

# MATLAB EXPO

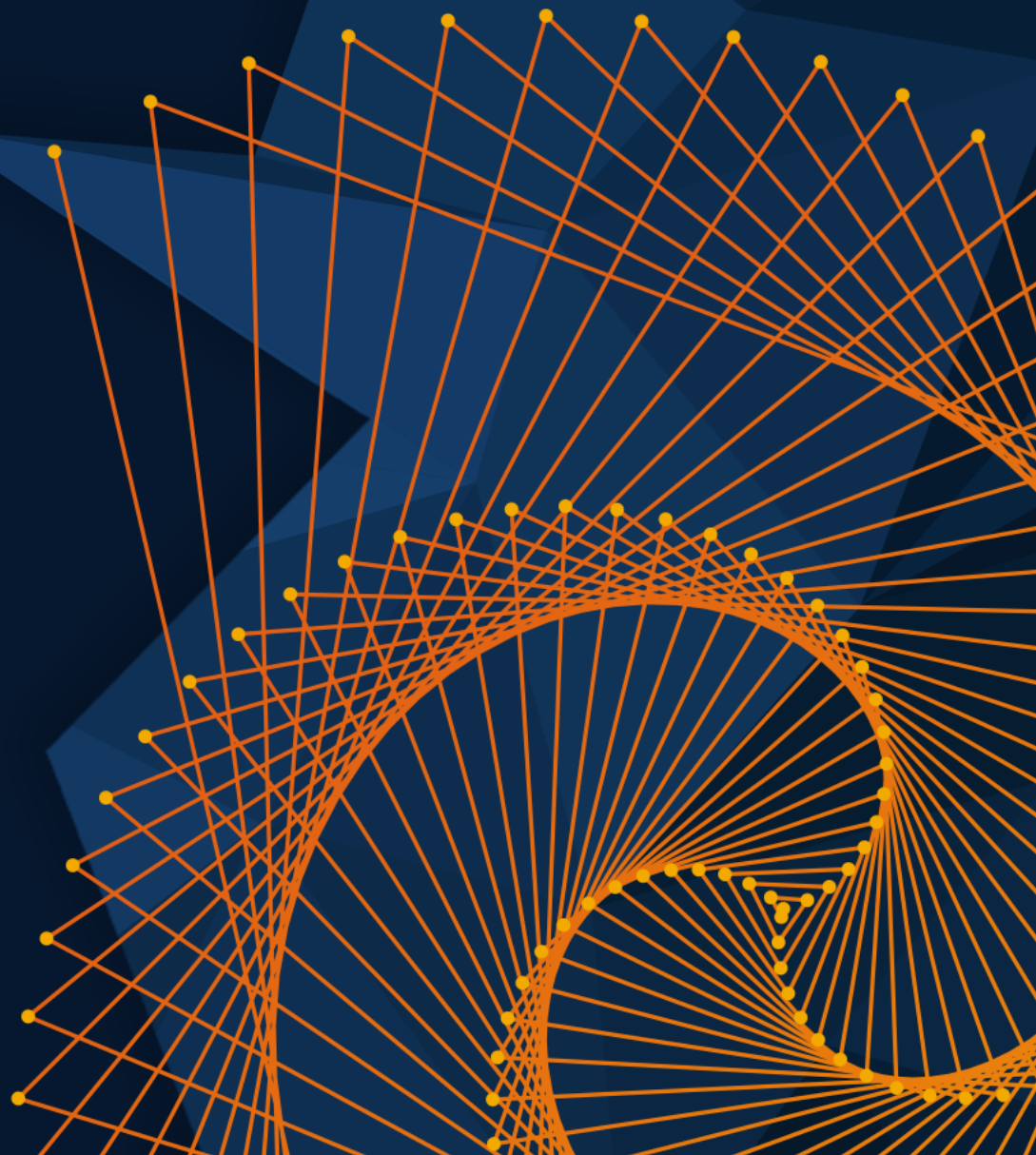
 INDIA

11 July 2024 | Bengaluru

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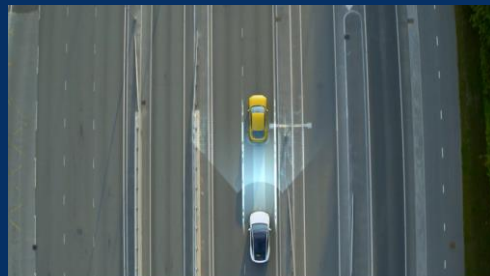
## Model-Based Design for Digital Engineering: Impact and Directions

*Tom Erkinen*





# Application Trends



**Autonomous**



**Connectivity**



**Electrification**

# Application Trends



**Autonomous**

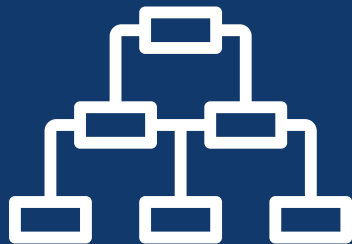


**Connectivity**



**Electrification**

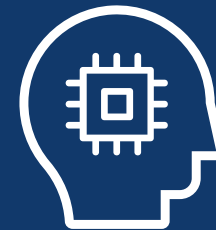
# Workflow Trends



**Systems Engineering  
& Design**



**Modern  
Software Practices**



**AI for  
System Development**

## Application Trends



Autonomous

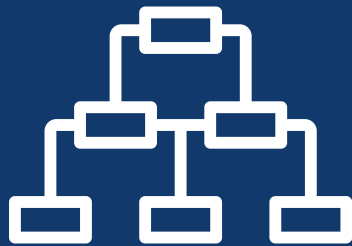


Connectivity



Electrification

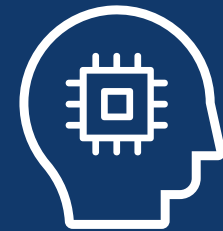
## Workflow Trends



Systems Engineering  
& Design

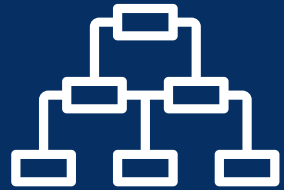


Modern  
Software Practices



AI for  
System Development

# Workflow Trends



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

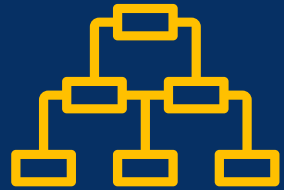


5. Apply standard software workflows
6. Design and simulate in the cloud



7. Design your system with AI

# Workflow Trends



1. Automate everything
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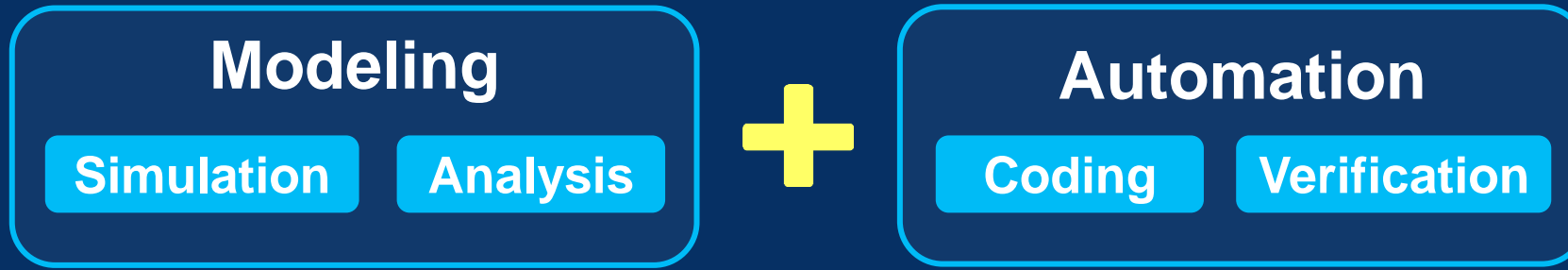
# ① Automate everything



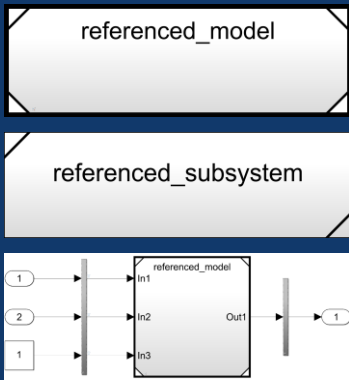


# ① Automate everything

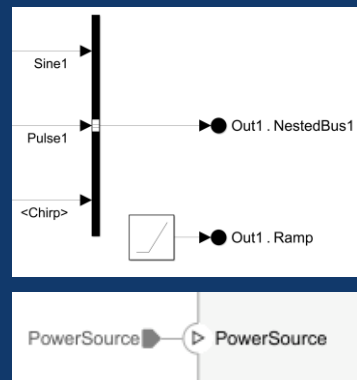
**Next Talk:** What's New in MATLAB and Simulink R2024a



# 2 Scale to complex systems



Components



Buses, Ports,  
and Connectors

VariantManagement	
Controller	
Linear Controller	Ctrl == Controller
Nonlinear Controller	Ctrl == Controller
Smart Controller	Ctrl == Controller
Sensor Modifier	
AISensor (...)	SmartSensorMod
FLSensor (...)	SmartSensorMod
Plant	
External (Model file: s...)	PlantLoc == Plant
Internal	PlantLoc == Plant
Experimental	SimType==Intern

Variant Manager

Block Parameters: vehicAOB

vehic\_AOB [Model Exchange, v1.0]

FMU Block

FMU with bus signals and structured parameters

[Open FMU Documentation File](#)

Parameters Simulation Input Output

Model Exchange settings

Enable FMU tolerance Relative t

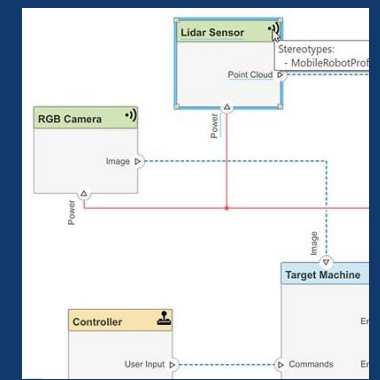
Block sample time (-1 for inherited): 0

Debugging

[Open FMU Working Directory...](#) Open

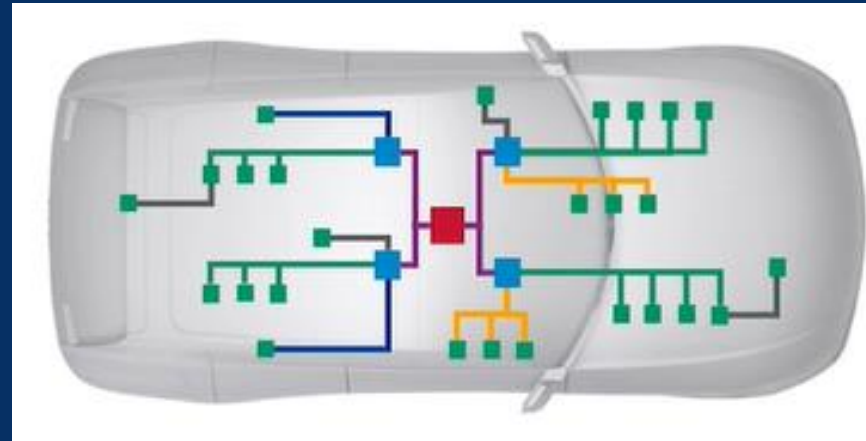
Enable FMU debug logging Redire

Third-Party Tool  
Integration

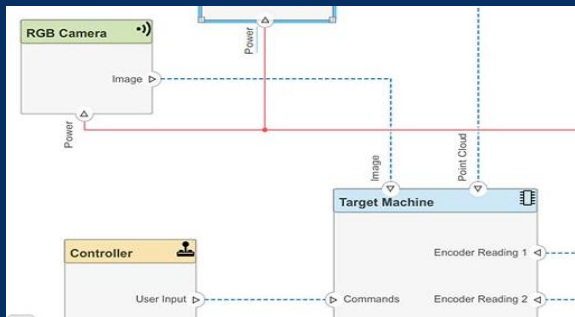


Architecture

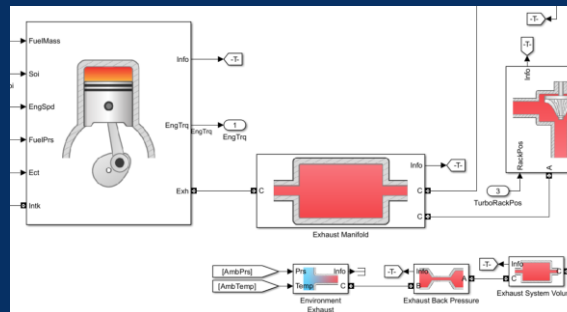
# 2 Scale to complex systems



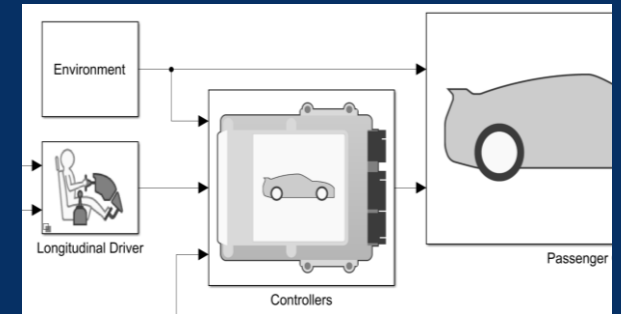
## Service-Oriented Architecture



System Composer



Components



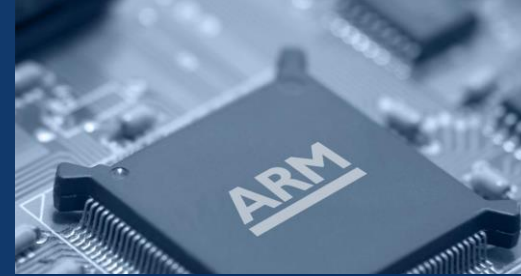
Full System

# ③ Use automatic code generation

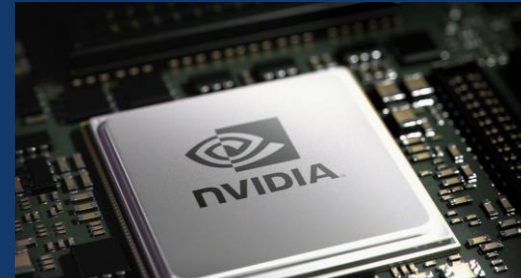
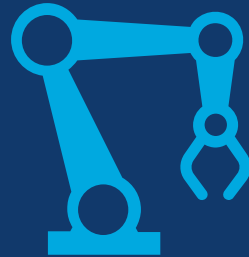


**3700**

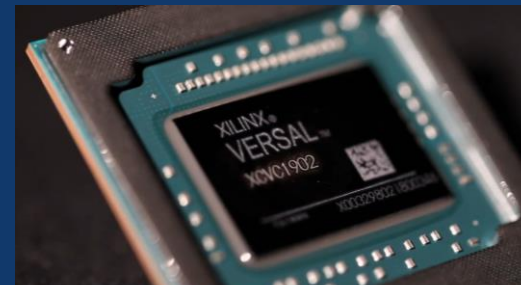
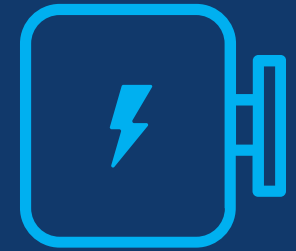
Organizations use automatic code generation



CPU



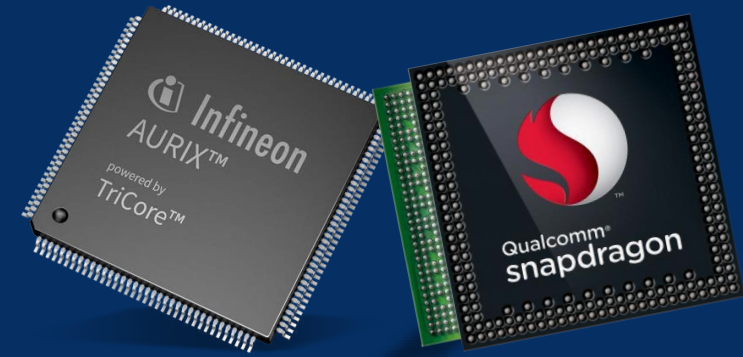
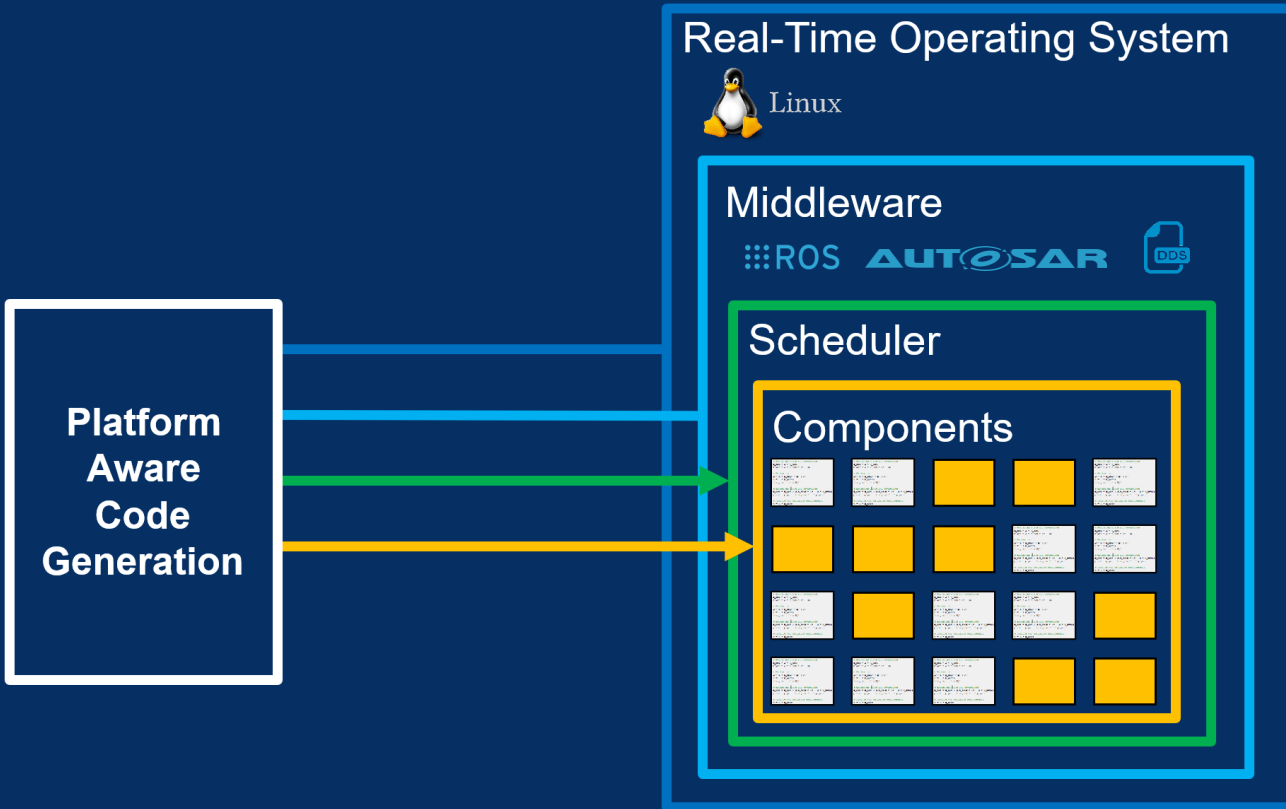
GPU



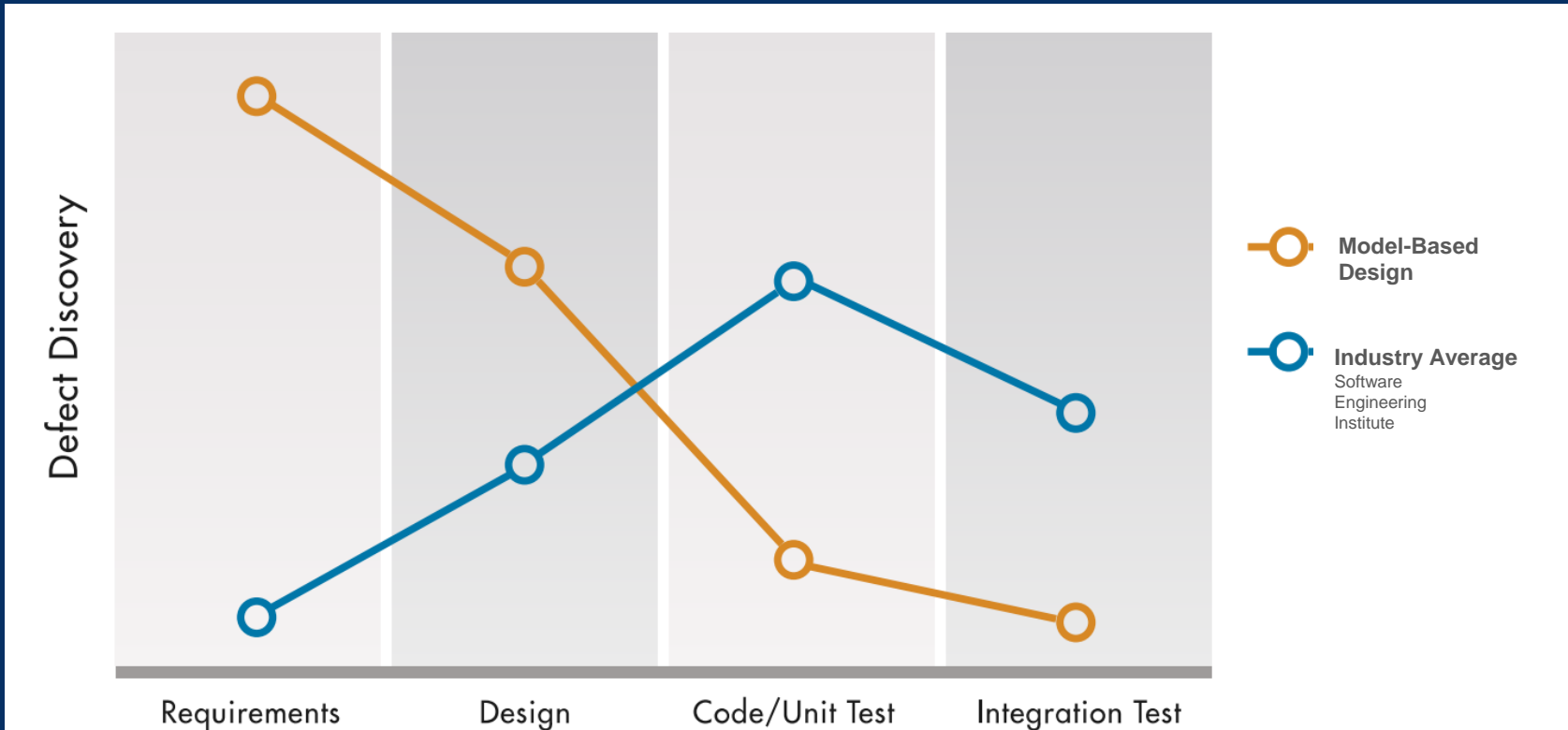
FPGA, ASIC, PLC



# 3 Use automatic code generation



# 4 Prevent and detect defects early



# 4 Prevent and detect defects early



Find Defects Sooner

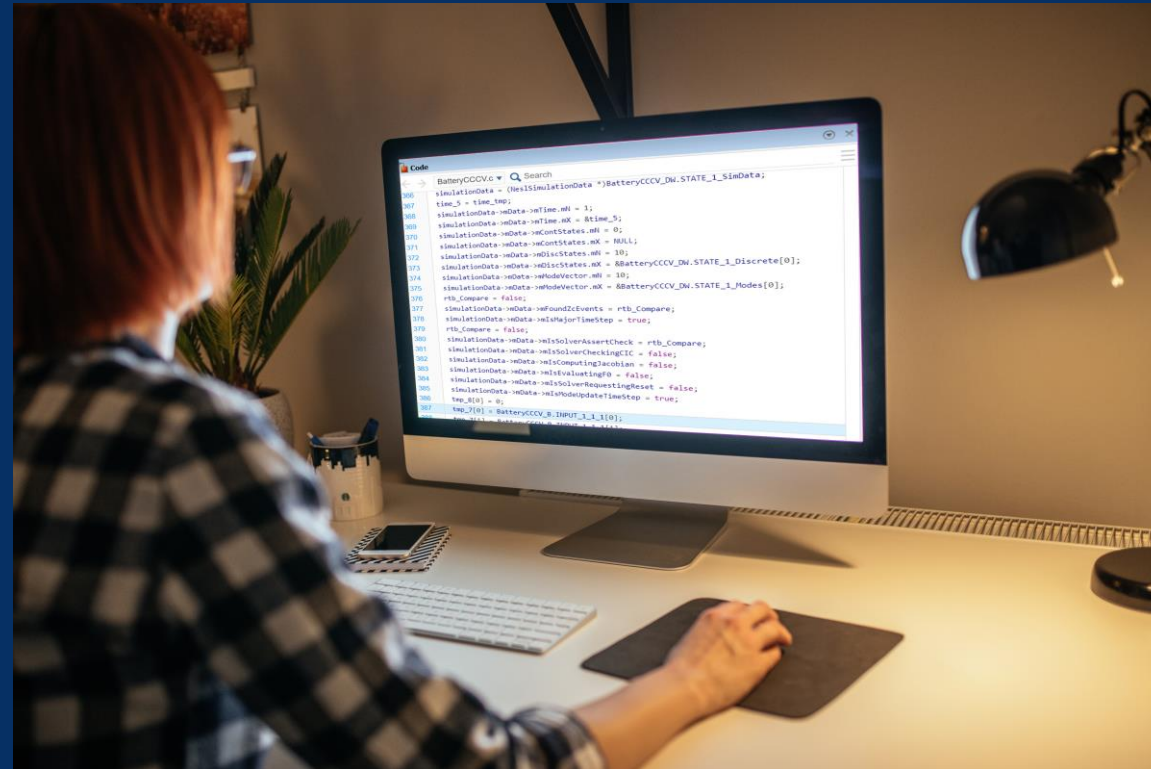
Design	Test	Code	Certify
Simulink Design Verifier	Simulink Test	Polyspace Bug Finder	DO Qualification Kit
Simulink Check	Simulink Coverage	Polyspace Code Prover	IEC Certification Kit
HDL Verifier	MATLAB Test	Polyspace Access	Simulink Code Inspector
Simulink Fault Analyzer	Polyspace Test		



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



The Saft Flex'ion Gen2



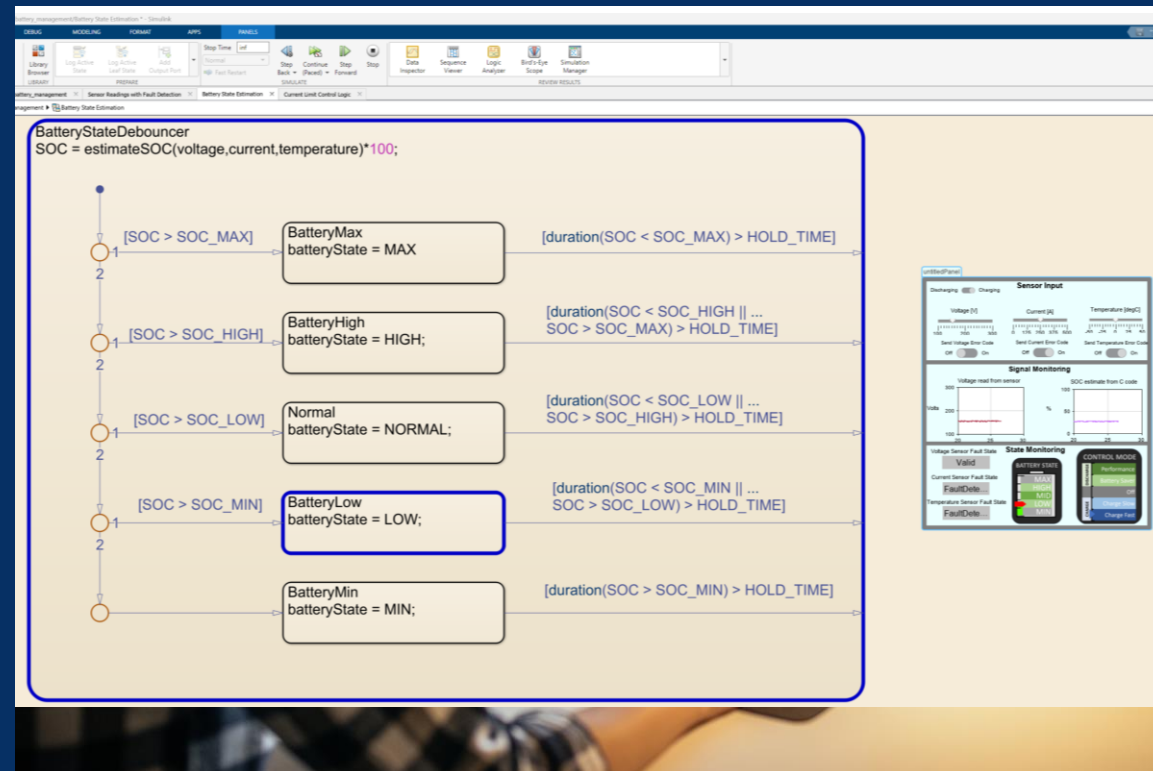




# UL Certification of Battery Management System Software with Model-Based Design



The Saft Flex'ion Gen2





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



The Saft Flex'ion Gen2



# Application Trends



Autonomous

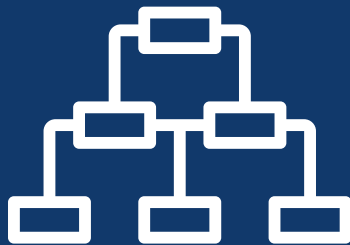


Connectivity



Electrification

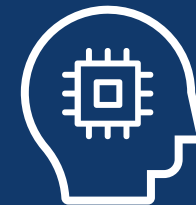
# Workflow Trends



Systems Engineering  
& Design

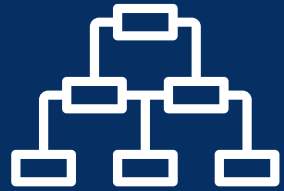


Modern  
Software Practices



AI for  
System Development

# Workflow Trends



1. Automate everything
2. Scale to complex systems
3. Use automatic code generation
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5. Apply standard software workflows
6. Design and simulate in the cloud



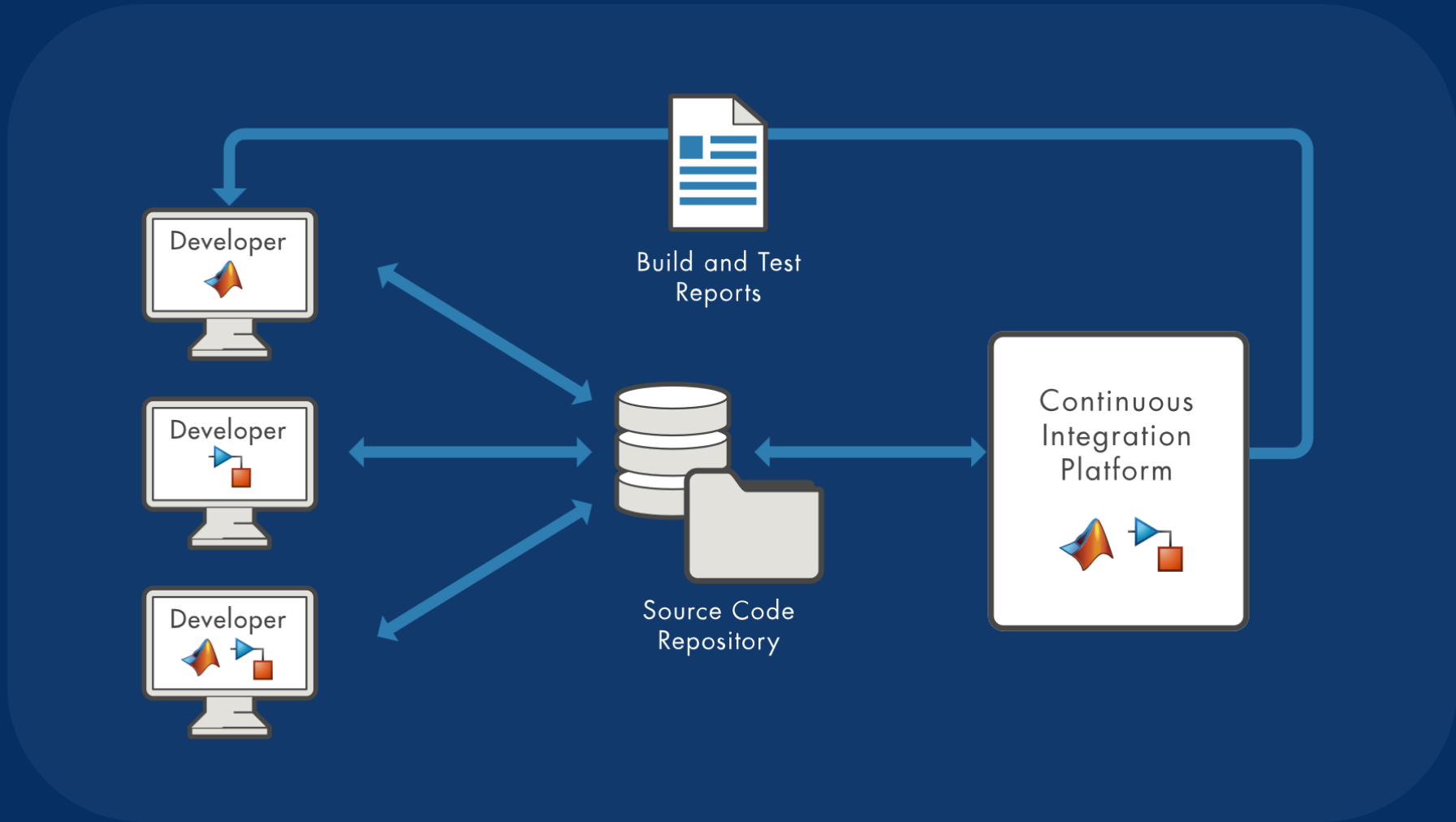
7. Design your system with AI

# 5 Apply standard software workflows



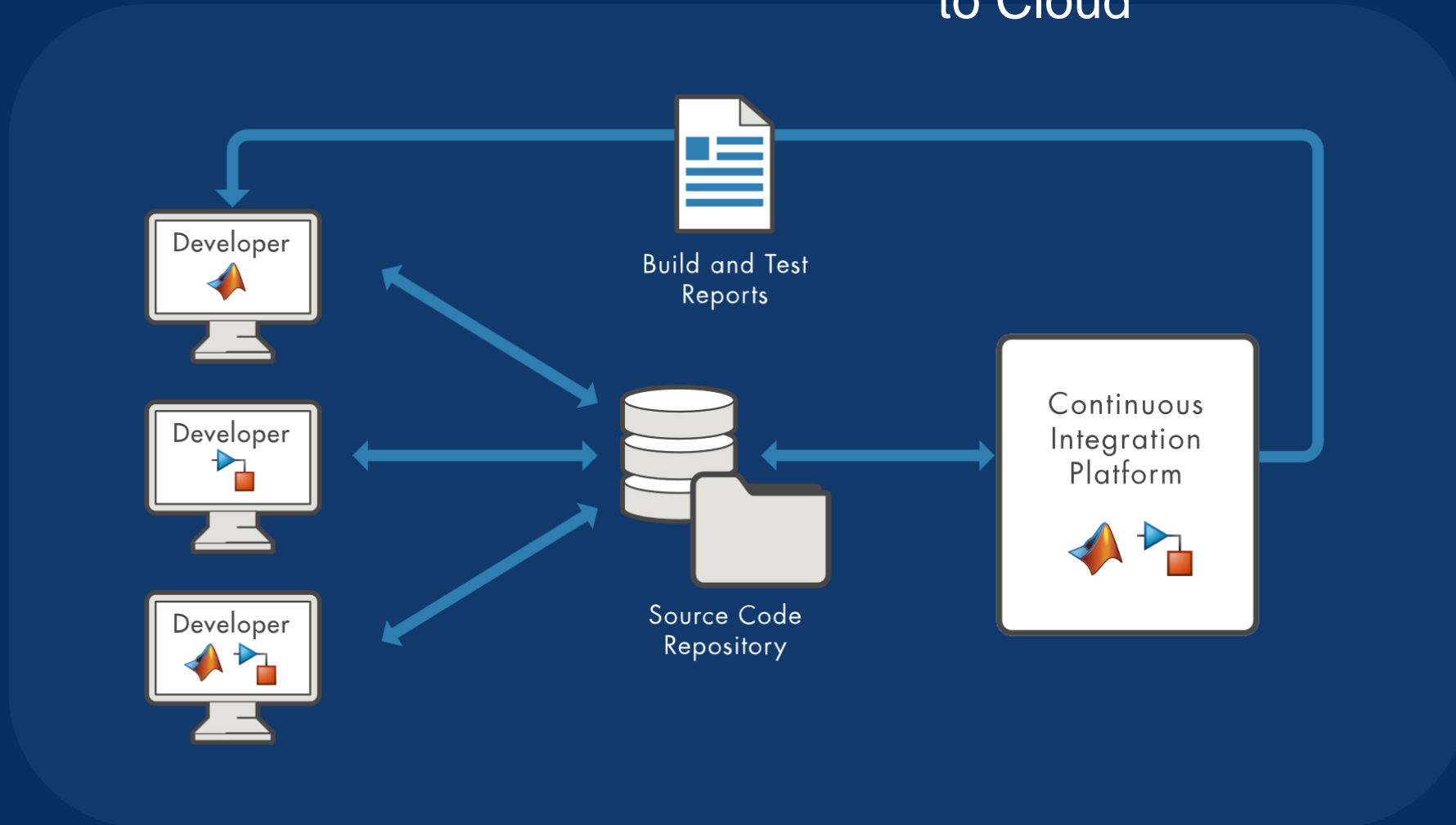
“Software is the language of automation.”  
- *Jensen Huang, co-founder and CEO of NVIDIA*

# 5 Apply standard software workflows



# 5 Apply standard software workflows

**Tech Talk:** Shaping Future Software Factories: Leveraging Model-Based Design for Scalability from Desktop to Cloud



# 5 Apply standard software workflows



Process Advisor: Flight\_Control

Model | Run All

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





# From Scripted Pipelines to Process Advisor

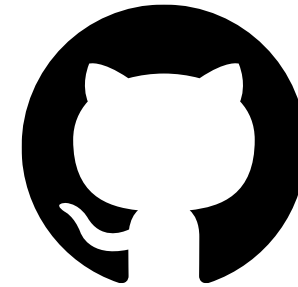




**Jenkins**



**git**



**MATLAB® & SIMULINK®**



**AUTOSAR**



“Bring everything into MATLAB.”

- *Martin Römpert, Continental Automotive Technologies GmbH*



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

2X



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

The diagram on the right shows a block diagram with two main components: 'PilotPitchCmd' (containing a block with the number 4) and 'PilotRollCmd' (containing a block with the number 5). Arrows indicate data flow between these components and other parts of the system.

Process Advisor

500 interfaces

1,000 components

100 compositions

# 6 Design and simulate in the cloud



The screenshot shows the MATLAB Online login page in a web browser. The browser's address bar displays 'matlab.mathworks.com'. The page header includes the MathWorks logo and 'MATLAB Online'. The main heading is 'MATLAB® Online'. Below this is the MathWorks logo, the label 'Email', and a text input field containing 'mcarone@mathworks.com'. A link for 'No account? Create one!' is visible, along with a note: 'By signing in you agree to our privacy policy.' A blue 'Next' button is positioned to the right of the input field, with a mouse cursor hovering over it. At the bottom of the page, there are two links: 'Learn about MATLAB Online' and 'Use MATLAB Drive™ to synchronize your MATLAB files'.

# 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



## Application Trends



Autonomous

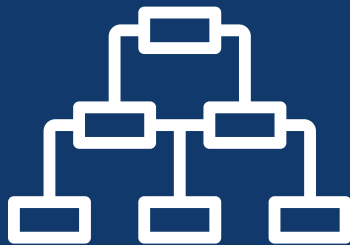


Connectivity



Electrification

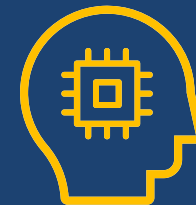
## Workflow Trends



Systems Engineering  
& Design



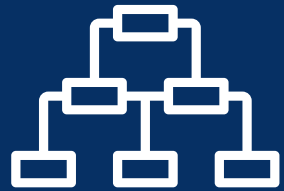
Modern  
Software Practices



AI for  
System Development



# Workflow Trends



1. Automate everything
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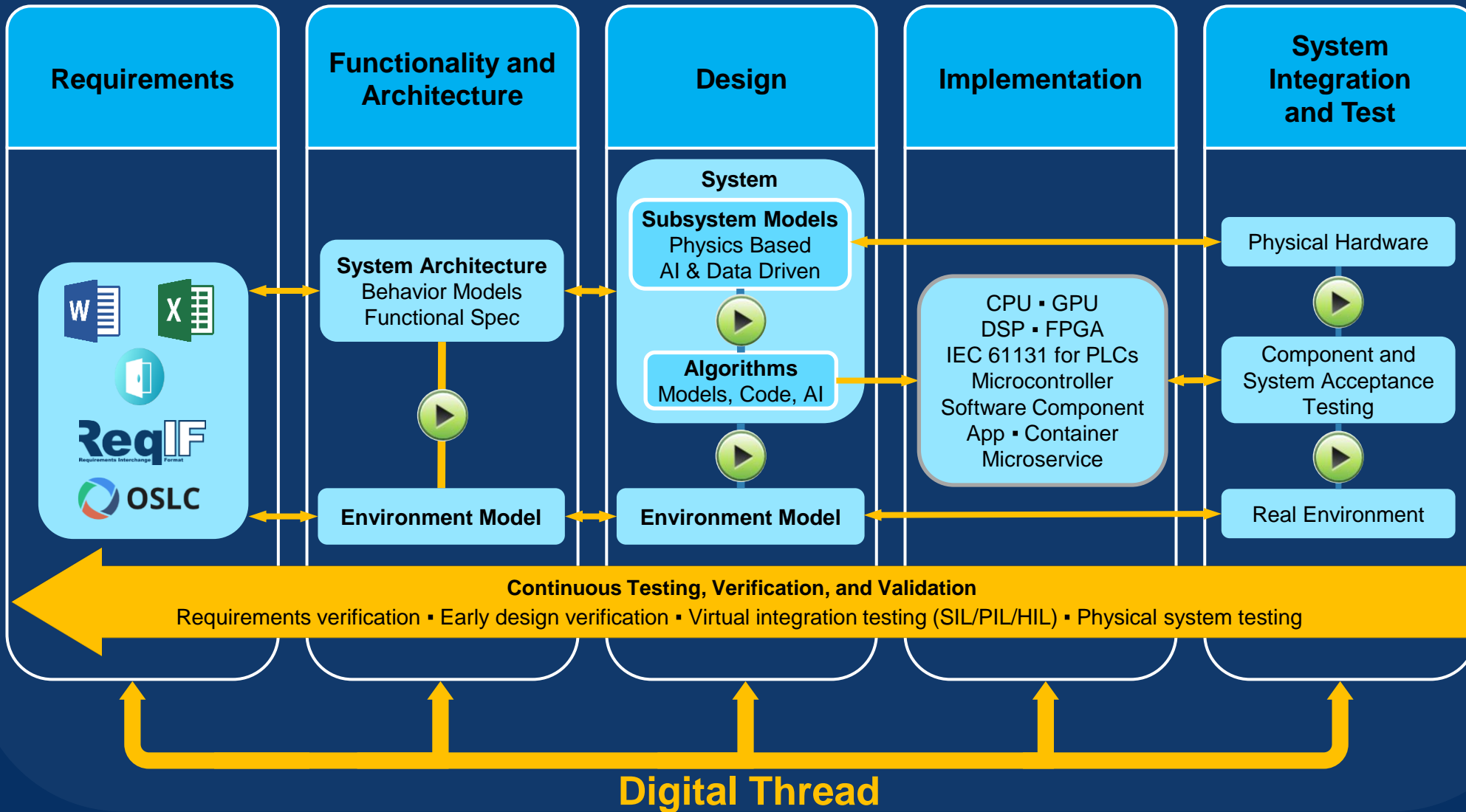


5. Apply standard software workflows
6. Design and simulate in the cloud



7. Design your system with AI

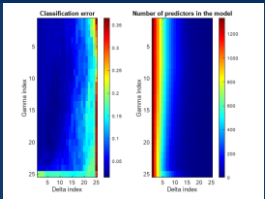
# 7 Design your system with AI



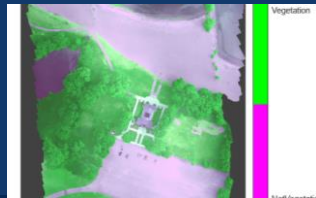
# 7 Design your system with AI



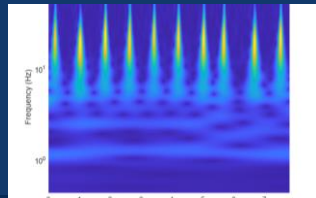
## AI Reference Examples



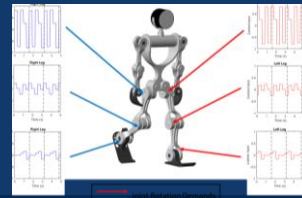
Predictive Maintenance



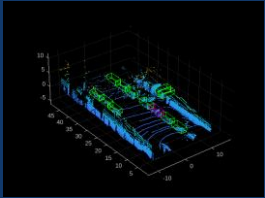
Hyperspectral Imaging



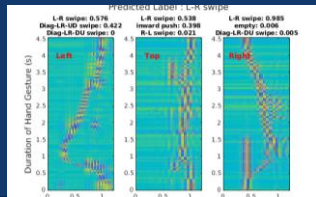
Signal Processing



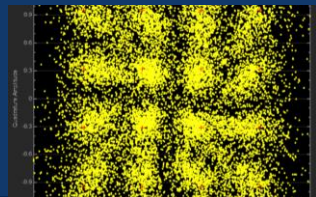
Robotic Control



Lidar Processing



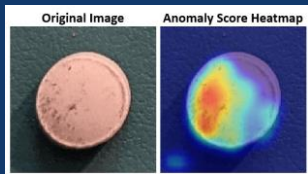
Radar Processing



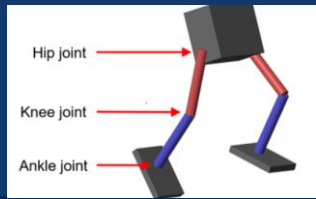
Wireless Communications



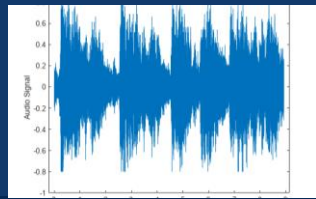
Automated Driving



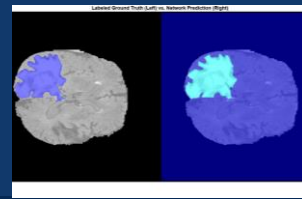
Visual Inspection



Reinforcement Learning



Audio

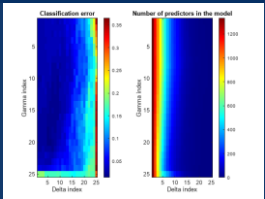


Medical Imaging

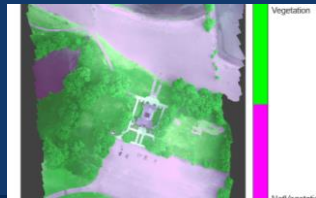
# 7 Design your system with AI

## Tech Talk: The Industrial AI Lifecycle: Dreaming, Designing, and Delivering in the Digital Age

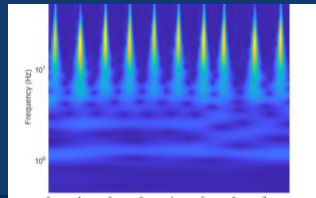
### AI Reference Examples



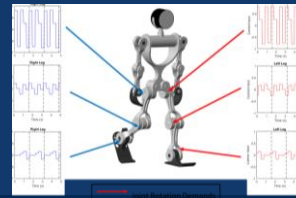
Predictive Maintenance



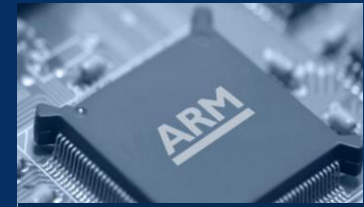
Hyperspectral Imaging



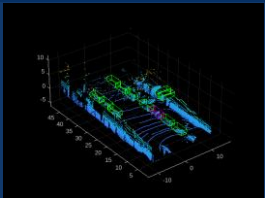
Signal Processing



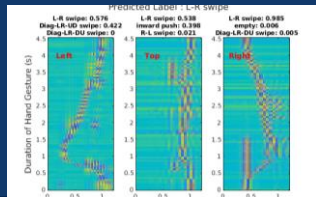
Robotic Control



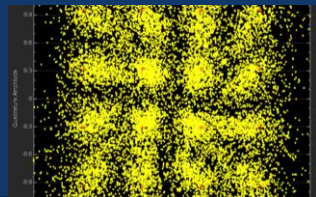
CPU



Lidar Processing



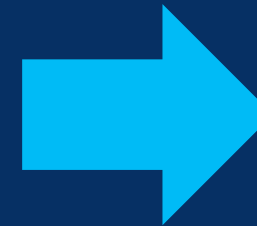
Radar Processing



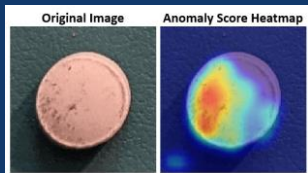
Wireless Communications



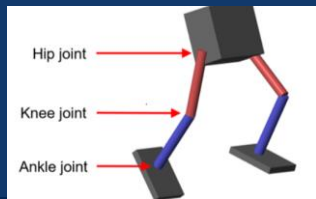
Automated Driving



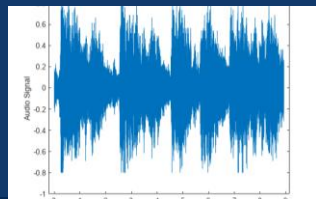
GPU



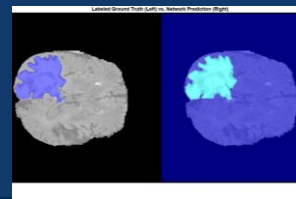
Visual Inspection



Reinforcement Learning



Audio



Medical Imaging



FPGA, ASIC, PLC



Mercedes-Benz

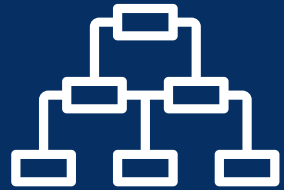
## Simulates Hardware Sensors with Deep Neural Networks



*“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*

# Workflow Trends



1. Automate everything
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7. Design your system with AI

# Application Trends



**Autonomous**



**Connectivity**



**Electrification**

# Workflow Trends



**Systems Engineering  
& Design**



**Modern  
Software Practices**

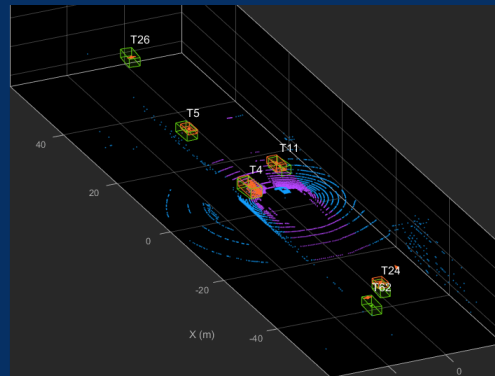


**AI for  
System Development**

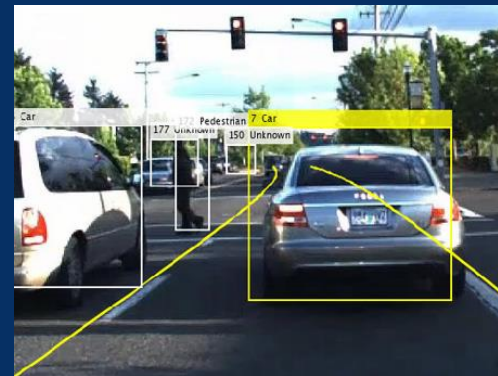
# Deliver autonomous systems



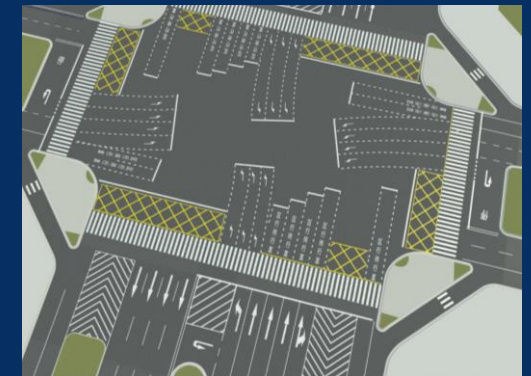
**Braking and Steering**



**Sensor Fusion and Tracking**



**Computer Vision  
Radar, Lidar**



**Road Network Design**



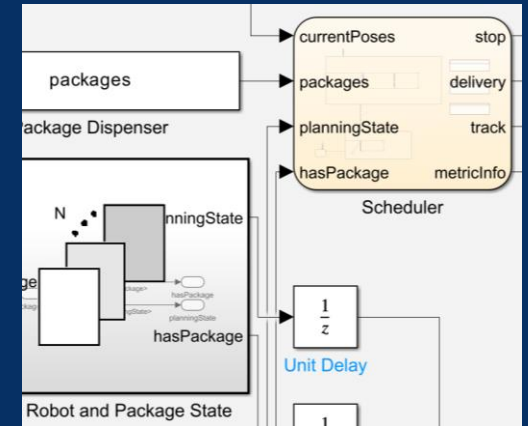
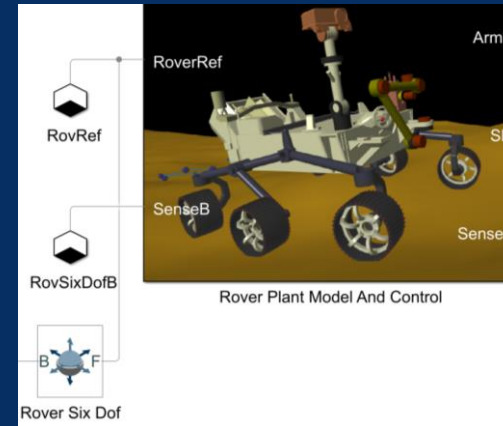
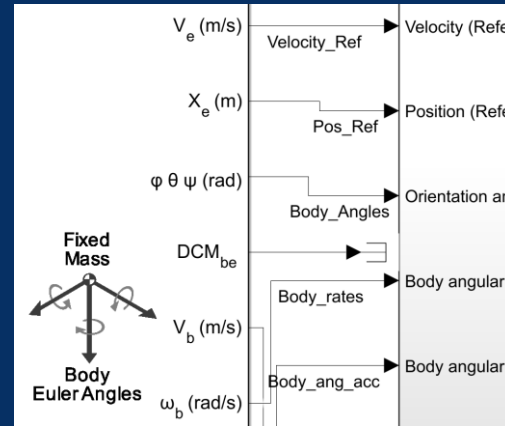
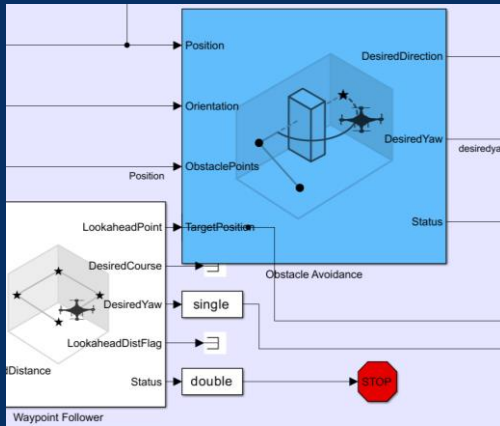


3D Editor | Logic

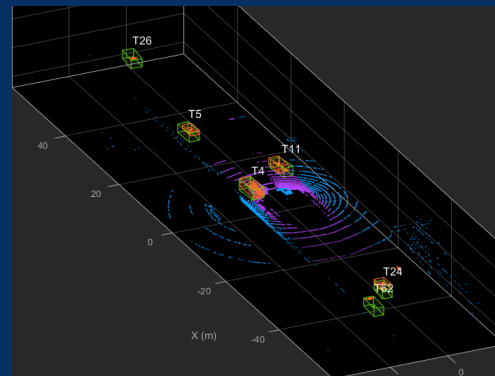
Library Browser

- 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
CementTruck	CementTruck	CementTruck	CementTruck



**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



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**Connectivity**



**Electrification**

# Workflow Trends



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**AI for  
System Development**

# 5G Standard



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d that  
neering,

# 6G standard



**RCR Wireless News**  
INTELLIGENCE ON ALL THINGS WIRELESS

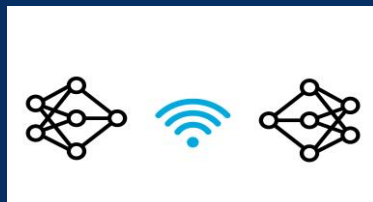
| China aims for 6G commercialization by 2030: Report

By  Juan Pedro Tomás December 13, 2023

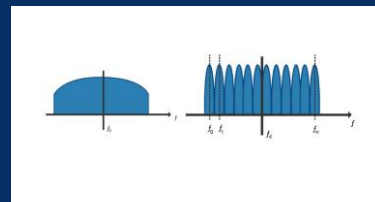
[6G](#) [Standards](#)

# 6G being designed now

## Key Technologies



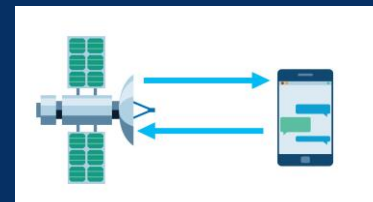
Artificial intelligence and machine learning



Spectrum bands



Network that can sense



Extreme connectivity



New network architectures

## MathWorks Products

Communications,  
5G, WLAN Toolboxes,  
w/ Deep Learning Toolbox

RF Blockset,  
Antenna Toolbox

WLAN Toolbox,  
5G Toolbox,  
Radar Toolbox

Satellite Communications  
Toolbox

Future







6G Exploration Library (R2024a)



# Wireless Trends – AI in Wireless

## Tech Talk: Integrating Radar and Wireless Communication Systems: Navigating the Trend with Modeling and Simulation




### 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



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# Workflow Trends



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**Autonomous**



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# Workflow Trends



**Systems Engineering  
& Design**

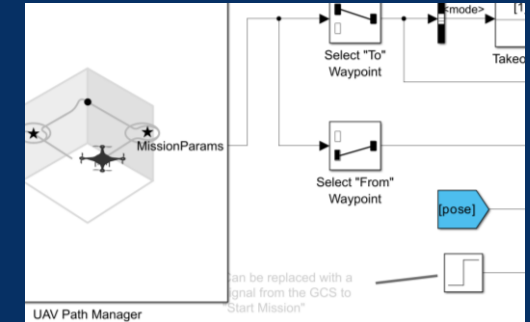
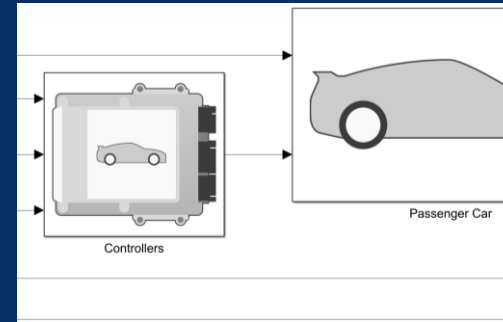
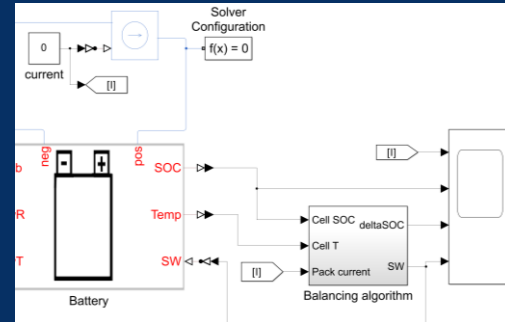
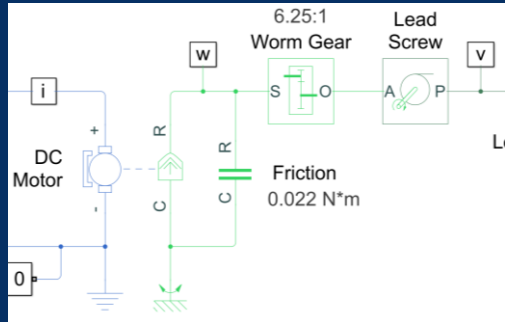


**Modern  
Software Practices**



**AI for  
System Development**

# Electric Vehicles



**Electric Motors**



**Battery Packs**



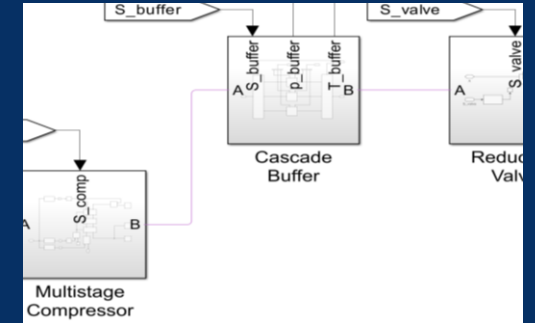
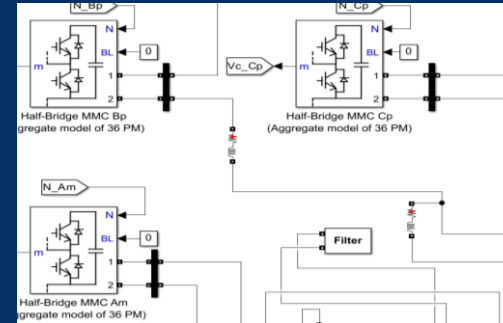
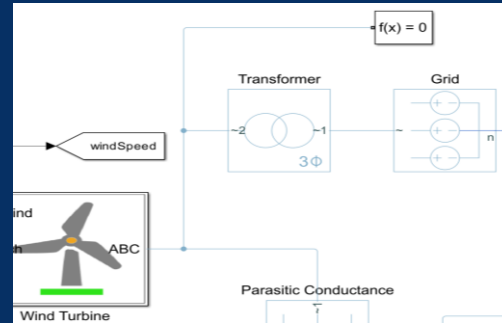
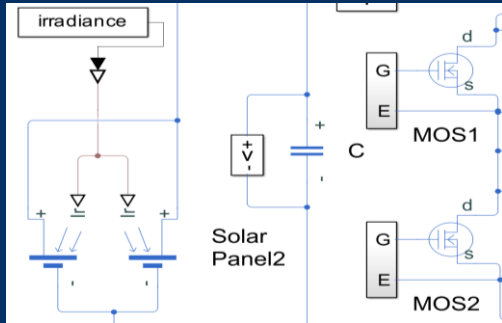
**Full Vehicle Models**



**Aerial Vehicles**

# Green Energy

# Tech Talk: Addressing Challenges of Meeting Net-Zero Goals with Simulation and Model-Based Design



Solar



Wind

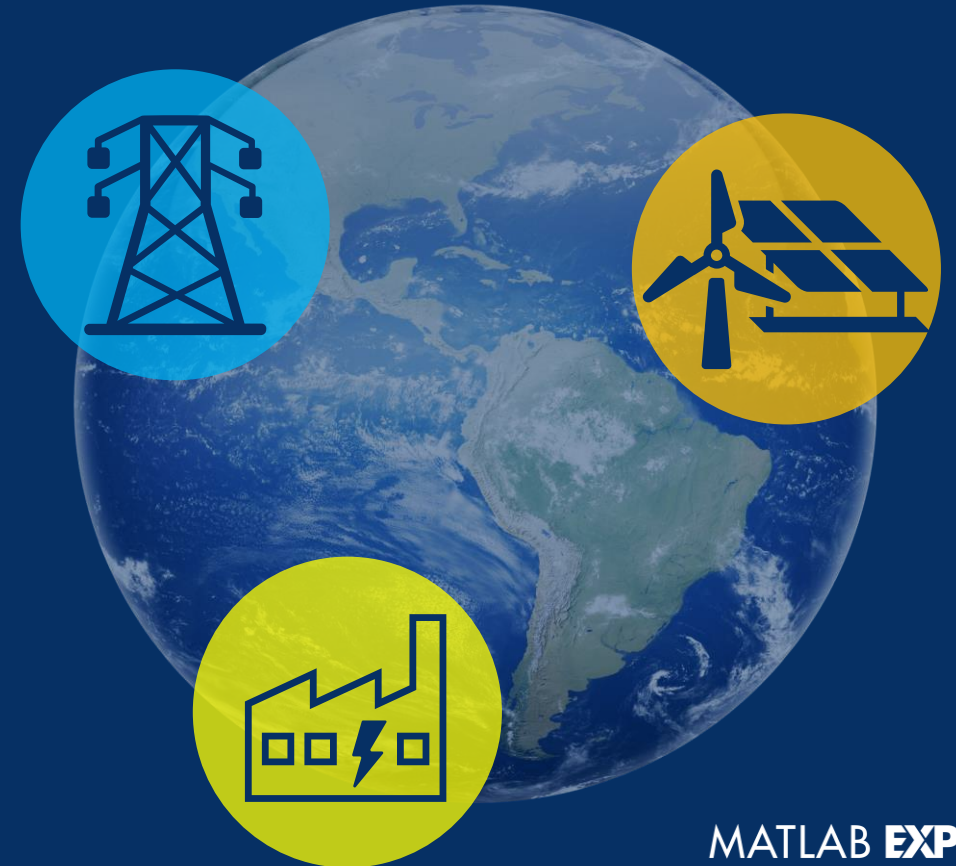


Hydroelectric



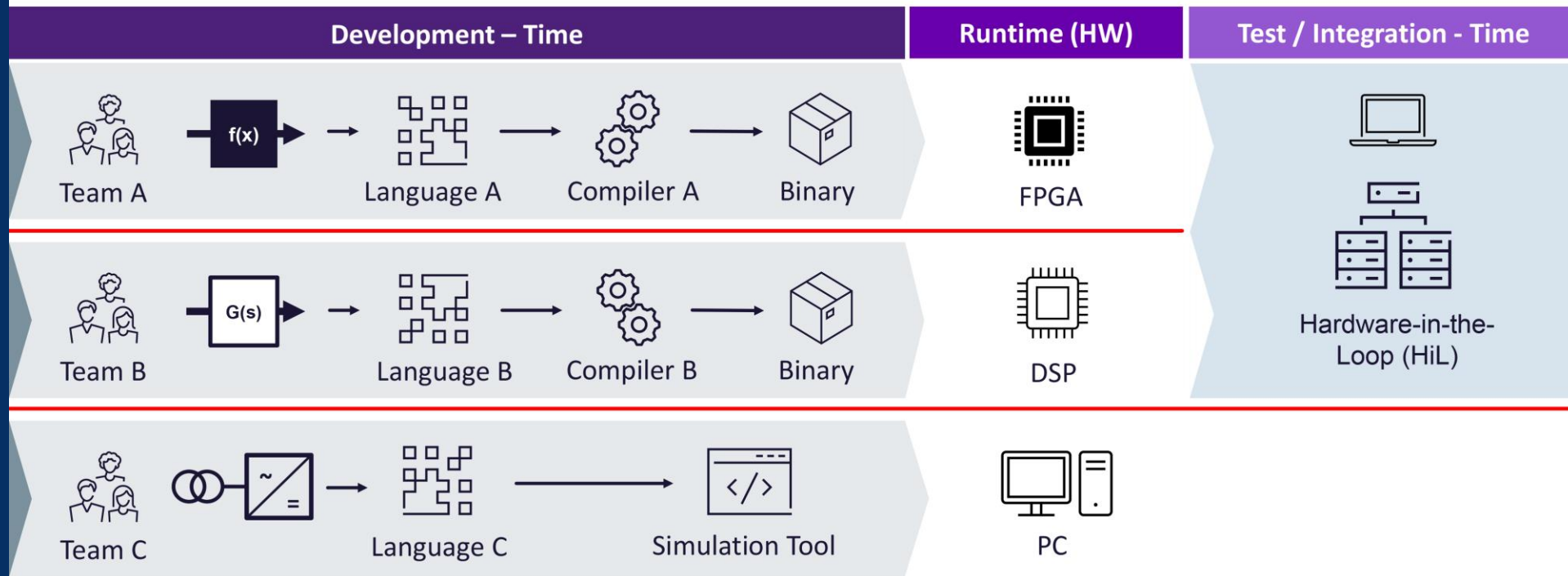
Green Hydrogen

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



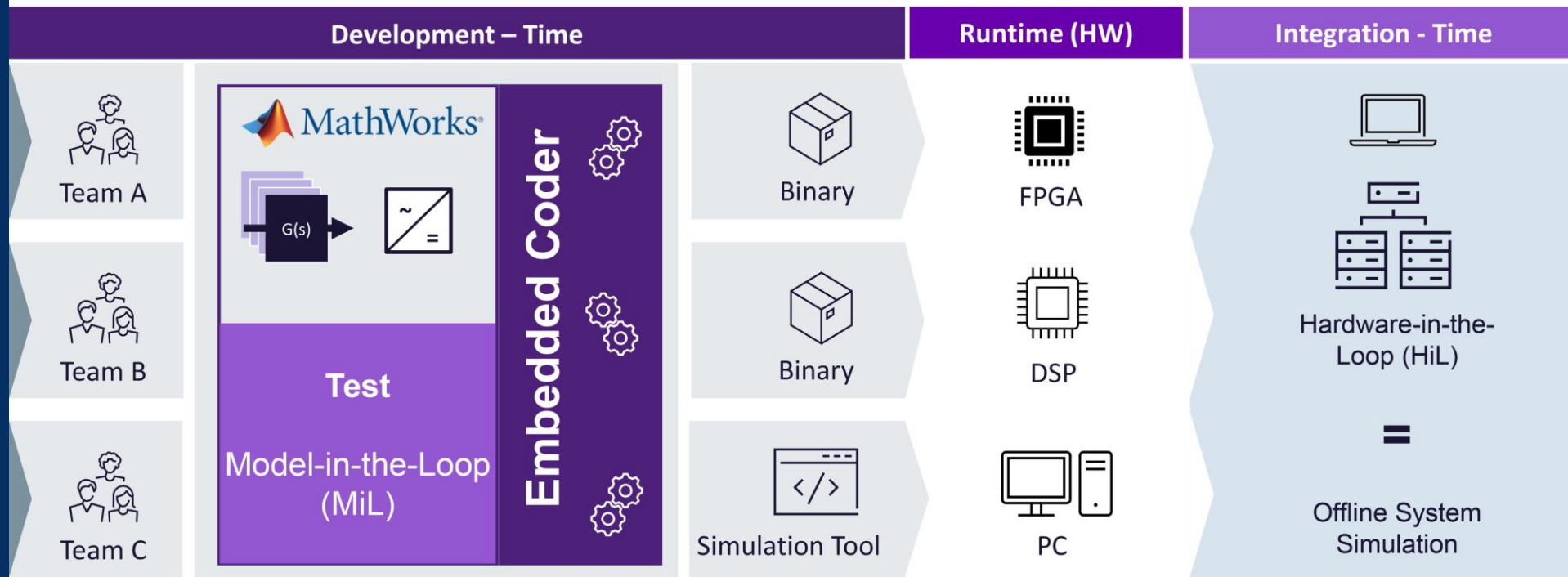
### Swimlane Engineering

When the organization shapes development

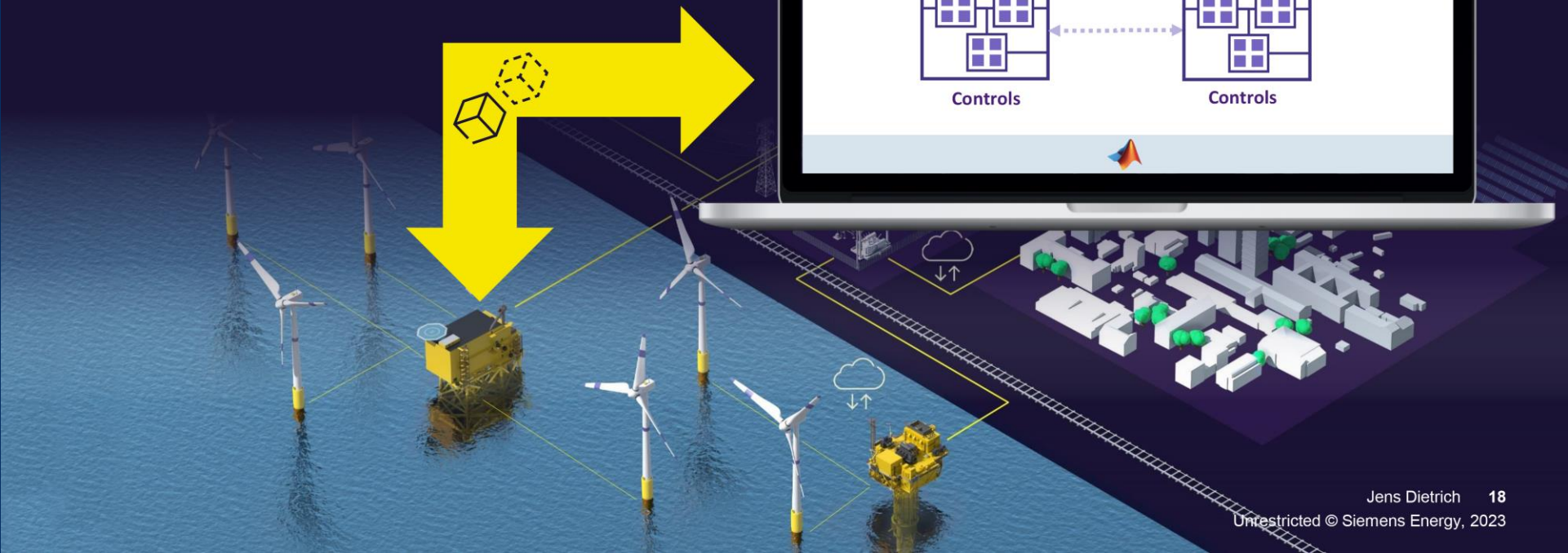
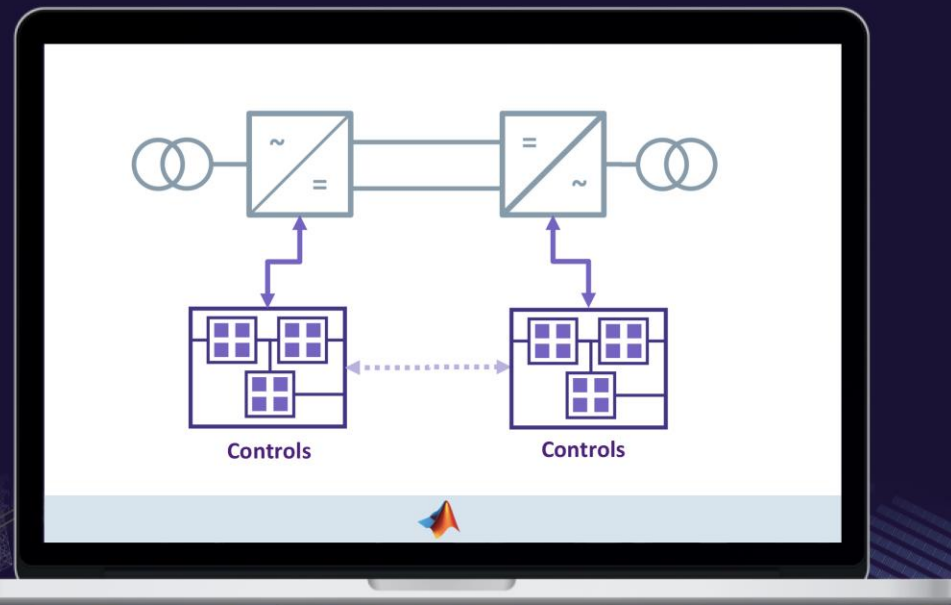


### Centralized Engineering Ecosystem

When development extends across the organization

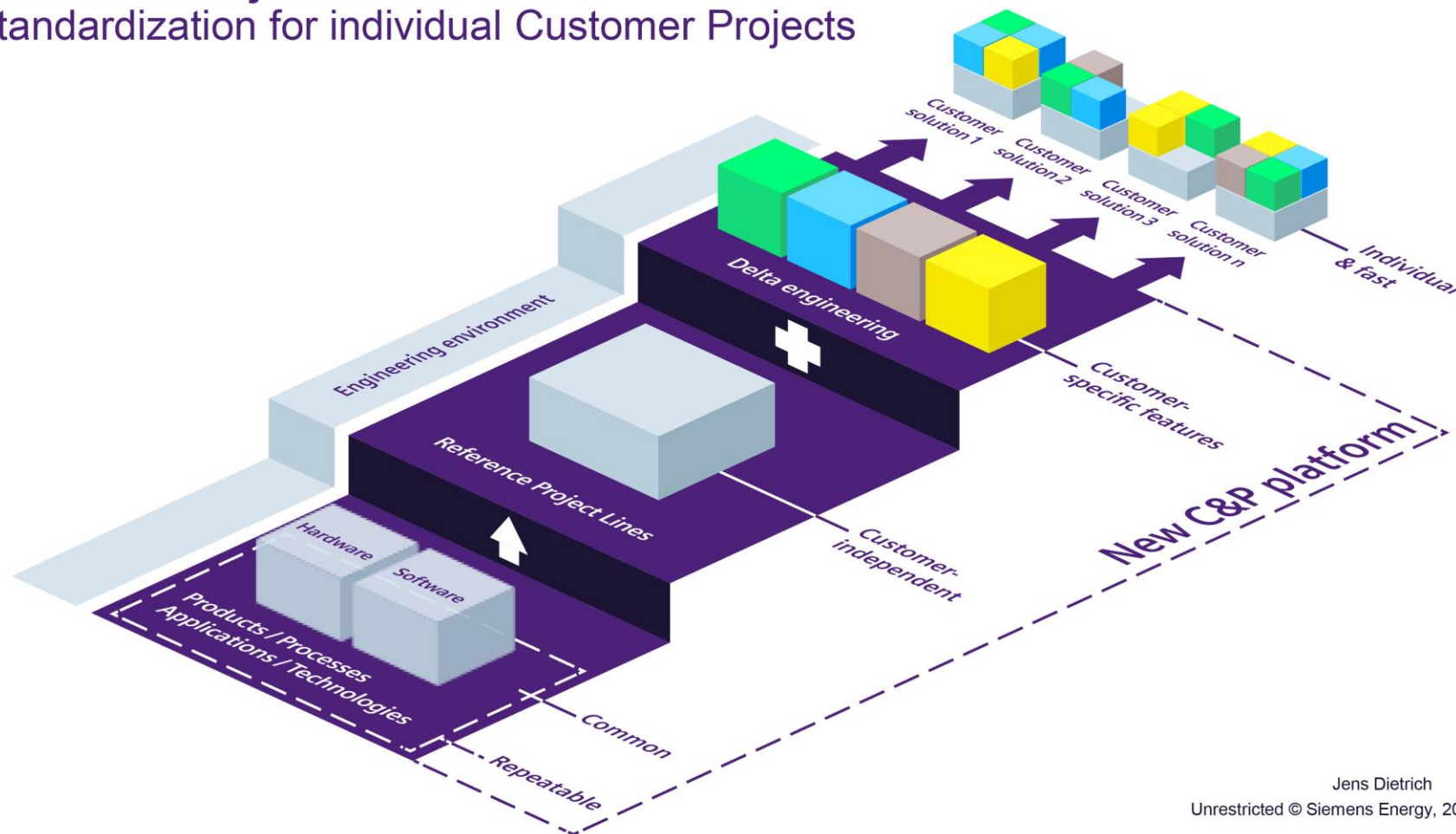


Putting everything together  
A Simulink based digital twin  
lets us analyze and test our  
system early on





### 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

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

## Workflow Trends

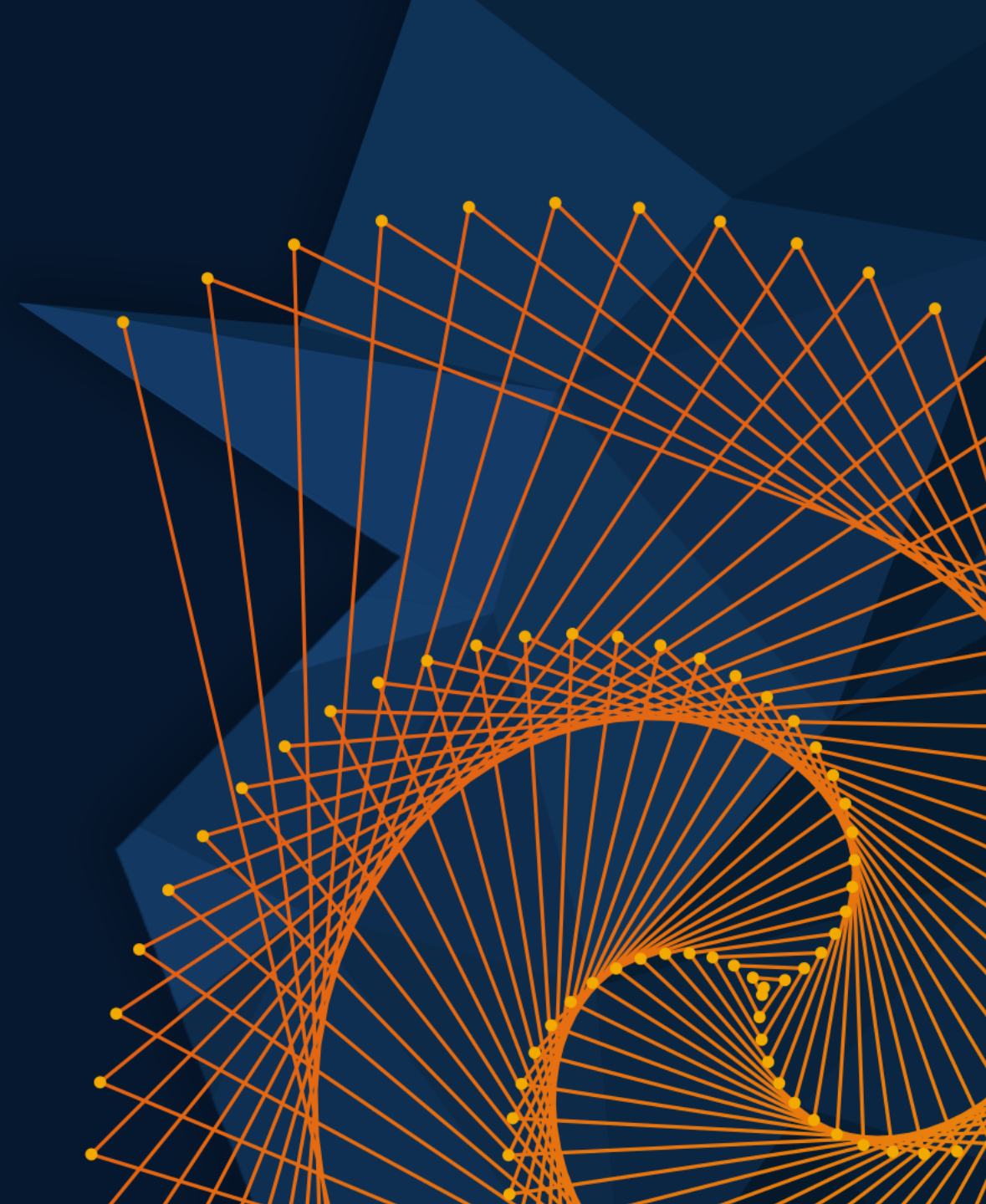
- ⑤ Apply standard software workflows
- ⑥ Design and simulate in the cloud
- ⑦ Design your system with AI

Systems Engineering  
& Design

Modern  
Software Practices

AI for  
System Development

# MATLAB EXPO



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