MathWorks
AUTOMOTIVE CONFERENCE 2023
Europe

Accelerating Development of Clean, Safe, Automated Software-Defined Vehicles

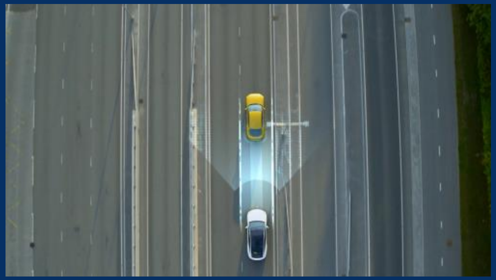
Andy Grace, MathWorks

MathWorks

Application Trends for the Software Defined Vehicle

Electrification

Connectivity

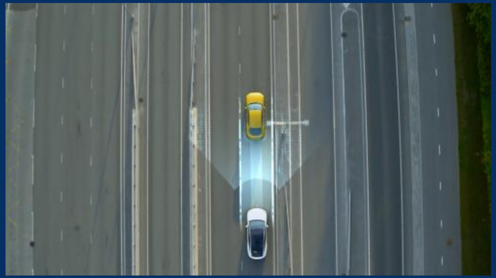


Autonomous

Application Trends for the Software Defined Vehicle

Electrification

Connectivity



Autonomous

Workflow Trends

Systems Engineering

Modern Software Practices

AI and Data-Driven Development

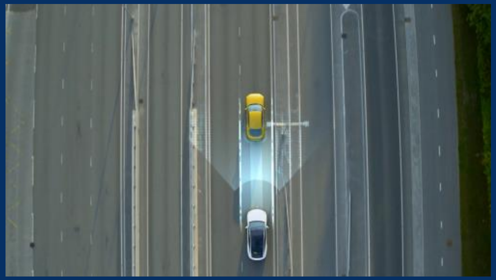
Application Trends for the Software Defined Vehicle

Electrification

#3 (39%)

Connectivity

#6 (19%)

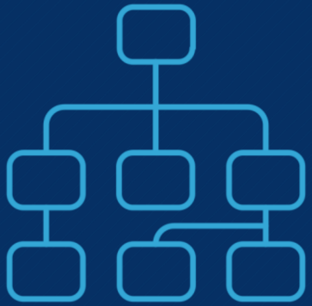


Autonomous

#4 (24%)

Top trends?

Workflow Trends



Systems Engineering

#1 (63%)

Modern Software Practices

#2 (58%)

AI and Data-Driven DevelCpment

#5 (21%)

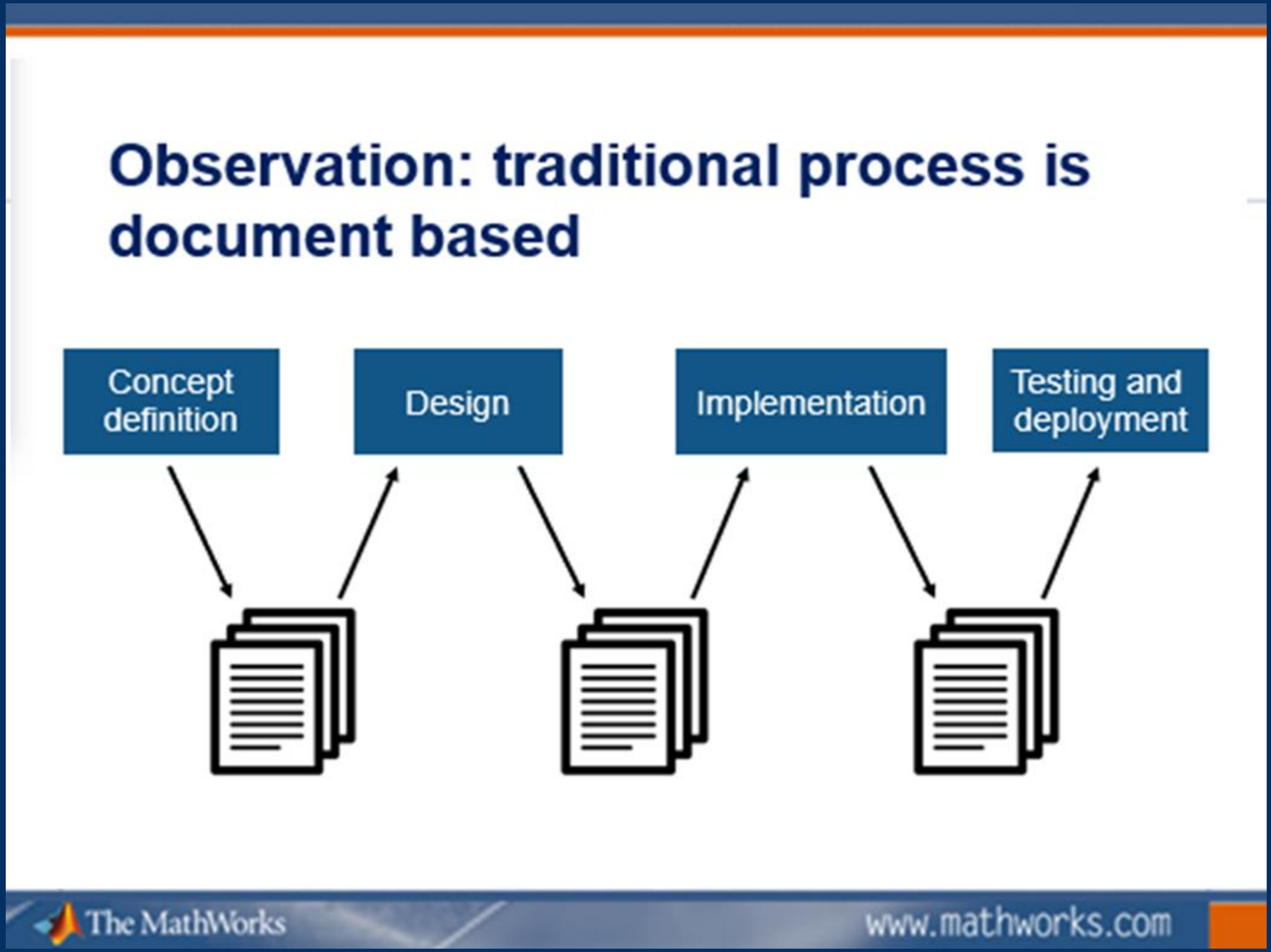
* MathWorks Advisory Board cross- industry survey, 274 responses

Historical perspective: First MathWorks Automotive Advisory

Germany, 1998

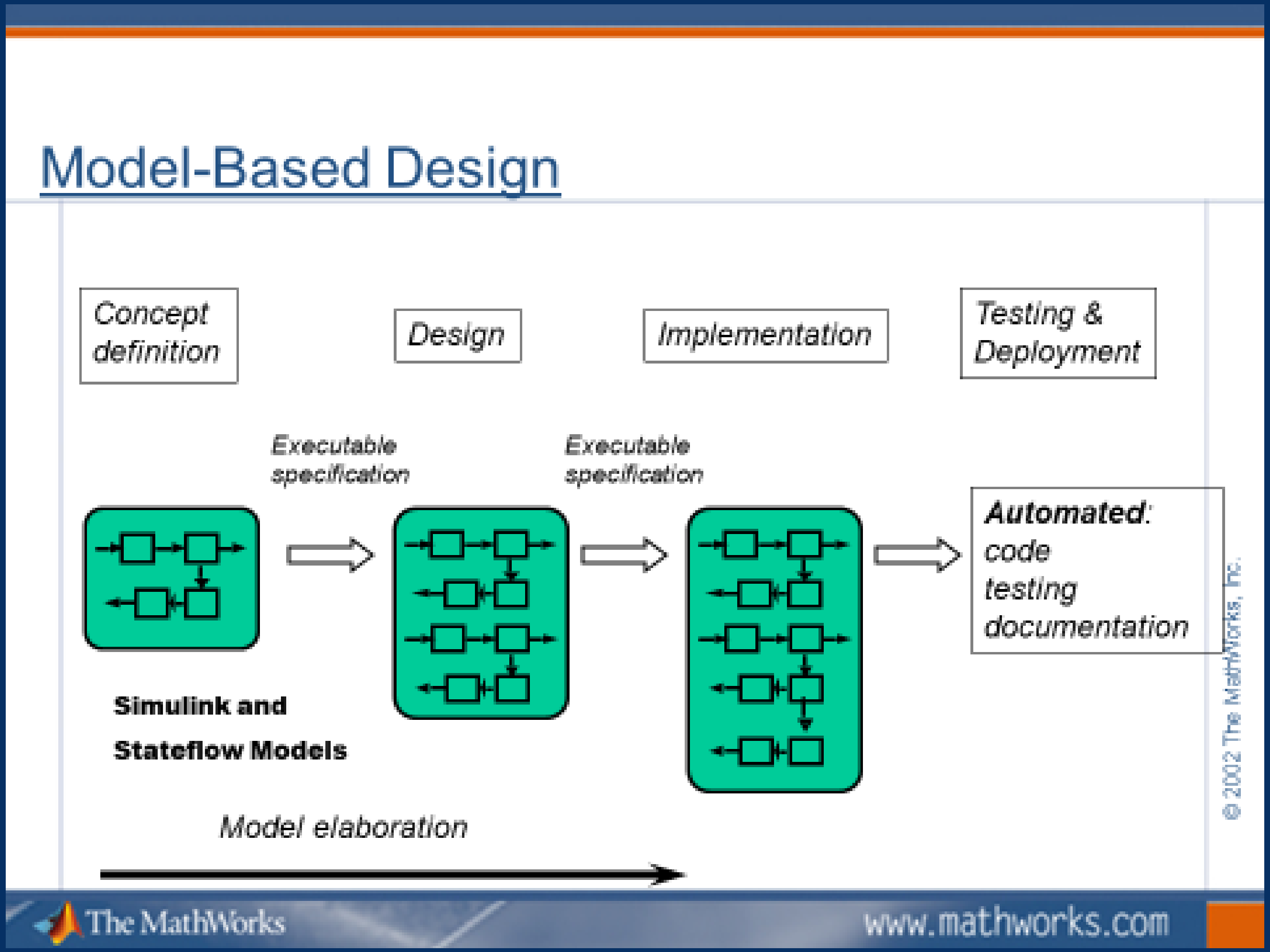
25 Years of MAB

Problem statement from initial MAB Meetings



25 Years of MAB

Vision emanating from initial MAB Meetings



Model-Based Design Framework

Modeling

Simulation | Analysis

+

Automation

Coding | Verification

Model-Based Design Framework

Modeling

Simulation | Analysis

\+

Automation

Coding | Verification

#1

Simulation (66%)

Analysis (43%)

#2

Coding (65%)

Verification (30%)

Survey: Which areas is your organization deriving the most value from Model-Based Design?
(pick up to three)

MathWorks®

Model-Based Design Framework

Modeling

Simulation | Analysis

+

Automation

Coding | Verification

How should Model-Based Design adapt?

Model-Based Design Framework

Process Automation

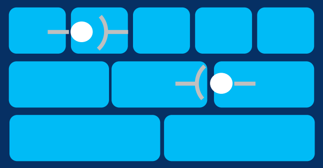
Modeling
- Simulation
- Analysis

+

Automation
- Coding
- Verification

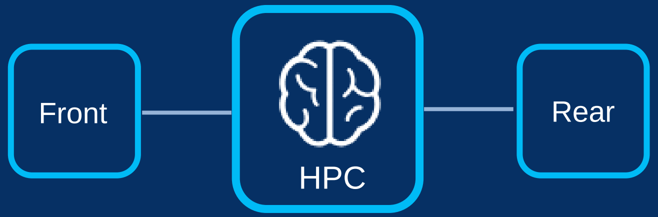
New MBD Approaches

Automated: CI/CD



Service Oriented Architectures

Cloud Development



Zonal and Vehicle HPCs

How to measure software operational performance?

DORA
DEVOPS RESEARCH & ASSESSMENT

Metric	Description
Lead Time for Changes	The time it takes from code commit to code successfully running in production.
Deployment Frequency	The frequency at which code is deployed to production.
Change Failure Rate	The percentage of deployments causing a failure in production.
Mean Time to Recover (MTTR)	The time it takes to recover from a failure in production.

Modern
Software Practices

How to measure software operational performance?

DORA
DEVOPS RESEARCH & ASSESSMENT

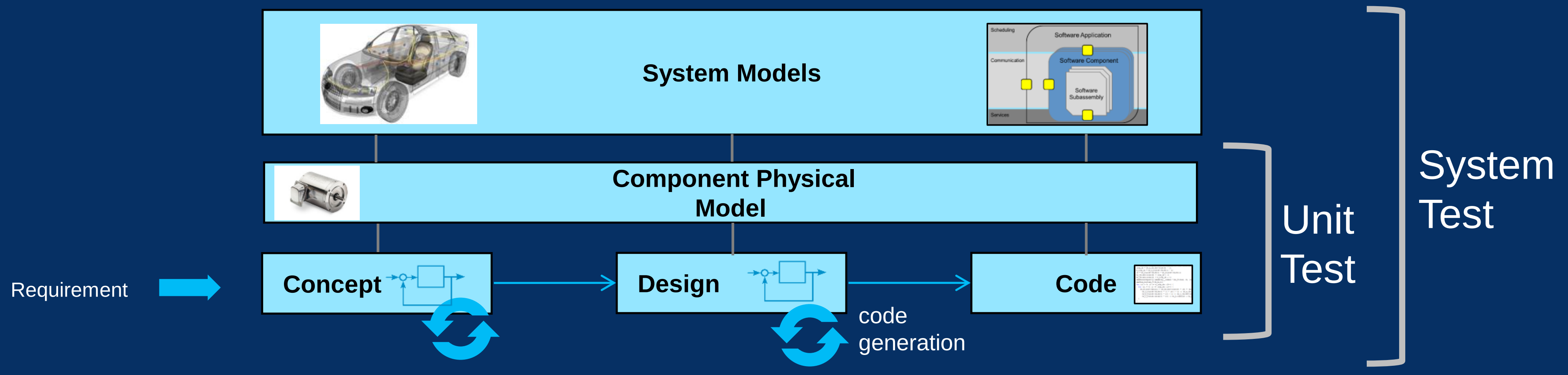
Role of Model-Based Design?

Metric	[illegible]
Lead Time for Changes	The time it takes from code commit to code successfully running in [illegible]
Deployment Frequency	The frequency at which code is deployed to production.
Change Failure Rat[illegible]	The percentage of deployments [illegible] production.
Mean Time to Recover (MTTR)	The time it takes to recover from a failure in production.

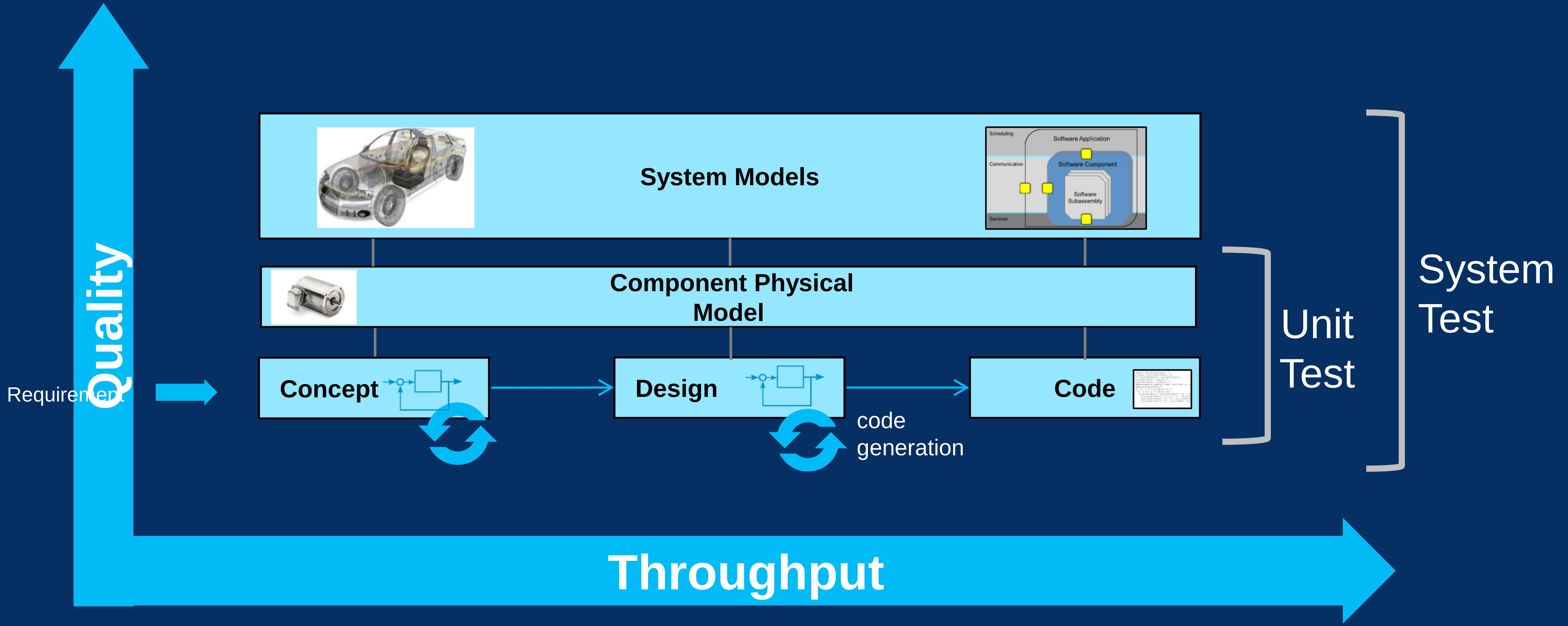
Throughput

Quality

Model-Based Design Workflow

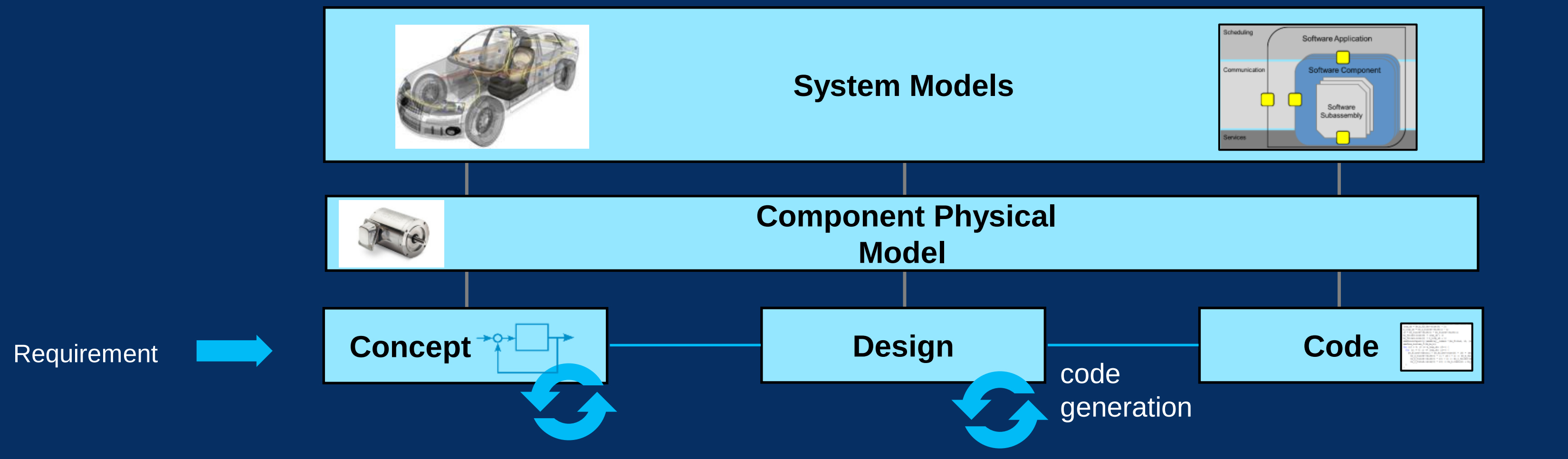


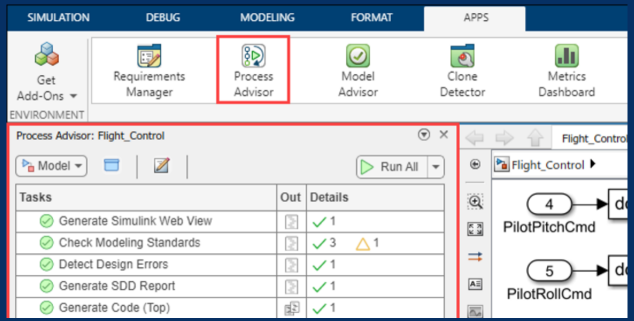
Model-Based Design Workflow



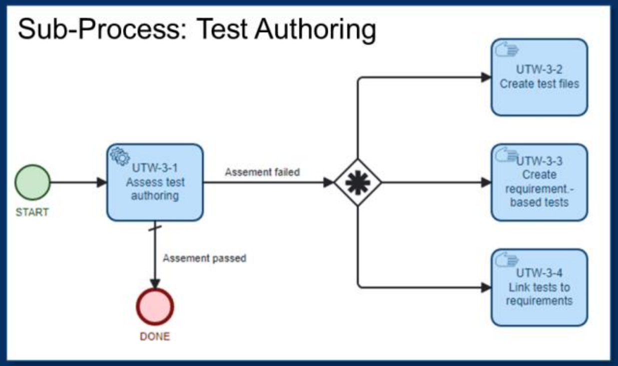
Full automation?

Model-Based Design: Integration and Automation



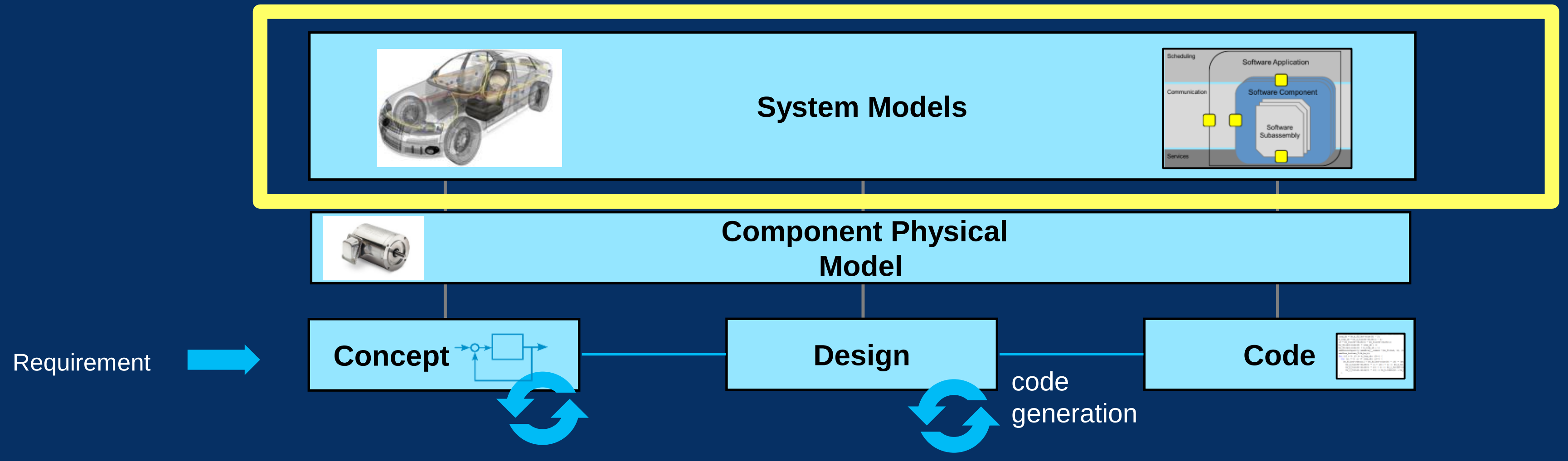


CI support package
R2022a



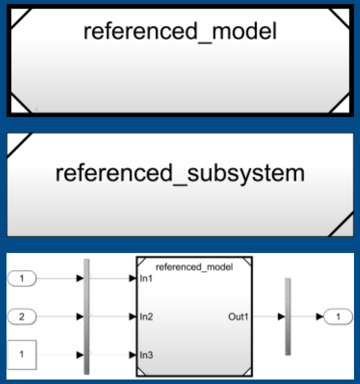
Detailed Testing Workflow

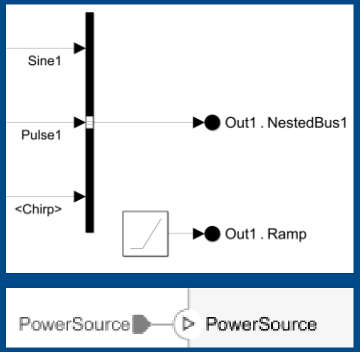
Model-Based Design: Integration and Automation

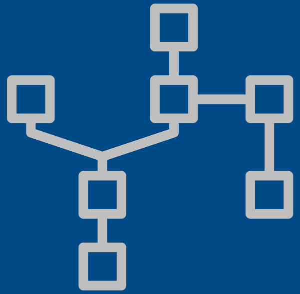


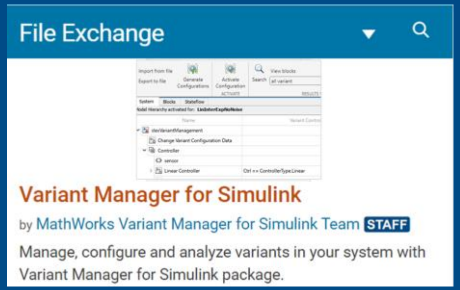
Simulink as a simulation integration platform

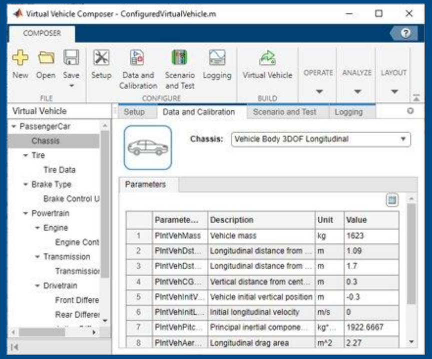
Simulink Scales to Complex Systems











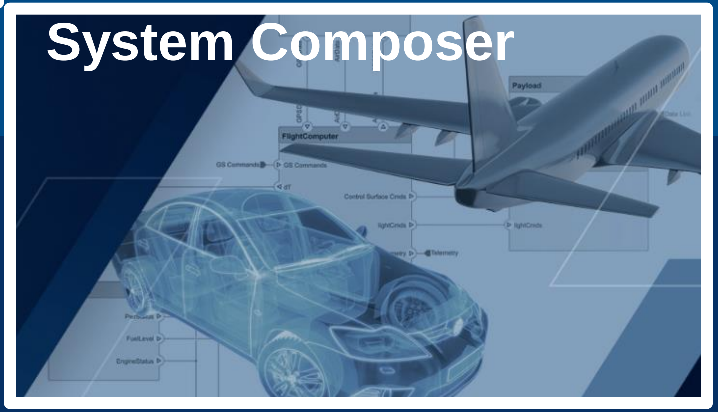
Components & test harnesses

Buses, ports, connectors

Architecture

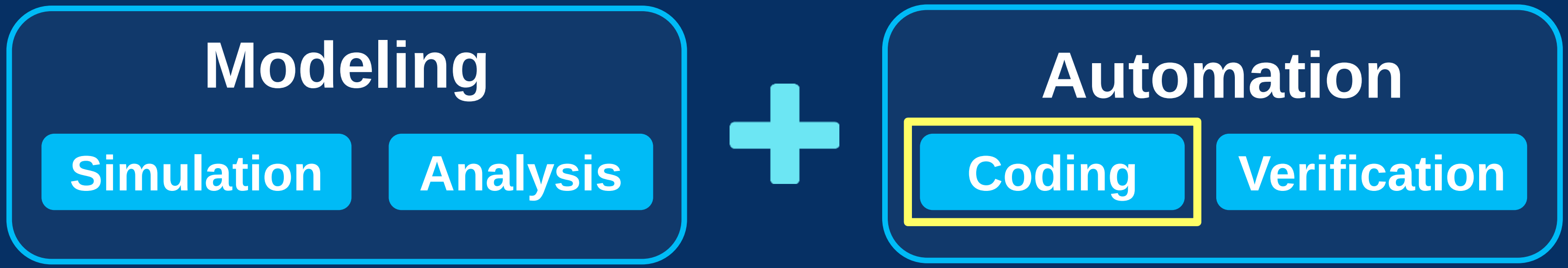
Variant Manager

Virtual Vehicle Composer



>500 organizations have adopted

MathWorks®


Modeling
Simulation
Analysis
Automation
Coding
Verification

Coding

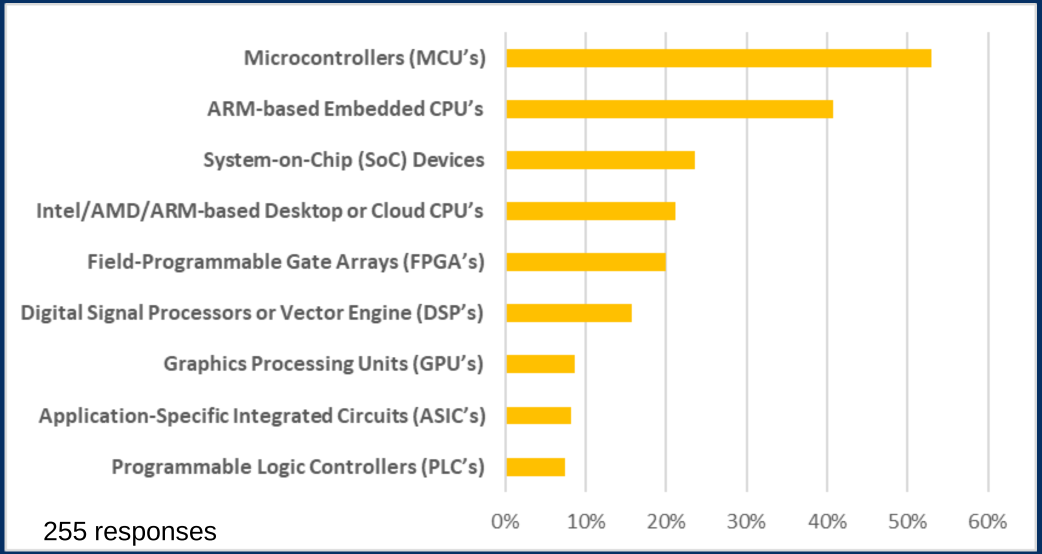
You successfully target a range of devices with code generation

4700 organizations
use automatic code generation

CPU

GPU

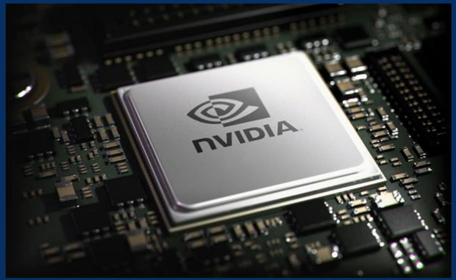
FPGA, ASIC, PLC



* MathWorks Advisory Board cross- industry survey

Each release we get more out of your hardware

127 FPS, Nvidia GPU



GPU

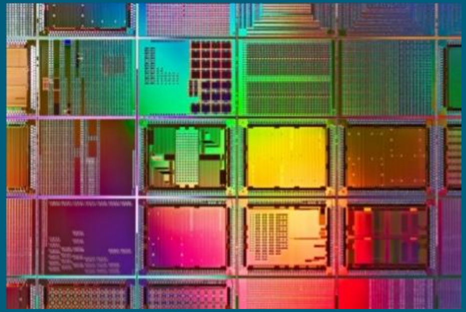
CPU

FPGA/SoC

MathWorks®

Coding

Each release we get more out of your hardware



Multicore

Cache

Accelerators

SIMD

Parallelization

Neighborhood Processing Subsystem in Simulink
R2022b

Improved SIMD for ARM, Intel and AMD
R2023a

Hardware Aware

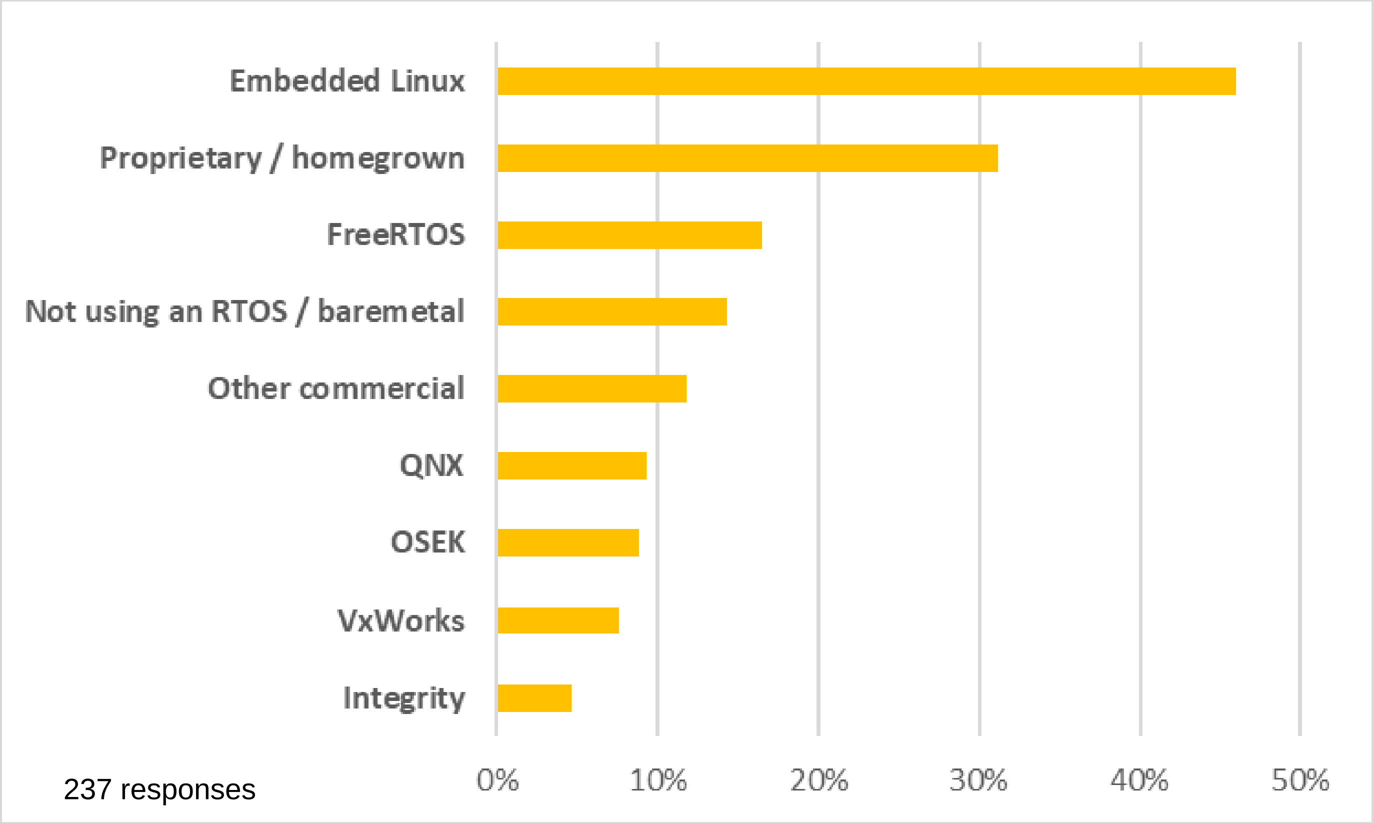
Xilinx Versal
R2022a

Infineon AURIX TC4x
R2022b

GPU Performance Analyzer
R2023a

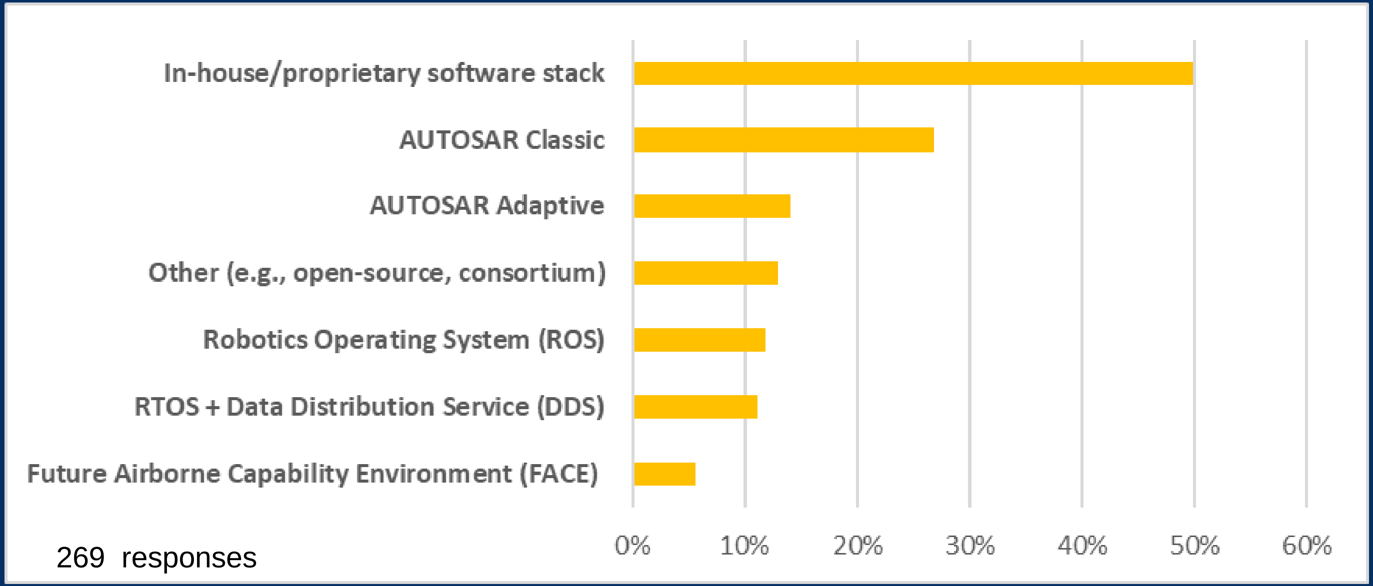
MathWorks®

MAB Survey: Which Real-Time Operating System (RTOS) is likely to be in your next generation of systems? (select all that apply)



* MathWorks Advisory Board cross- industry survey

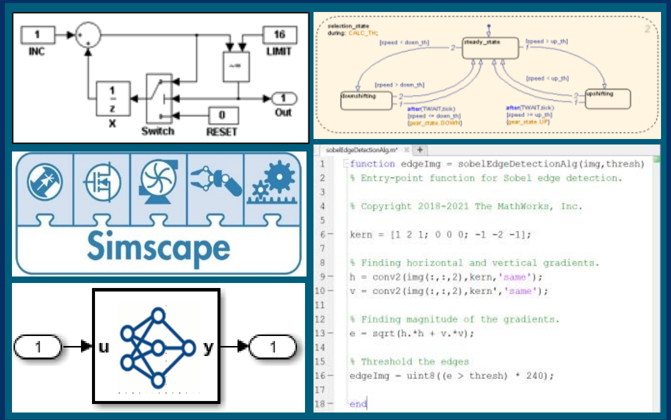
MAB Survey: Which standards-based architecture and middleware does your organization plan on using? (select all that apply)



* MathWorks Advisory Board cross- industry survey

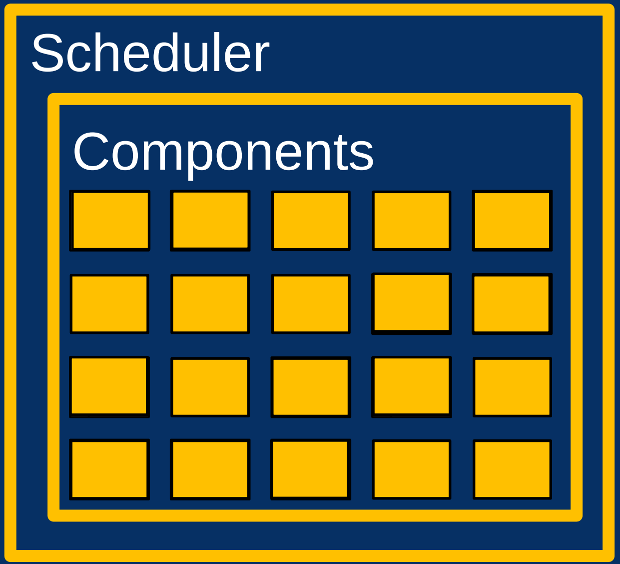
Coding

You have been successful deploying models as individual components and complete applications



controls, logic, physics, array, AI

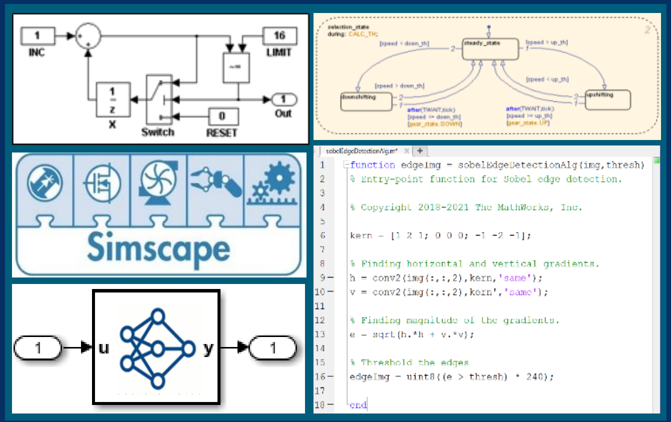
Code Generation



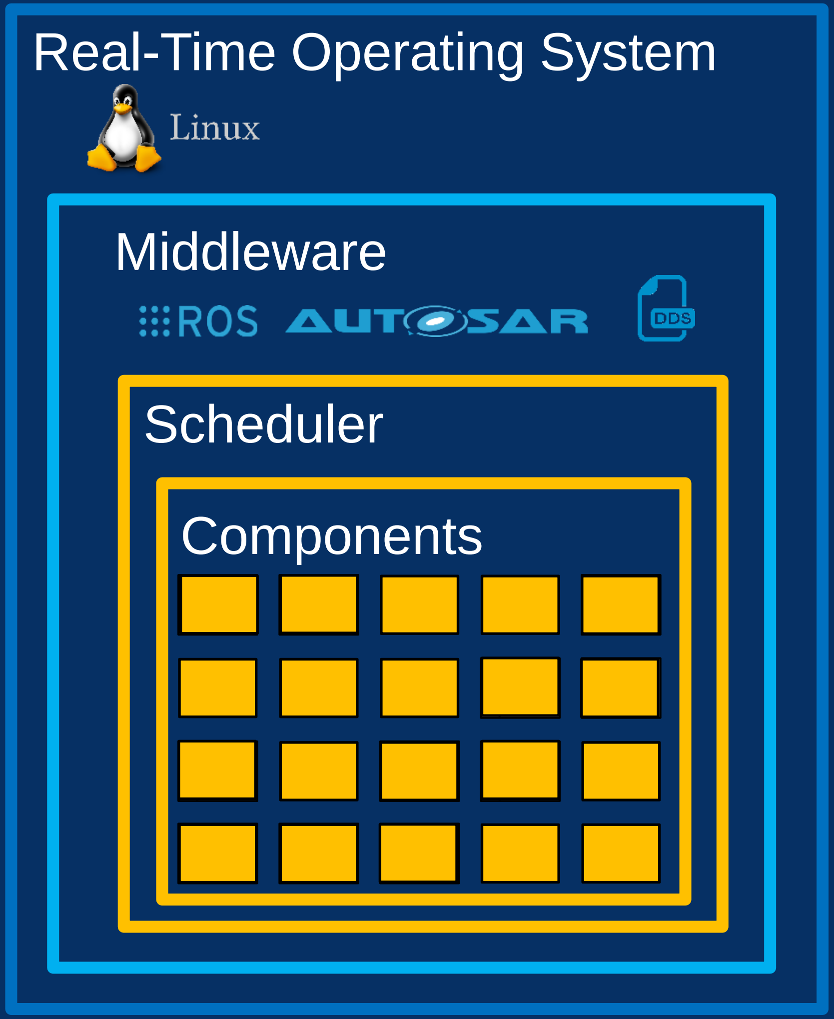
MathWorks®

Coding

We continue investing in architecture standards and middleware

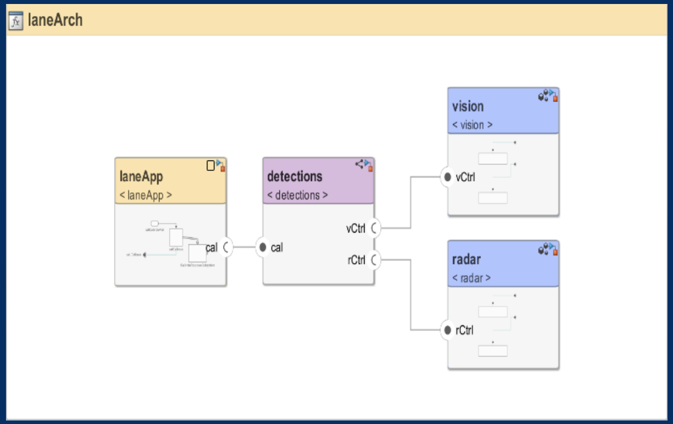


Platform Aware Code Generation



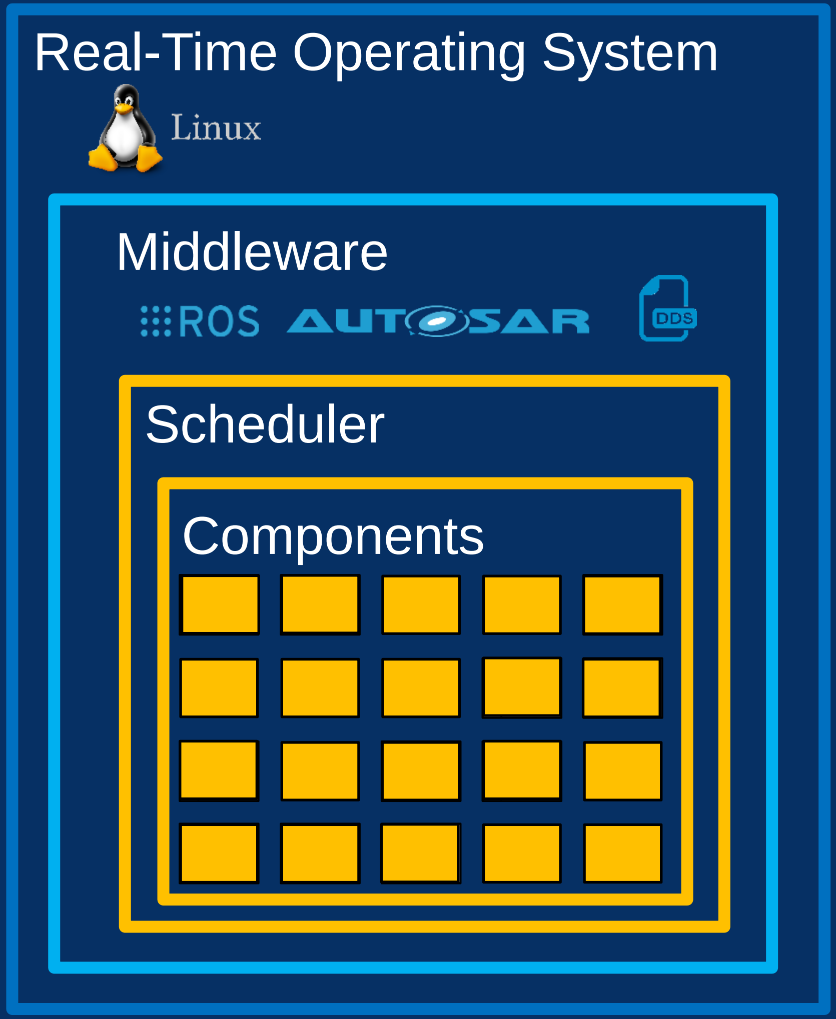
Coding

Use System Composer to model middleware more completely



System Composer

Platform Aware Code Generation



MathWorks®


Modeling
Simulation
Analysis
Automation
Coding
Verification

Find bugs 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

Requirements Toolbox

Model-Based Design Framework

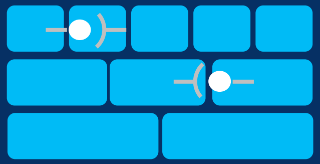
Process Automation

Modeling + **Automation**

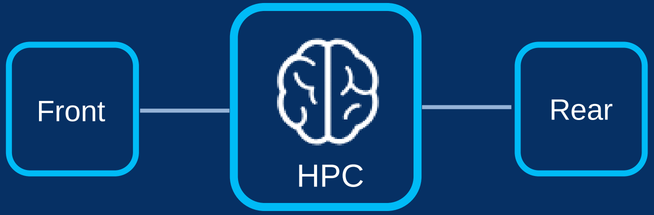
- Simulation
- Analysis
- Coding
- Verification

New MBD Approaches


Automated: CI/CD


Service Oriented Architectures


Cloud Development



Zonal and Vehicle HPCs

Cloud solutions roadmap

Access

Scaling

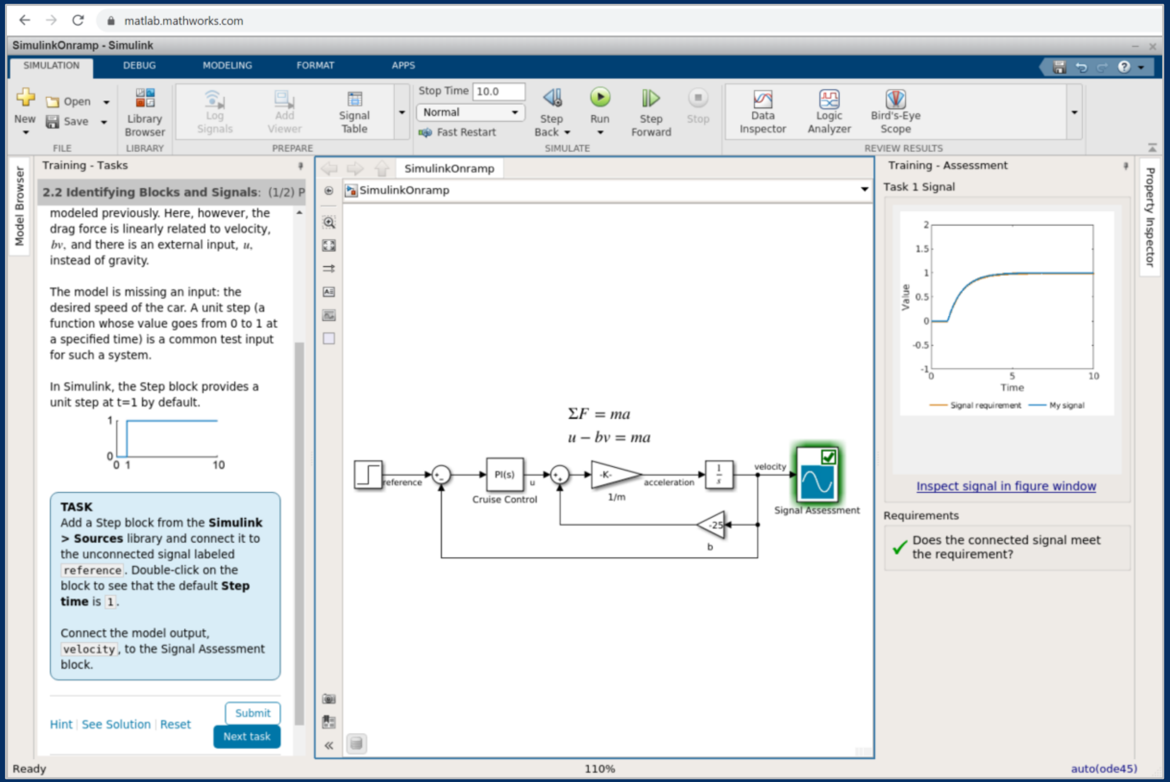
Collaboration

Cloud solutions roadmap

Access

Scaling

Collaboration



Simulink Online

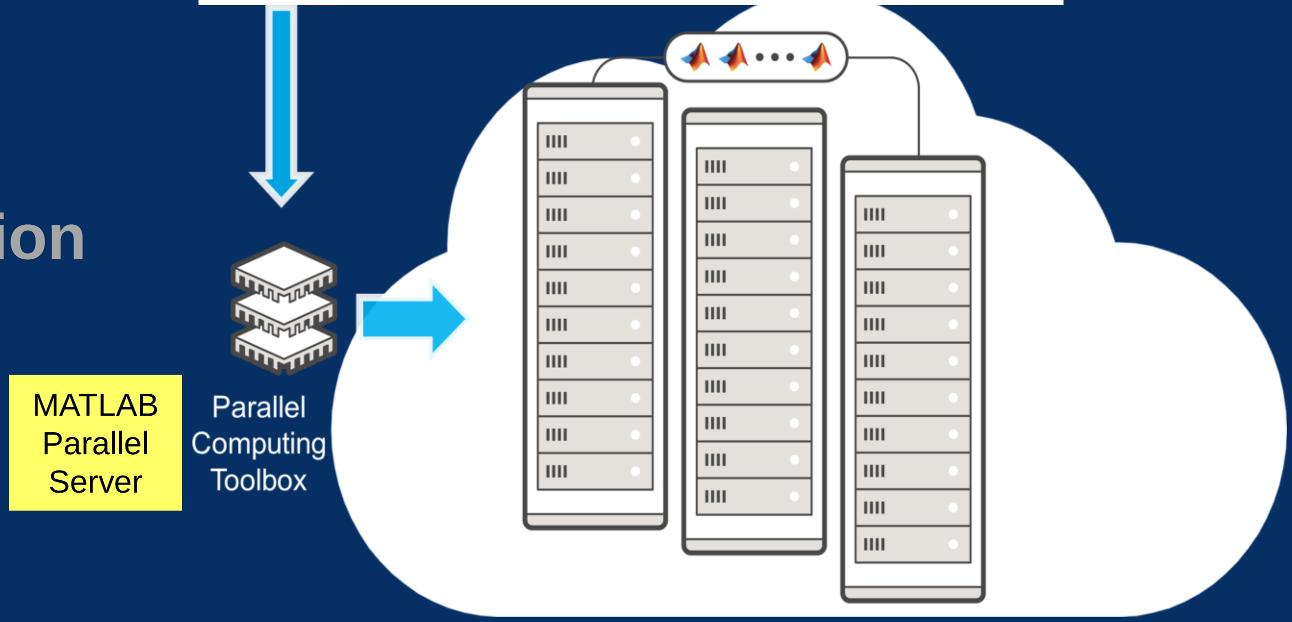
Cloud solutions roadmap

Access

Scaling

Collaboration

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



Massive simulation jobs

Cloud solutions scaling

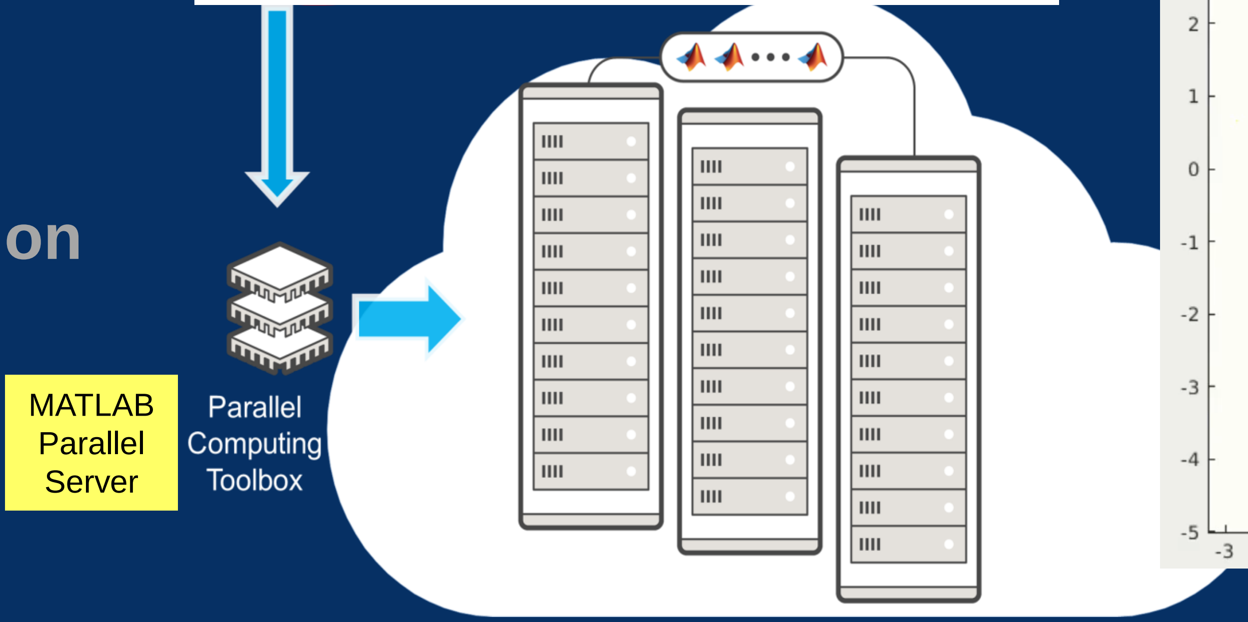
One million simulations finished in 2.5 minutes!
Over 1 day if ran serially

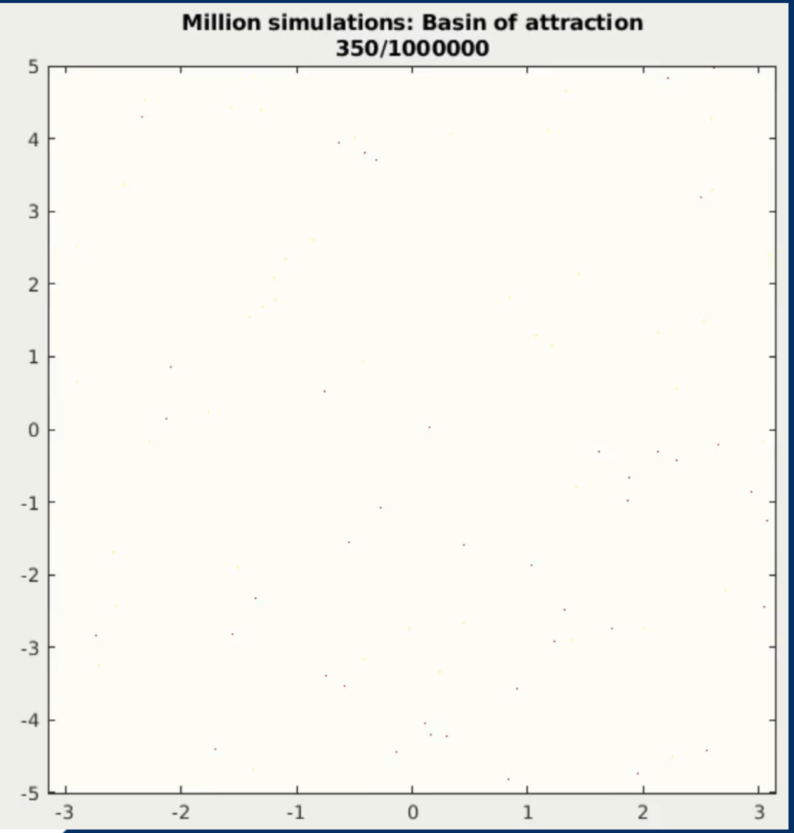
Access

Scaling

Collaboration

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



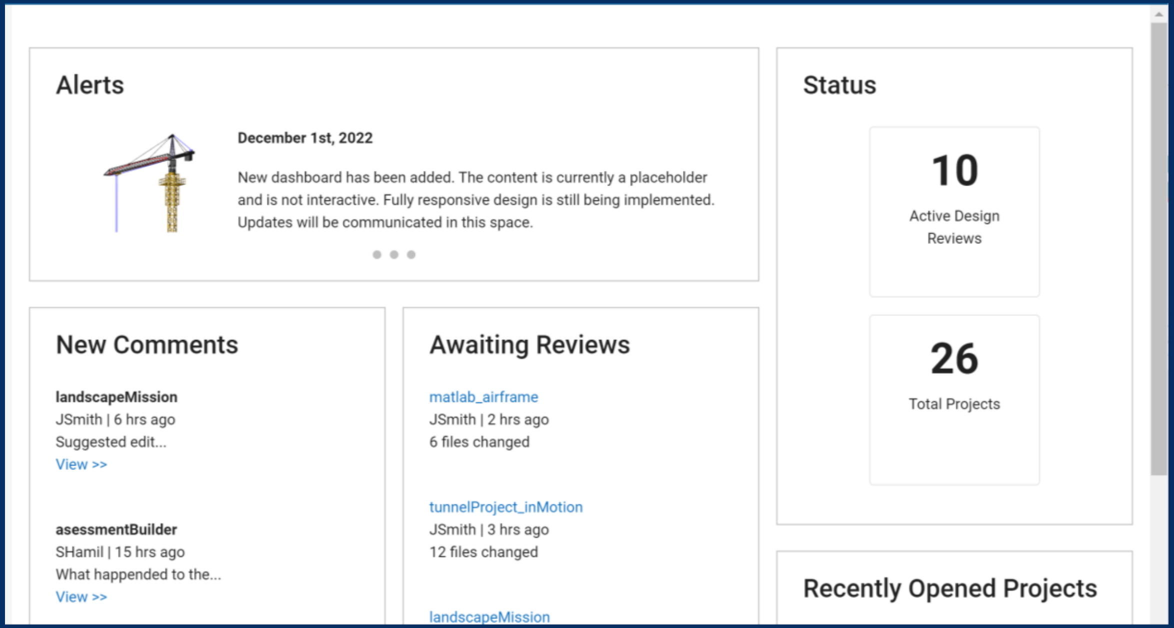


Cloud solutions roadmap

Access

Scaling

Collaboration



Project dashboard

Design review

Instant search

Modeling

Simulation | Analysis

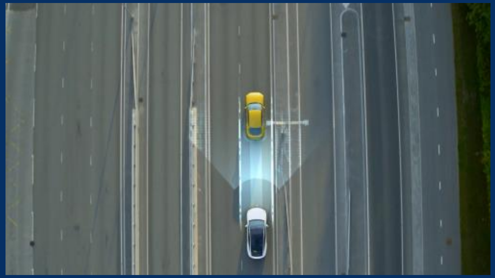
Automation

Coding | Verification

Deep Solutions

Electrification

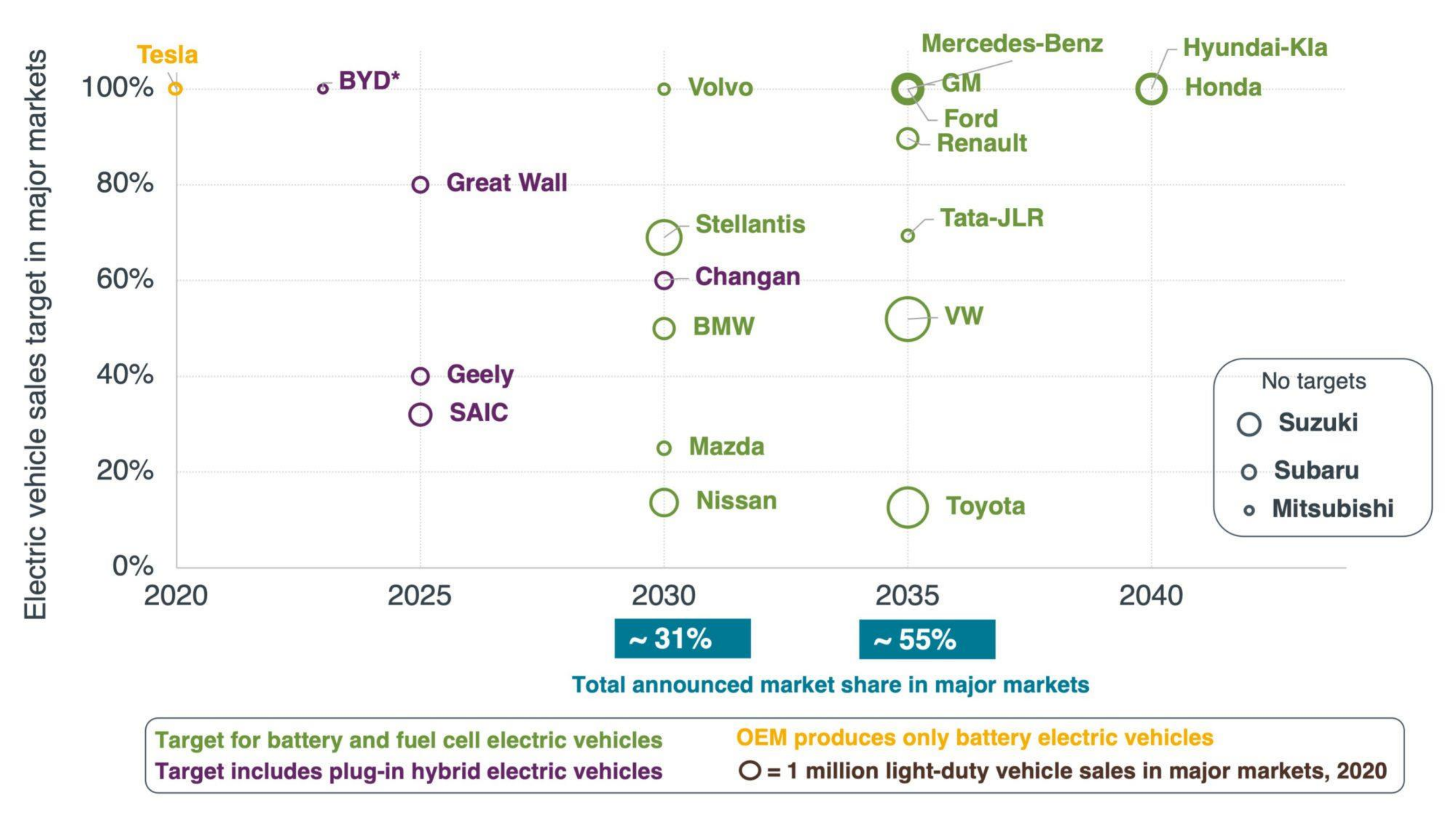
Connectivity



Autonomous

MathWorks®

31% EVs by 2030 – According to OEM Announcements

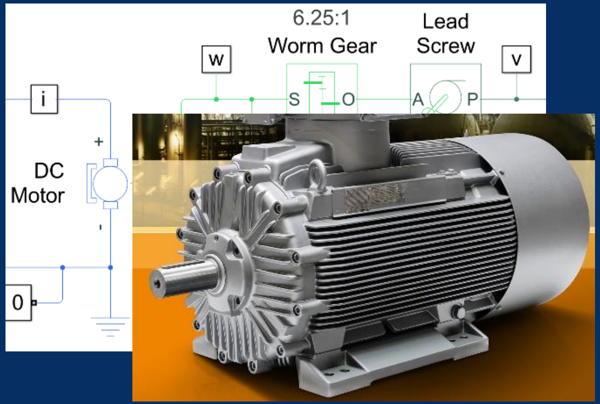


- EV announcements made for about 55% of the total automotive market.

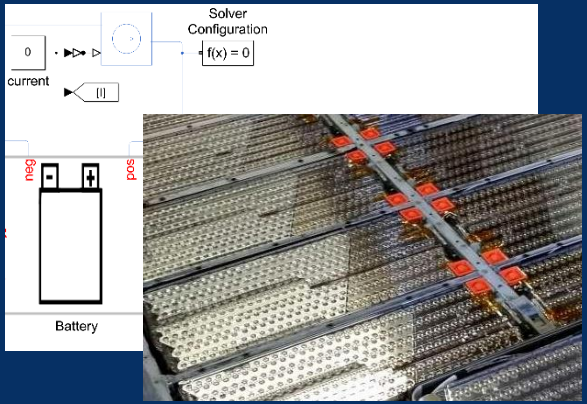
Source

Analyzed top 23 companies, by sales. Weighted target by major market sales

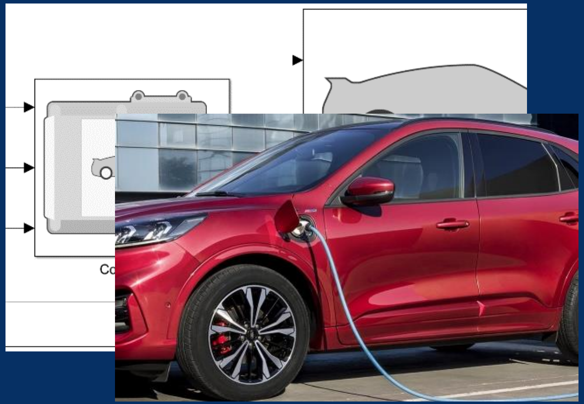
Electric Vehicles



Electric motors

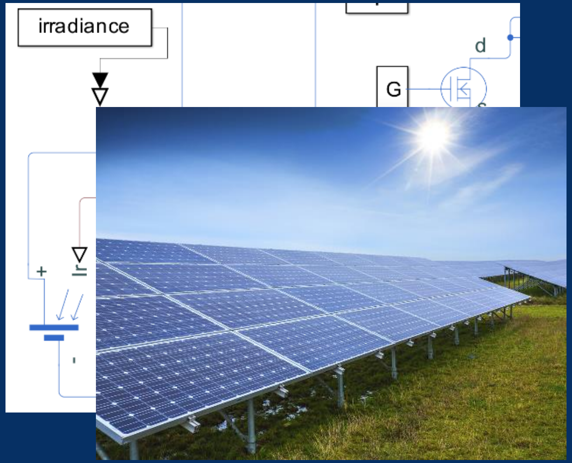


Battery packs

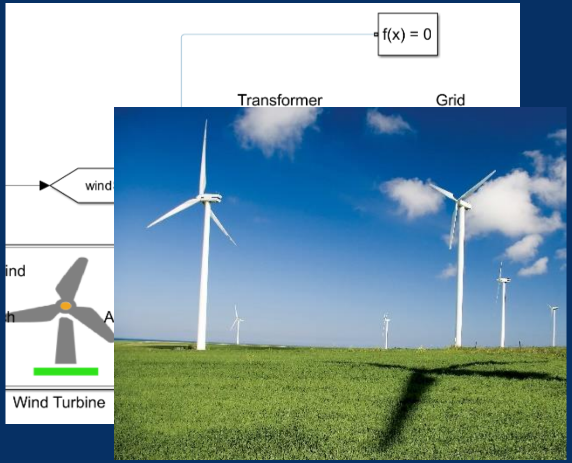


Full vehicle models

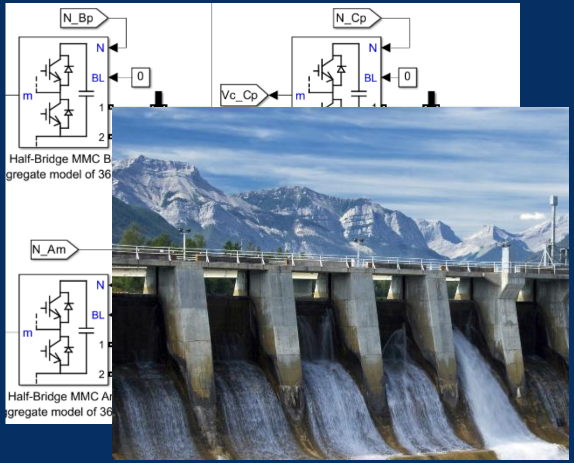
Green Energy



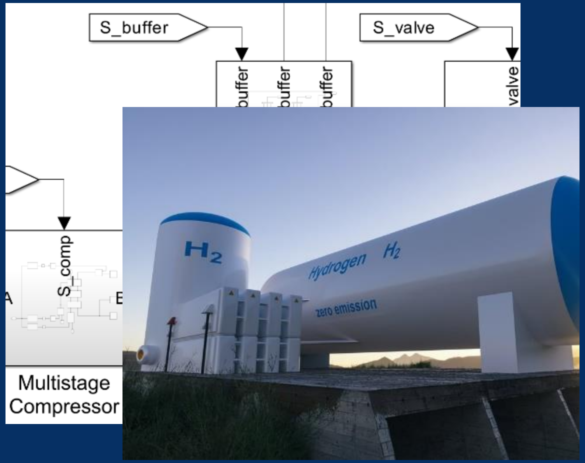
Solar



Wind



Hydroelectric



Green Hydrogen

MathWorks®

Modeling

Simulation | Analysis

+

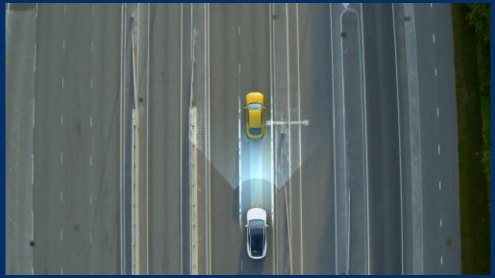
Automation

Coding | Verification

Deep Solutions

Electrification

Connectivity



Autonomous

MathWorks®

Wireless, RF, and Mixed Signal Product Portfolio

	Digital Baseband	Standards	Implement & Test
Model & Simulate	Communications Toolbox	5G Toolbox, LTE Toolbox, WLAN Toolbox, Satellite Comms Toolbox, Bluetooth Toolbox	Wireless HDL Toolbox, SoC Blockset, Wireless Testbench
RF & Mixed Signal	RF Toolbox, RF Blockset, Antenna Toolbox, Mixed Signal Blockset, SerDes Toolbox, Signal Integrity Toolbox, RF PCB Toolbox		

Modeling

Simulation | Analysis

Automation

Coding | Verification

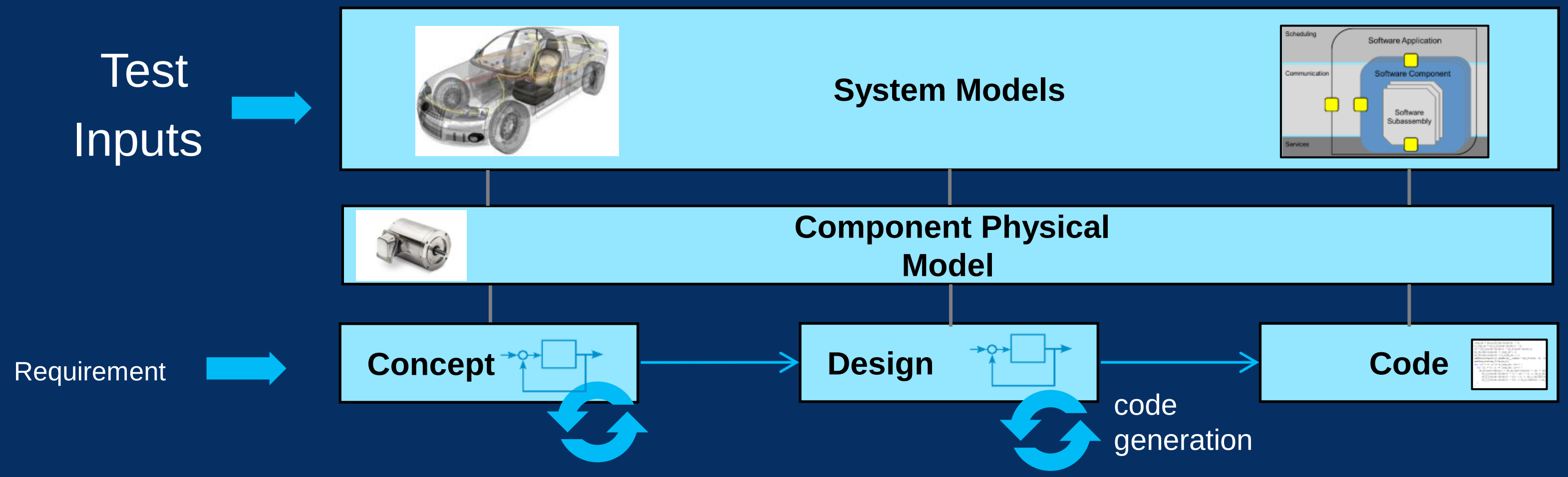
Deep Solutions

Electrification

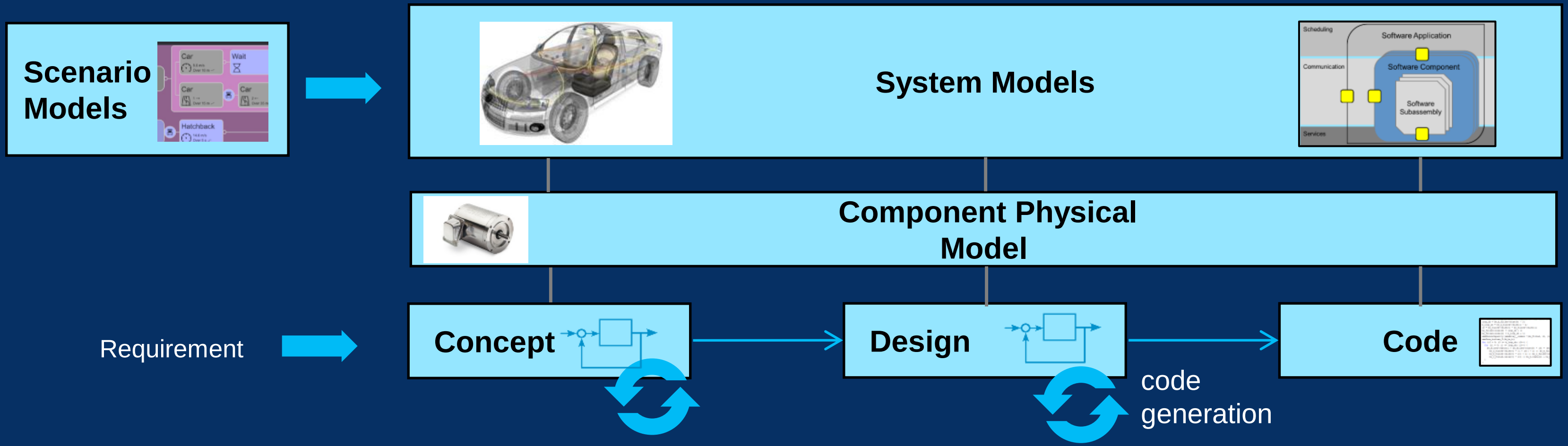
Connectivity

Autonomous

Model-Based Design Workflow



Model-Based Design Workflow



RoadRunner Scenario

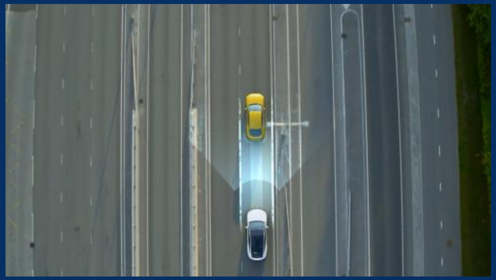
Autonomous Product Portfolio

Industry-Based	Automated Driving Toolbox	Robotics System Toolbox	UAV Toolbox
Navigation, Tracking & Perception	Sensor Fusion Toolbox	Navigation Toolbox	Lidar Toolbox
Middleware	AUTOSAR Blockset	ROS Toolbox	DDS Blockset
Scene & Scenario	RoadRunner + Asset	RoadRunner Scene Builder	RoadRunner Scenario

Application Trends for the Software Defined Vehicle

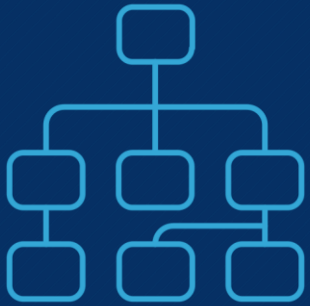
Electrification

Connectivity



Autonomous

Workflow Trends

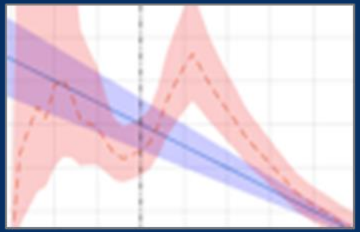


Systems Engineering

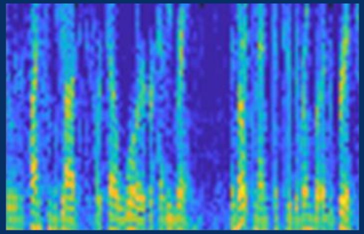
Modern Software Practices

Data-Driven Development and AI

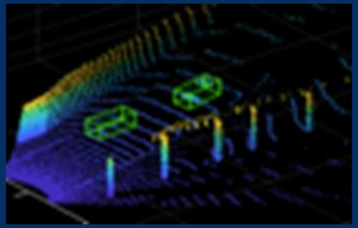
AI Reference Examples

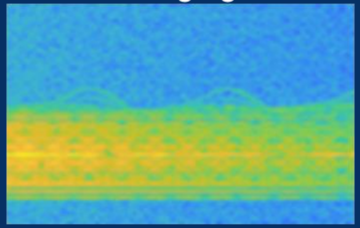

Predictive Maintenance

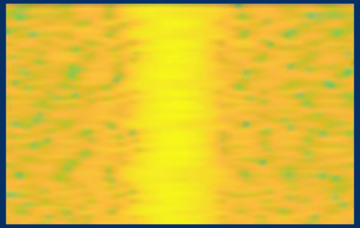

Hyperspectral Imaging


Signal Processing

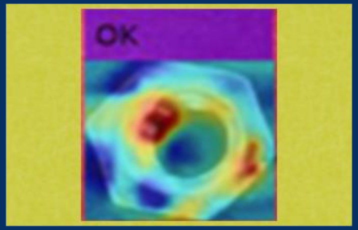

Robotic Control


Lidar Processing

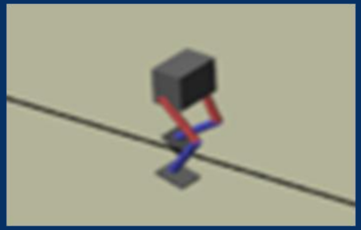

Radar Processing


Wireless Communications

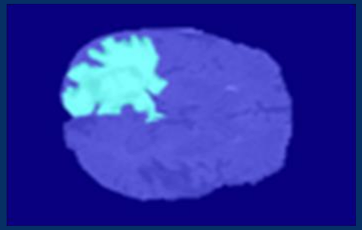

Automated Driving



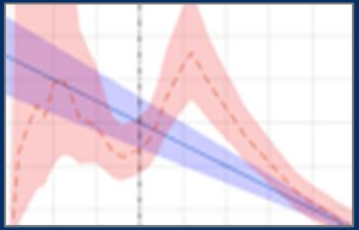
Visual Inspection


Reinforcement Learning

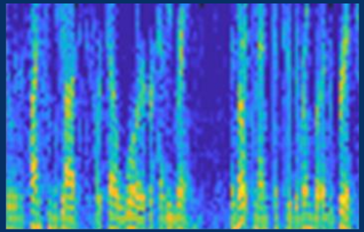

Audio


Medical Imaging

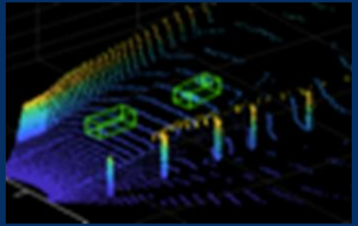
AI Reference Examples

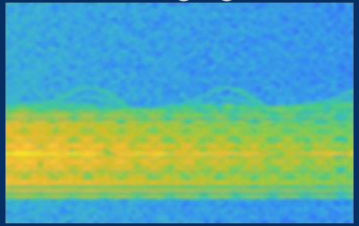

Predictive Maintenance

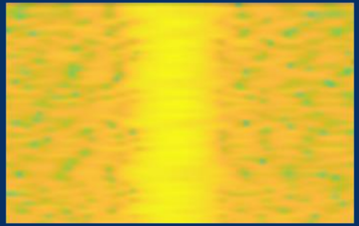

Hyperspectral Imaging


Signal Processing

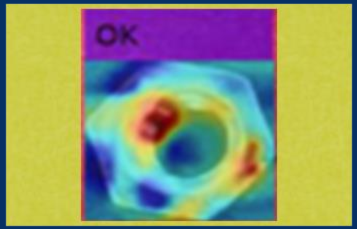

Robotic Control


Lidar Processing

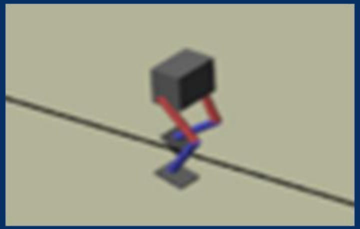

Radar Processing


Wireless Communications

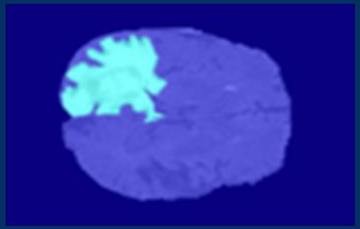

Automated Driving

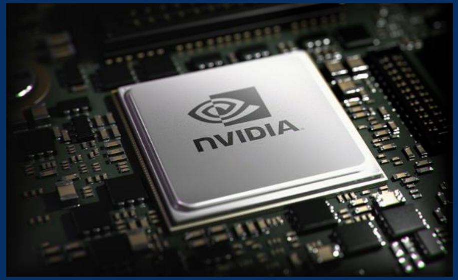


Visual Inspection


Reinforcement Learning


Audio


Medical Imaging



GPU

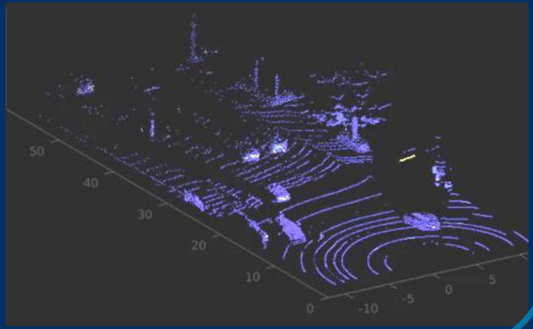
CPU

FPGA/SoC

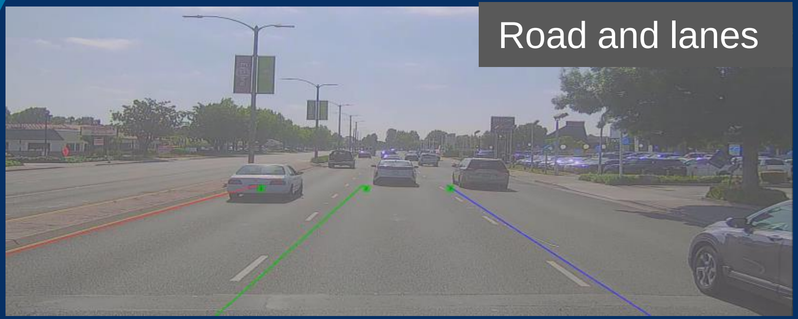
Applying AI to Real-World Sensor Data (Virtual Scenario Generation)

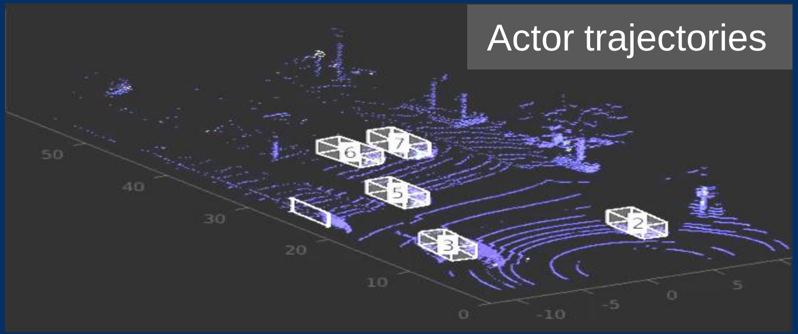
Scenario Builder Add-on for Automated Driving Toolbox

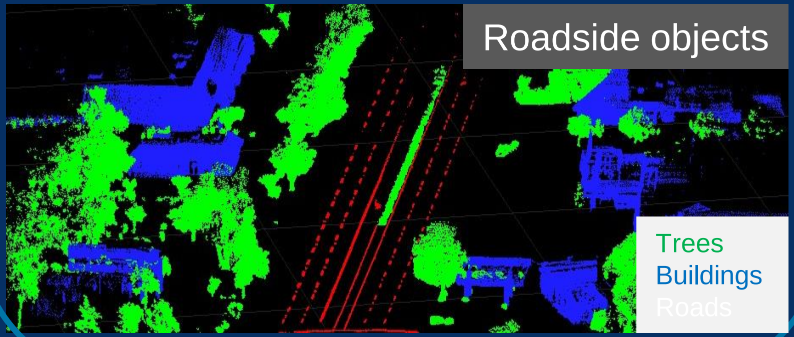
Recorded sensor data



Perception AI models







Deep3dbox, CLRNet
PVRCNN, RandLANet, K-lane

Reconstructed RoadRunner Scenario

~10x faster than a human in creating scenarios from data

MathWorks®

Modeling

Simulation | Analysis

\+

Automation

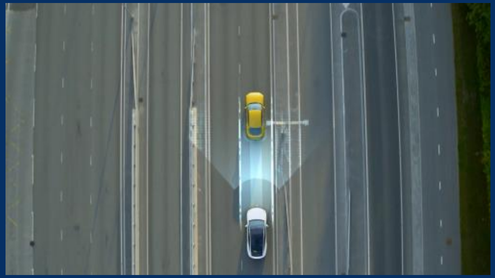
Coding | Verification

Deep Solutions

↓

Electrification

Connectivity



Autonomous

Model-Based Design Workflow