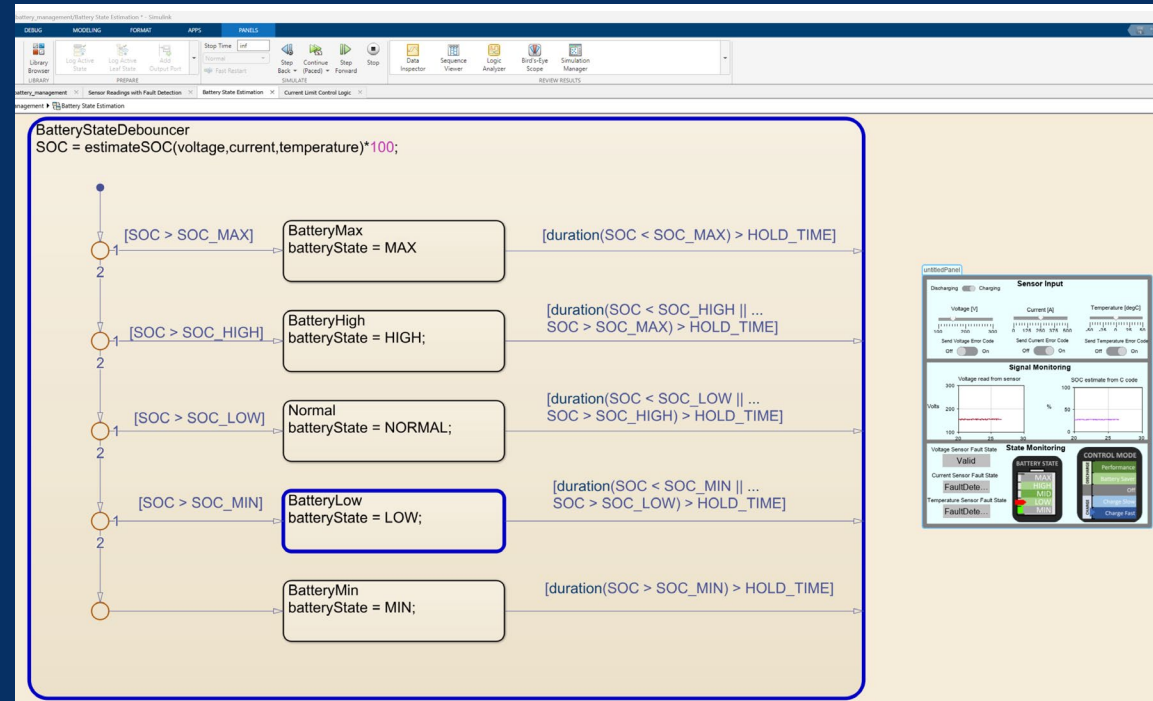


saft

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SAFT

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The Saft Flex'ion Gen2





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



The Saft Flex'ion Gen2

2X

Application Trends



Autonomous

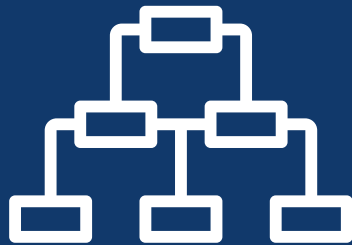


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Electrification

Workflow Trends



Systems Engineering
& Design

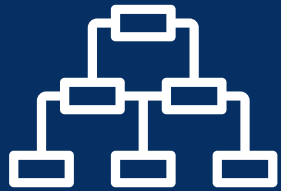


Modern
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5. Apply standard software workflows
6. Design and simulate in the cloud



7. Design your system with AI



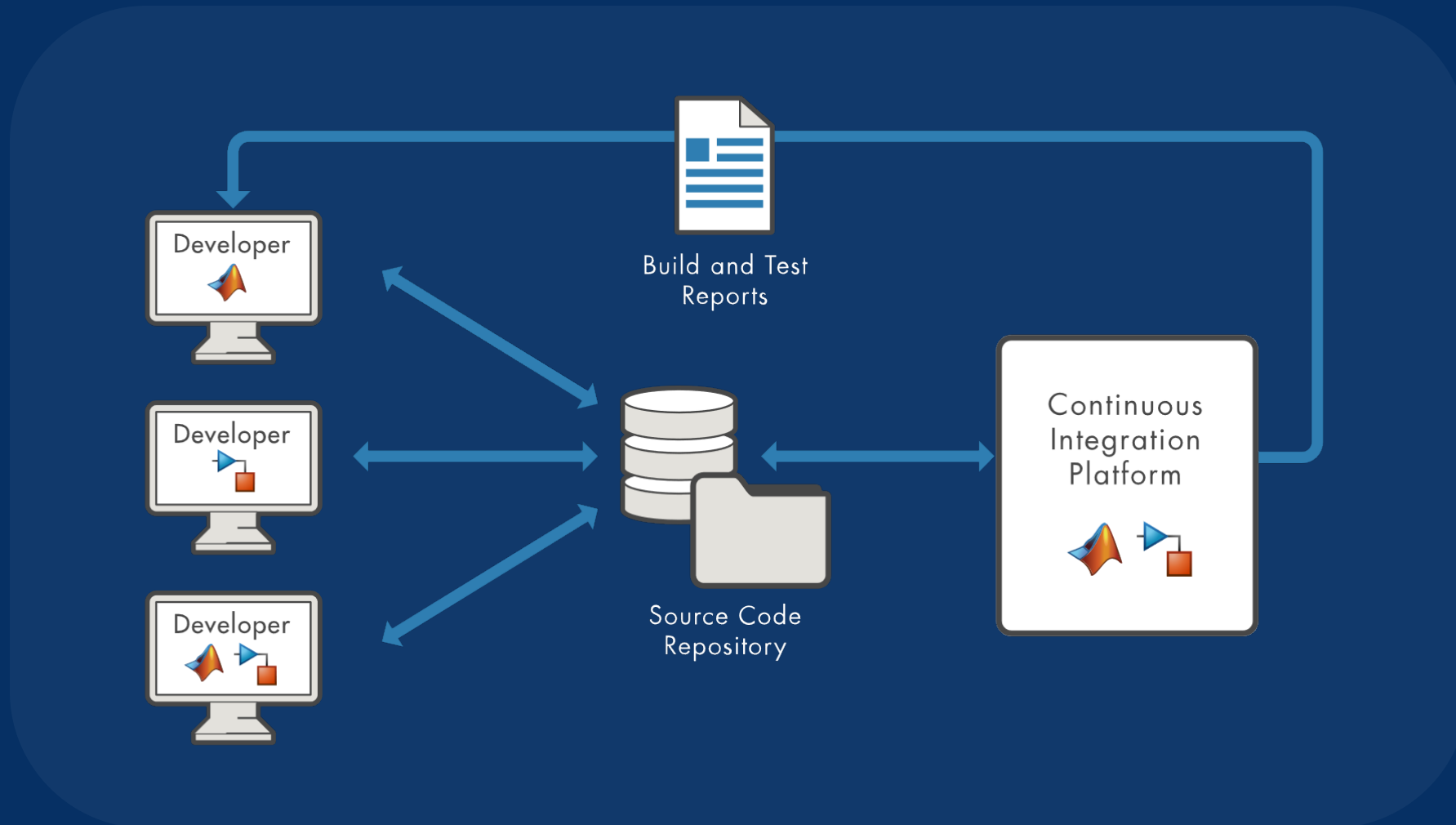
5 Apply standard software workflows



“Software is the language of automation.”

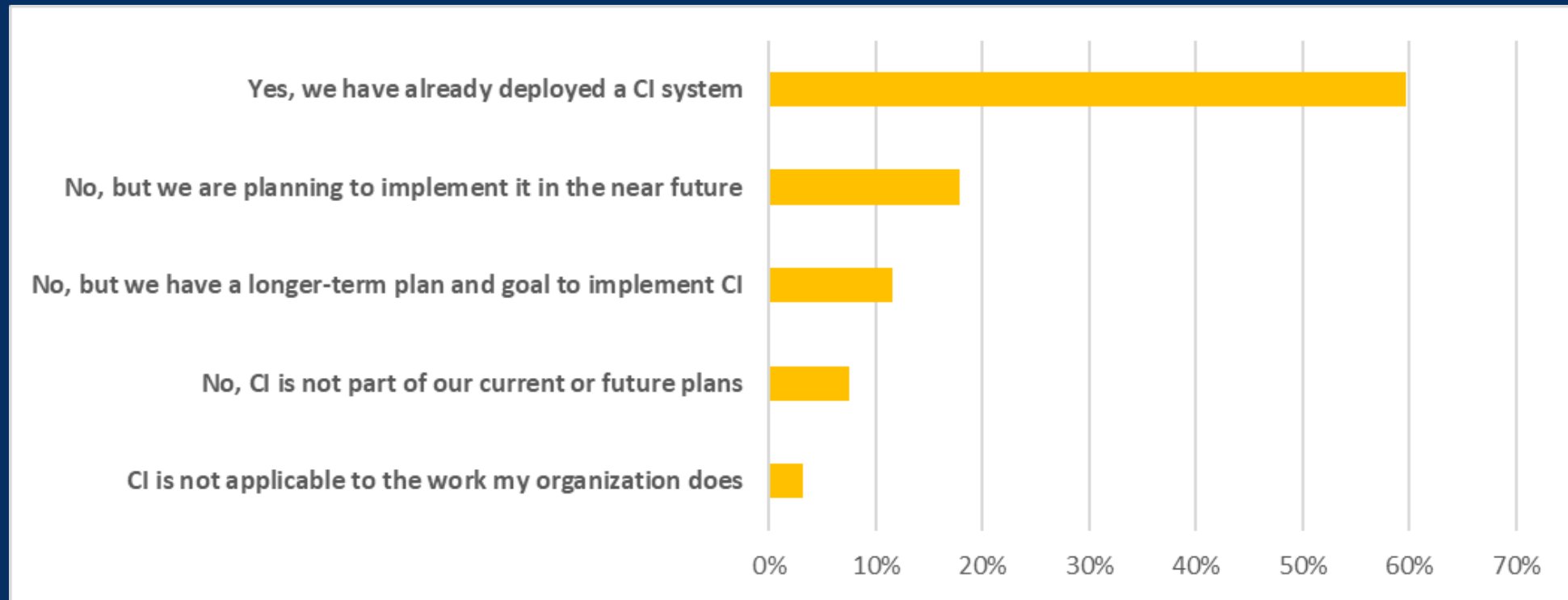
- *Jensen Huang, co-founder and CEO of NVIDIA*

5 Apply standard software workflows

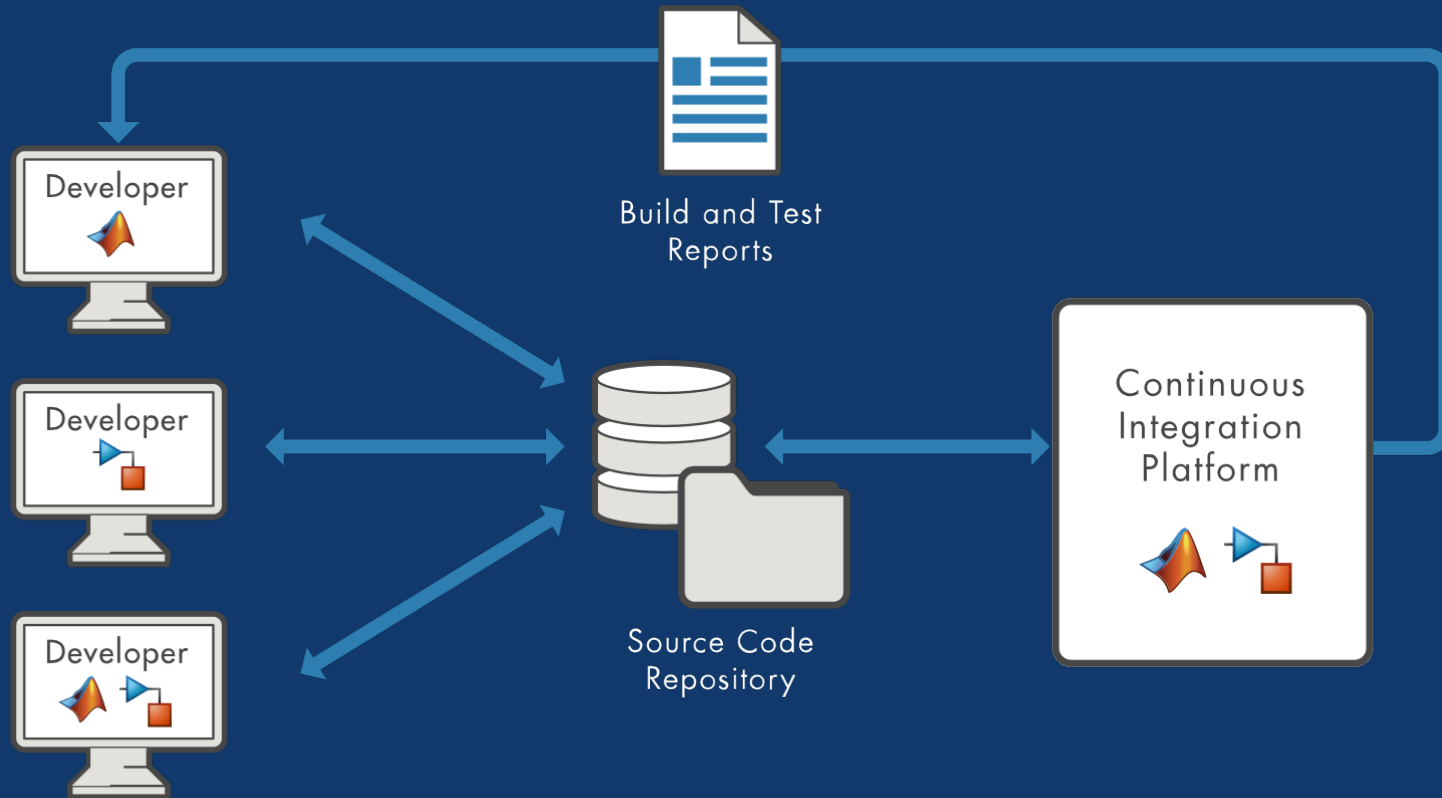




Does your organization currently use a continuous integration (CI) system? (select one)



5 Apply standard software workflows



5 Apply standard software workflows



Technical Articles and Newsletters

Overview Search Technical Articles Newsletters ▾ Cleve's Corner Collection

Workflow Steps

The workflow consists of the following steps (Figure 4):

1. **Trigger** a pipeline in GitLab and observe that the Verify and Build stages
2. **Detect** a test-case failure in GitLab CI pipeline and create an Issue to tra
3. **Reproduce** the issue on our desktop MATLAB.
4. **Fix the issue** in the model.
5. **Test locally** to ensure the test case passes.
6. **Review** the changes on the testing branch.
7. **Commit** the change to Git and trigger the CI pipeline in GitLab.

Step-by-Step Tutorials

The screenshot shows the MATLAB Process Advisor interface. The 'MODELING' tab is selected, and the 'Process Advisor' tool is highlighted with a red box. The interface displays a table of tasks and their results, along with a diagram of the model structure.

Tasks	Out	Details
Generate Simulink Web View	Out	✓ 1
Check Modeling Standards	Out	✓ 3 ⚠ 1
Detect Design Errors	Out	✓ 1
Generate SDD Report	Out	✓ 1
Generate Code (Top)	Out	✓ 1

The diagram on the right shows the model structure with blocks labeled 'PilotPitchCmd' and 'PilotRollCmd'.

Process Advisor



From Scripted Pipelines to Process Advisor





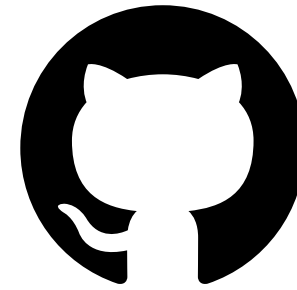
From Scripted Pipelines to Process Advisor



Jenkins



git



MATLAB® & SIMULINK®



AUTOSAR



From Scripted Pipelines to Process Advisor



“Bring everything into MATLAB.”

- *Martin Römpert, Continental Automotive Technologies GmbH*



From Scripted Pipelines to Process Advisor



Tasks	Out	Details
Generate Simulink Web View		✓ 1
Check Modeling Standards		✓ 3 ⚠ 1
Detect Design Errors		✓ 1
Generate SDD Report		✓ 1
Generate Code (Top)		✓ 1

Process Advisor

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



From Scripted Pipelines to Process Advisor



Tasks	Out	Details
✓ Generate Simulink Web View		✓ 1
✓ Check Modeling Standards		✓ 3 1
✓ Detect Design Errors		✓ 1
✓ Generate SDD Report		✓ 1
✓ Generate Code (Top)		✓ 1

Process Advisor

2X



From Scripted Pipelines to Process Advisor



Process Advisor: Flight_Control

Tasks	Out	Details
✓ Generate Simulink Web View		✓ 1
✓ Check Modeling Standards		✓ 3 1
✓ Detect Design Errors		✓ 1
✓ Generate SDD Report		✓ 1
✓ Generate Code (Top)		✓ 1

Flight_Control

PilotPitchCmd

PilotRollCmd

Process Advisor

500 interfaces

1,000 components

100 compositions

6 Design and simulate in the cloud



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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);
```

Massive simulations



Parallel
Computing
Toolbox



MATLAB
Parallel Server



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

Application Trends



Autonomous

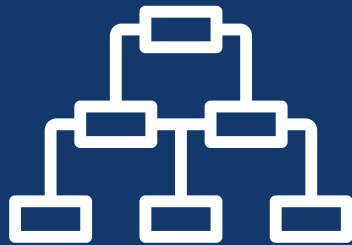


Connectivity



Electrification

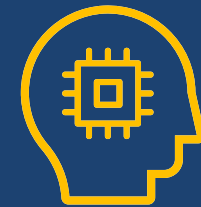
Workflow Trends



Systems Engineering
& Design

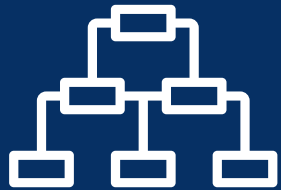


Modern
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AI for
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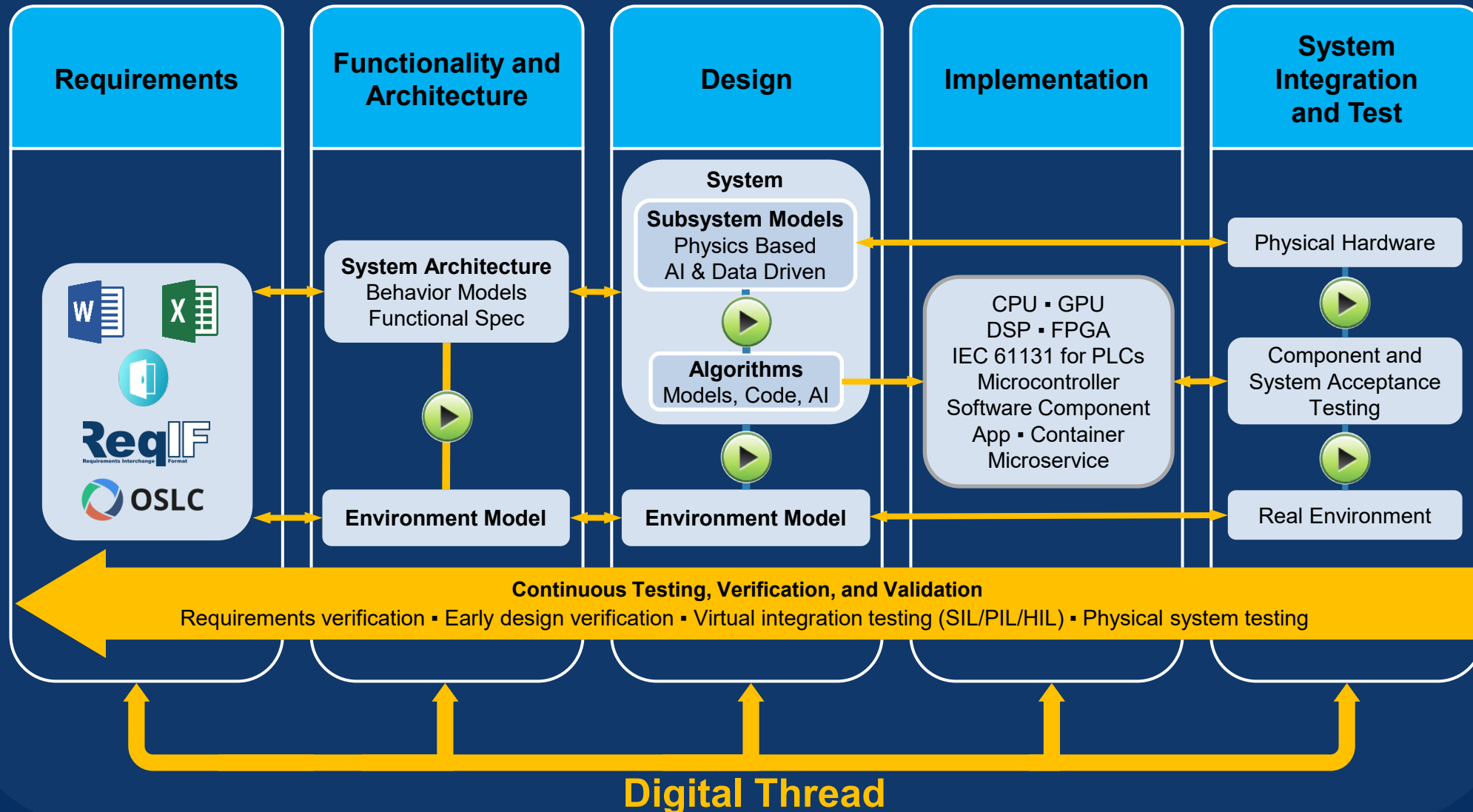


7. Design your system with AI



7 Design your system with AI

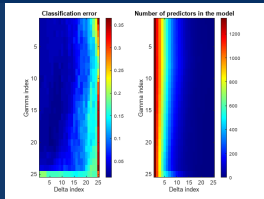
Integrating AI into Model-Based Design





7 Design your system with AI

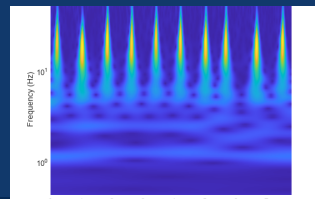
AI Reference Examples



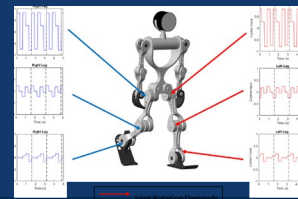
Predictive Maintenance



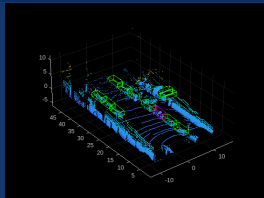
Hyperspectral Imaging



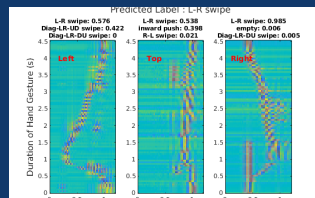
Signal Processing



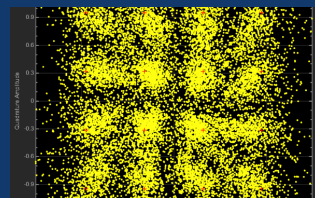
Robotic Control



Lidar Processing



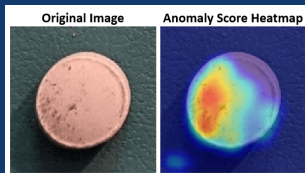
Radar Processing



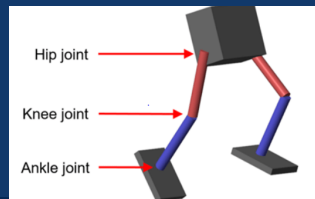
Wireless Communications



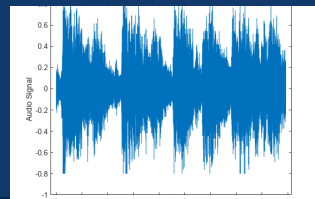
Automated Driving



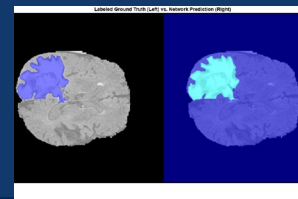
Visual Inspection



Reinforcement Learning



Audio

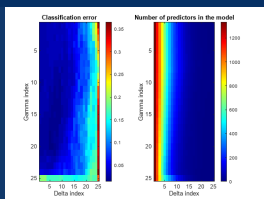


Medical Imaging

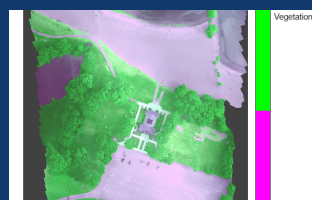


7 Design your system with AI

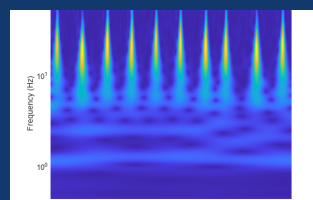
AI Reference Examples



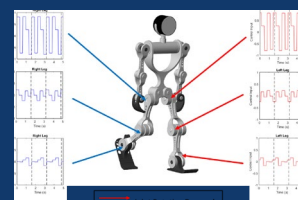
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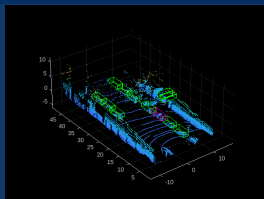
Signal Processing



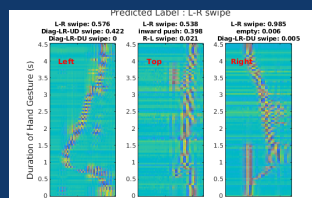
Robotic Control



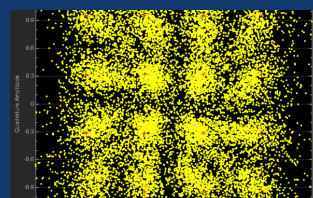
CPU



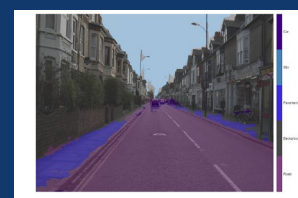
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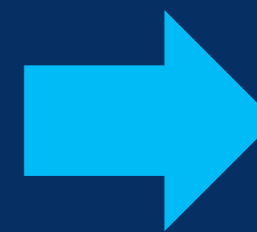
Radar Processing



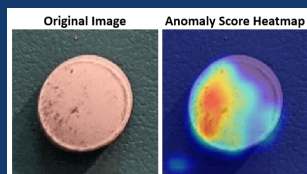
Wireless Communications



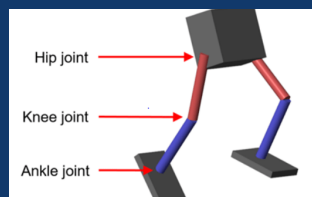
Automated Driving



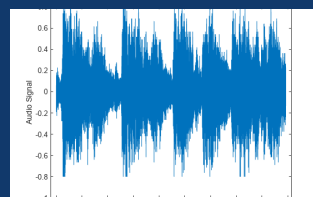
GPU



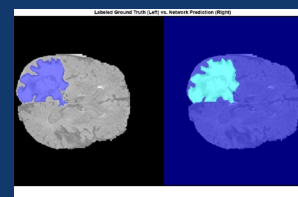
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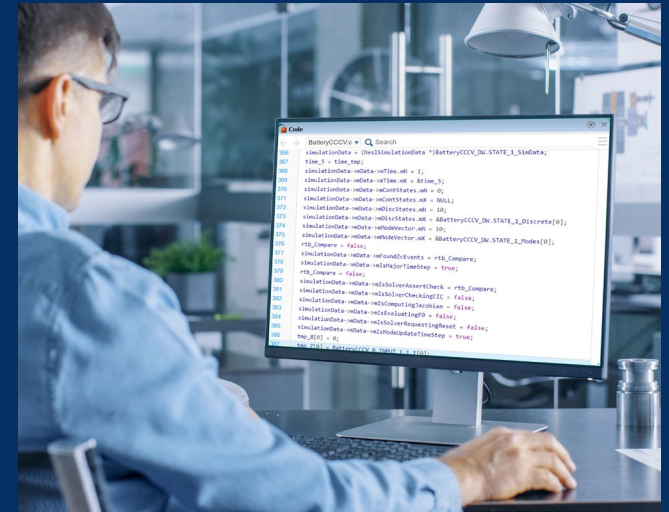
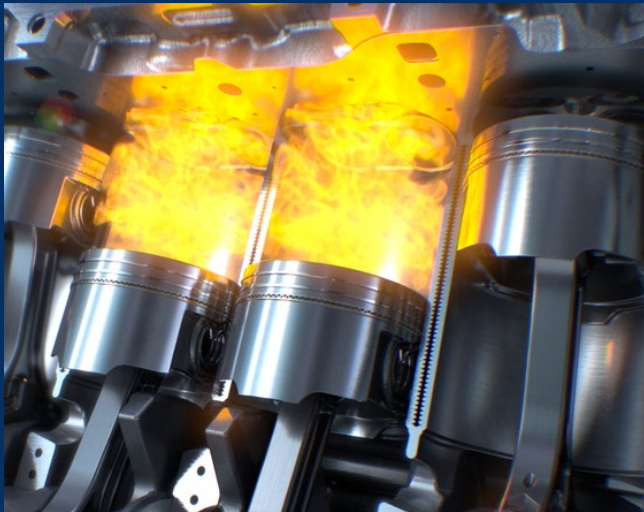
Medical Imaging



FPGA, ASIC, PLC



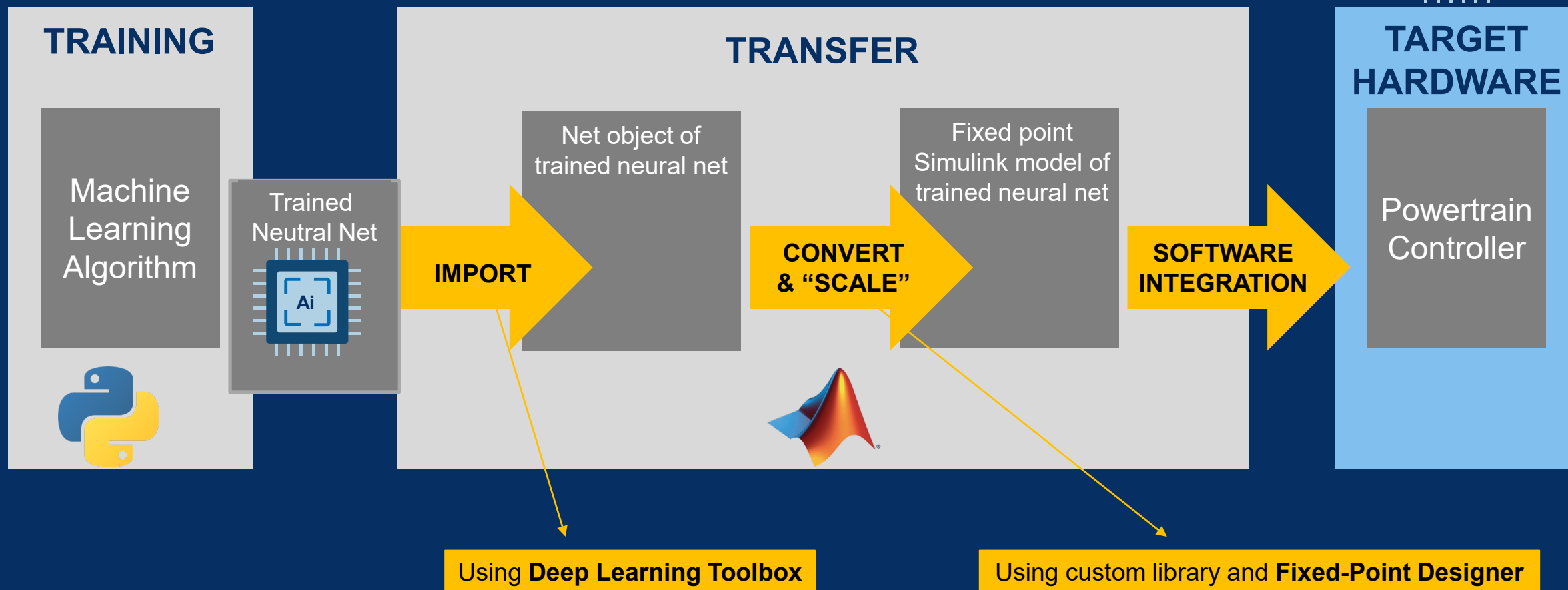
Simulates Hardware Sensors with Deep Neural Networks





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



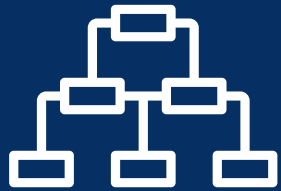
Mercedes-Benz

Simulates Hardware Sensors with Deep Neural Networks



6X

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Workflow Trends



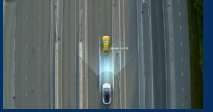
**Systems Engineering
& Design**



**Modern
Software Practices**



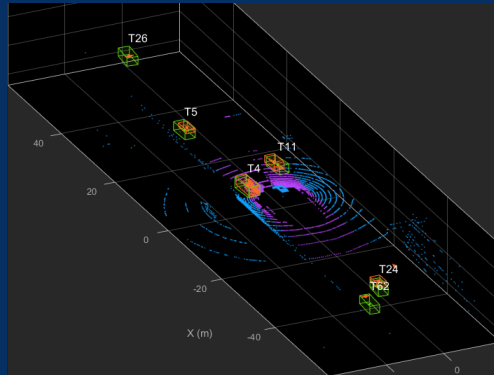
**AI for
System Development**



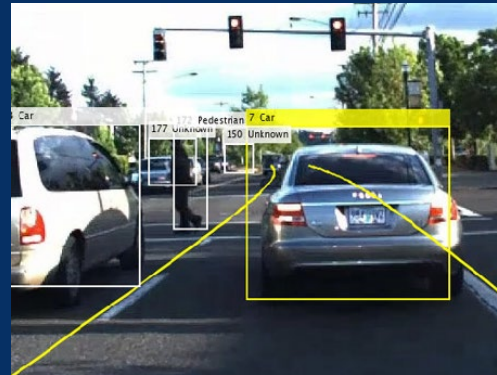
Deliver autonomous systems



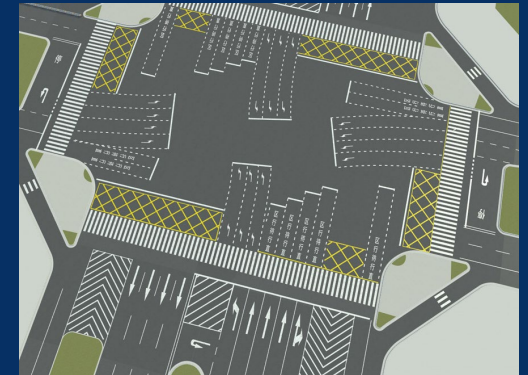
**Braking and
Steering**



**Sensor Fusion and
Tracking**



**Computer Vision
Radar, Lidar**



**Road Network
Design**



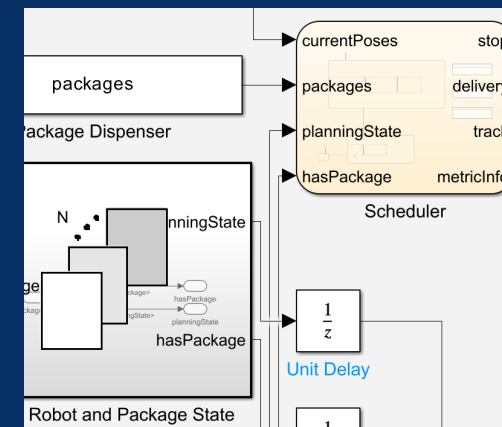
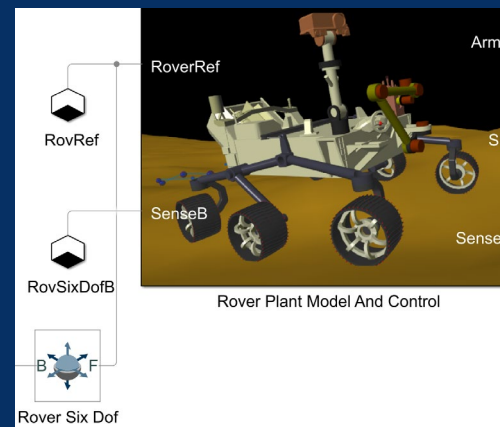
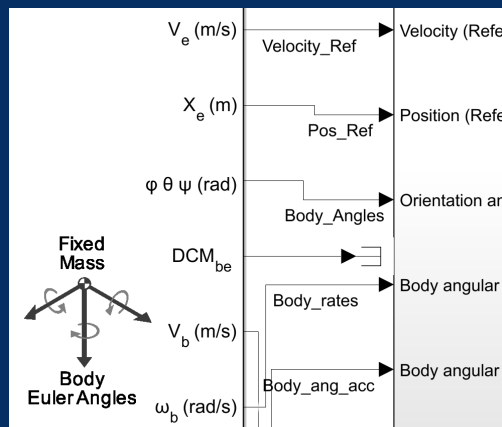
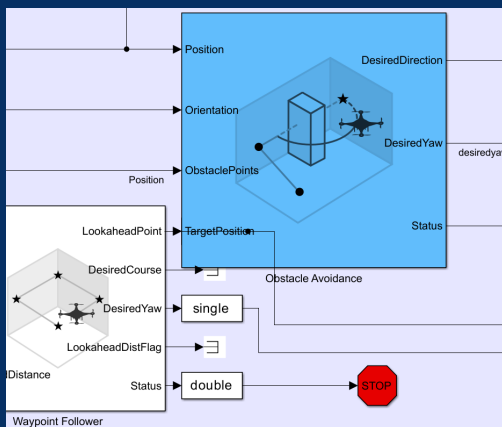
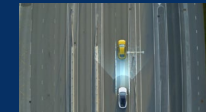
2D Editor | Logic

Library Browser

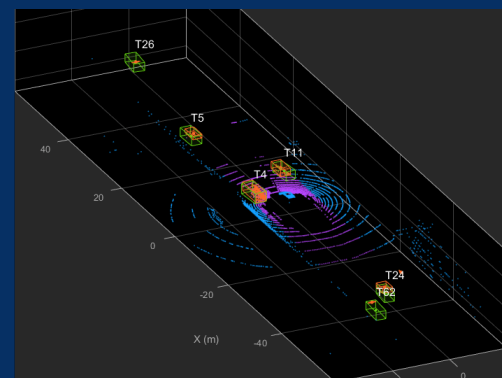
- Assets
 - Assemblies
 - Behaviors
 - Buildings
 - Damage
 - Extrusions
 - Markings
 - Materials
 - Posts
 - Props
 - Rail
 - RoadStyles
 - Signs
 - Stencils
 - Test
 - Vehicles

Ambulance	Ambulance_Details_Diff	Ambulance_Details_Diff_U...	Ambulance_Details_Norm
Ambulance_Details_Spec	Ambulance_Diff	Ambulance_Norm	Ambulance_Spec
CementTruck	CementTruck_Diff	CementTruck_Norm	CementTruck_Spec

Logic Editor: A purple rounded rectangle is connected to a blue circle with a clock icon.



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



Connectivity



Electrification

Workflow Trends



**Systems Engineering
& Design**



**Modern
Software Practices**



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System Development**



5G Standard





5G Standard

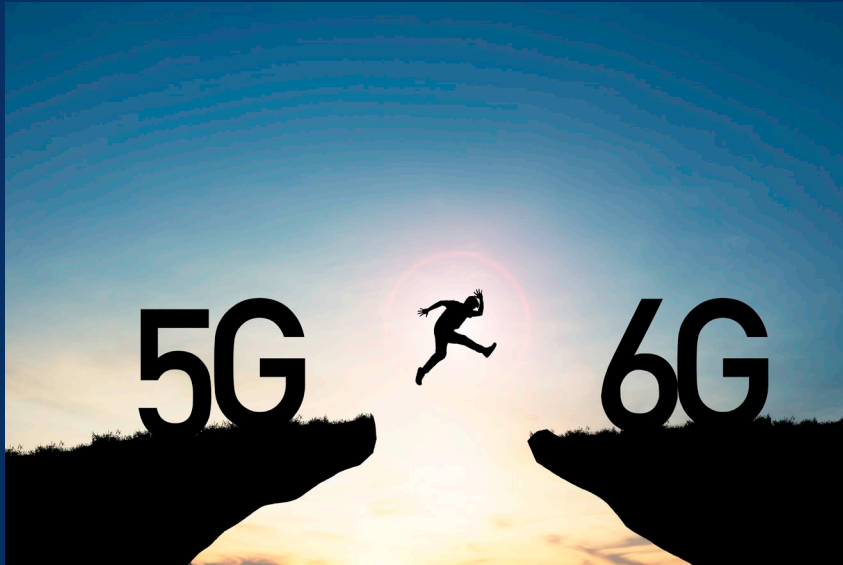


“One of MATLAB’s differentiators is its vertical products like 5G Toolbox. We use that toolbox to generate datasets for testing algorithms. We have not been able to find that capability in other software suites.”

*- 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



Master Class: How to Develop Next Generation AI-Based Wireless Communications Systems
Daniel Aronsson and Nadia Shivarova, *MathWorks*




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

Application Trends



Autonomous



Connectivity



Electrification

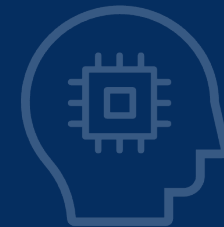
Workflow Trends



**Systems Engineering
& Design**



**Modern
Software Practices**



**AI for
System Development**

Application Trends



Autonomous



Connectivity



Electrification

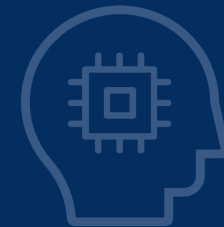
Workflow Trends



**Systems Engineering
& Design**



**Modern
Software Practices**

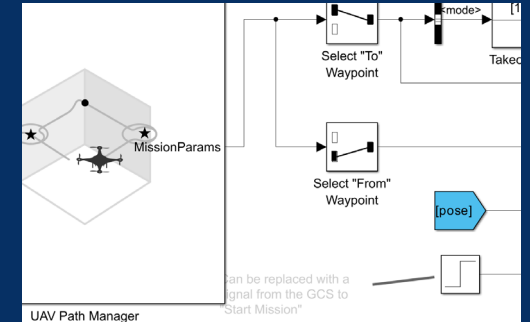
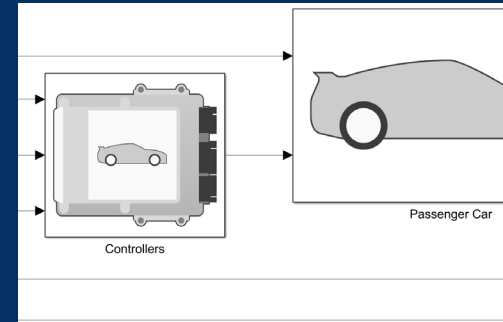
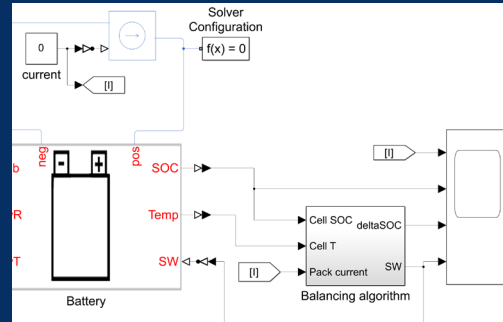
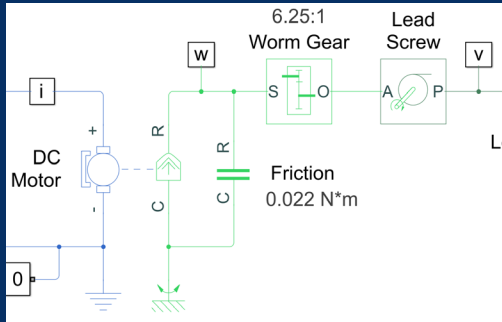


**AI for
System Development**

Electric Vehicles



Optimising the Energy Efficiency of Electric Vehicles with Simulink and Simscape
 Andrew Curtis and Victoria Rothwell, *Polestar*



Electric Motors



Battery Packs



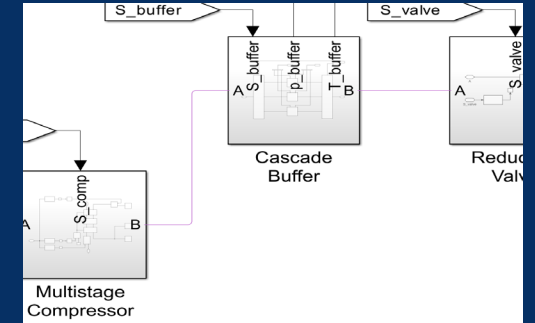
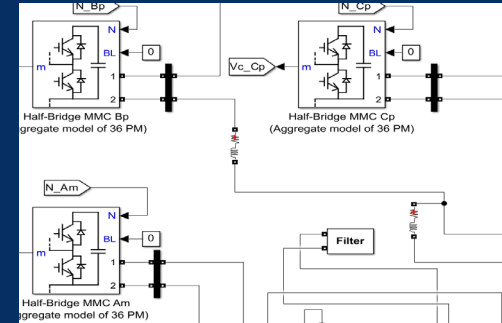
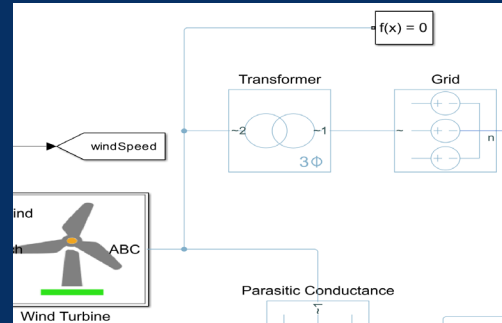
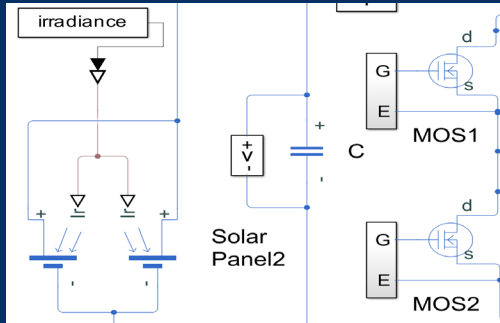
Full Vehicle Models



Aerial Vehicles



Green Energy



Solar



Wind



Hydroelectric



Green Hydrogen

SIEMENS ENERGY

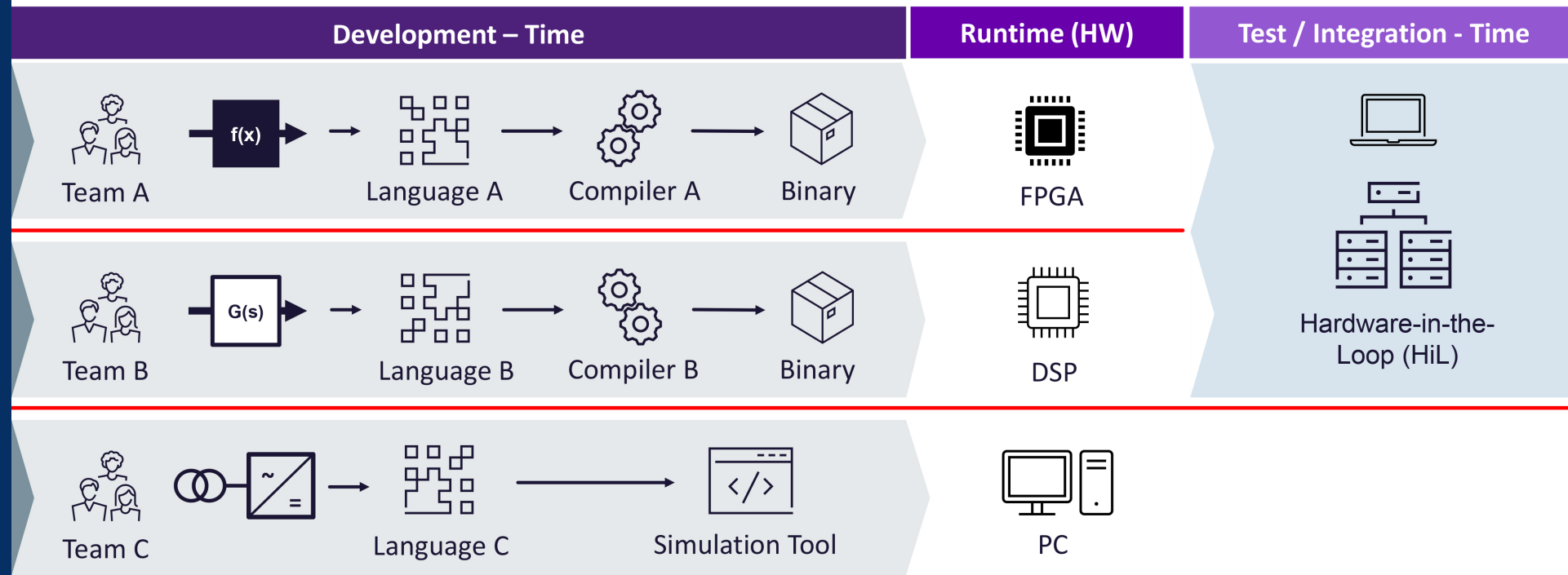
Enables the Global Energy Transition

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



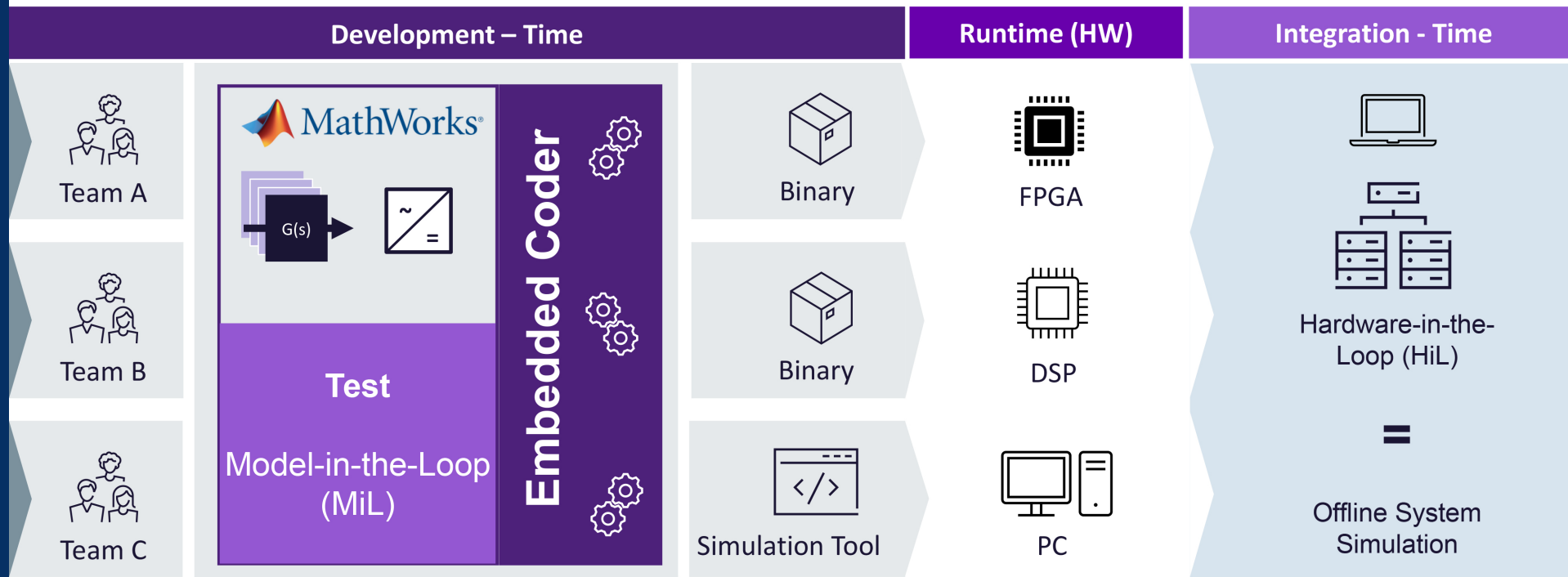
Swimlane Engineering

When the organization shapes development



Centralized Engineering Ecosystem

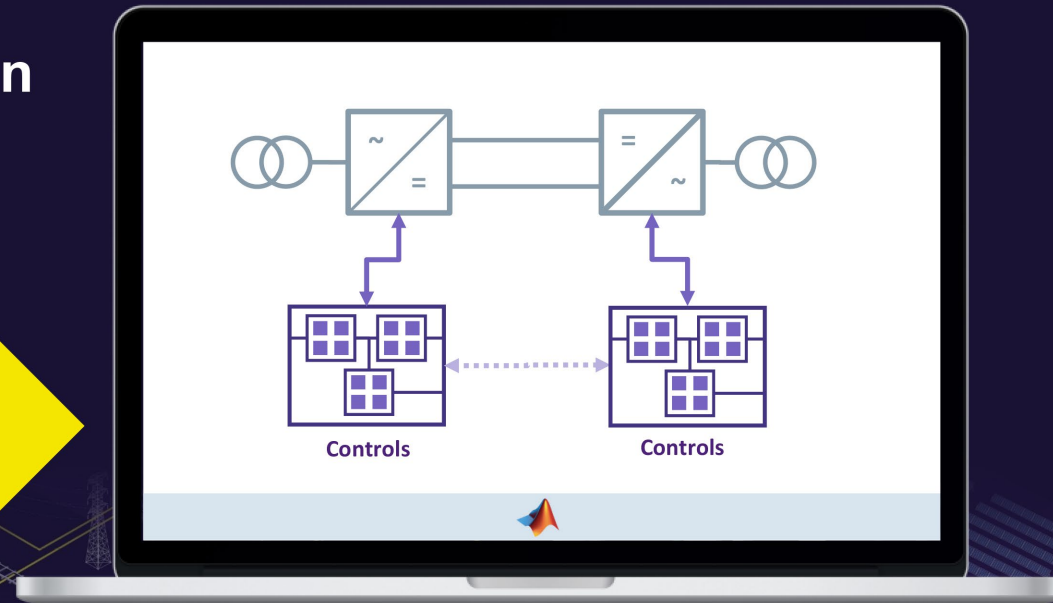
When development extends across the organization



SIEMENS ENERGY

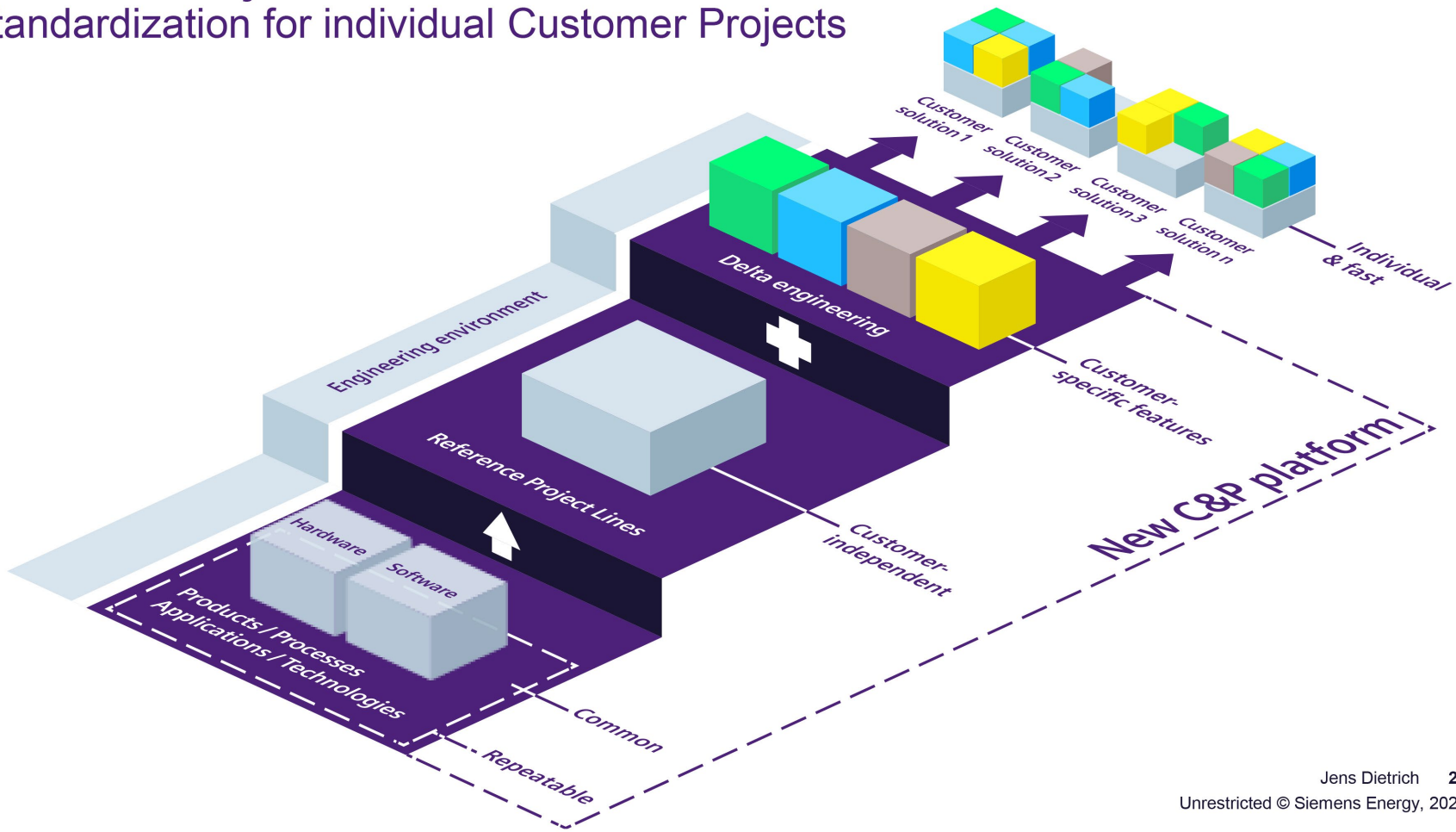
Enables the Global Energy Transition

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



Enables the Global Energy Transition

Reference Project Lines Standardization for individual Customer Projects



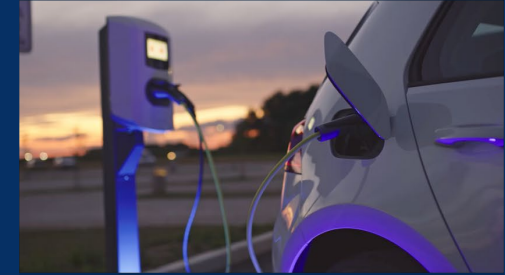
Application Trends



Autonomous

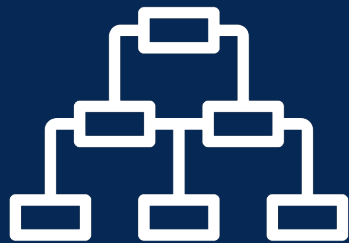


Connectivity



Electrification

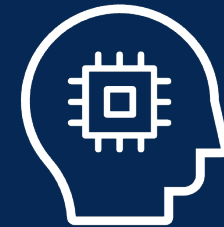
Workflow Trends



**Systems Engineering
& Design**



**Modern
Software Practices**



**AI for
System Development**

Application Trends



Autonomous



Connectivity



Electrification



Workflow Trends

Systems Engineering
& DesignModern
Software PracticesAI for
System Development

Application Trends

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

Workflow Trends

- ⑤ Apply standard software workflows
- ⑥ Design and simulate in the cloud
- ⑦ Design your system with AI

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System Development

MATLAB EXPO

UNITED KINGDOM

Thank you



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