MathWorks
AUTOMOTIVE CONFERENCE 2024
India

The Roadmap for Software-Defined Vehicles and Disruptive Technologies

Jim Tung
MathWorks

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Software-Defined Vehicle

Brand-Distinctive Features and Main Customer Value Will Come From Software

Customer expectations
- Sustainable and safe mobility
- Digital life continuity

Technology and innovation
- Electrification
- Autonomy
- Connectivity

Business opportunity
- App stores, software features on demand
- Subscription plans for software services

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More Value and Resilience in Vehicles By Delivering Features Through Software Quickly and Reliably

Challenges

- Increased complexity of functions
- Increased need for Functional Safety
- System/software development platforms need to evolve
- Processes and team interactions must change even more

Patterns of Functionality and Dysfunctionality

Software-Defined

Modern Software Practices
- Fast development
- Frequent releases
- High automation

Data-Driven Functionality

Leverages Cloud

Vehicles

Reliability

Functional Safety

Physical Components

Software-Defined Vehicles

Modern Software Practices

Reliability

Data-Driven Functionality

Functional Safety

Leverages Cloud

Physical Components

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Software-Defined Vehicles

Modern Software Practices

Reliability

Data-Driven Functionality

Functional Safety

Leverages Cloud

Physical Components

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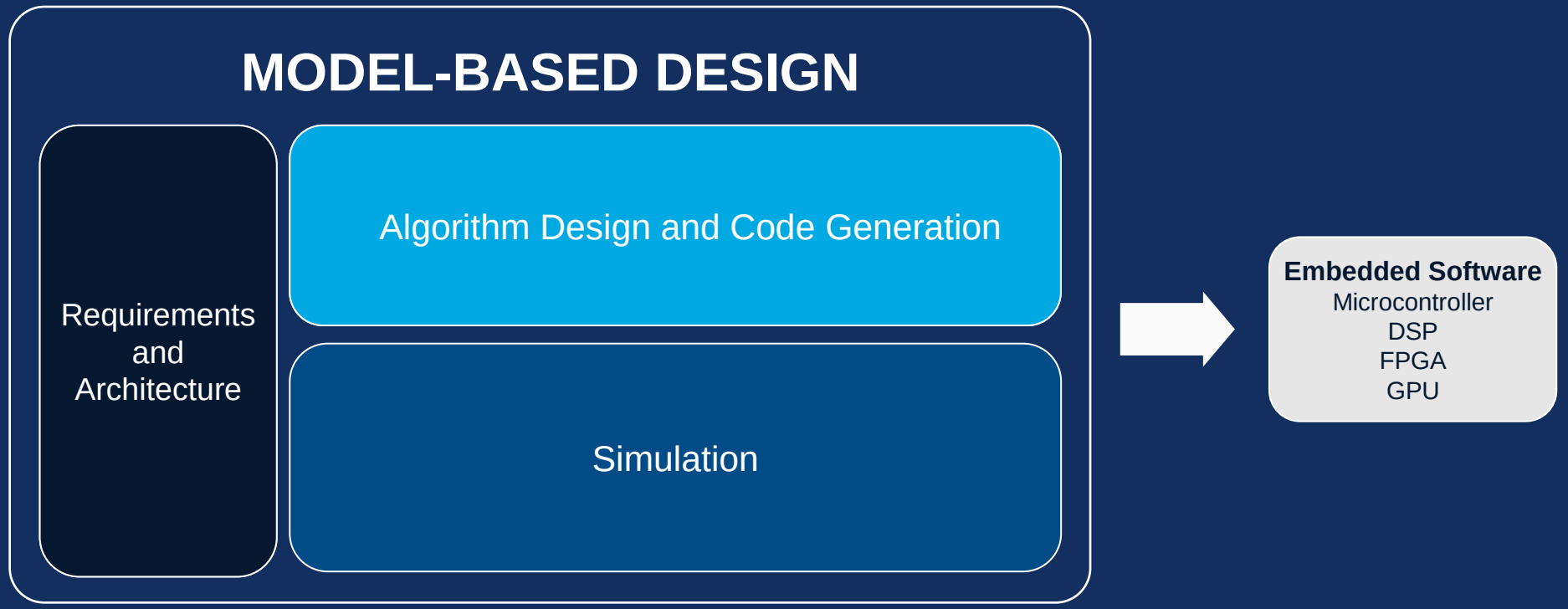
Systems



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Performance Gains using Model-Based Design

Systems

Company	Product	Benefits Claimed
Bosch	eBike Drive Unit	Updated designs ready for retest in 5 minutes
BMW	Body, Chassis, Engine, BMS	Supports Agile development methodology
Geely	Body domain controller	Integration test time reduced by 80% One-time pass rate greater than 90%
Continental	Chassis control	Eliminated 6 months of effort Verification time cut by 50%
LG Electronics	Inverter for EV and HEVs	Verification time reduced by 20%
Kostal	Electronic steering column lock module	Development & certification time cut by 30%
Lear	Body control module	Zero warranty issues reported
SAIC	Hybrid control unit	From concept to production in 18 months
Toyota	Various production ECUs	Development time cut by 50%

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Lear	Body control module	**Zero warranty issues** reported
SAIC	Hybrid control unit	From concept to production in **18 months**
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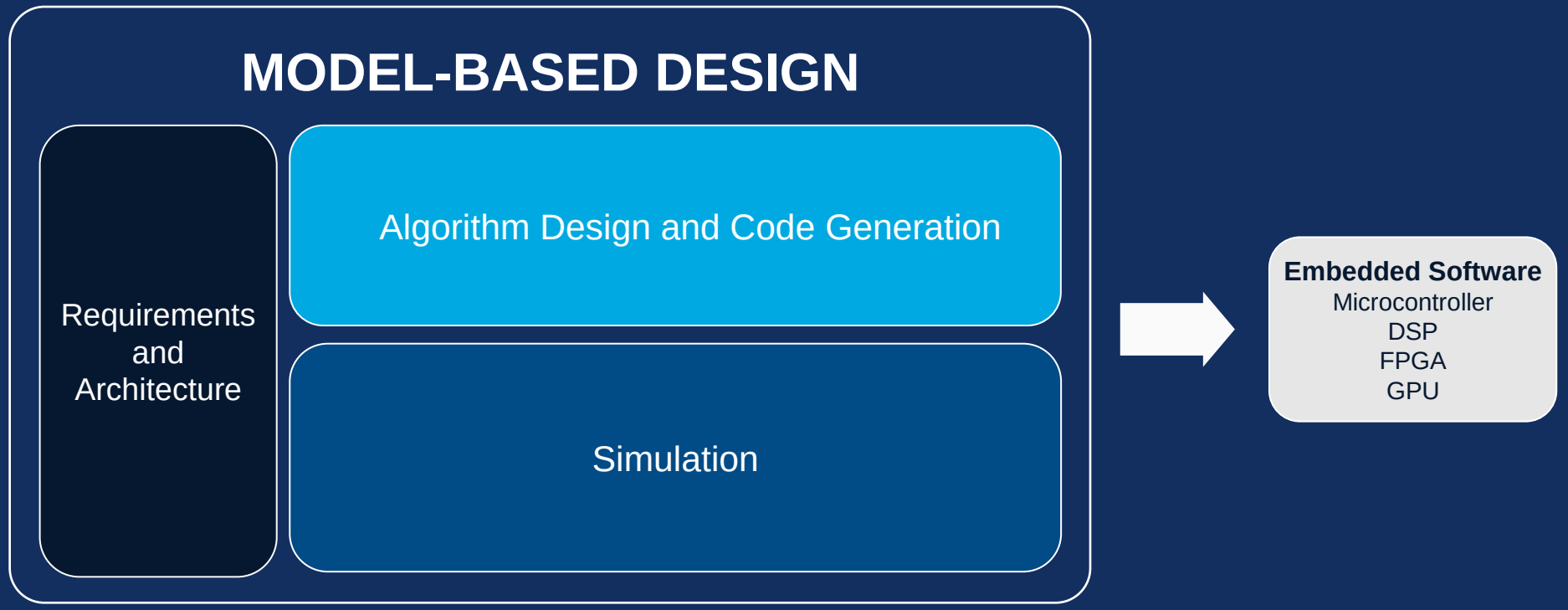
ONVO 乐道

(ONVO: 2nd brand of NIO)

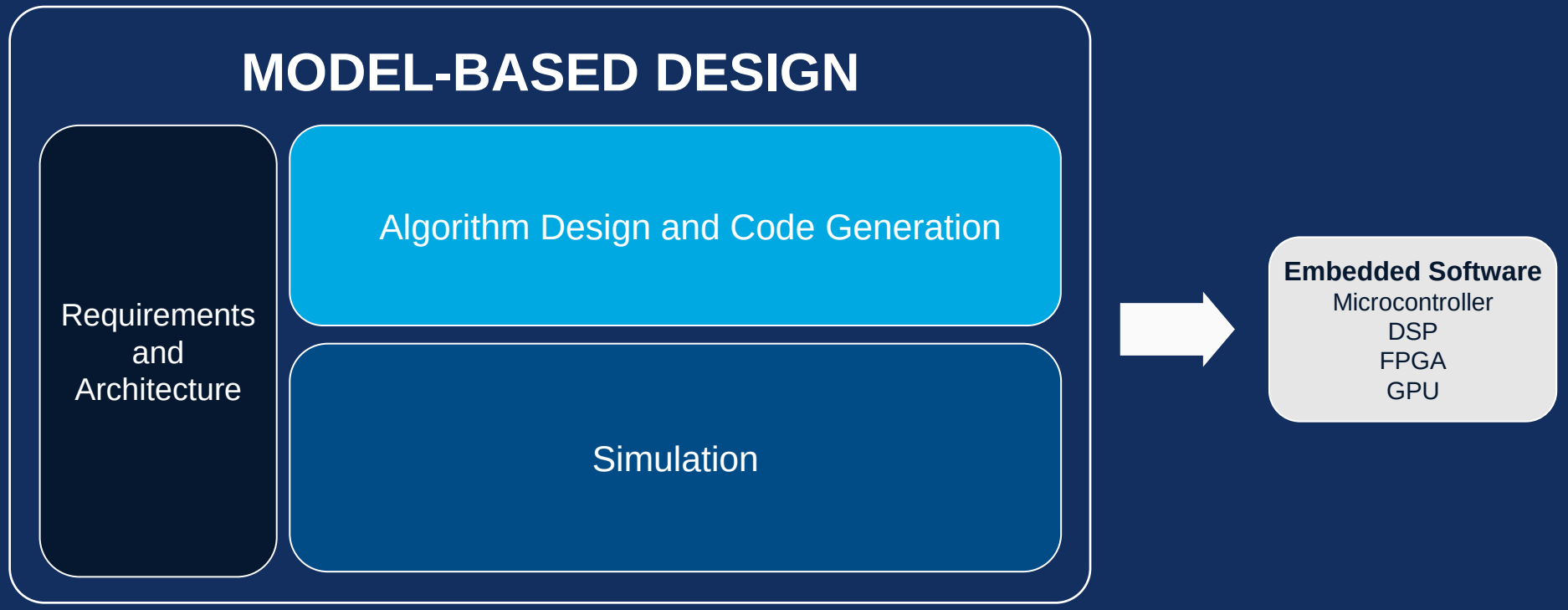
How to Implement Energy and Drive Quality Management of BEV Efficiently and Accurately in MATLAB

1		**Highlights**：8大亮 … 滑控制模型、冷却回路自动切换模型 … 生成APP]。eight key features: [Dynamic … Discharging, Traction Control Model for P … Auto-Configuration/Batch Run Ap … **8 key features Dynamic allocation of motor torque, driver model, intelligent battery charging/discharging, traction control, circuit cooling, ….**
2		**Efficiency**： 仿真 … 等。Simulation efficiency improved by 50%: Highly integrated simulation input, automatic report generation, and automatic data processing, etc. **Simulation efficiency improved by 50%**
3		**Accuracy**： 防真 … 型、整车参数模拟等。Simulation error reduc … quivalent model, controller equivalent model, vehicle parameter simulation, etc. **Simulation error reduced to as low as 1%**
4		**Scenarios**： 动力 … 仿真工况、热管理模块等。24 power simulation s … of electric drives, vehicle controllers, sin … **24 power simulation scenarios and 8 efficiency simulation scenarios**


MODEL-BASED DESIGN
Requirements and Architecture
Algorithm Design and Code Generation
Simulation
Embedded Software
Microcontroller
DSP
FPGA
GPU

7 Types of Waste (Muda)

1. Transportation
2. Inventory
3. Motion
4. Waiting
5. Over-Processing
6. Over-Production
7. Defects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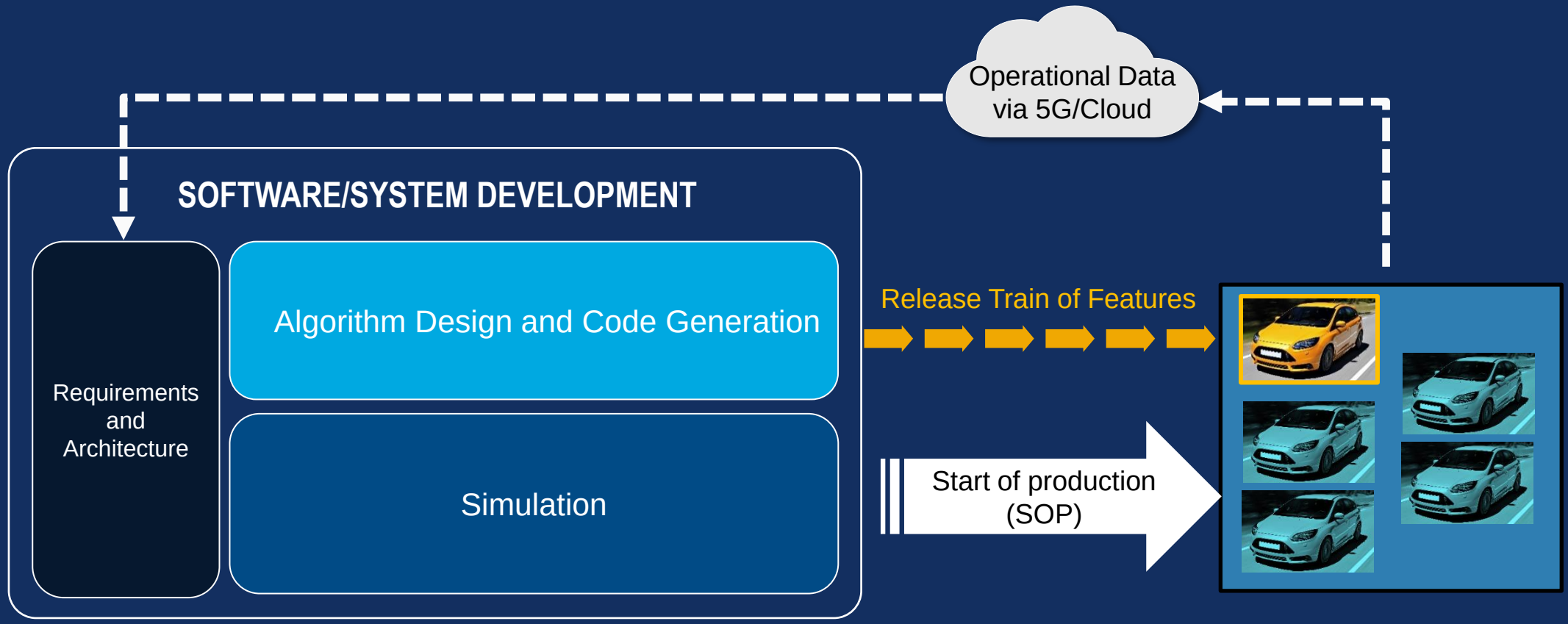
FPGA
GPU


Operational Data
via 5G/Cloud
SOFTWARE/SYSTEM DEVELOPMENT
Requirements
and
Architecture
Algorithm Design and Code Generation
Simulation
Release Train of Features
Start of production
(SOP)

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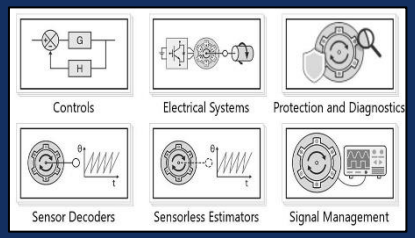
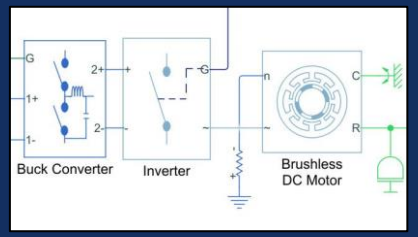
Systems

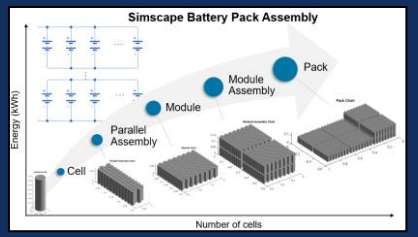
MATLAB® & SIMULINK®



Motor Control Blockset



Simscape Electrical



Simscape Battery

Embedded Coder
HDL Coder

MODEL-BASED DESIGN

Requirements and Architecture

Algorithm Design and Code Generation

Simulation


Full System


Components

Embedded Software
Microcontroller
DSP
FPGA
GPU

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Systems

MATLAB® & SIMULINK®

C++ | DDS | python™

Magnetics | Thermal | fmi

ROS 2™ | NVIDIA | PyTorch

AI Frameworks

MODEL-BASED DESIGN

Requirements and Architecture

Algorithm Design and Code Generation

Simulation

Full System

Components

Embedded Software
Microcontroller
DSP
FPGA
GPU

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Systems

MODEL-BASED DESIGN

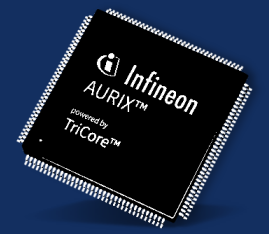
Requirements and Architecture

Algorithm Design and Code Generation

Simulation

Full System

Components



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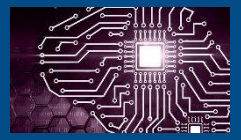
Systems

MODEL-BASED DESIGN

Requirements and Architecture

Algorithm Design and Code Generation

Simulation



Virtual Processor in Synopsys Virtualizer

Full System

Components

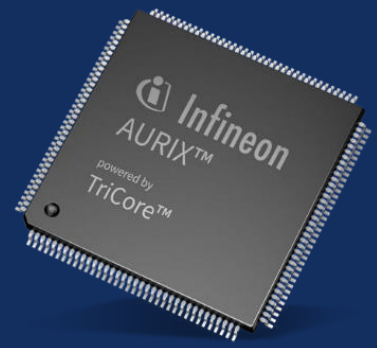
Infineon

OPTIMIZE RIGHT

MathWorks

SHIFT LEFT

SYNOPSYS®



Infineon
AURIX™
microcontroller

MathWorks®

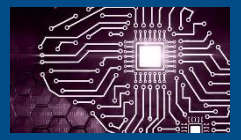
Systems

MODEL-BASED DESIGN

Requirements and Architecture

Algorithm Design and Code Generation

Simulation



Virtual Processor in Hexagon Simulator

Full System

Components

Qualcomm

OPTIMIZE RIGHT

MathWorks

SHIFT LEFT

Qualcomm

Snapdragon

Qualcomm®
Hexagon™ NPU
for Snapdragon

MathWorks

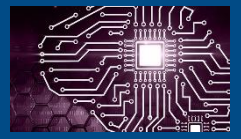
Systems

MODEL-BASED DESIGN

Requirements and Architecture

Algorithm Design and Code Generation

Simulation



Virtual Processor

Full System

Components

Embedded Systems
Microcontroller
DSP
FPGA
GPU

MathWorks®

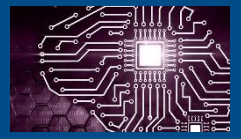
Systems

MODEL-BASED DESIGN

Requirements and Architecture

Algorithm Design and Code Generation

Simulation



Virtual Processor

Full System

Components

In-vehicle HPC
Microprocessor

Embedded Systems
Microcontroller
DSP
FPGA
GPU

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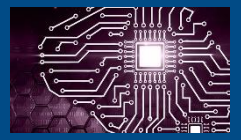
Systems

MODEL-BASED DESIGN

Requirements and Architecture

Algorithm Design and Code Generation

Simulation



Virtual Processor functionality from NXP

Full System

Components

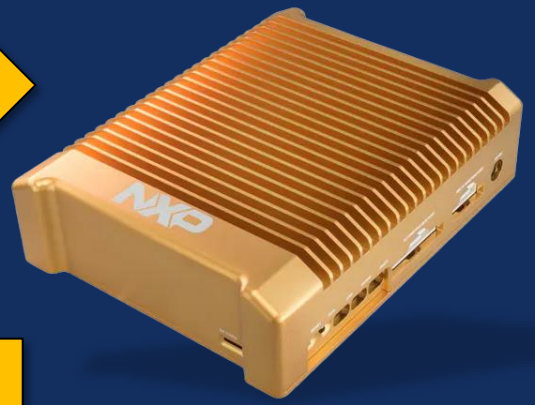
NXP

OPTIMIZE RIGHT

MathWorks

SHIFT LEFT

NXP



NXP® GoldBox for in-vehicle HPC

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Systems

MODEL-BASED DESIGN

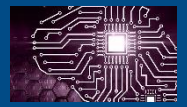
Requirements and Architecture

Algorithm Design and Code Generation

Simulation


Full System


Components


Virtual Processor

Embedded Systems
Microcontroller
DSP
FPGA
GPU

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ZEEKR

Design and testing of service-oriented vehicle application software based on model development

Combines ZEEKR ARK OS with MATLAB/Simulink

- **Automatically generate** a service-oriented framework model based on service information
- **Encapsulate** the ZEEKR ARK OS middleware module
- **Generate** Simulink code and **integrate** into ZEEKR ARK OS
- **Leverage** the ZEEKR ARK OS software development and testing toolkit for code testing

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Systems

MODEL-BASED DESIGN

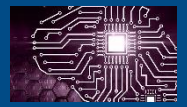
Requirements and Architecture

Algorithm Design and Code Generation

Simulation


Full System


Components


Virtual Processor

Embedded Systems
Microcontroller
DSP
FPGA
GPU

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Systems

MODEL-BASED DESIGN

Requirements and Architecture

System Composer

requirements and traceability

system decomposition

system analysis and optimization

SOA definitions

cost 800 USD
weight 2 lbs
power 150 W

Algorithm Design and Code Generation

Test and Verification

Embedded Systems
Microcontroller
DSP
FPGA
GPU

Simulink Test
verification

Simulink Fault Analyzer
safety, security, reliability

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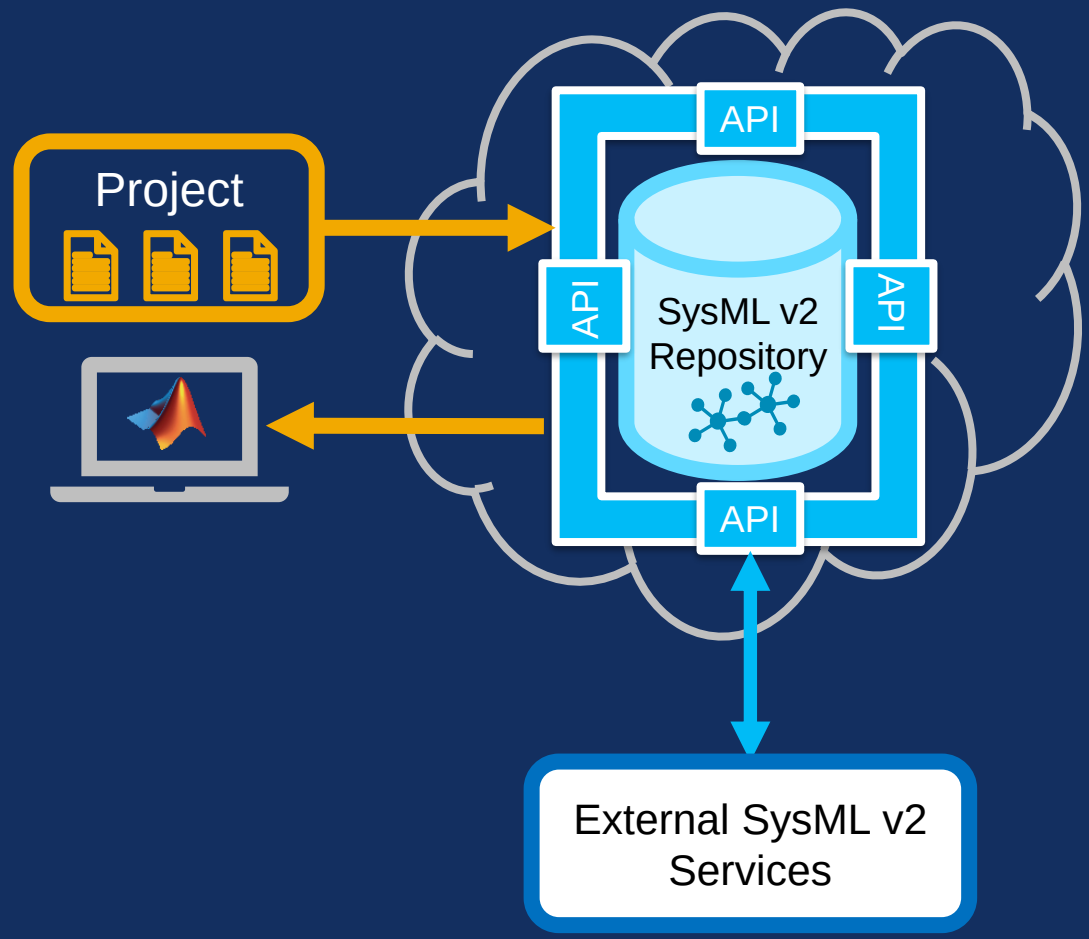
Supporting the SysML v2 standard

- System Composer is already well-aligned with the modeling and semantic concepts of SysML v2
- We plan to provide access to System Composer model data through SysML v2 RESTful APIs
- Interoperability is our top priority



MODEL-BASED DESIGN

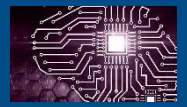
Requirements and Architecture

Algorithm Design and Code Generation

Simulation


Full System


Components


Virtual Processor

On-board HPC
Microprocessor

Embedded Systems
Microcontroller
DSP
FPGA
GPU

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Systems

RoadRunner Scenario

Construction site

MODEL-BASED DESIGN

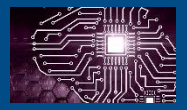
Requirements and Architecture

Algorithm Design and Code Generation

Simulation


Full System


Components


Virtual Processor


Scenarios

On-board HPC
Microprocessor

Embedded Systems
Microcontroller
DSP
FPGA
GPU

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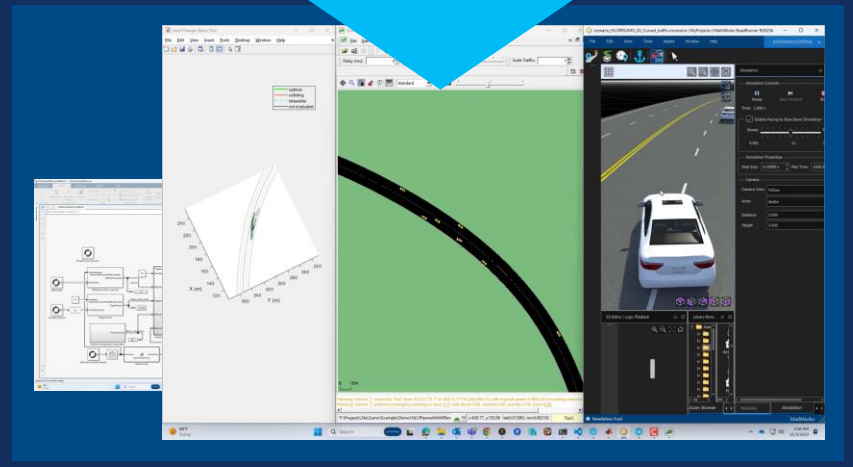
RoadRunner Scenario

ASAM OpenSCENARIO

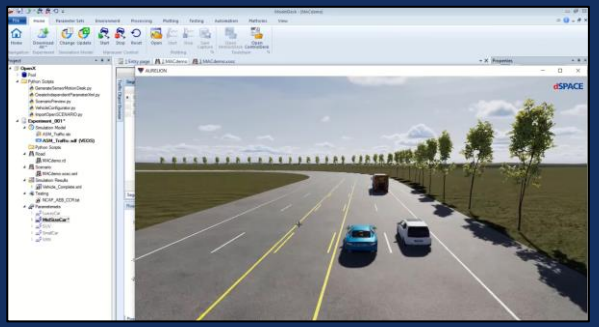
Direct Interface



Simulink + Unreal

CARLA

IPG CarMaker



dSPACE AURELION

esmini

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Systems

MODEL-BASED DESIGN

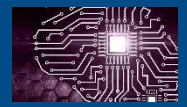
Requirements and Architecture

Algorithm Design and Code Generation

Simulation


Full System


Components


Virtual Processor


Scenarios

On-board HPC
Microprocessor

Embedded Systems
Microcontroller
DSP
FPGA
GPU

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Software-Defined Vehicles

Modern Software Practices

Reliability

Data-Driven Functionality

Functional Safety

Leverages Cloud

Physical Components

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Software-Defined Vehicles

Modern Software Practices
- Fast development
- Frequent releases
- High automation

Data-Driven Functionality

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Functional Safety

Physical Components

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+ Systems

SOFTWARE FACTORY

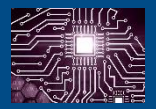
- Code-Based Development
- DevOps and CI Platforms

MODEL-BASED DESIGN

- Requirements and Architecture
- Algorithm Design and Code Generation
- Simulation


Full System


Components


Virtual Processor


Scenarios

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+ Systems

SOFTWARE FACTORY

MODEL-BASED DESIGN

Requirements and Architecture

Code-Based Development

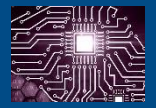
DevOps and CI Platforms

Algorithm Design and Code Generation

Virtualization


Full System


Components


Virtual Processor


Scenarios

MathWorks®

+ Systems

SOFTWARE FACTORY

MODEL-BASED DESIGN

Requirements and Architecture

Code-Based Development

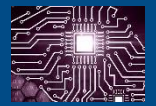
DevOps and CI Platforms

Algorithm Design and Code Generation

Virtualization


Full System


Components


Virtual Processor


Scenarios

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SOFTWARE FACTORY

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Requirements and Architecture

Code-Based Development

DevOps and CI Platforms

Algorithm Design and Code Generation

Virtualization


Full System


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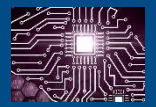
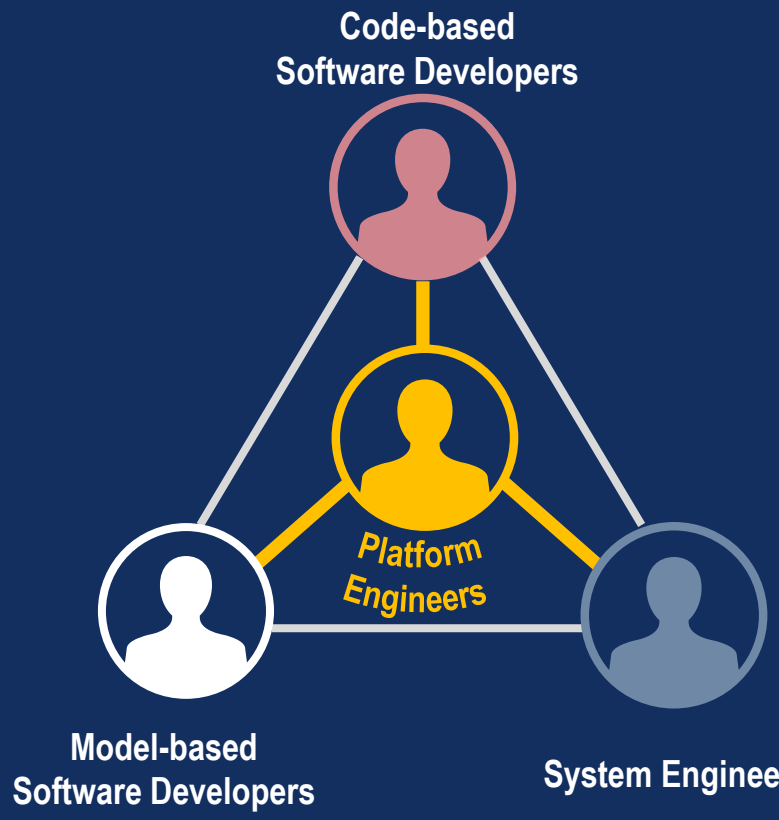

Virtual Processor


Scenarios

MathWorks

+ Systems

Empowering Platform Engineers: Accelerating MATLAB Startup with Custom Cloud Images



MATLAB Cold-Start start-up time: 1~~2 minutes~~!

1 minute → 25 seconds

Point platform engineers to MathWorks Reference Architectures on GitHub

Search "**matlab github packer**"

DevOps and CI Platforms

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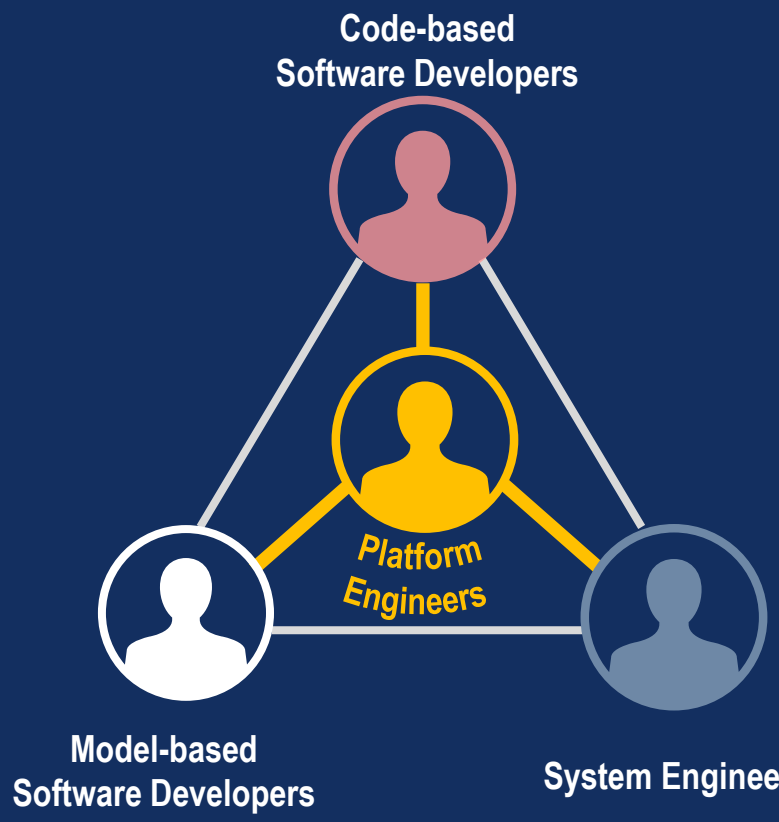
Integrations to Leverage Data, DevOps, and Cloud

+ Systems



Cassandra
Neo4j
Prometheus
Databricks
Domino Data Lab
MQTT
AWS DynamoDB
Azure BLOB Storage
AWS Athena
Spark
OPC UA
AWS S3
Hadoop
MongoDB
OpenTelemetry
AVEVA PI
PostgreSQL
Azure Cosmos DB
TIBCO Spotfire
Kafka
Google Storage
Google BigQuery
Azure Data Lake
Azure HDInsight
Azure Keyvault
RabbitMQ
Cloudera Data Platform
Tableau
Power BI
Modbus
Apache Ambari

DevOps and CI Platforms

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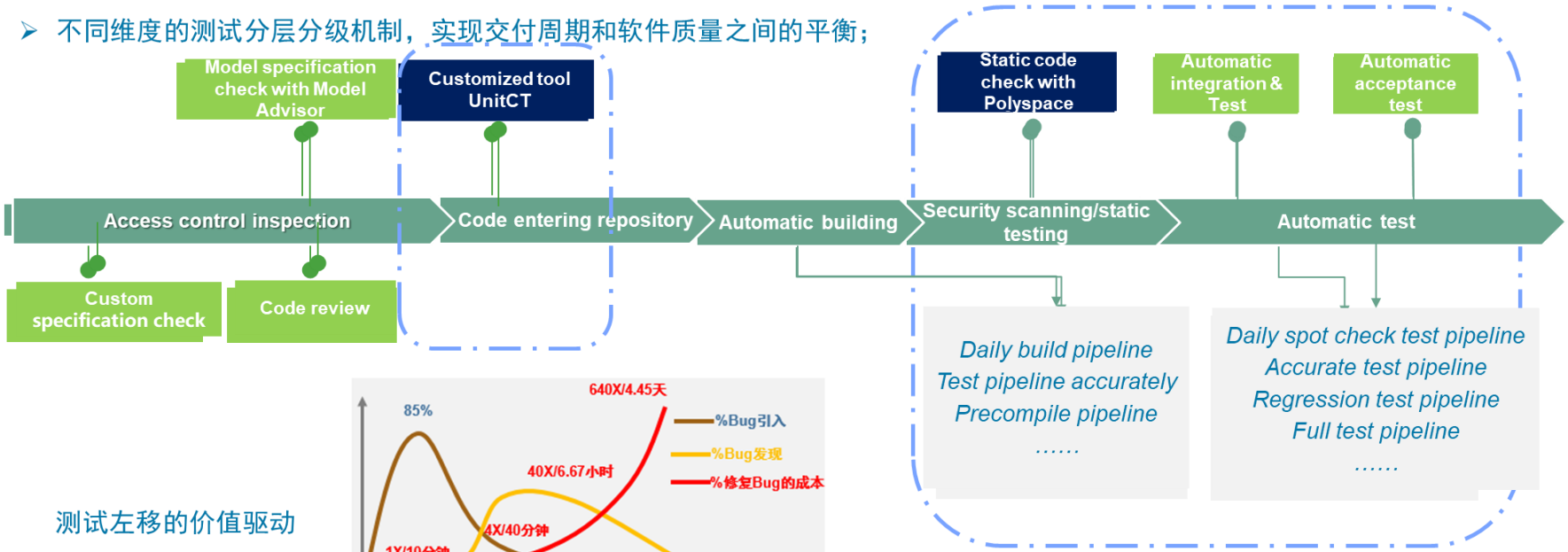
19th Asian Games Hangzhou 2022

GEELY 吉利控股集团

DevOps Empowering software development quality improvement

Simulink accelerates CICT to build a protective net of software quality

- 软件开发V模型右侧，全部实现自动化测试，提高软件开发效率；
- CICT环节，实现自动化流转和反馈机制，持续迭代和反馈；
- 不同维度的测试分层分级机制，实现交付周期和软件质量之间的平衡；



测试左移的价值驱动

《Software Engineering Economics》*调查结果表明，在软件开发早期阶段发现问题的解决成本要远远低于功能测试/软件释放后的解决成本。因此，通过**加强软件单元测试环节**以达到**测试左移**/测试前置，是**降低后期问题解决成本**的有效途径。

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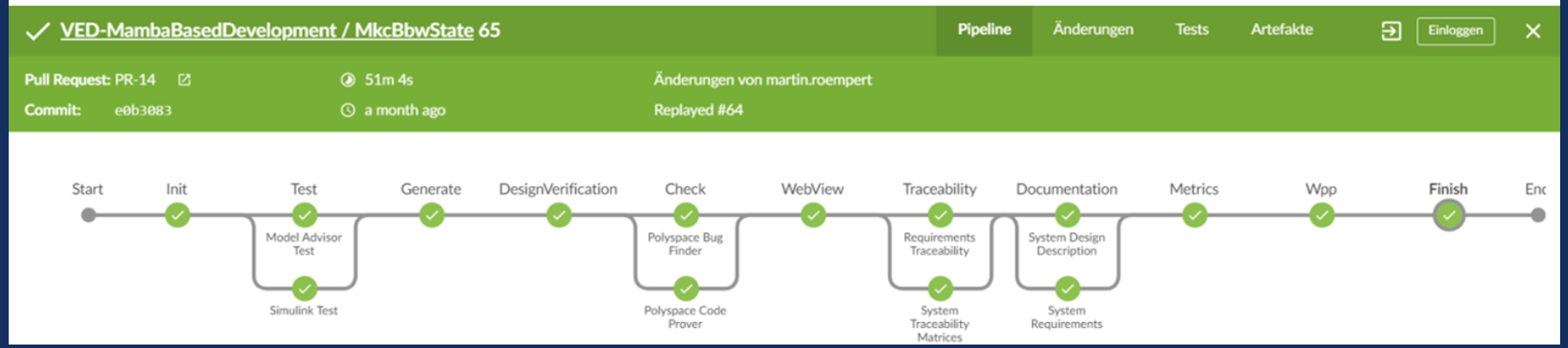
Continental: Software Factory and Model-Based Design

Initial CI Pipeline - Jenkins

- Source Control
- Repository Handling
- Automation
- Implementation
- Artifacts Handling

CI/CD 2.0: From Scripted Jenkins Pipelines to Process Advisor



Software-Defined Vehicles

Modern Software Practices

Reliability

Data-Driven Functionality

Functional Safety

Leverages Cloud

Physical Components

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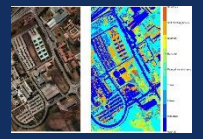
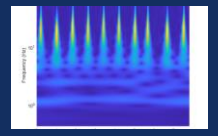
Design **AI** into your system

+ Systems

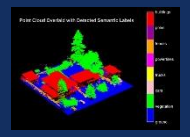
AI Reference Examples

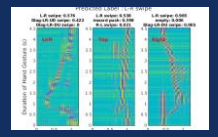
Predictive Maintenance

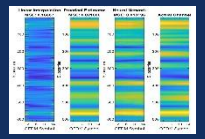

Hyperspectral Imaging


Signal Processing

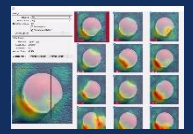

Robotic Control

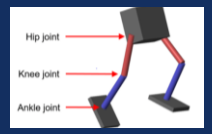

Lidar Processing


Radar Processing

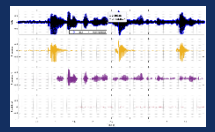

Wireless Communications

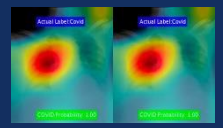

Automated Driving

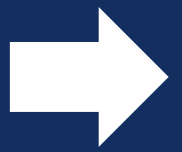

Visual Inspection



Reinforcement Learning


Audio


Medical Imaging



CPU

GPU

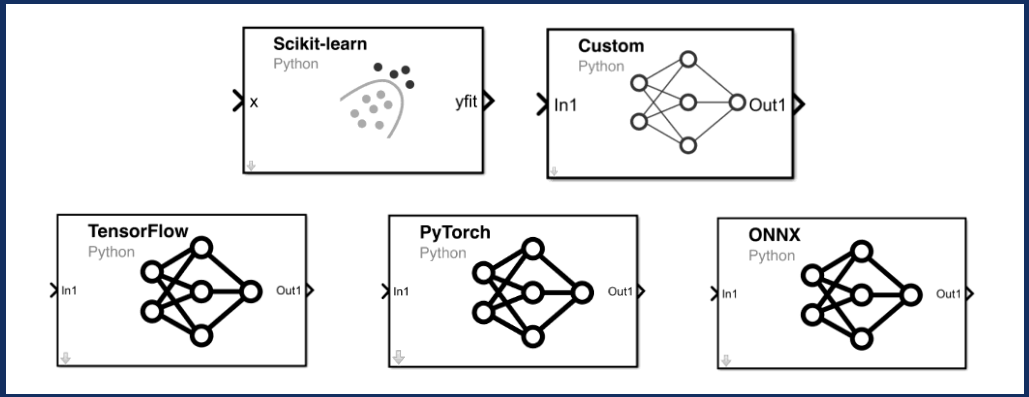
FPGA

MathWorks®

+ Systems

If your AI model is created with PyTorch, integrate it into MATLAB and Simulink

Integrate AI models in a Simulink system design for Model-Based Design



MATLAB works with TensorFlow, PyTorch, and Python:

- Co-execution
- Model converters
- MATLAB Deep Learning Model Hub

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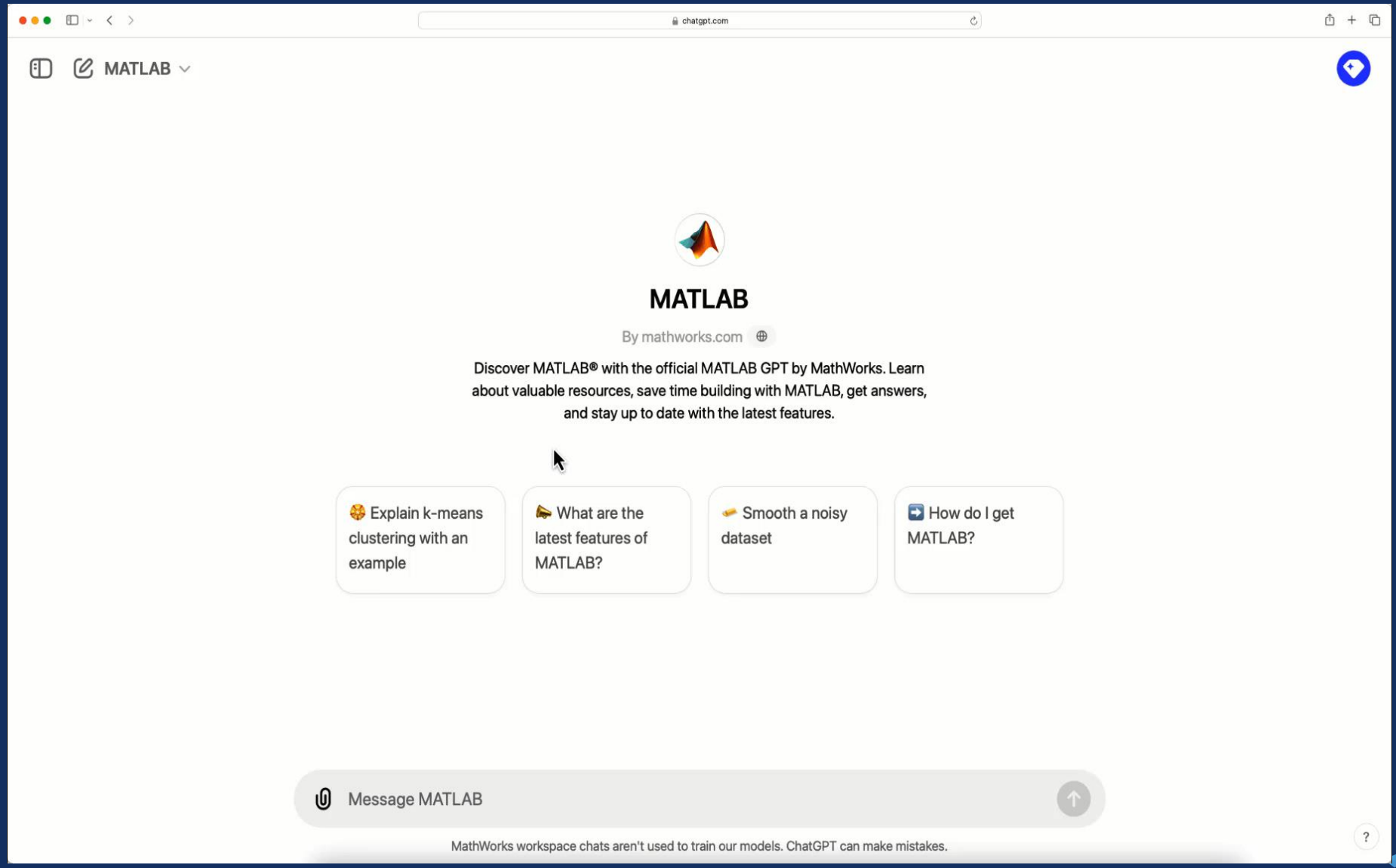
Generative AI for MATLAB MATLAB GPT for ChatGPT



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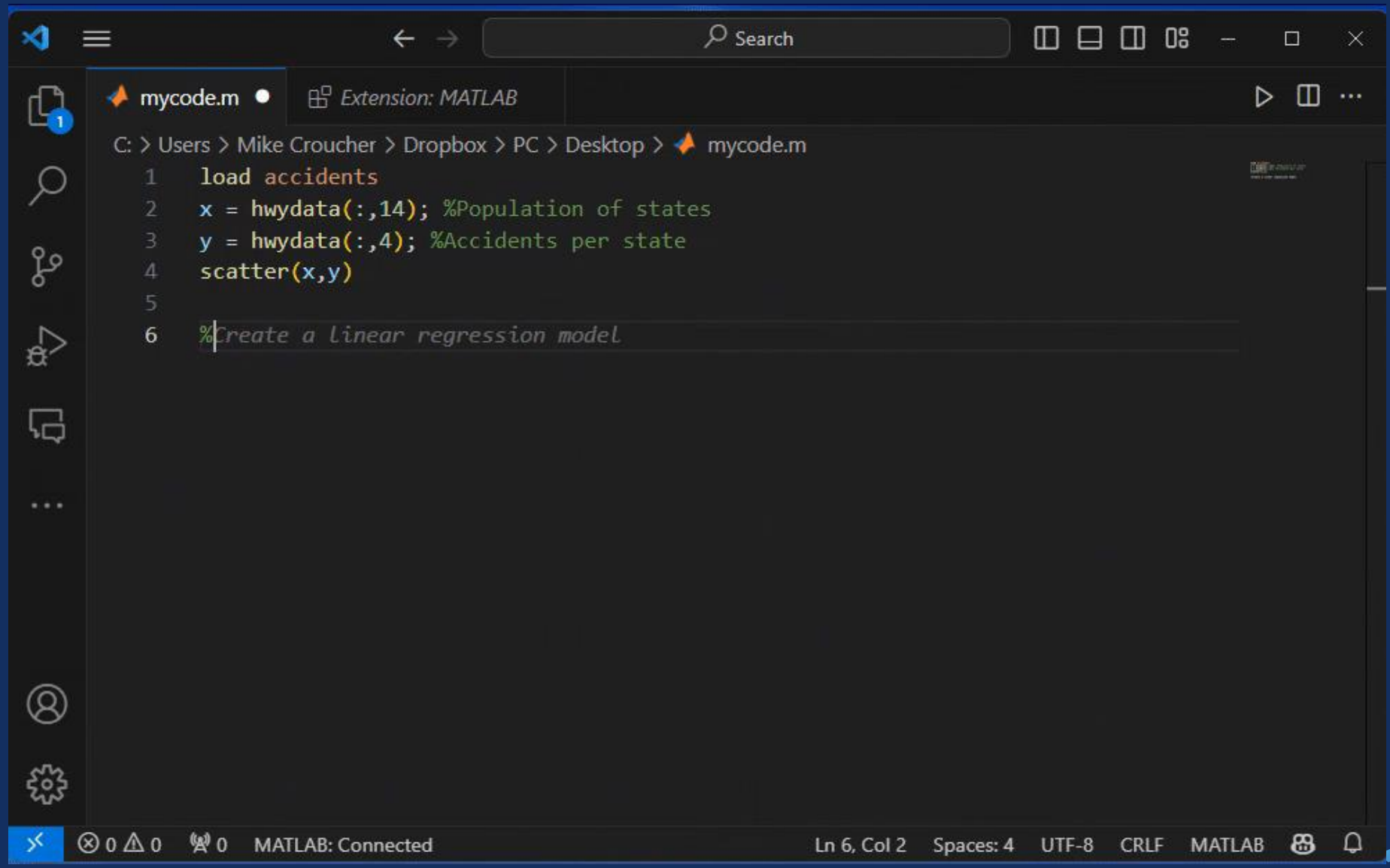
Generative AI for MATLAB MATLAB Extension for Visual Studio Code



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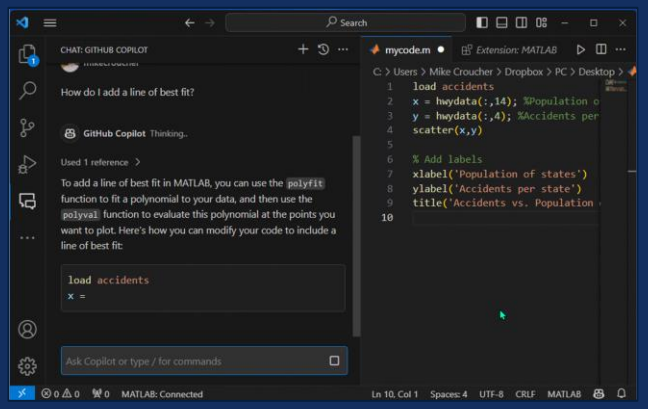
Visual Studio Code screenshots used with permission from Microsoft

Generative AI for MATLAB

Available at OpenAI GPT Store

MATLAB GPT for ChatGPT

Available at Visual Studio Marketplace



MATLAB Extension for VS Code

Customer Talk Today

TATA ServiceSage: A Gen AI-Based RCA Chat Assistant
Bhakti Kalghatgi and Shubham Gupta, *Tata Motors*

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Visual Studio Code screenshots used with permission from Microsoft

Generative AI for MATLAB, Simulink, and Polyspace

In development:
MATLAB Copilot

Planned 2025

In development:
Simulink Copilot

Planned 2025

In development:
Polyspace Copilot

Planned 2025

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Visual Studio Code screenshots used with permission from Microsoft

Software-Defined Vehicles

Modern Software Practices

Reliability

Data-Driven Functionality

Functional Safety

Leverages Cloud

Physical Components

MathWorks®

+ Systems

Leveraging Cloud for Scale and Automation

SOFTWARE FACTORY

MODEL-BASED DESIGN

Requirements and Architecture

Code-Based Development

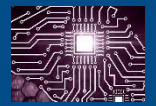
DevOps and CI Platforms

Algorithm Design and Code Generation

Virtualization


Full System


Components


Virtual Processor


Scenarios

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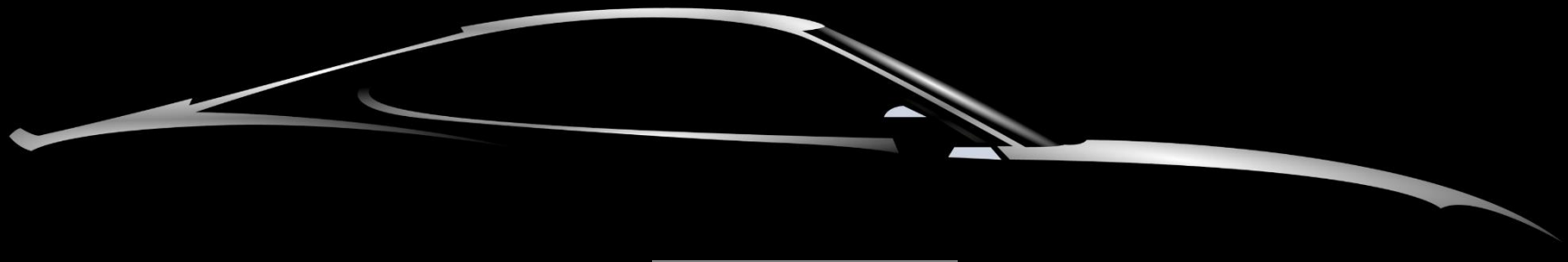
+ Systems

Can we quickly develop a major feature with no hardware changes, leveraging the cloud?

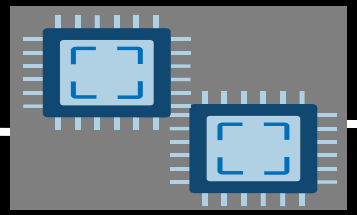
"**Sport+**" Mode

▲ Reduce 0-60mph time

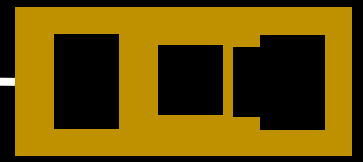
↔ Minimum Range Change



Infotainment System (IVI)
QM



Vehicle Control Unit (HPC)
ASIL-B



Battery Management (Embedded Edge)
ASIL-D

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Leveraging the Cloud

+ Systems

Automotive Software Development in the Cloud

aws FOR AUTOMOTIVE

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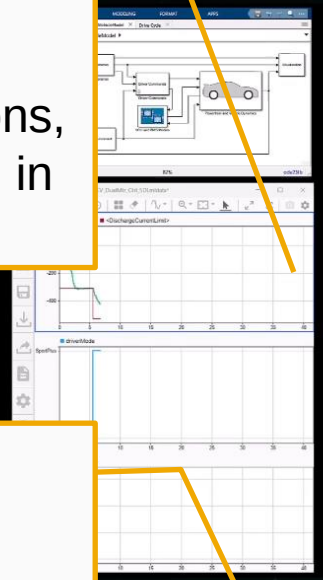
MATLAB & Simulink



Elektrobit

SYNOPSYS®

- Run parallel simulations
- Automate model checks, simulations, report generation in CI pipelines

- Automatically generate code, interactively or in CI pipeline

- Invoke function from instrument cluster

- Integrate application code with production middleware

- Integrate with detailed virtual ECU

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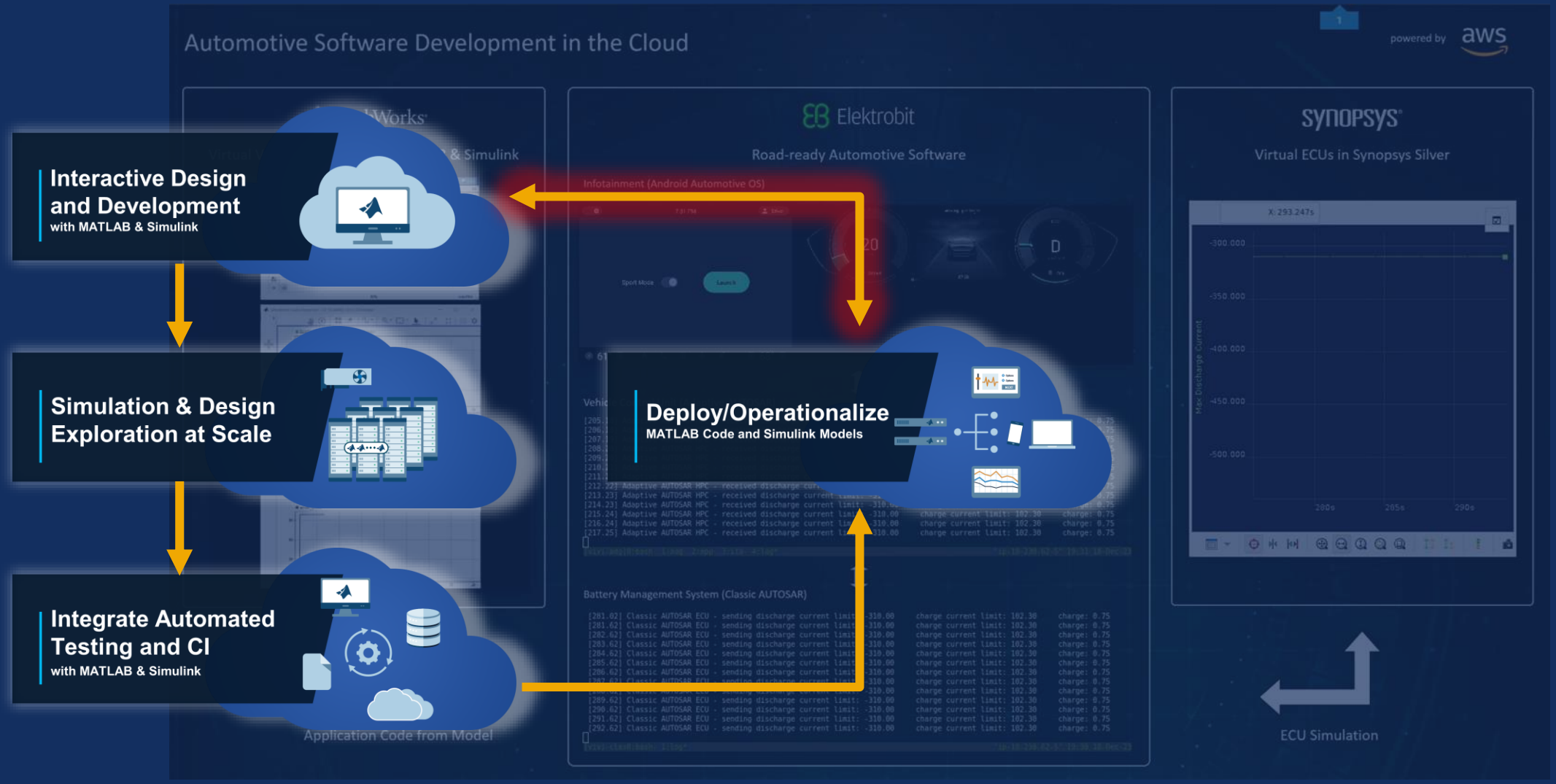
+ Systems



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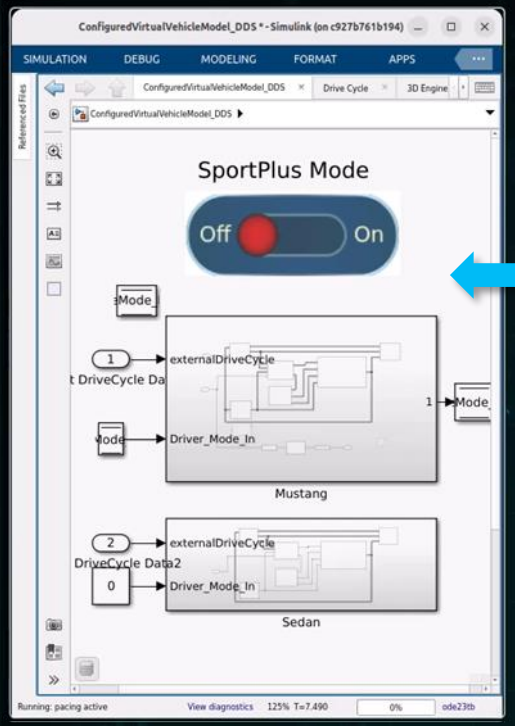
+ Systems

Automotive Software Development in the Cloud

powered by aws

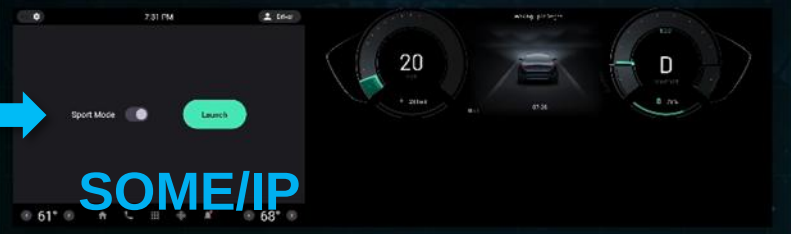


Application Code from Model

Elektrobit

Road-ready Automotive Software

Infotainment (Android Automotive OS)



synopsys

Virtual ECUs in Synopsys Silver

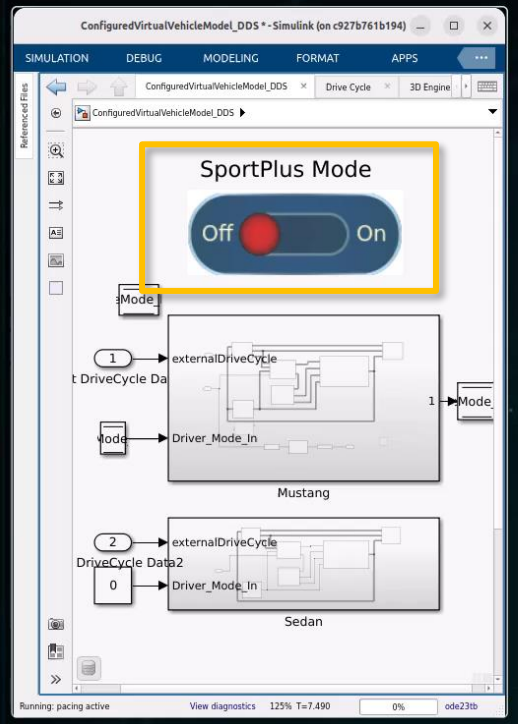
ECU Simulation

MathWorks

+ Systems

Automotive Software Development in the Cloud

powered by aws

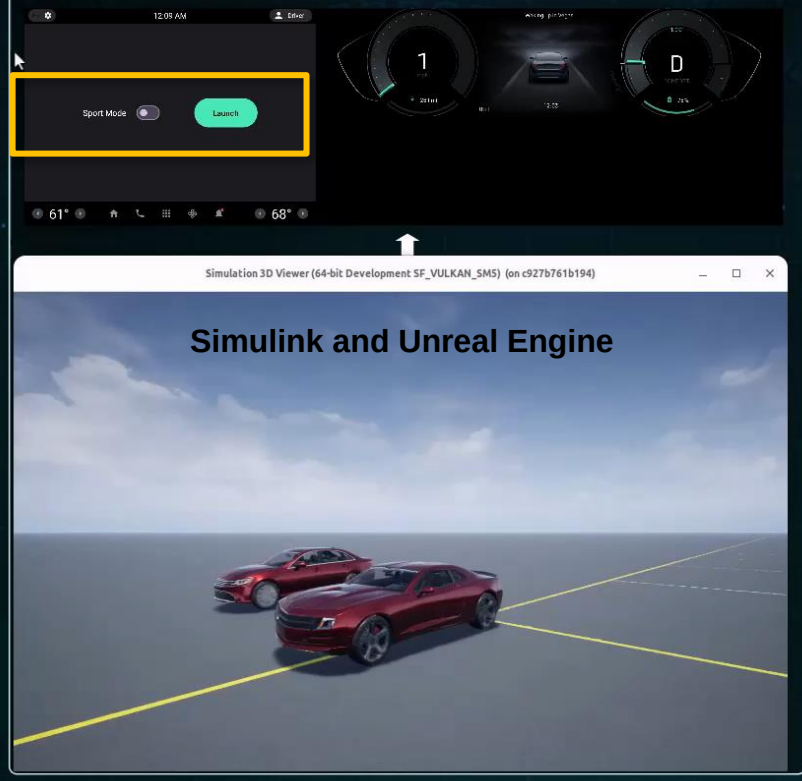


Application Code from Model

Elektrobit

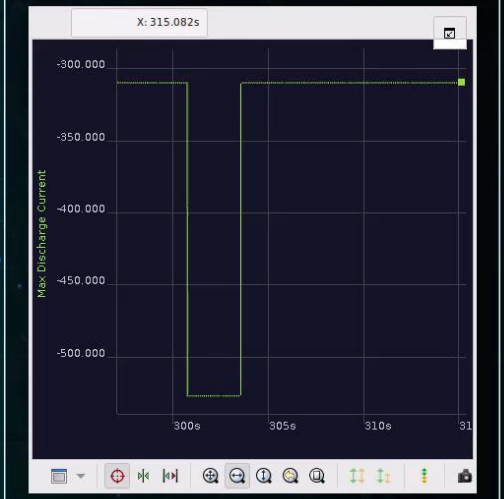
Road-ready Automotive Software

Infotainment (Android Automotive OS)



SYNOPSYS®

Virtual ECUs in Synopsys Silver



ECU Simulation

Background: **Algorithm Only**

Foreground: **Algorithm + Production Middleware + Virtual Processor**

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Software-Defined Vehicles

- Modern Software Practices
- Reliability
- Data-Driven Functionality
- Functional Safety
- Leverages Cloud
- Physical Components

Qualcomm · fmi · SYNOPSYS® · NXP · Elektrobit · python™ · PyTorch · ETAS · Infineon · dSPACE · aws FOR AUTOMOTIVE

Athena · Spark · AWS S3 · Hadoop · MongoDB · AVEVA PI · OpenTelemetry · PostgreSQL · Azure Cosmos DB · TIBCO Spotfire · Kafka · Google Storage · Google BigQuery · Azure Data Lake · Azure HDInsight · Azure Keyvault · RabbitMQ · Cloudera Data Platform · Tableau · Power BI · Modbus · Apache Ambari

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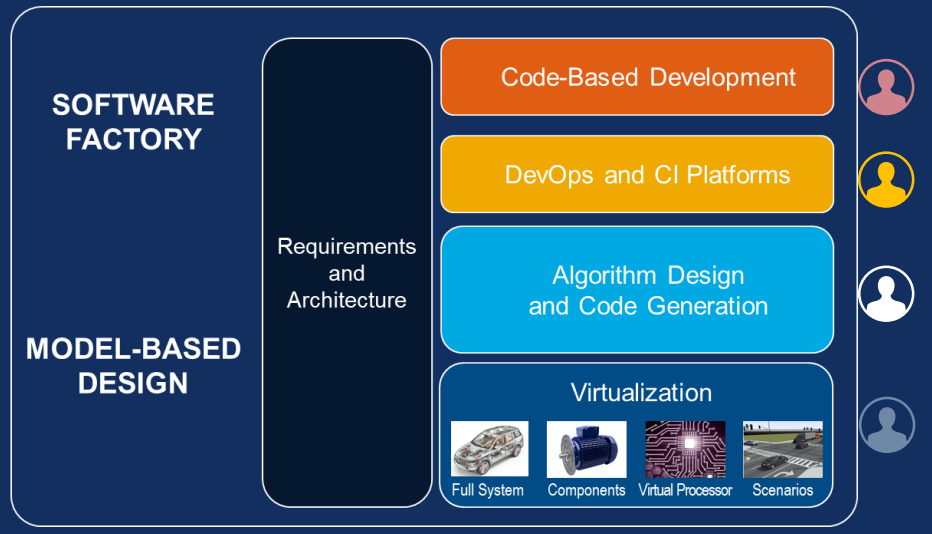
AI in your systems
in our engineering tools



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Integrations, Processes, and Teamwork for SDV

Align systems and software-defined mindsets to plan, and align toolchains to act

Sync up with MathWorks India as we work with your teams around the world

Catch up on our latest capabilities so we can work together to support the shift to SDV

Enjoy the conference!

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Thank you