MATLAB EXPO

June 11, 2024 | Korea

Model-Based Design for Digital Engineering: Impact and Directions

Arun Mulpur

MathWorks

Digital Engineering:
A holistic approach to designing complex engineered systems

Use **models** instead of documents

Integrate **data** across models

Evolve design team **culture**

Model-Based Design for Digital Engineering

Application Trends

Autonomous

Connectivity

Electrification

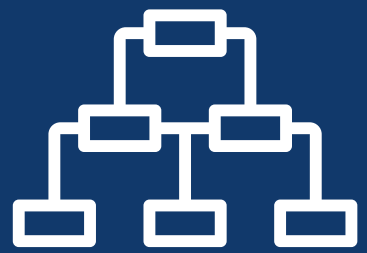
Application Trends

Autonomous

Connectivity

Electrification

Workflow Trends



Systems Engineering & Design

Modern Software Practices

AI for System Development

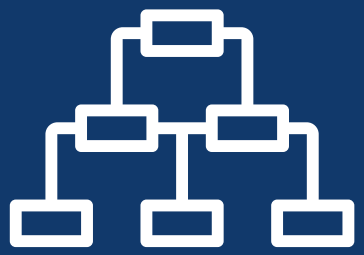
Application Trends

Autonomous

Connectivity

Electrification

Workflow Trends



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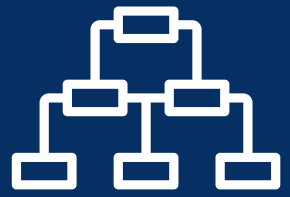
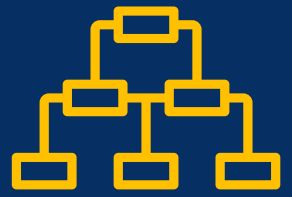


1. Automate everything
2. Scale to complex systems
3. Use automatic code generation
4. Prevent defects early

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

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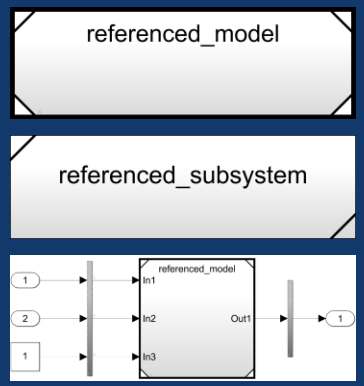
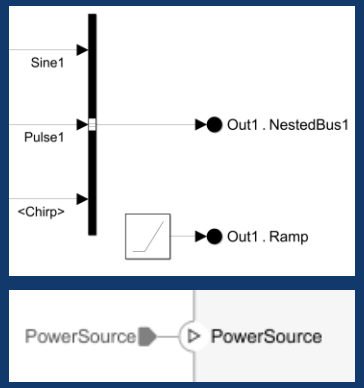
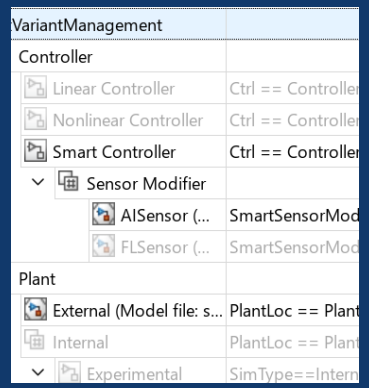
② Scale to complex systems



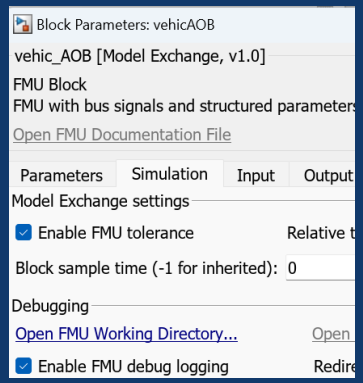
Components



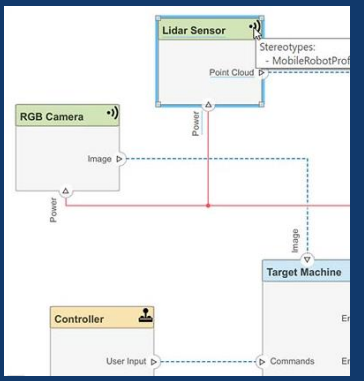
Buses, Ports, and Connectors



Variant Manager

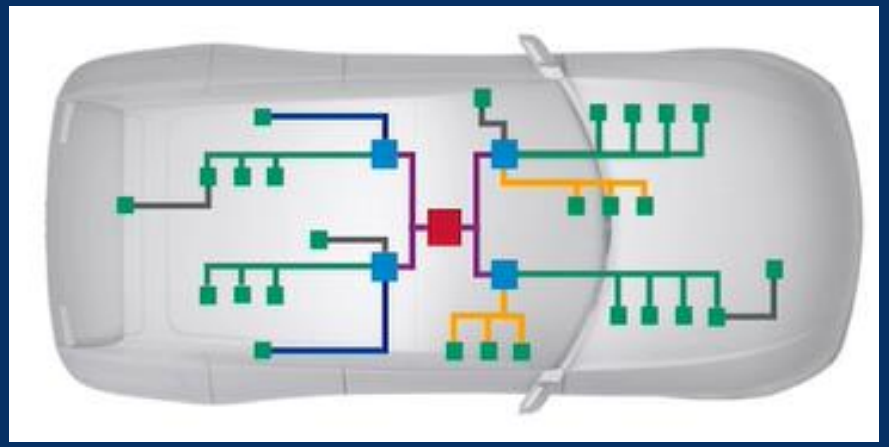


Third-Party Tool Integration

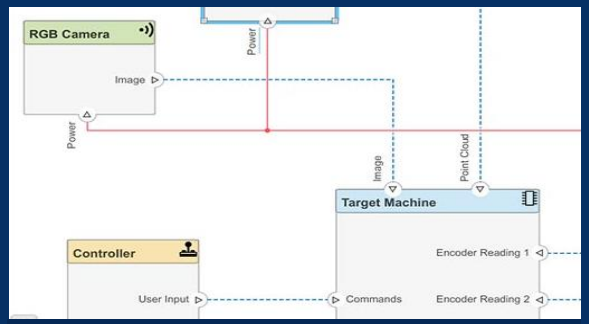


Architecture

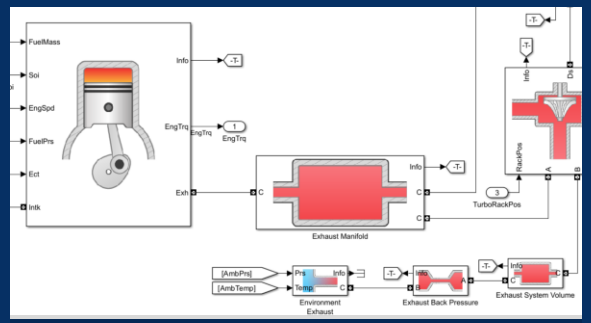
② Scale to complex systems



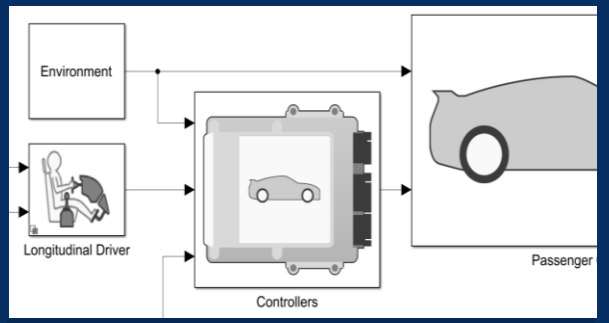
Service-Oriented Architecture



System Composer



Components

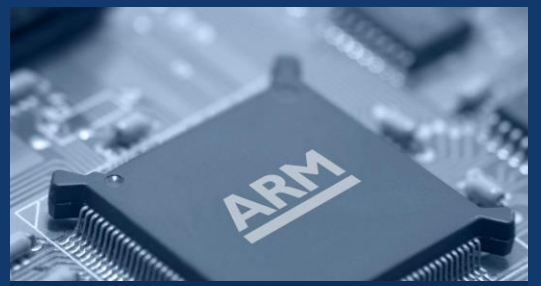


Full System

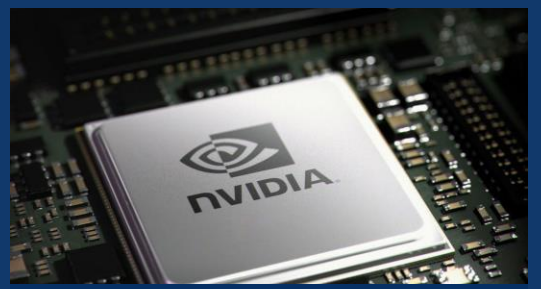
3 Use automatic code generation

3700

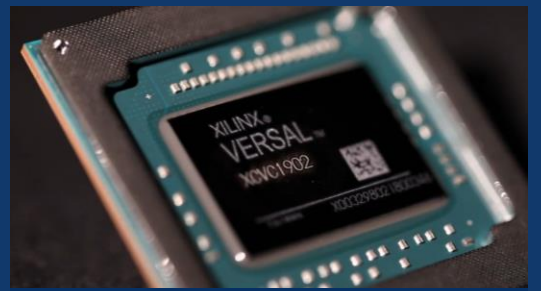
Organizations use automatic code generation



CPU

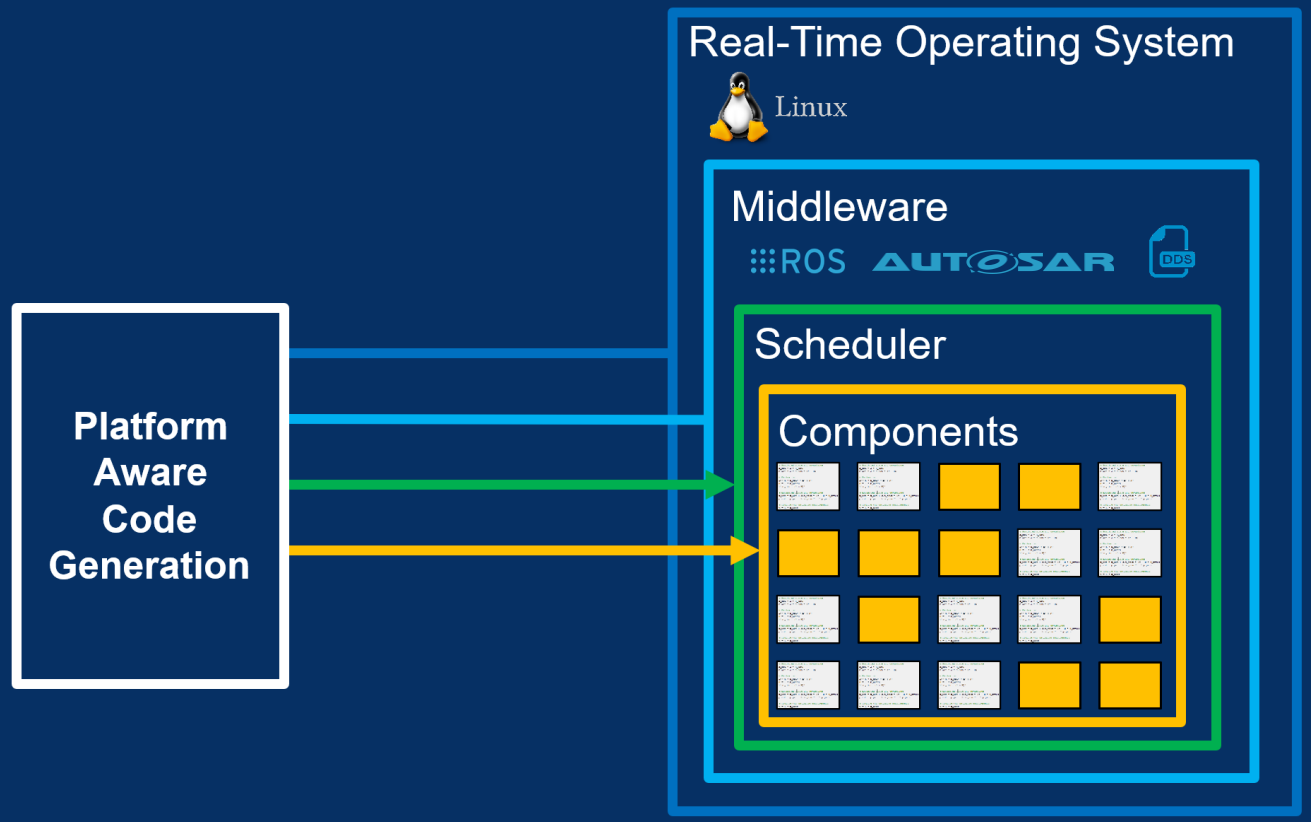


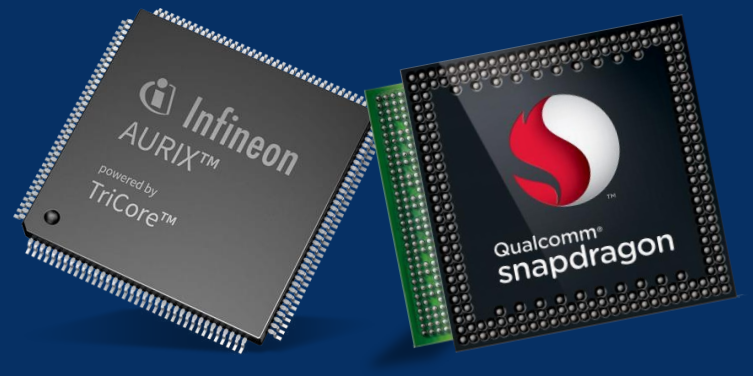
GPU



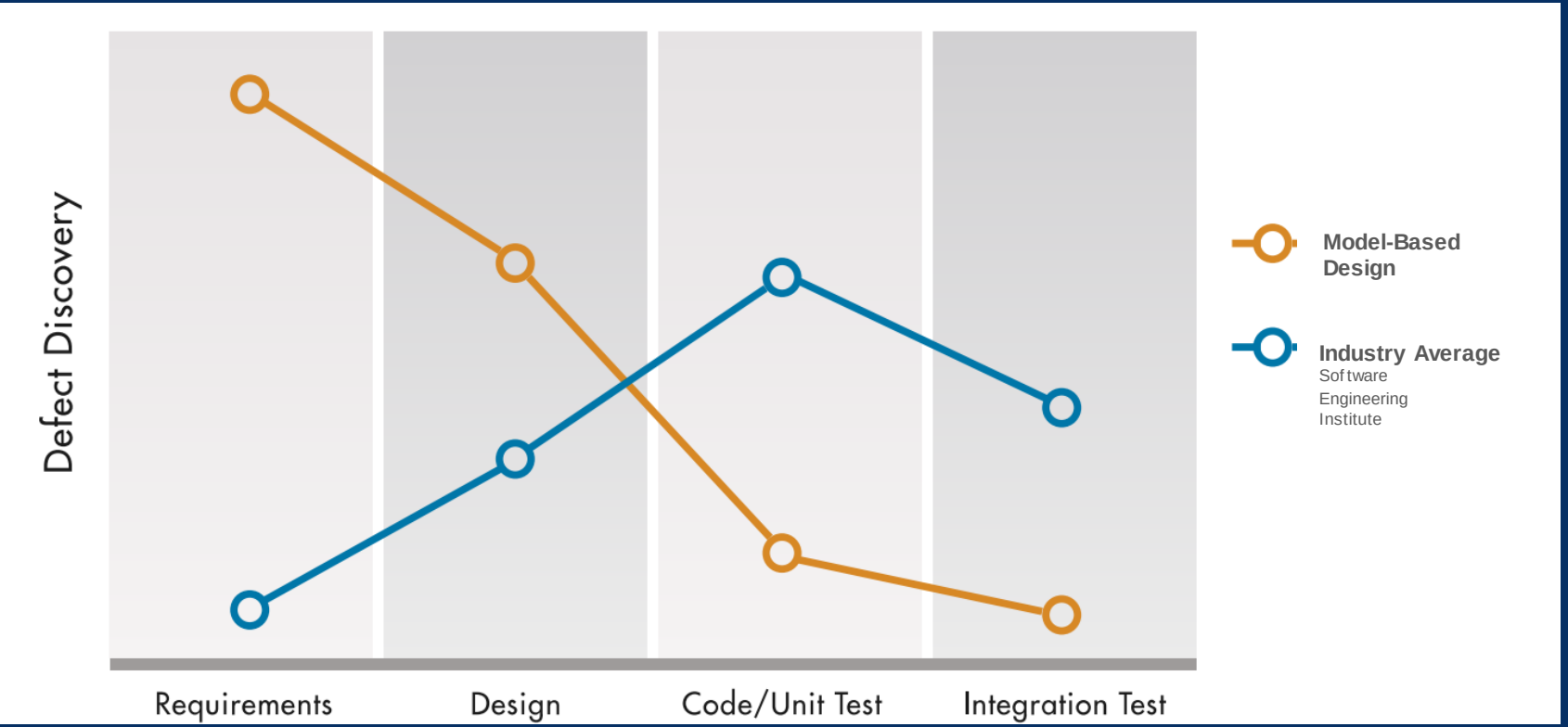
FPGA, ASIC, PLC

3 Use automatic code generation





4 Prevent defects early



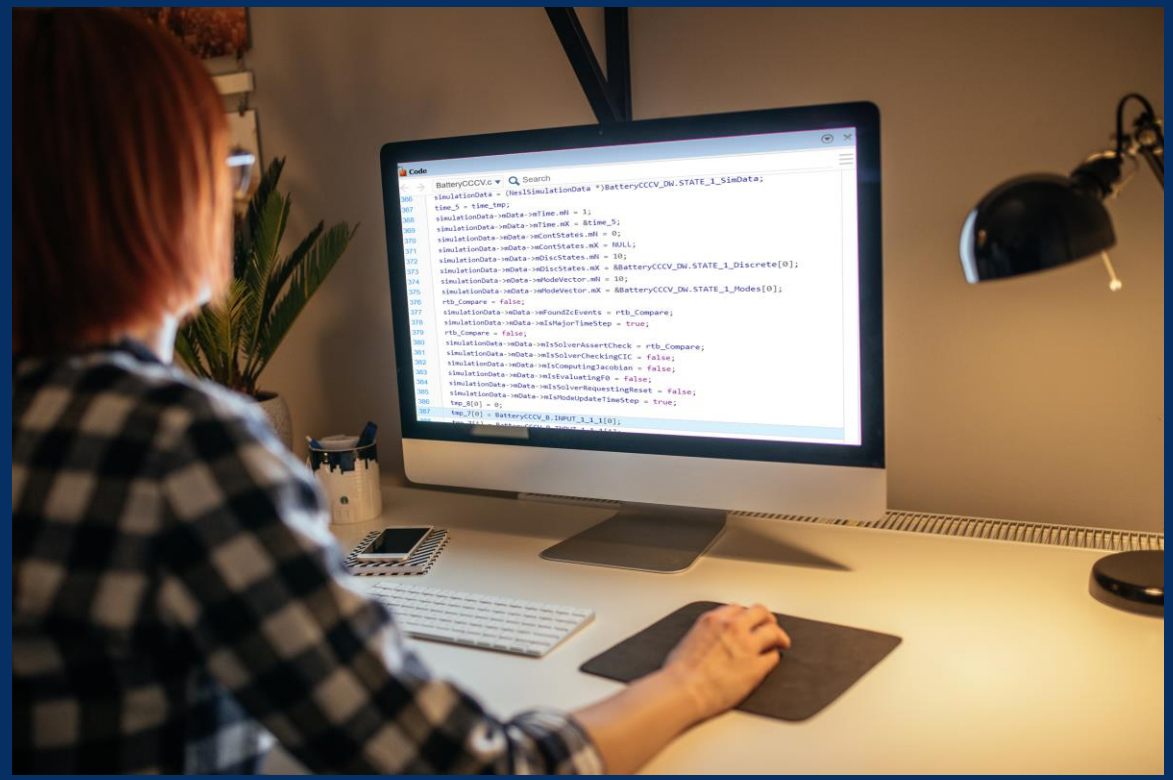
4 Prevent defects early

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	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



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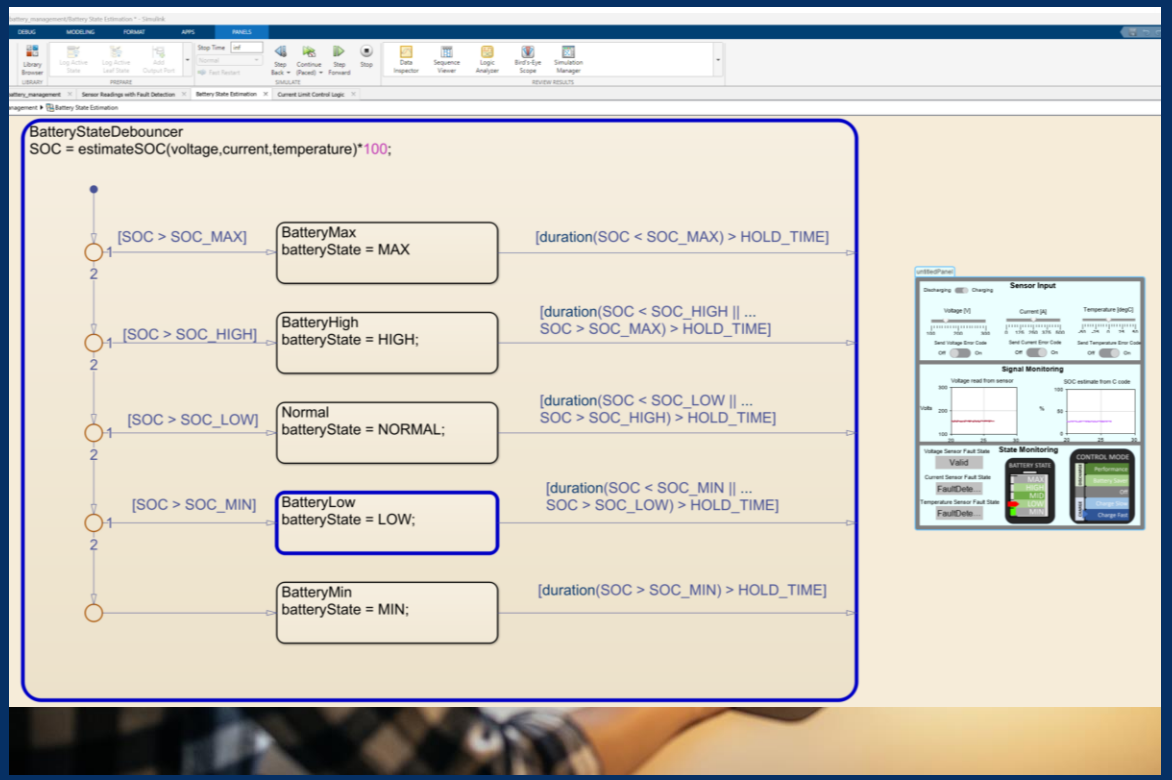

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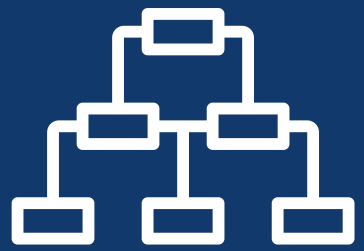

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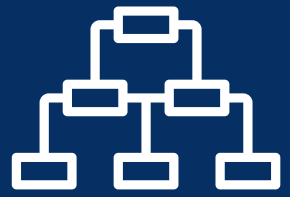

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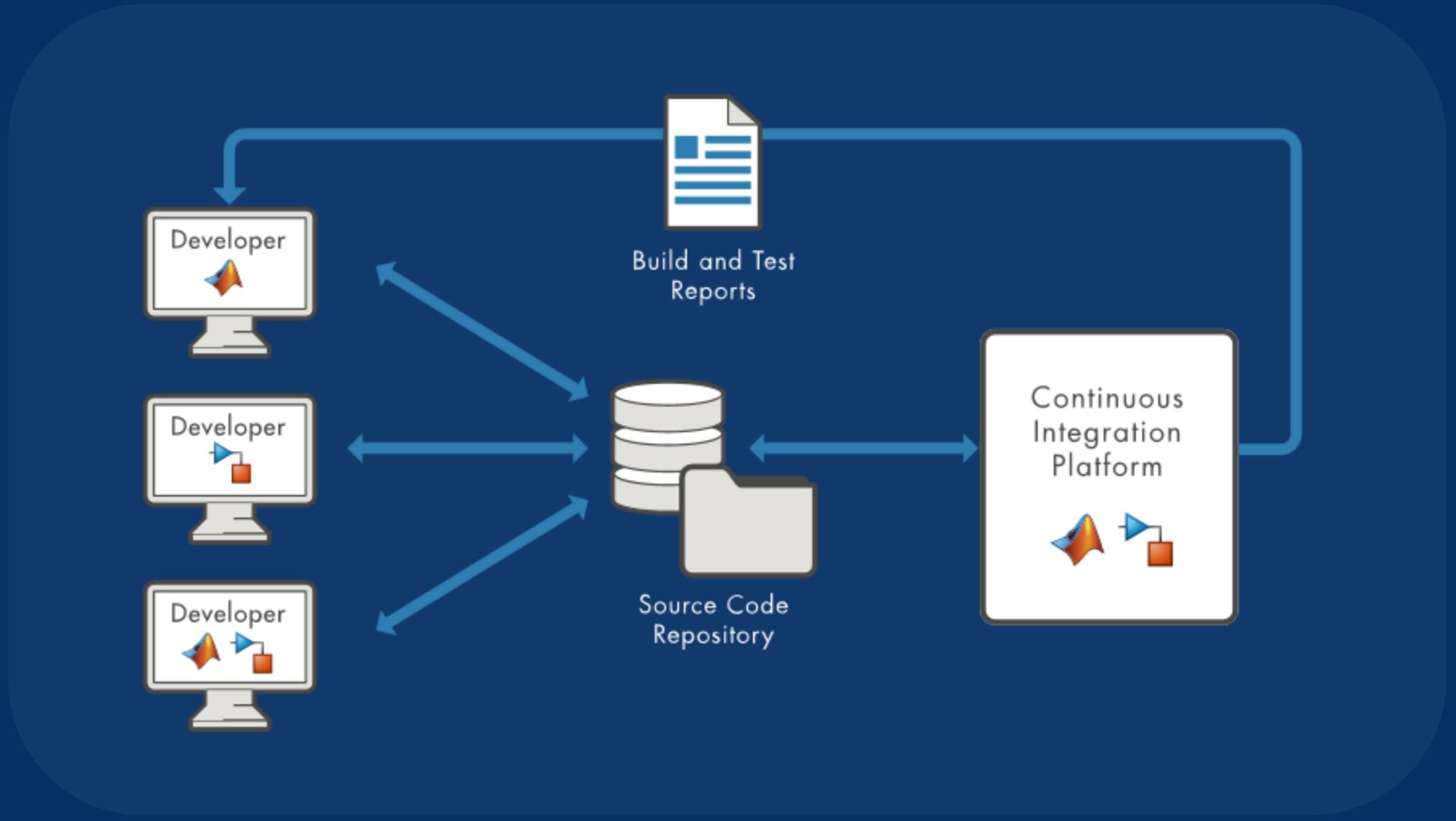
5 Apply standard software workflows

"Software is the language of automation."

- Jensen Huang, co-founder and CEO of NVIDIA

5 Apply standard software workflows



Model Based Design 확대

SW 개발 시간 단축

✓ 시뮬레이션 가능한 모델 활용

Seamless SW 개발 환경

✓ SW 개발 난이도 감소 및 품질 향상

모델 기반 Variant 관리

✓ 모델 기반으로 다양한 사양 대응

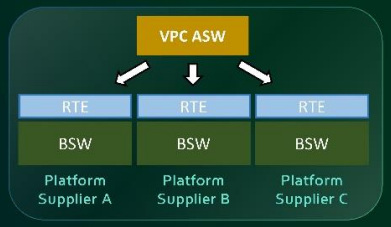
+

✓ 기능안전/A-SPICE 강화

ISO 26262

AUTOMOTIVE SPICE®

✓ AUTOSAR 확대

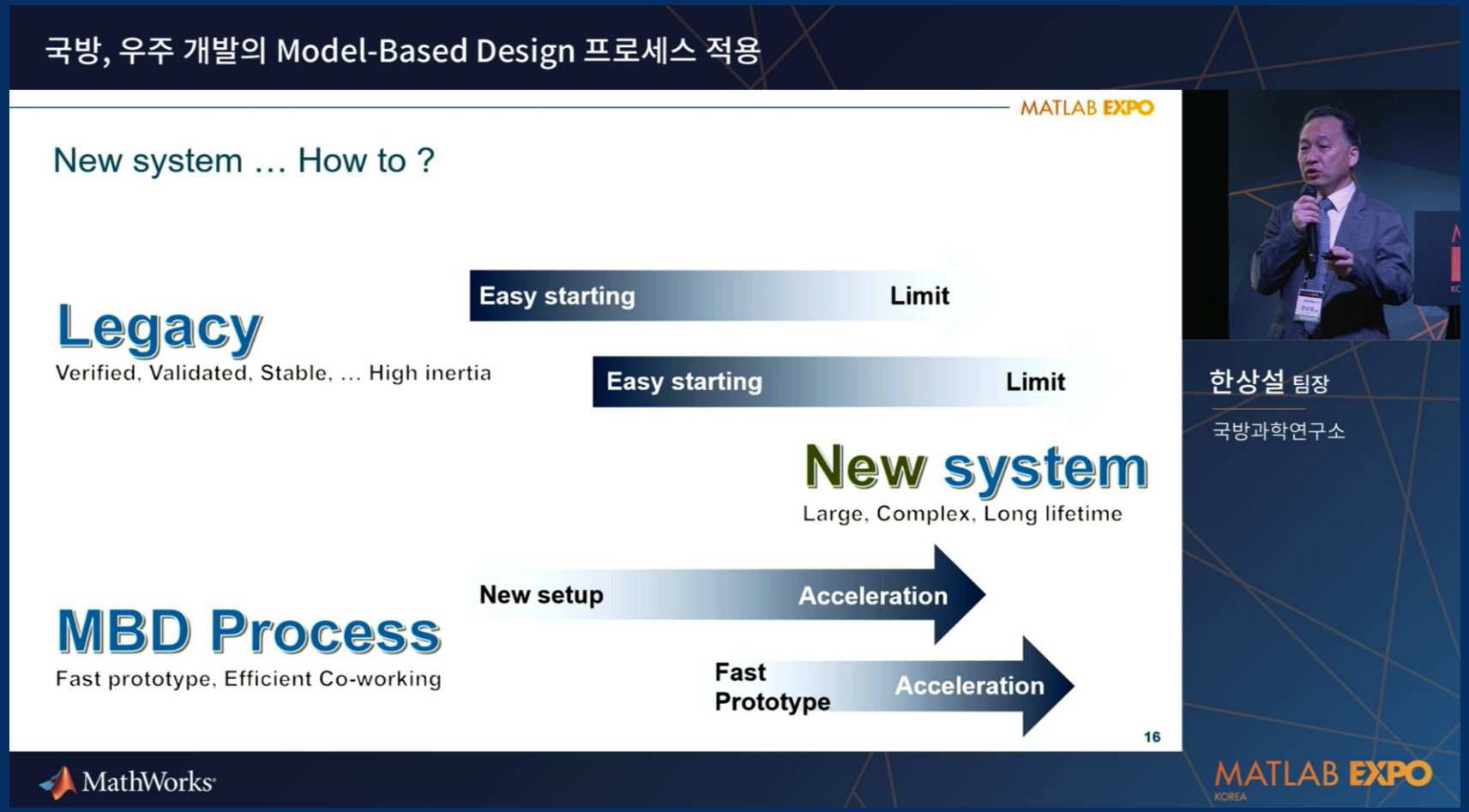


✓ 가상화 & 자동화 검증 확대

✓ DevOps 도입

HYUNDAI MOTOR GROUP

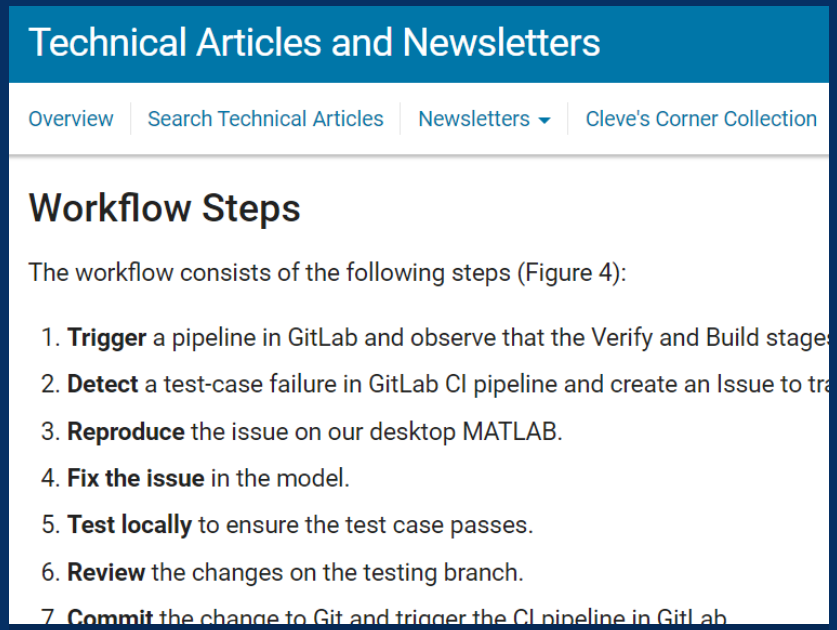
- Vehicle Platform Control (VPC) – 1st domain-based controller
- Utilized MBD to develop two SoCs
- Common MBD development platform with Tier 1s



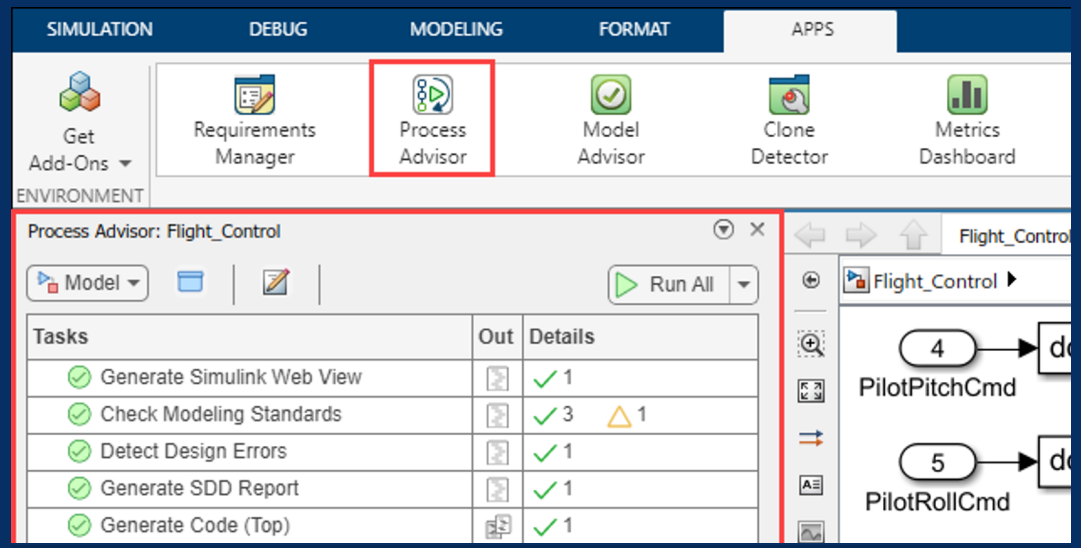
국 방 과 학 연 구 소
Agency for Defense Development

- ADA's process shift from Legacy Workflows to MBD leads to accelerated development and improved reliability
- MBD impact seen in technology-intensive Korea space sector

5 Apply standard software workflows



Step-by-Step Tutorials



Process Advisor

Continental

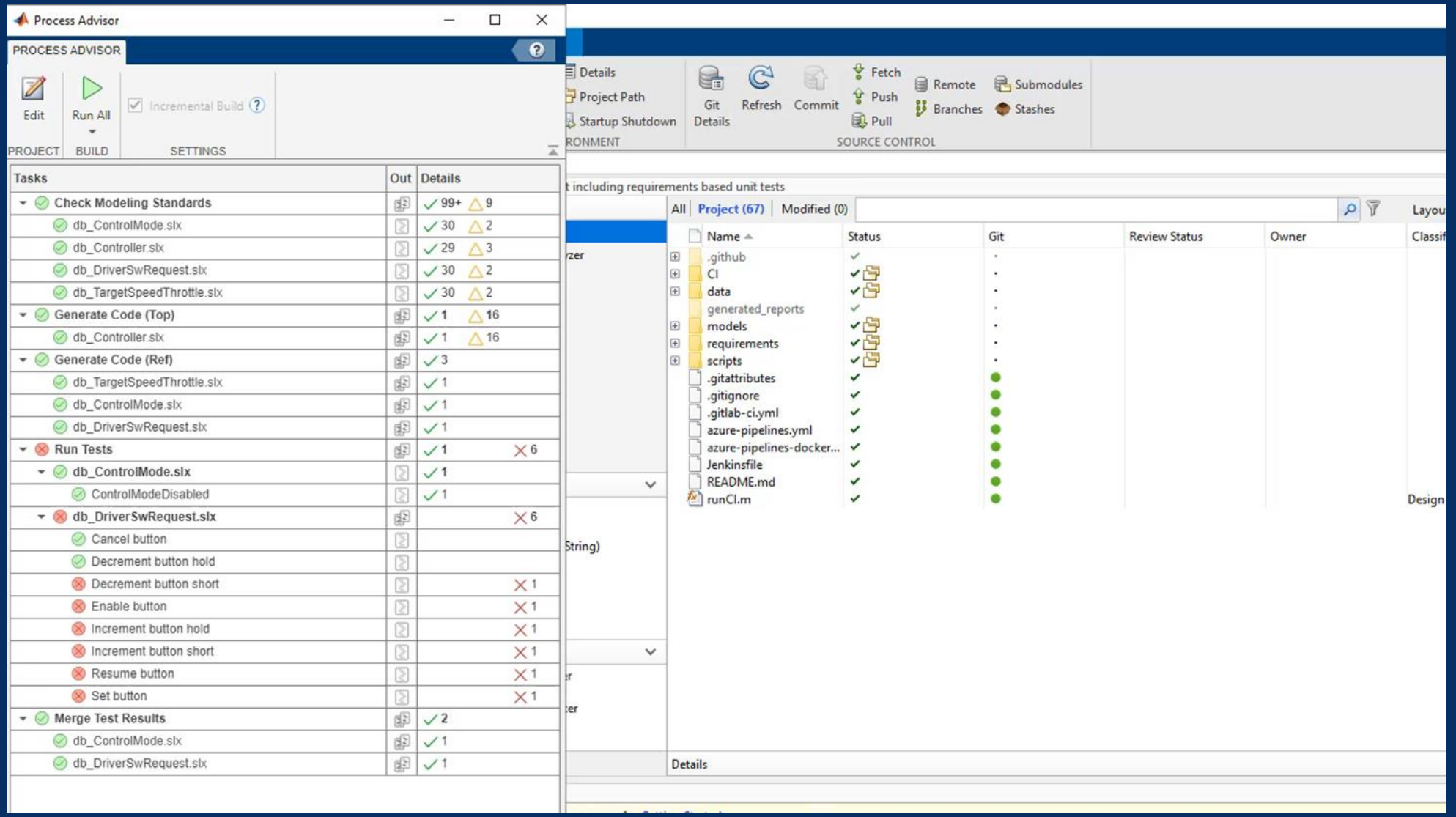
From Scripted Pipelines to Process Advisor

From Scripted Pipelines to Process Advisor

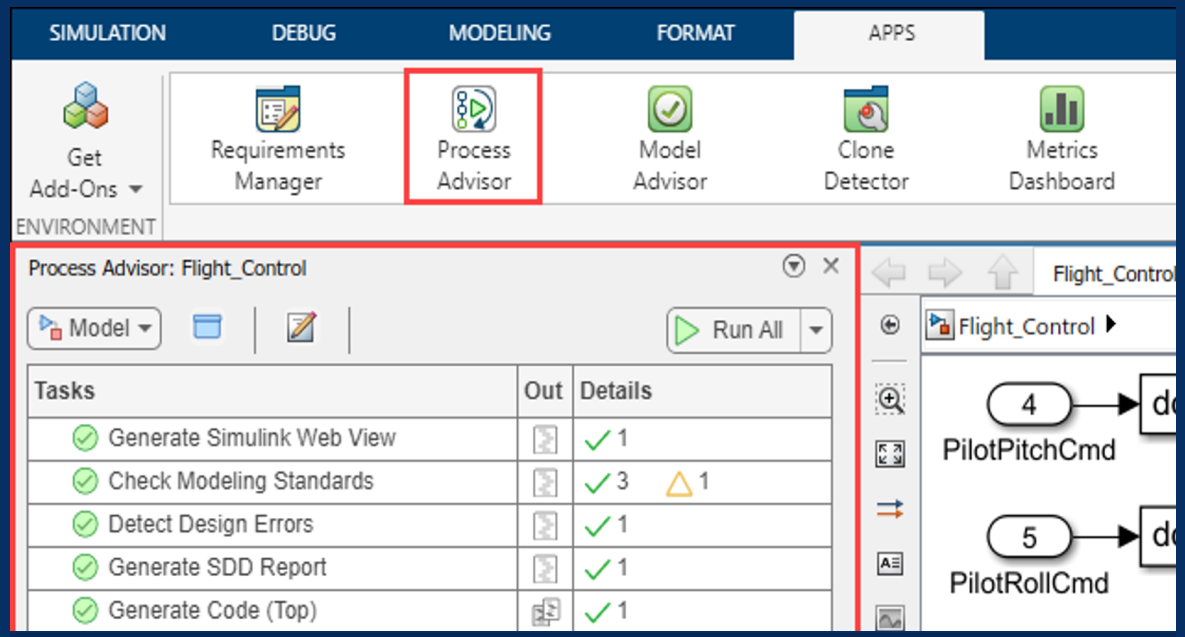
"Bring everything into MATLAB."

- Martin Römpert, Continental Automotive Technologies GmbH

From Scripted Pipelines to Process Advisor



From Scripted Pipelines to Process Advisor



Process Advisor

- Utilize the digital thread to run only what you need
- Identify stale tests
- Interact with the model

2X

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

Example: Integrating four widely used toolchains

MathWorks®

aws FOR AUTOMOTIVE

Elektrobit

SYNOPSYS®

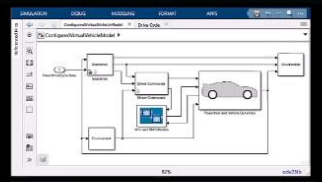
6 Design and simulate in the cloud

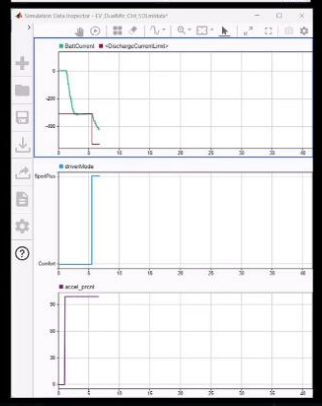
Automotive Software Development in the Cloud

powered by aws FOR AUTOMOTIVE

MathWorks

Virtual Vehicle Simulation in MATLAB & Simulink





Application Code from Model

Elektrobit

Road-ready Automotive Software

Infotainment (Android Automotive OS)

Vehicle Control Unit (Adaptive AUTOSAR)

```
[205.18] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[206.18] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[207.19] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[208.20] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[209.20] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[210.21] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[211.21] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[212.22] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[213.23] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[214.23] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[215.24] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[216.24] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[217.25] Adaptive AUTOSAR HPC - received discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[vivi-adg]0:bash  1:adg  2:app  3:ita-  4:log*                                                    "ip-10-230-62-5" 19:31 18-Dec-23
```

Battery Management System (Classic AUTOSAR)

```
[281.02] Classic AUTOSAR ECU - sending discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[281.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[282.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[283.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
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[291.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[292.62] Classic AUTOSAR ECU - sending discharge current limit: -310.00     charge current limit: 102.30     charge: 0.75
[vivi-clas0:bash- 1:log*                                                                             "ip-10-230-62-5" 19:30 18-Dec-23
```
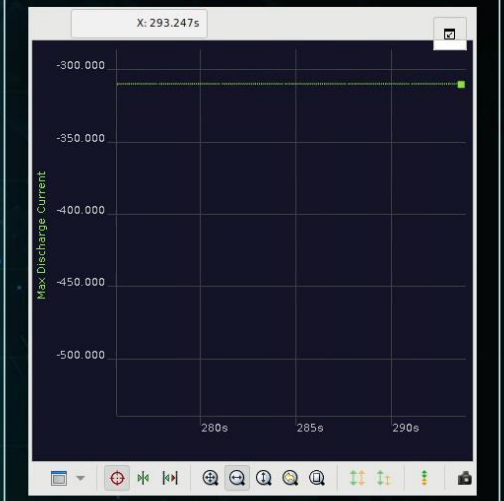

SYNOPSYS

Virtual ECUs in Synopsys Silver



ECU Simulation

MATLAB EXPO

Application Trends

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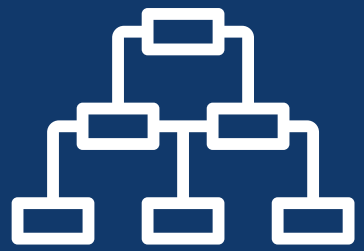

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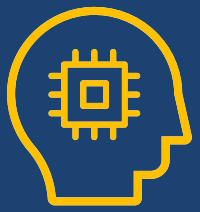
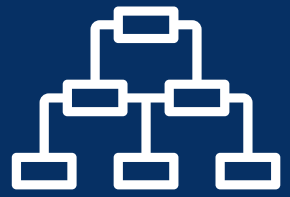


AI for System Development

Workflow Trends



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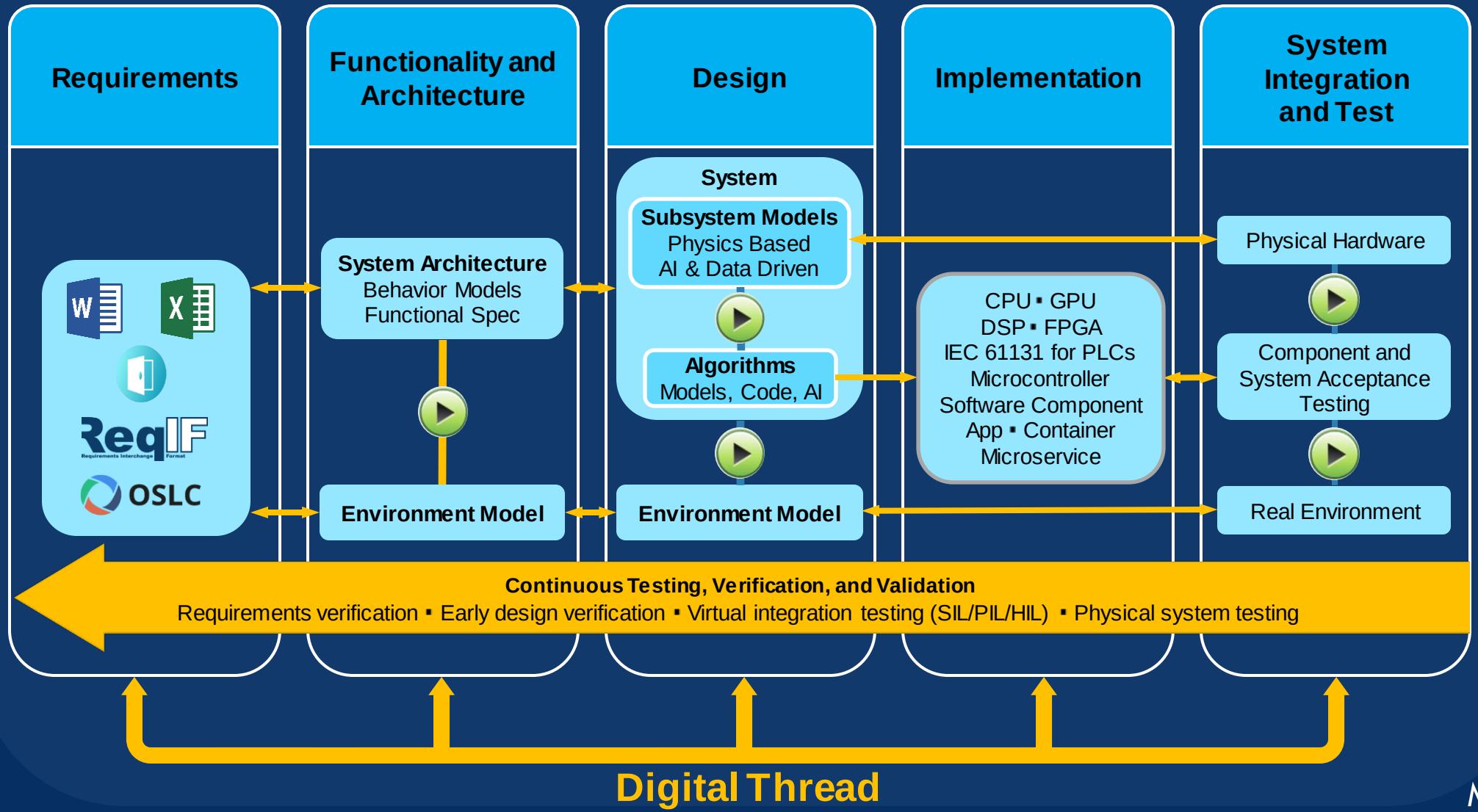
7 Design your system with AI

Integrating AI into Model-Based Design



7 Design your system with AI

AI

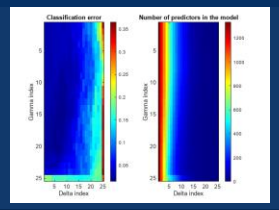
Find out more:

AI Playground in the Demo Showcase

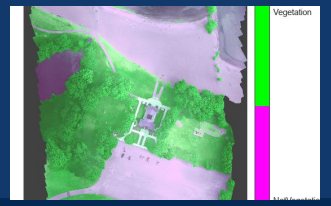
See the latest advances in AI and MATLAB.

⑦ Design your system with AI

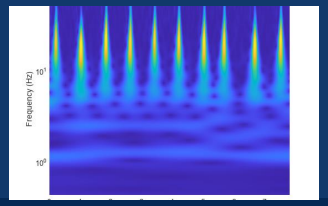
AI Reference Examples



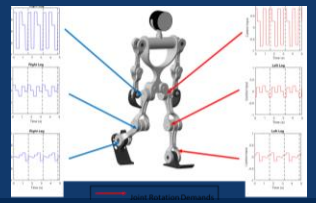
Predictive Maintenance



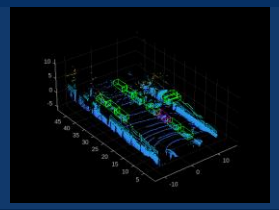
Hyperspectral Imaging



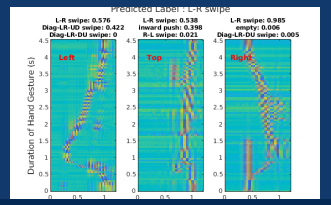
Signal Processing



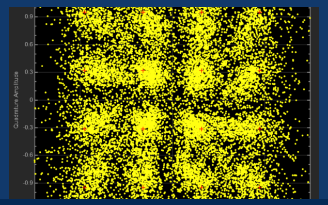
Robotic Control



Lidar Processing

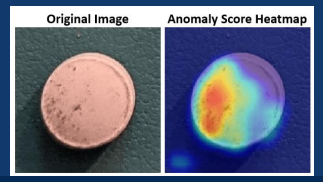


Radar Processing

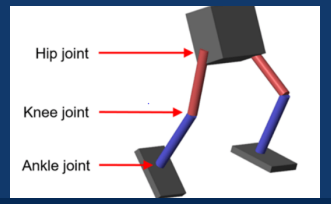


Wireless Communications

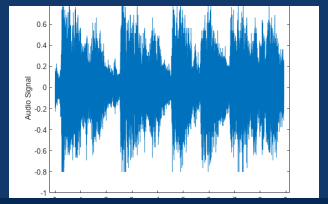
Automated Driving



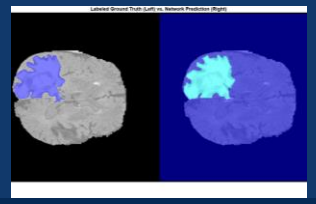
Visual Inspection



Reinforcement Learning



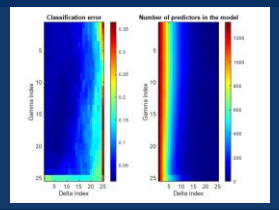
Audio

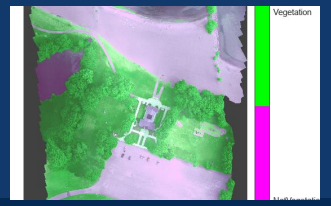


Medical Imaging

⑦ Design your system with AI

AI Reference Examples


Predictive Maintenance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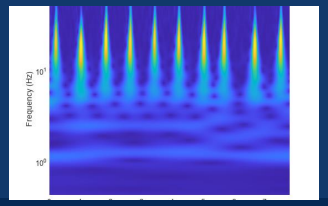
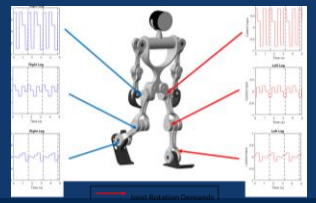
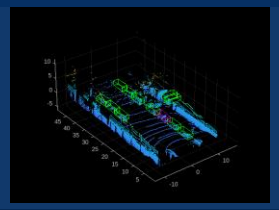
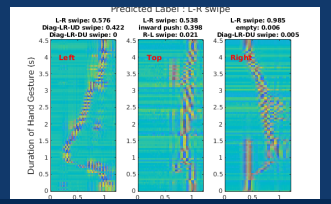
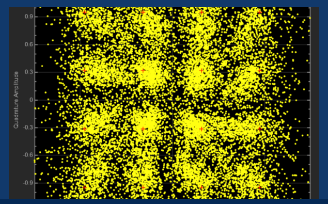

Signal Processing


Robotic Control

CPU

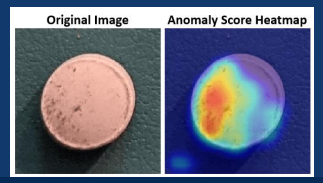

Lidar Processing


Radar Processing

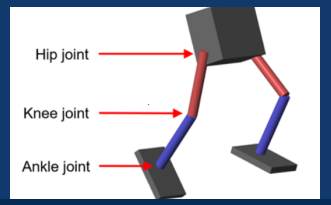

Wireless Communications


Automated Driving

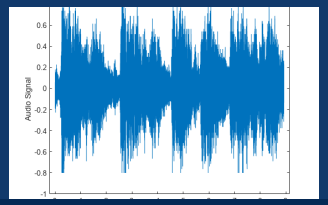
GPU



Visual Inspection



Reinforcement Learning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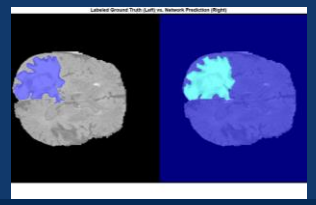

Medical Imaging

FPGA, ASIC, PLC

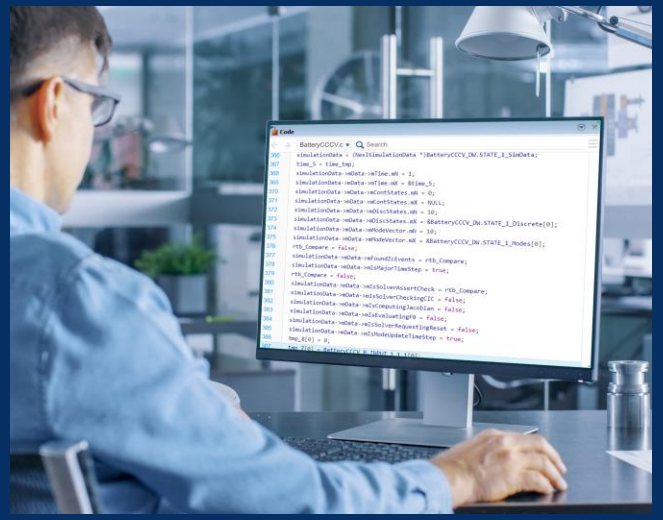
Mercedes-Benz

Simulates Hardware Sensors with Deep Neural Networks

Mercedes-Benz

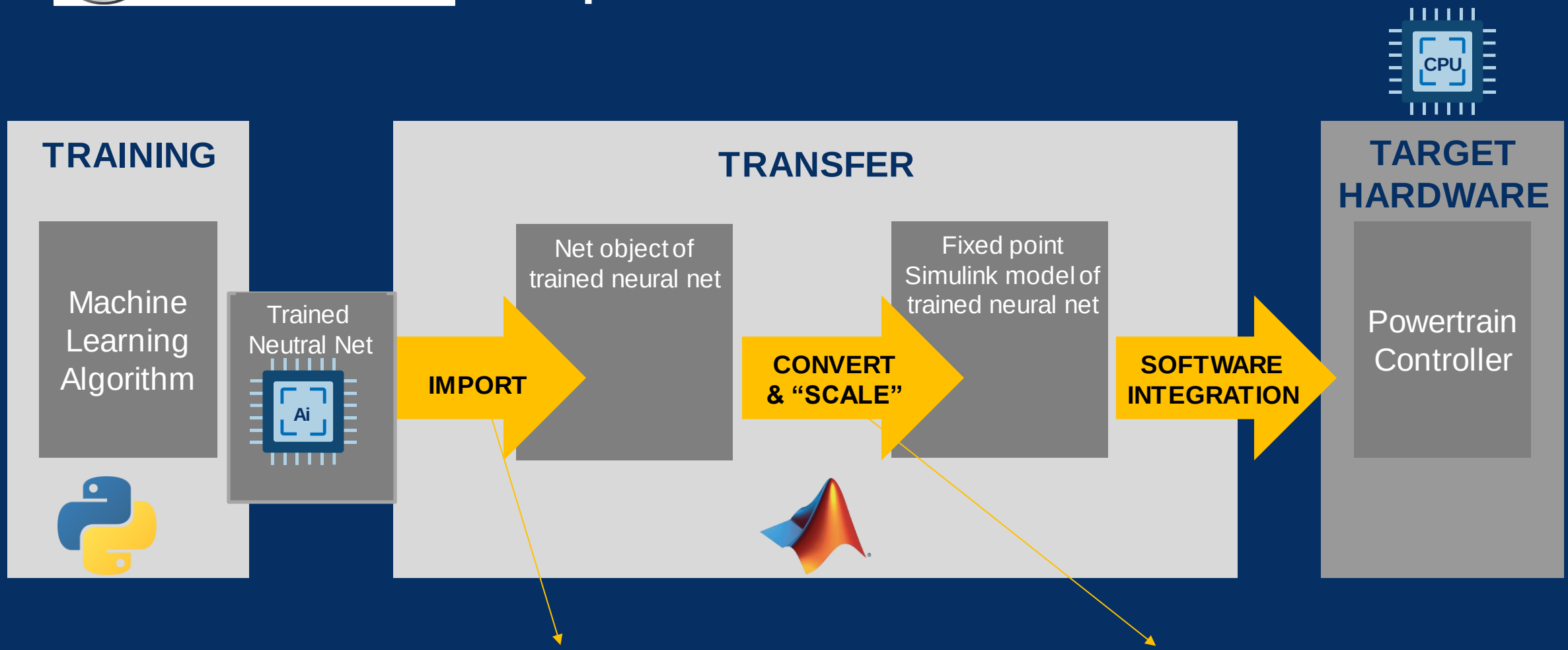
Simulates Hardware Sensors with Deep Neural Networks

QKeras



Mercedes-Benz

Simulates Hardware Sensors with Deep Neural Networks



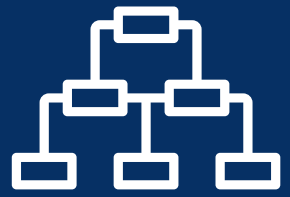
Simulates Hardware Sensors with Deep Neural Networks

*"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

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

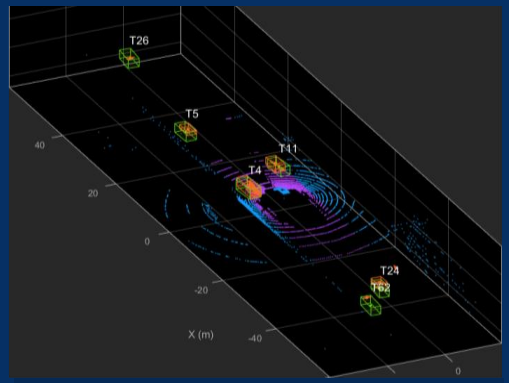
Systems Engineering & Design

Modern Software Practices

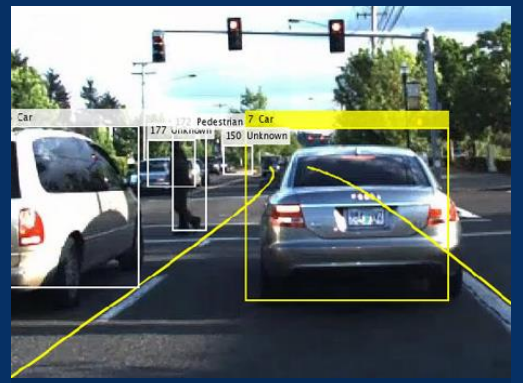
AI for System Development

Deliver autonomous systems

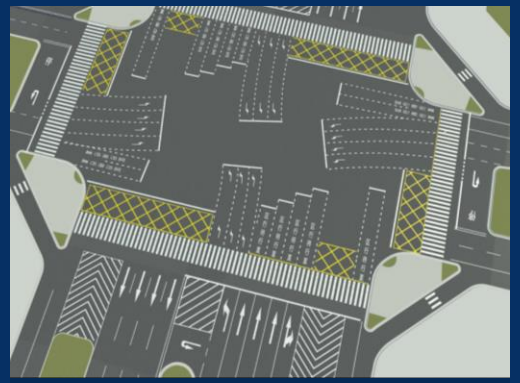
Braking and Steering



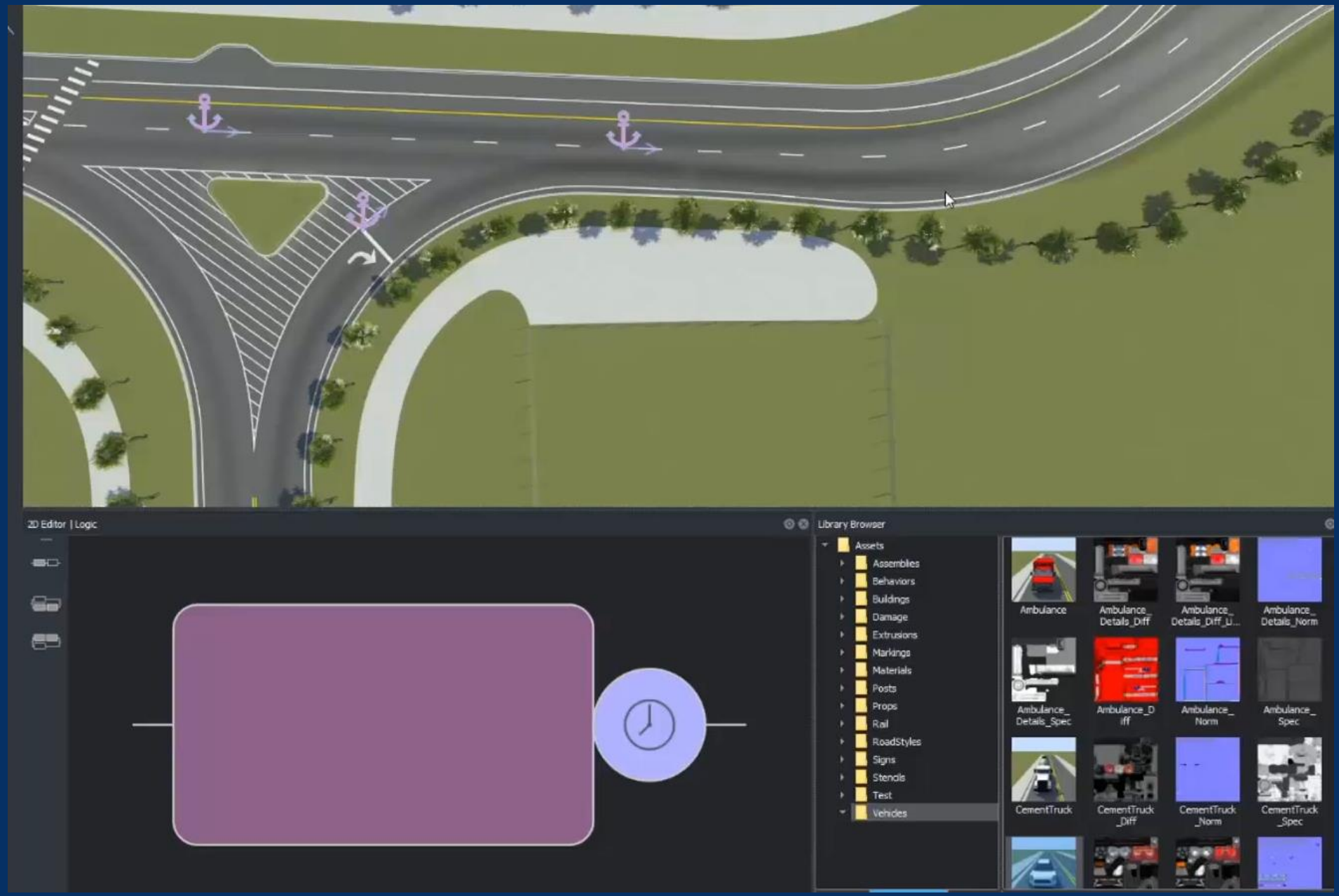
Sensor Fusion and Tracking

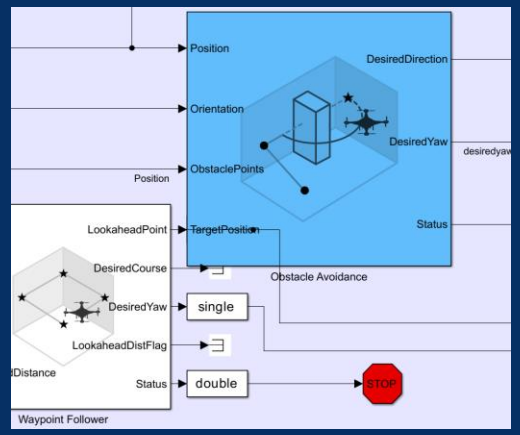


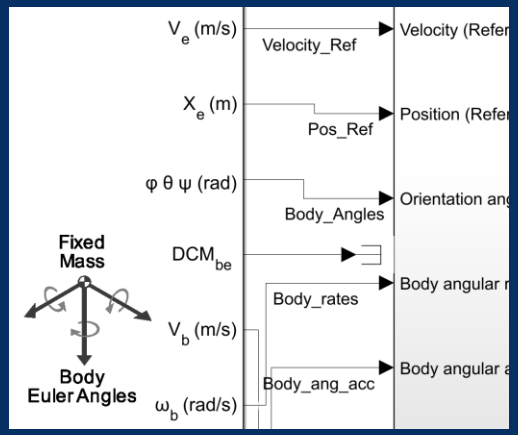
Computer Vision Radar, Lidar

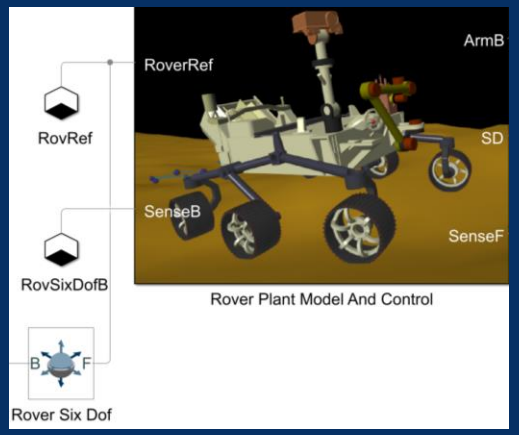


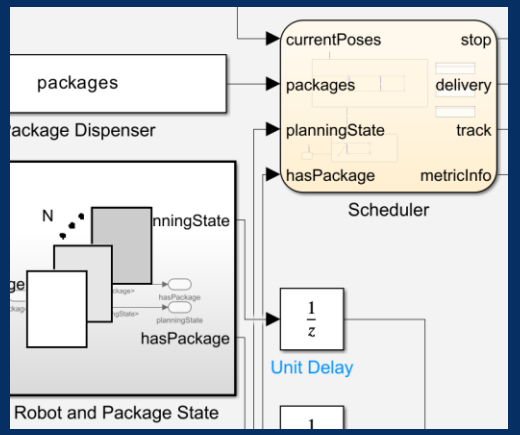
Road Network Design


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

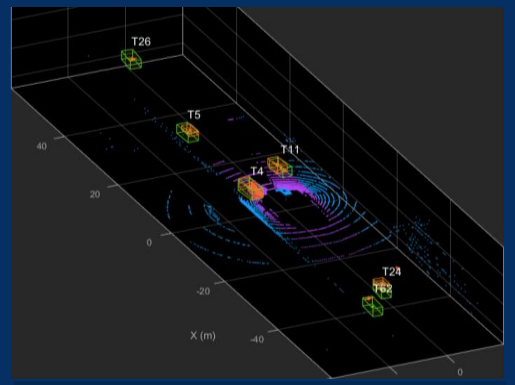








Unmanned Aerial Vehicle



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

Connectivity

Electrification

Workflow Trends

Systems Engineering & Design

Modern Software Practices

AI for System Development

5G Standard

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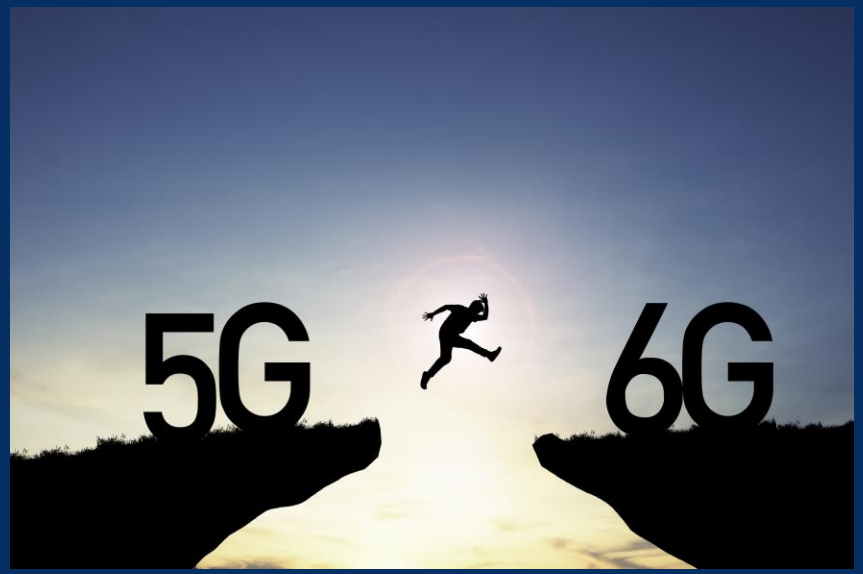
neering,

6G Technology Implications



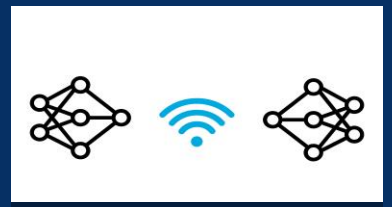
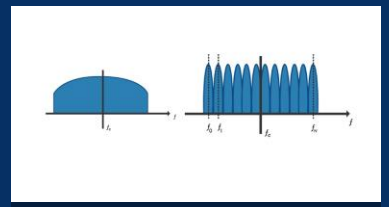
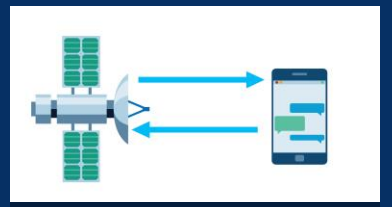
RCRWireless News
INTELLIGENCE ON ALL THINGS WIRELESS

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	

6G Exploration Library (R2024a)

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

Connectivity

Electrification

Workflow Trends

Systems Engineering & Design

Modern Software Practices

AI for System Development

Application Trends

Autonomous

Connectivity

Electrification

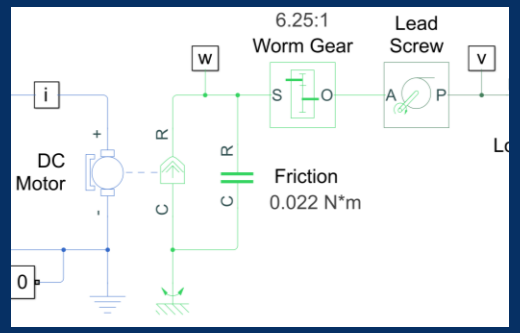
Workflow Trends

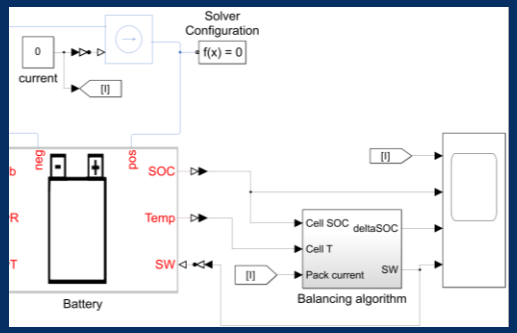
Systems Engineering & Design

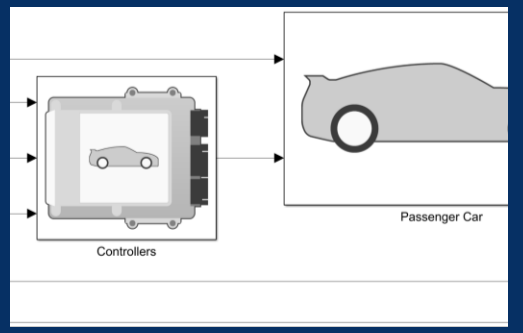
Modern Software Practices

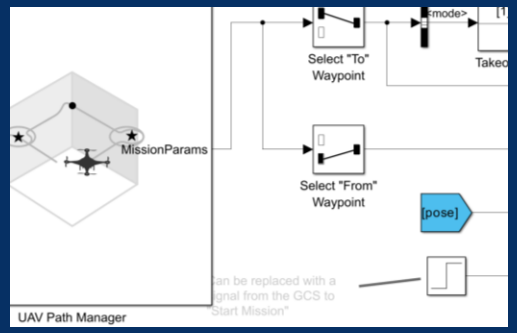
AI for System Development

Electric Vehicles









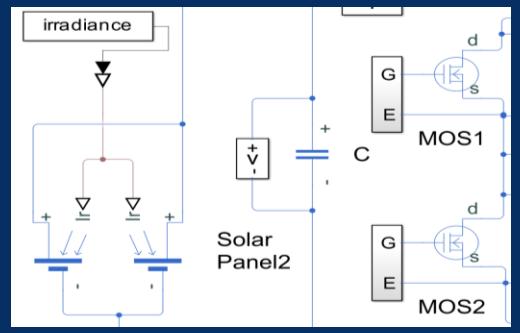
Electric Motors

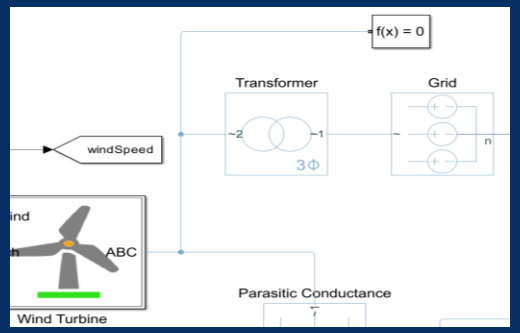
Battery Packs

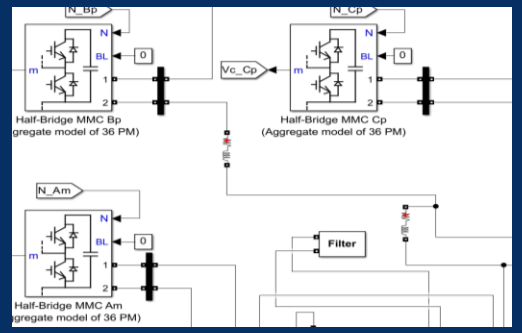
Full Vehicle Models

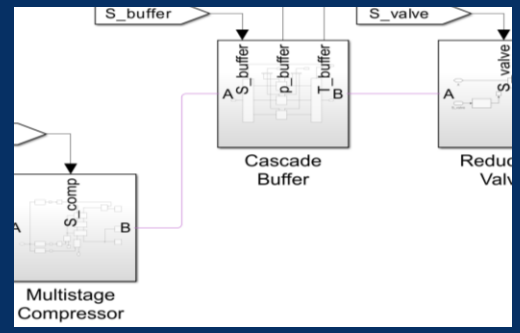
Aerial Vehicles

Green Energy









Solar

Wind

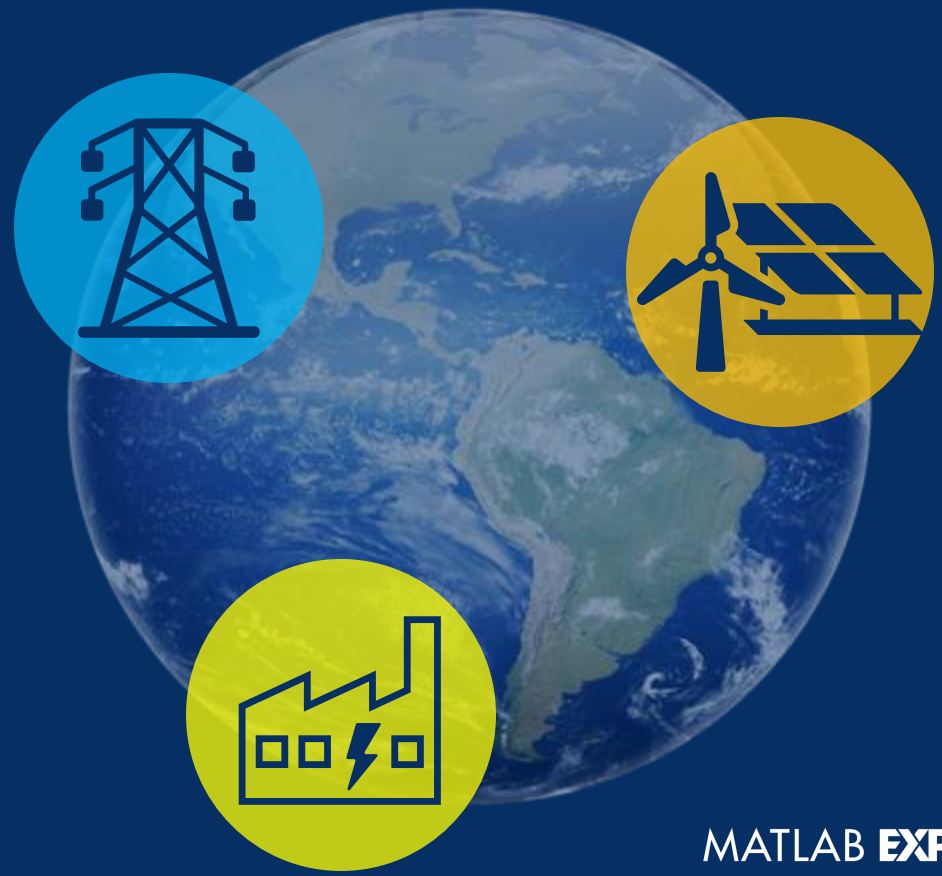
Hydroelectric

Green Hydrogen

SIEMENS energy

Enables the Global Energy Transition

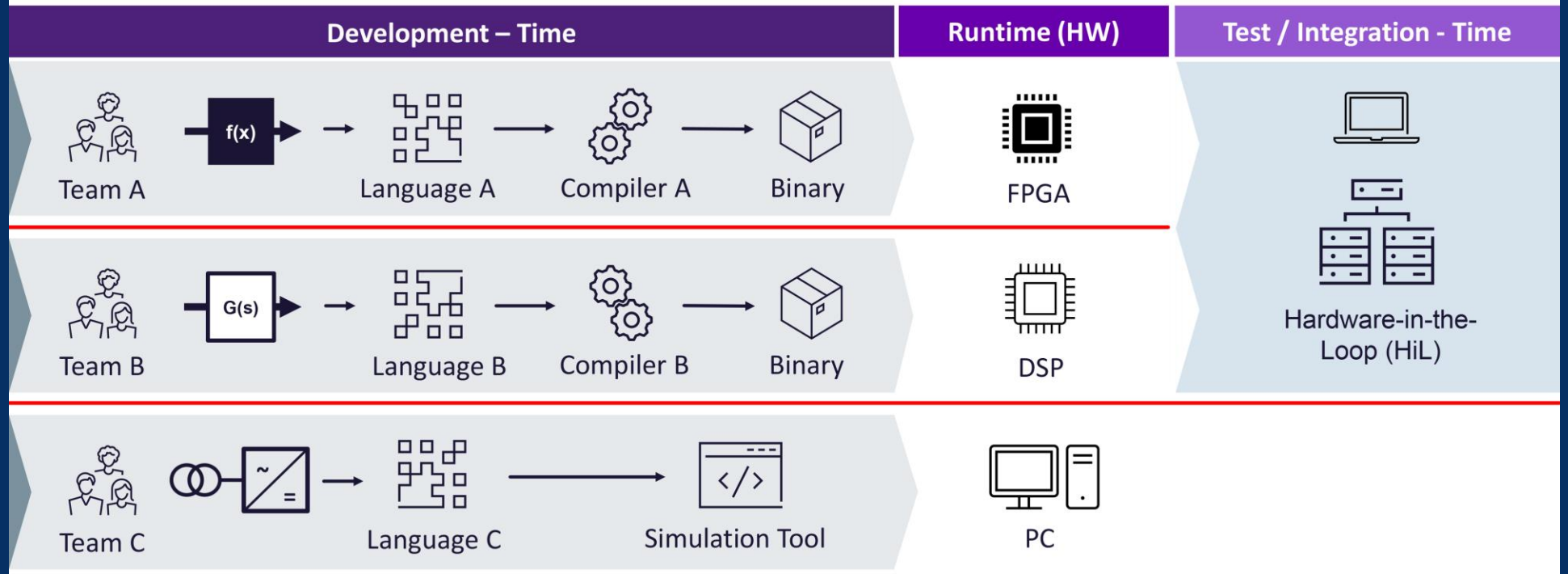
1. Engineer solutions in solar, biomass, hydrogen, wind
2. Retrofit or upgrade infrastructure
3. Strengthen electrical grid



SIEMENS energy

Enables the Global Energy Transition

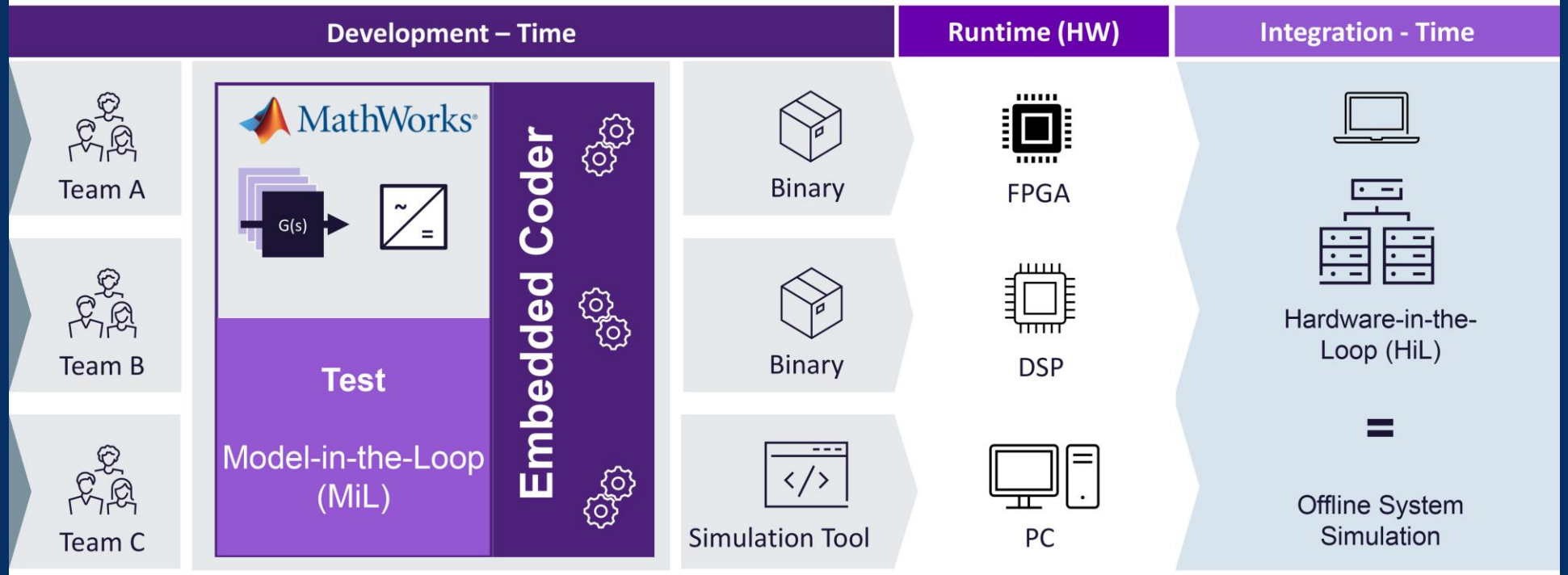
Swimlane Engineering
When the organization shapes development



Enables the Global Energy Transition

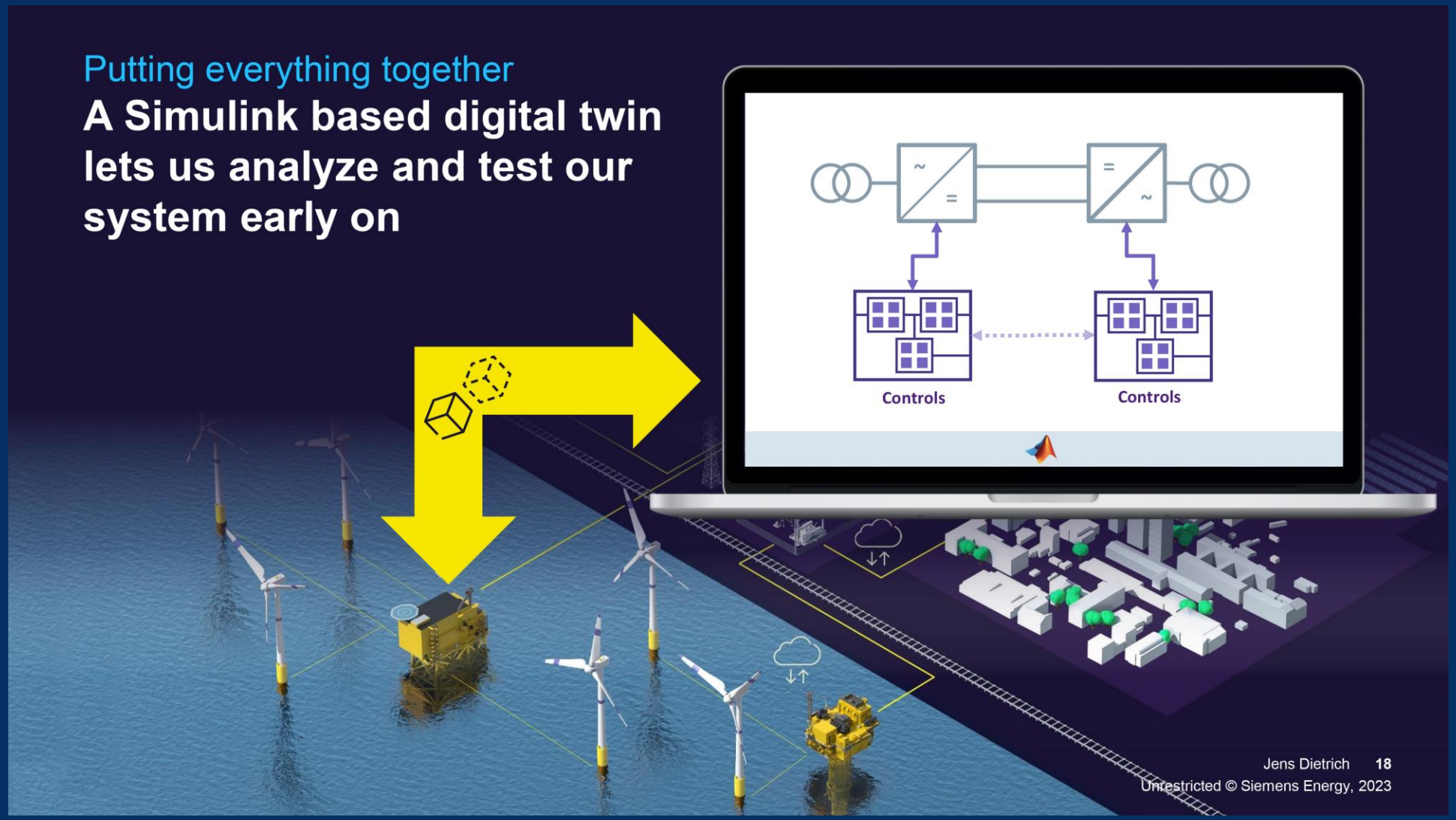
Centralized Engineering Ecosystem

When development extends across the organization



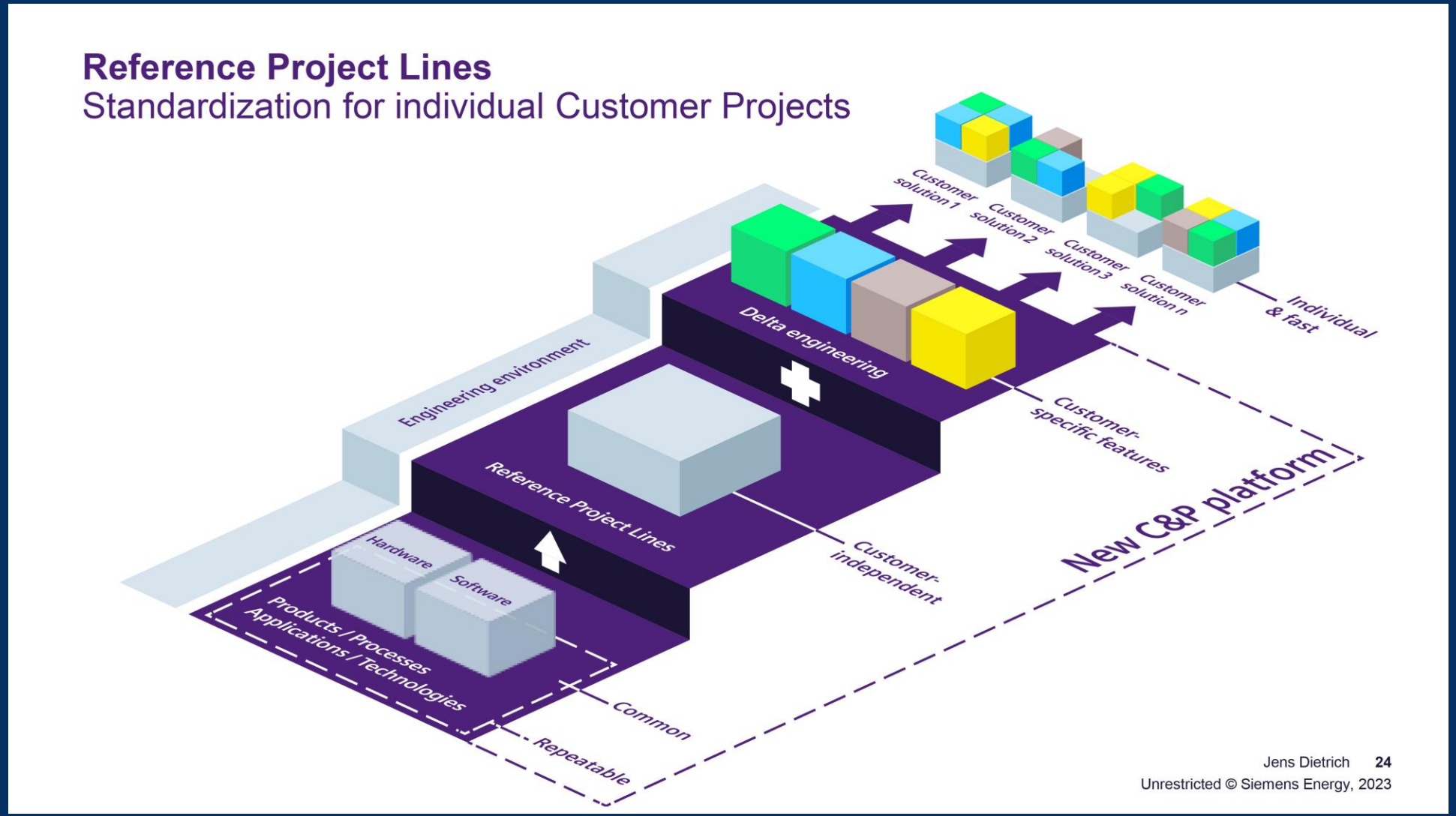
Jens Dietrich 21

SIEMENS energy Enables the Global Energy Transition



SIEMENS energy

Enables the Global Energy Transition



Application Trends

Autonomous

Connectivity

Electrification

Workflow Trends

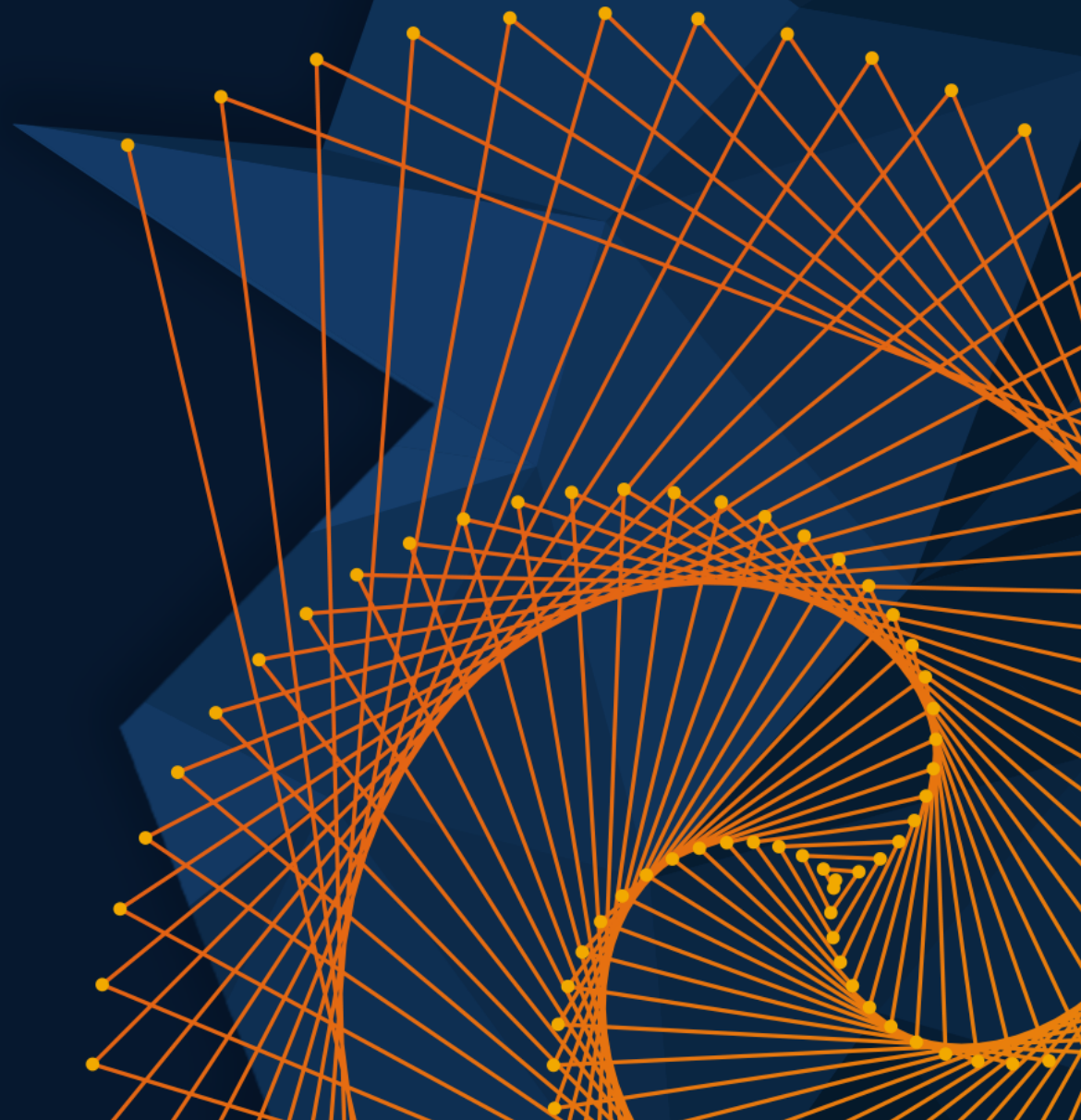
Systems Engineering & Design

Modern Software Practices

AI for System Development

MATLAB EXPO

Thank you



MathWorks®