

MathWorks
AUTOMOTIVE CONFERENCE 2022
India

Evolution of Model-Based Design for Future Mobility

November 16 | Pune



Vijayalayan R, MathWorks

How are Megatrends transforming Automotive R&D?

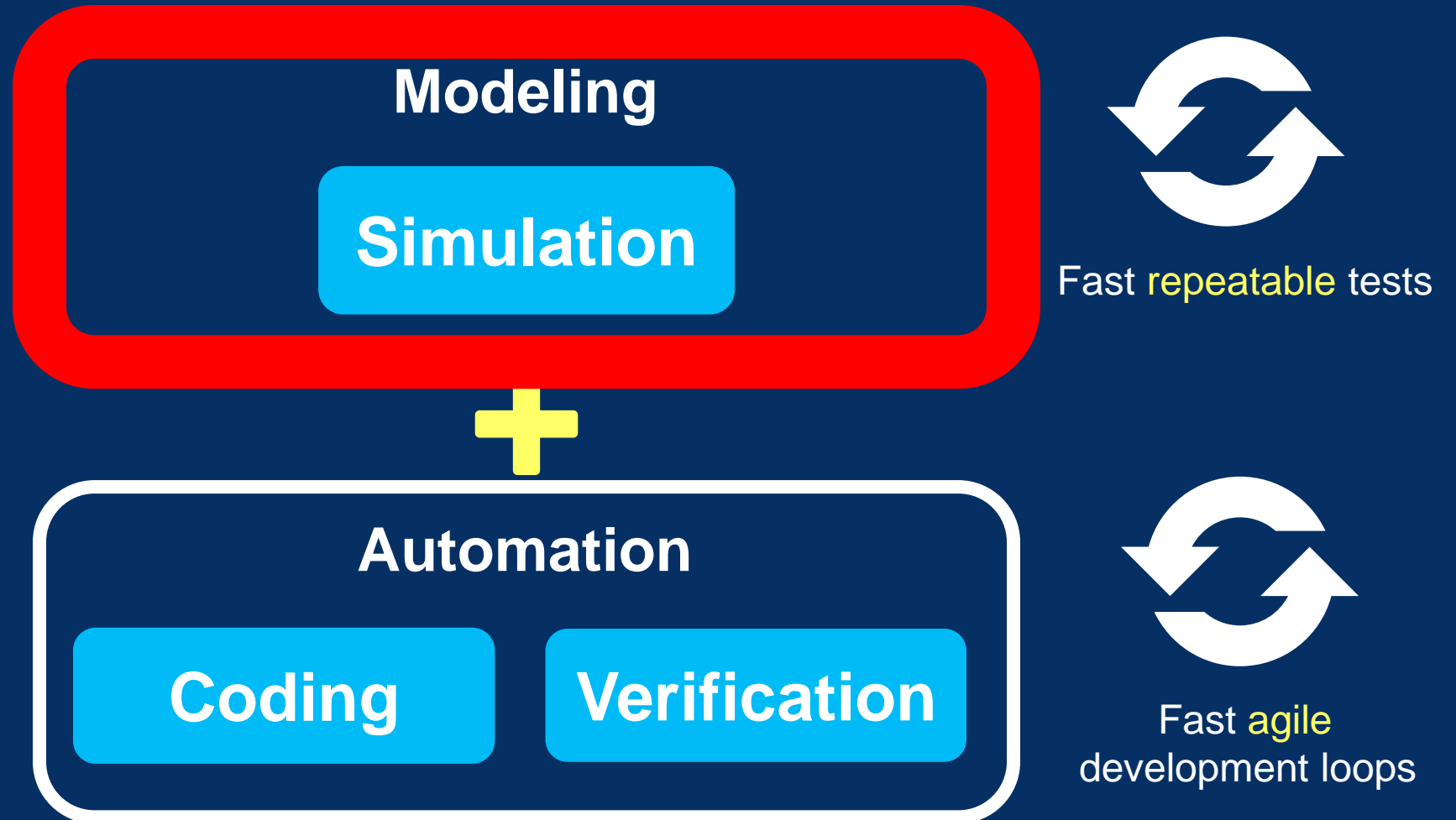


- Need for Virtual Development and Test Grounds
- Handling increasing system and software complexity
- Building innovative features and enhancing existing products
- Workforce mobility and skills

Rise of Model-Based Design

What is Model-Based Design?

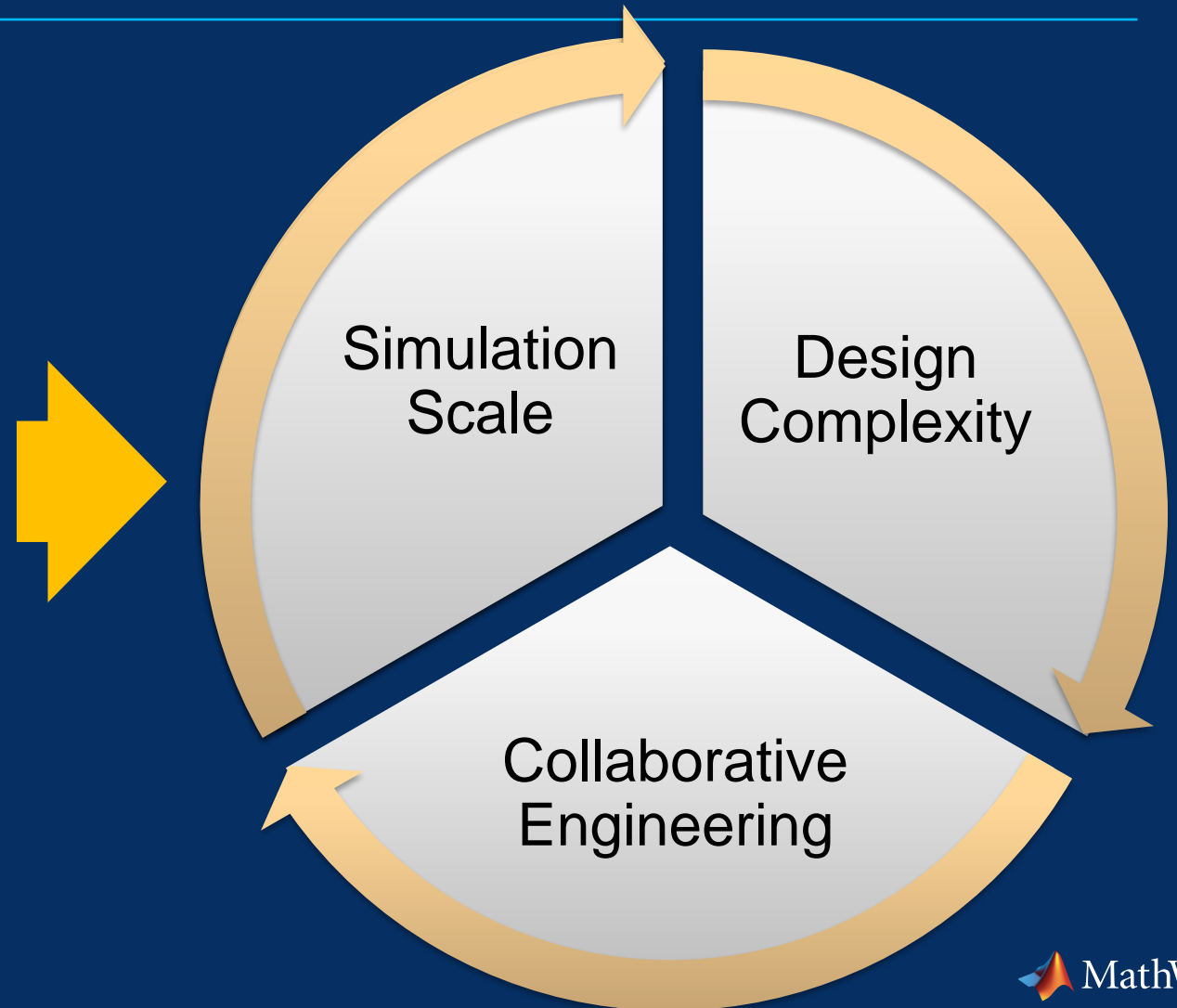
Systematic use of models **throughout** the development process



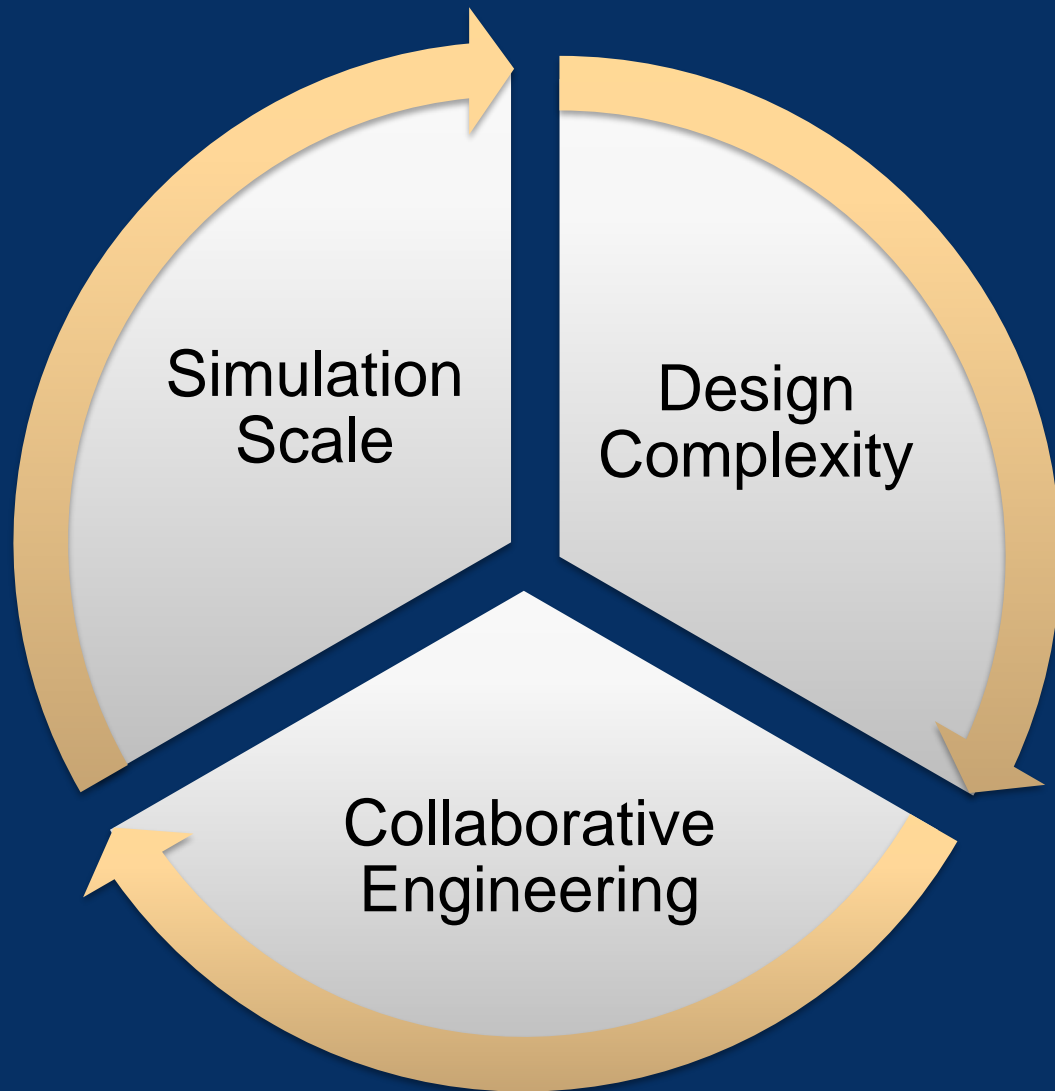
How is Model-Based Design Evolving?

The Three Evolutionary Forces at Play

- Need for Virtual Development and Test Grounds
- Handling increasing system and software complexity
- Building innovative features and enhancing existing products
- Workforce mobility and skills



The Three Evolutionary Forces at Play



Why are these trends important?

What are customers doing today about these trends?

How does Model-Based Design evolve to meet the needs of future mobility?

Trend: Systems → Full Vehicle Simulation



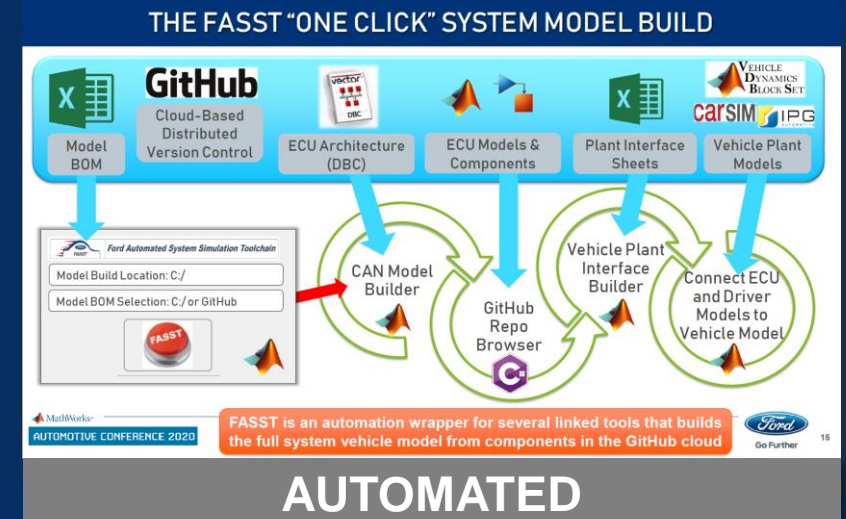
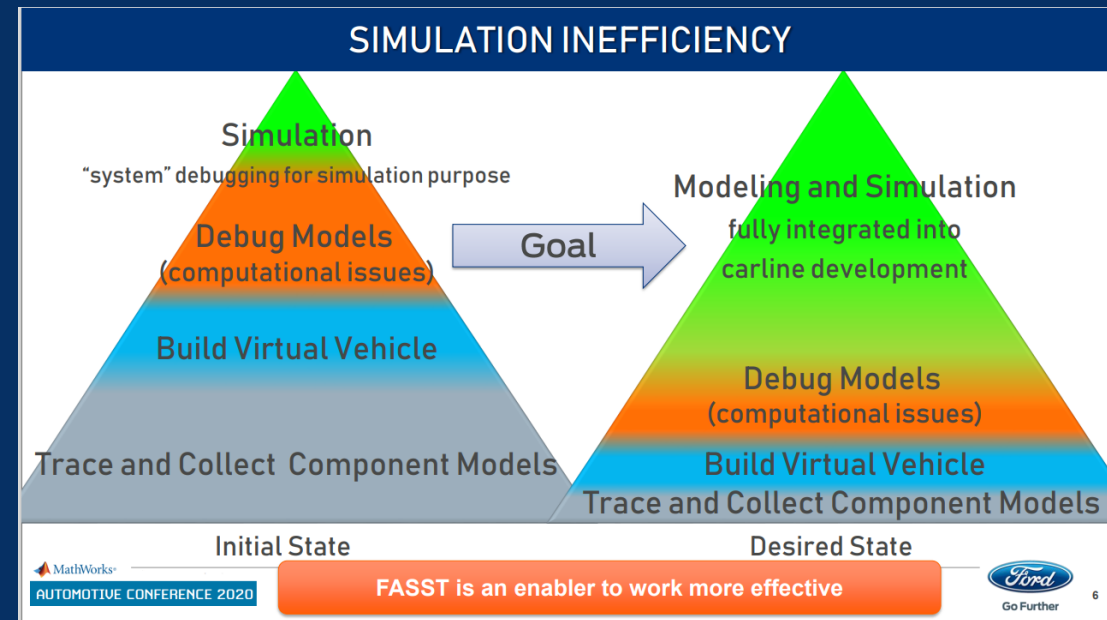
Full Vehicle Simulation

FORD uses an automated system simulation toolchain to build a virtual vehicle in minutes and Detect System Issues Early in Development

Ford & MathWorks collaborated on a standard framework Ford Automated System Simulation Toolchain (FASST) which has 500+ users today

FASST

- reduced virtual vehicle build time from months to minutes
- enabled groups needing to perform different analysis tasks to build their own virtual vehicles



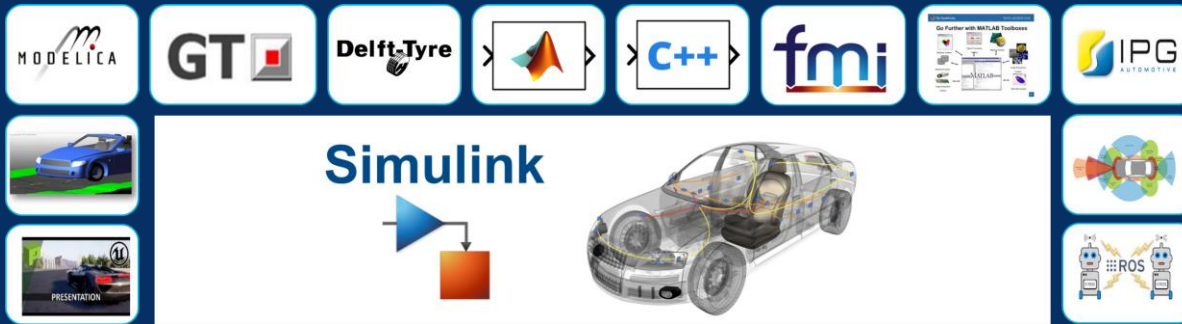
MathWorks Vision for Virtual Vehicle

Every function designer can ***create a virtual vehicle within minutes*** with desired details in physics and software, and prototype, calibrate, and validate their functions in simulation

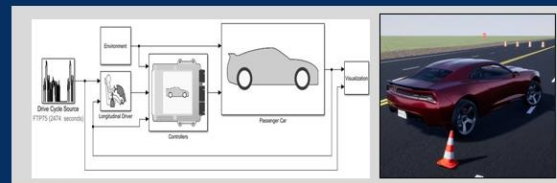
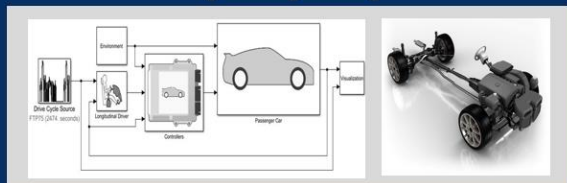
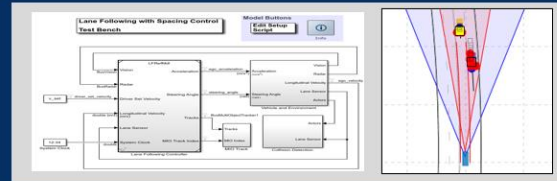
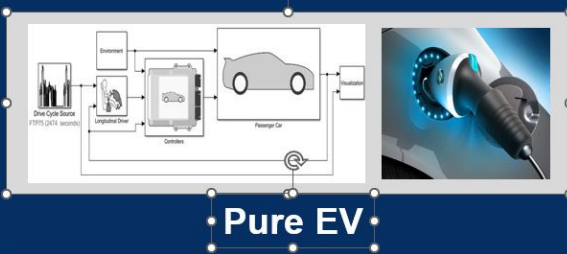
Goals

- Maximize frontloading via simulation
- Deliver rich out-of-box capabilities and openness for tailoring
- Provide world class simulation integration platform (SIP)

How is Simulink evolving?



Automotive Reference Applications



	Parameter N...	Description	Unit	Value
1	PIntVehMass	Vehicle mass	kg	1623
2	PIntVehDstCG...	Longitudinal distance from center ...	m	1.09
3	PIntVehDstCG...	Longitudinal distance from center ...	m	1.7

More details about frontloading of vehicle development using virtual vehicles :

Cross Domain Vehicle Simulation for EV System Analysis & Development

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Lingegowda Aurobindo
Bosch Global Software Technologies

Virtual Development of Battery and BMS

Abhisek Roy, MathWorks



Panel Discussion on Virtualization: Accelerating the future of mobility



Rashmi Gopala Rao, MathWorks
Moderator



Mike Sasena
MathWorks US



Asif Tamboli
TATA Consultancy Services



Neha Mishra
Cummins India Ltd.



Anand Bhang
FEV India Pvt. Ltd.

Validation of AUTOSAR Software via Virtual ECU using MATLAB & Simulink

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Dr. Vivek Venkobarao, Vitesco Technologies



Konstantin Alexeev, Vitesco Technologies

Trend: Simulating Environment → **Simulating Scenarios**



Scenario Simulations for Autonomy

PORSCHE: ADAS/AD virtual platform for end-to-end software development, testing and validation

Challenge :

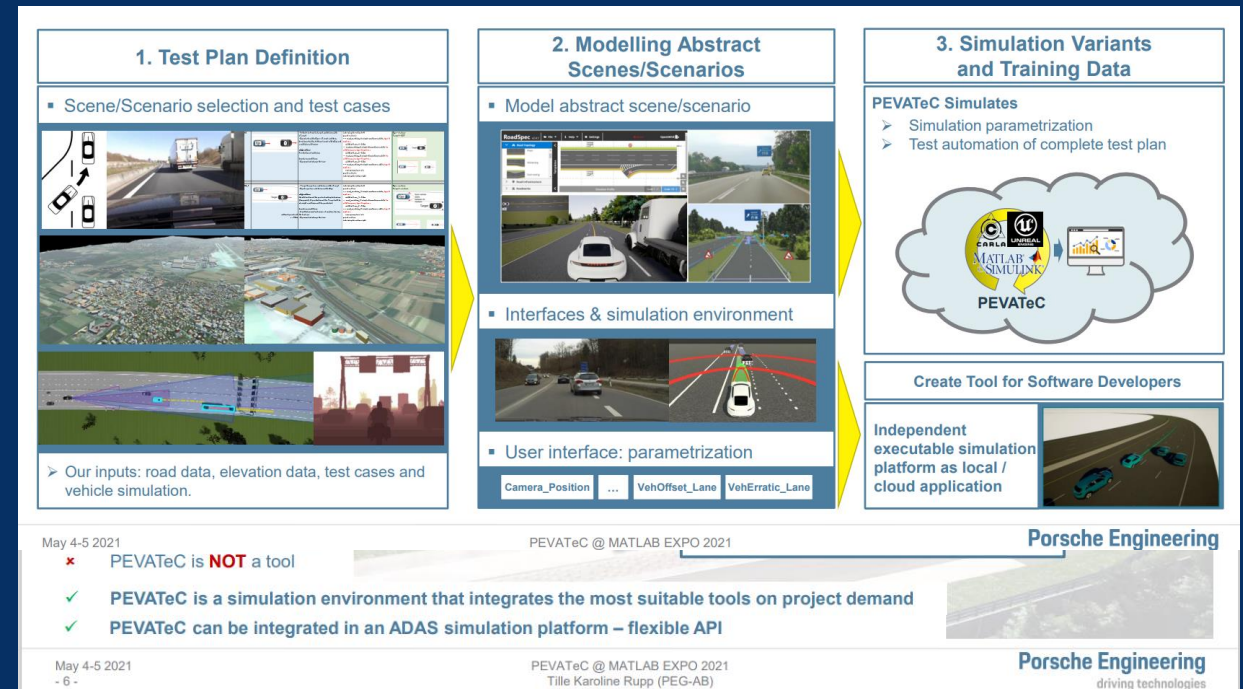
- Evolving classic simulation to adaptive, flexible and modular simulation platform
- HW & SW providers from diverse disciplines

Solution :

- **PEVATeC** - Flexible and Modular simulation environment for virtual ADAS/AD Testing

Results:

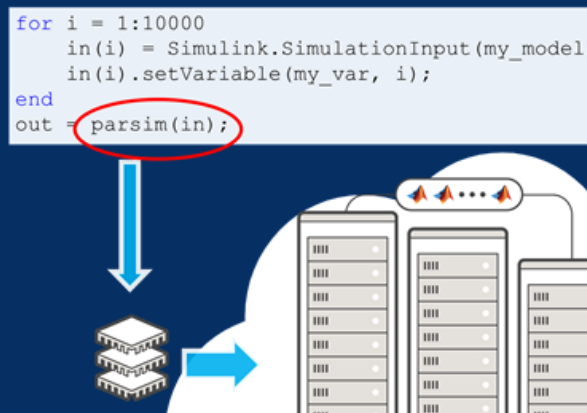
- customized parametrization of scene, scenarios, and sensors
- smart integration of software algorithms into a full vehicle simulation environment



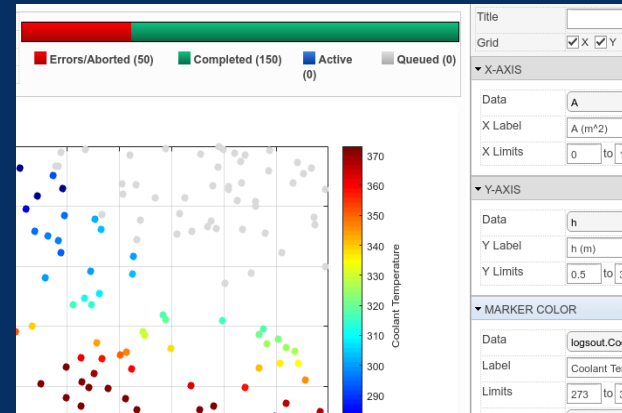
How is Simulink evolving?



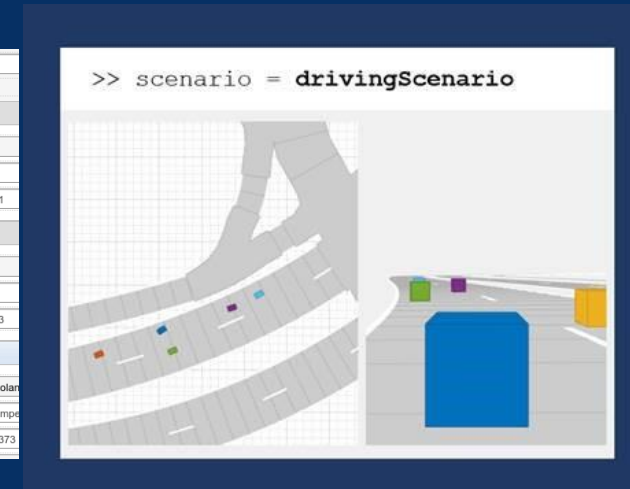
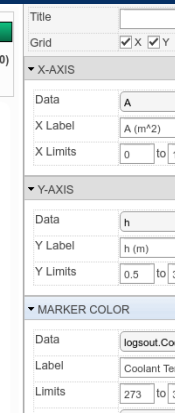
X 1,000,000's



Parallel simulations



Simulation Manager



Programmatic test creation

To know more about building and scaling up simulation for AD systems, attend the below sessions:

Bringing real world to simulation for virtual testing of Automated Driving (AD)

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Ninad Pachhapurkar, ARAI



Jyoti Kale, ARAI

End-to-end closed loop validation of Automated Driving (AD) systems

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Deepika CP, KPIT Technologies



Bhagayashree Mukkawar, KPIT Technologies



Chinmayi Jamadagni, KPIT Technologies



Sanket S Shinde, KPIT Technologies



Srinivas Boppidi, KPIT Technologies

Environment modeling and Virtual Validation for ADAS/AD features



Munish Raj
Application Engineer
MathWorks India
mrj@mathworks.com



Dr. Rishu Gupta
Principal Application Engineer
MathWorks India
rishug@mathworks.com



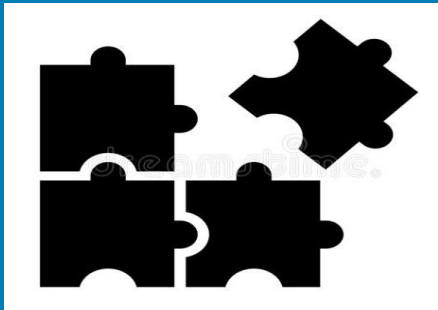
Simulink platform is evolving to meet the demands of scaled up simulations



Full Vehicle Simulation



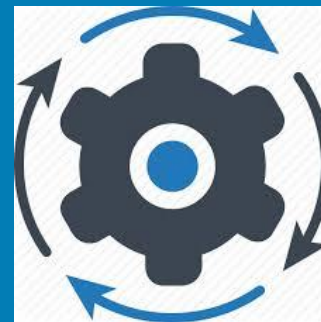
Scenario Simulations for Autonomy



Integrating models and components



Simulation Performance

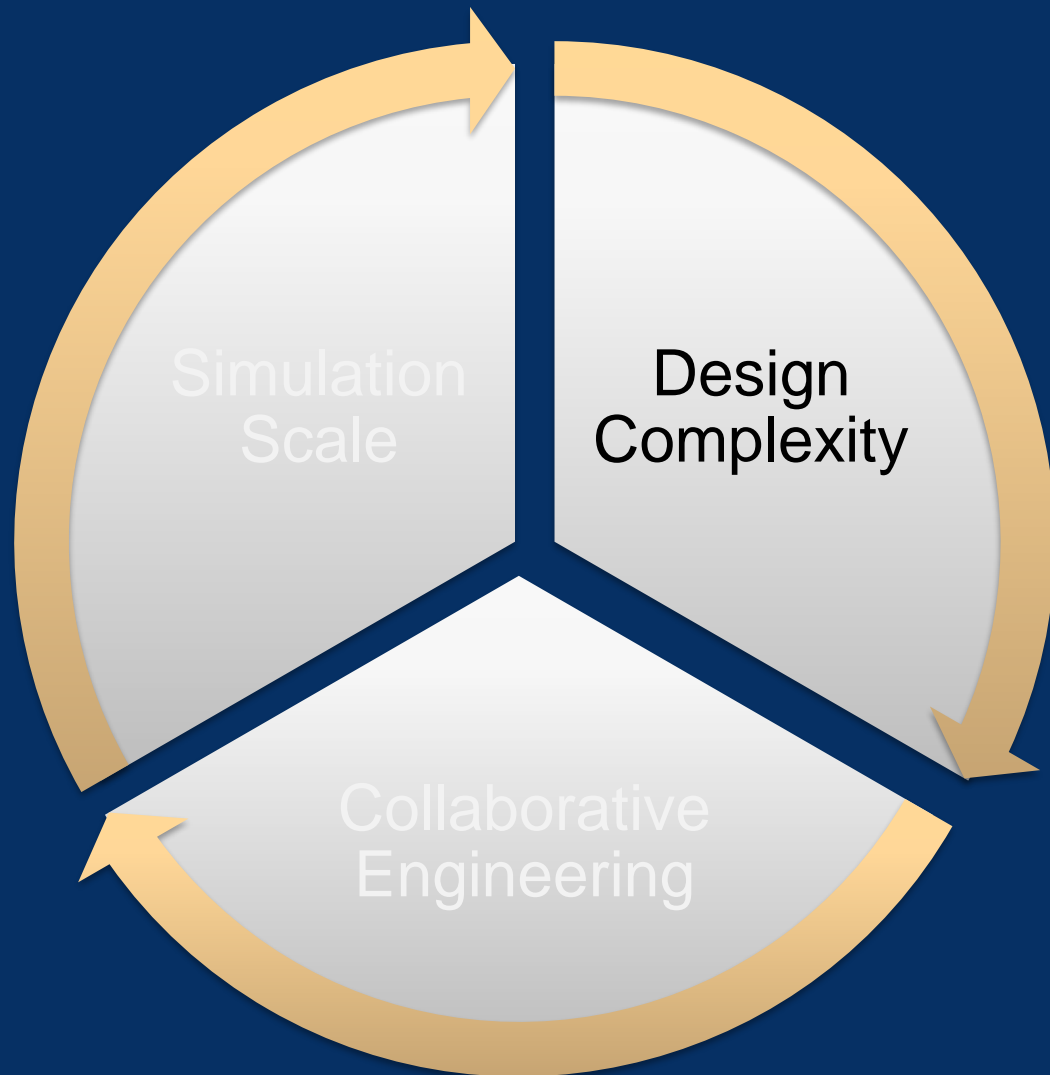


Operationalization



Scenario Simulation

The Three Evolutionary Forces at Play



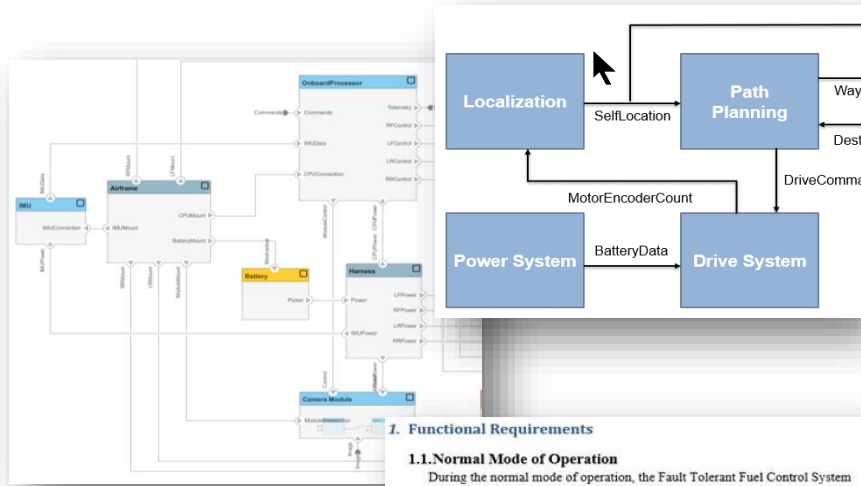
Why are these trends important?

What are customers doing today about these trends?

How does Model-Based Design evolve to meet the needs of future mobility?

Trend : Bridging the gap between Model-Based Systems Engineering and Model-Based Design

Model-Based Systems Engineering



1. Functional Requirements

1.1. Normal Mode of Operation

During the normal mode of operation, the Fault Tolerant Fuel Control System shall determine the fuel rate which is injected at the valves.

1.1.1. Stoichiometric mixture ratio

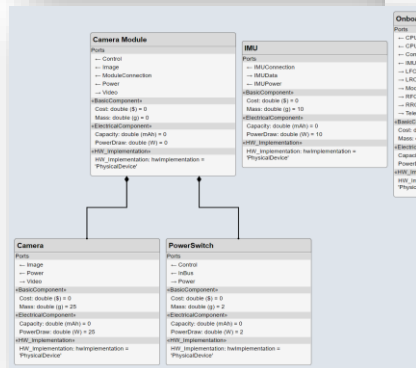
During normal mode of operation, the System shall maintain the stoichiometric mixture target ratio of 14.6.

1.1.2. Oxygen Sensor (EGO)

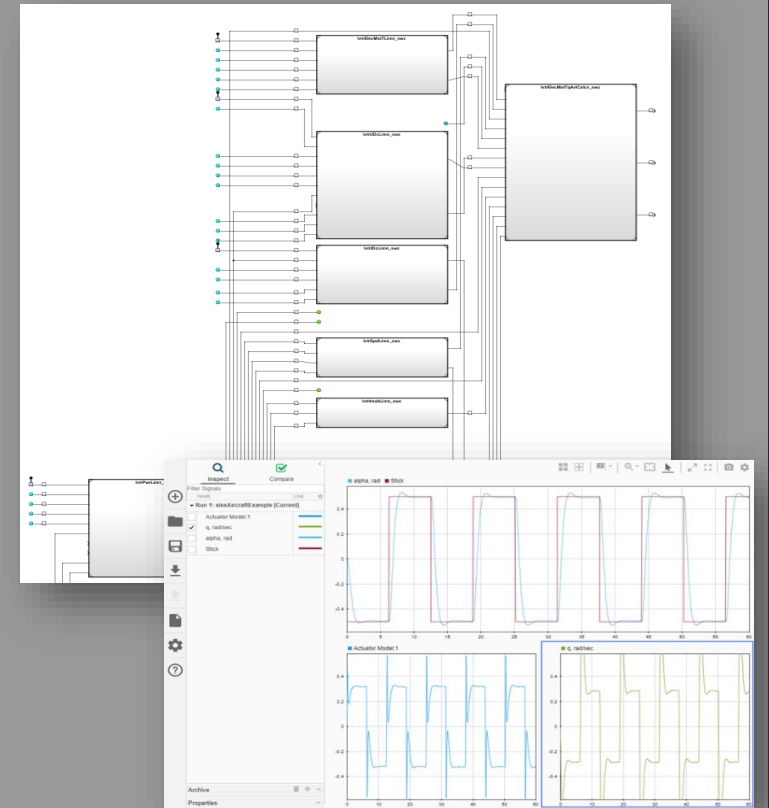
The System shall determine the amount of residual oxygen present in the exhaust gas (EGO) by reading the value of the EGO sensor. During a calibratable warm up period the oxygen sensor correction shall be disabled.

1.1.3. High Oxygen Level

If the EGO sensor determines a high oxygen level present in the exhaust gas, the System shall increase the fuel rate in order to maintain the stoichiometric mixture target ratio.



Model-Based Design



Delphi Technologies : AUTOSAR Architecture Modeling of Multi-core Electric Powertrain Controller for Next Generation Inverter

Challenge :

- Gap between architecture and design models
- Gaps in requirement traceability
- Lack of support for intuitive and performance analysis

Solution : Delphi Technologies used System Composer and AUTOSAR Blockset for AUTOSAR Based System Engineering

Results :

- Architecture to Requirements –Seamless Approach
- Intuitive and Performance Analysis

Architecture to Requirements – Seamless Approach

Label	Source	Type	Destination
AUTOSAR_Multi_Core.simx	Changed source: 0/3		Changed destination: 0/3
Polarion: AINV-58075	SafetyCore1_Application	Implements	http://polarionprod1.delphidrive.com/polarion/
Polarion: AINV-58341	BSWCore0_Application	Implements	http://polarionprod1.delphidrive.com/polarion/
Polarion: AINV-59475	AUTOSAR_Multi_Core	Implements	http://polarionprod1.delphidrive.com/polarion/

How is Model-Based Design Evolving to support the needs of System Engineers?

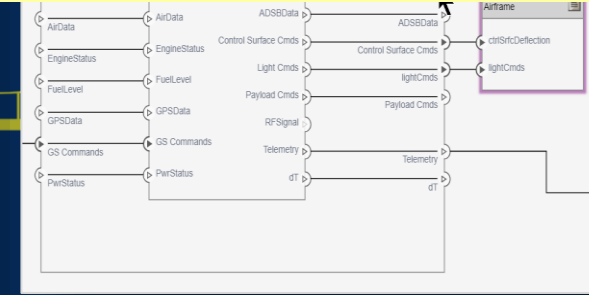
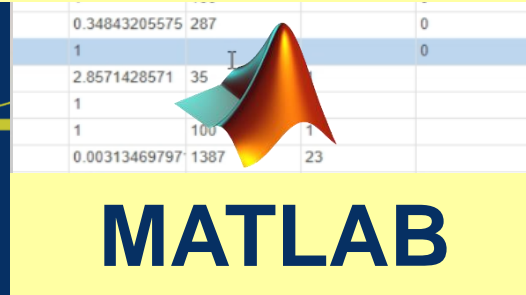
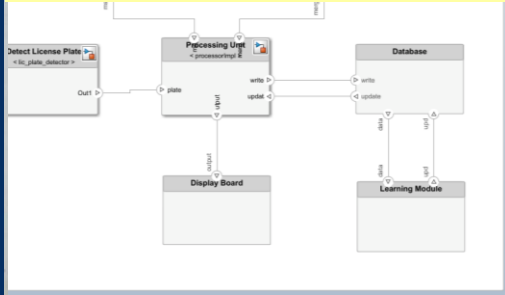
Be Intuitive

Facilitate Analysis

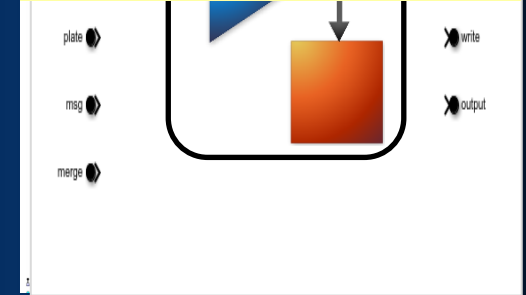
Tackle Complexity

Enable Implementation

System Composer



Simulink

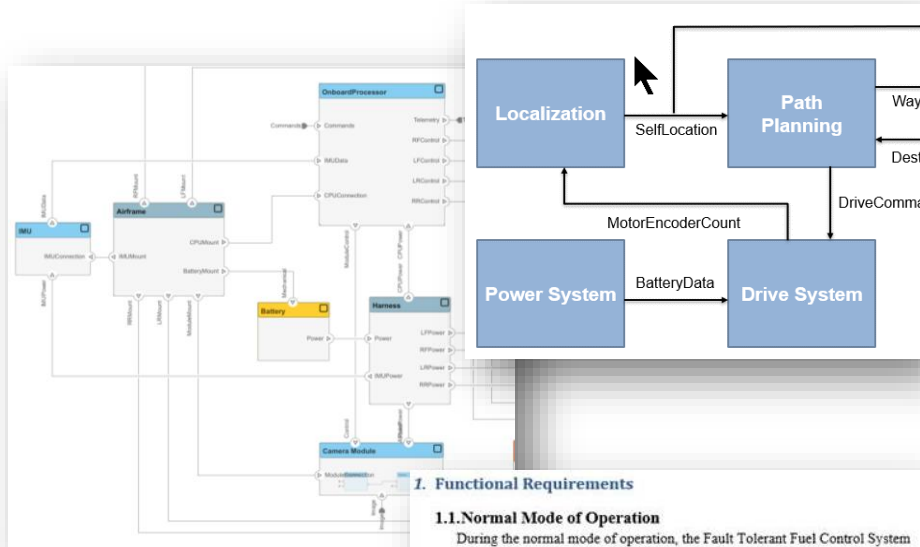


Requirements Coverage Reporting and Impact Analysis

Simulink Requirements

Index	Summary	Implemented
> 1.1	Airworthiness	<div style="width: 80%; background-color: blue;"></div>
> 1.2	Communications	<div style="width: 100%; background-color: blue;"></div>
▼ 1.3	Payload Capabilities	<div style="width: 100%; background-color: blue;"></div>
1.3.1	Carrying Capacity	<div style="width: 70%; background-color: blue;"></div>
1.3.2	Payload Bay Capacity	<div style="width: 100%; background-color: blue;"></div>
1.3.3	Default Payload	<div style="width: 100%; background-color: blue;"></div>
1.3.4	Payload Protection	<div style="width: 100%; background-color: blue;"></div>

Model-Based Systems Engineering



1. Functional Requirements

1.1. Normal Mode of Operation

During the normal mode of operation, the Fault Tolerant Fuel Control System shall determine the fuel rate which is injected at the valves.

1.1.1. Stoichiometric mixture ratio

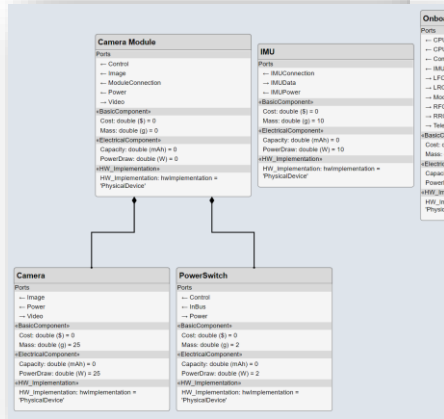
During normal model stoichiometric mixture

1.1.2. Oxygen Sensor (EGO)

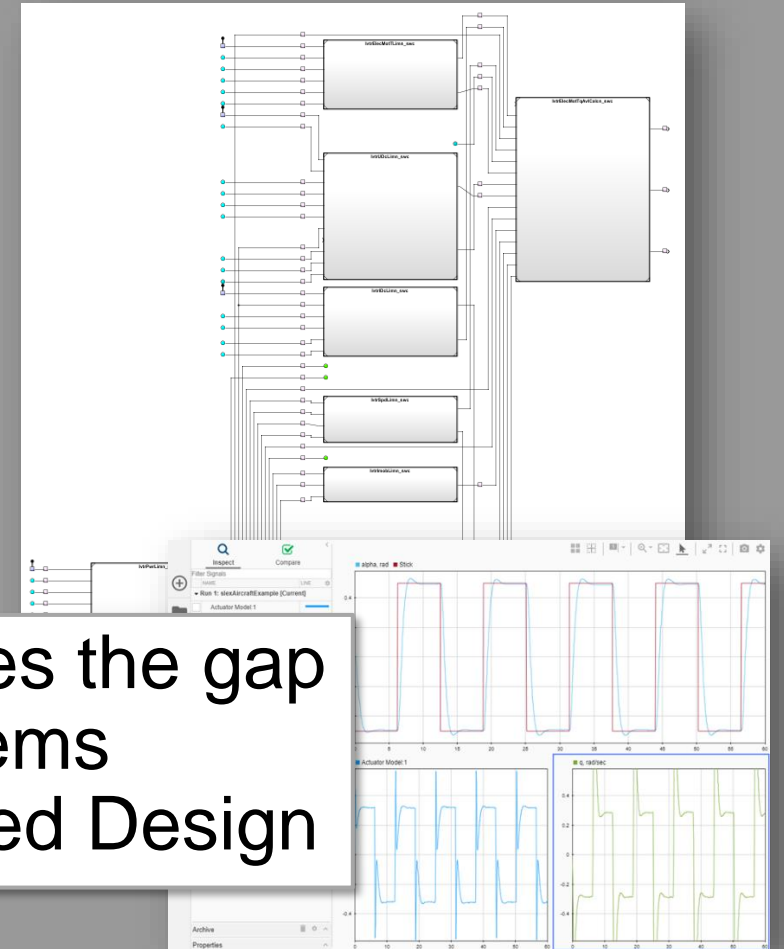
The System shall detect exhaust gas (EGO) by calibratable warm up

1.1.3. High Oxygen Level

If the EGO sensor detects gas, the System shall adjust stoichiometric mixture



Model-Based Design

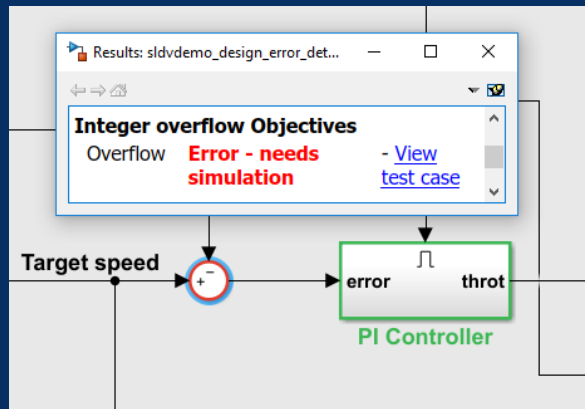


System Composer™ bridges the gap between Model-Based Systems Engineering and Model-Based Design

How is Model-Based Design evolving to address software complexity?

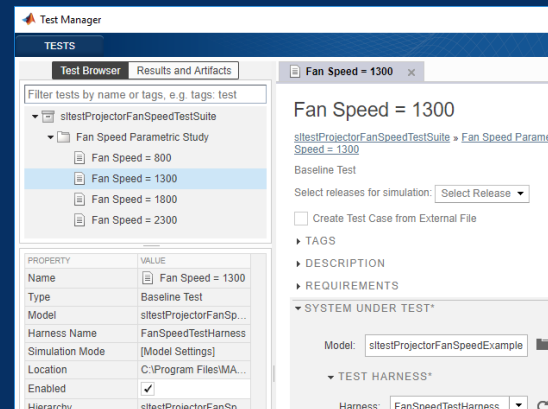
Automated Test and Verification

Find bugs



Simulink Design Verifier
Polyspace Bug Finder

Manage tests



Simulink Test

Check & Coverage



Simulink Check
Simulink Coverage

Inspect code

Code Verification Results : Verified

Function Interface Verification Results : Verified

Function	Status	Details
slcidemo_roll_initialize	Verified	-
slcidemo_roll_step	Verified	-

Model To Code Verification Results : Verified

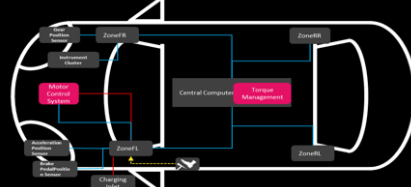
Status	Details
Verified	Model objects with status Verified : 42
	Model objects with status Partially processed : 0
	Model objects with status Unable to process : 0
	Model objects with status Failed to verify : 0

Simulink Code Inspector

To know more about handling system and software complexity

TCS TATA CONSULTANCY SERVICES Building on belief

MBSE Approach for designing Functionally Safe Electrification Systems




- Authoring System, sub system requirements
- NW architecture and Req allocation
- Service Definition and Allocation
- End-End Traceability
- Architecture Views

Date : 16th November, 2022

MBSE and Functional Safety solutions for Next Gen Architecture

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Polyspace & Docker



```
root@ip-172-31-28-97:~/polyspace-bug-finder-server-docker# sudo docker run --rm -e PLM_LICENSE_FILE=27000ec2-65-1-114-242.ap-south-3.compute.amazonaws.com -v "$(pwd) /work" polyspace-bug-finder-server:2022b polyspace-bug-finder-server -sources /work/src/simple_niv.c -results-dir /work/ps_results
polyspace-bug-finder-server #2022b Update 1 #PID22 PGID22

Polyspace verification of polyspace project.
Starting at 11/15/2022, 13:03.

Verifying sources compliance ...
```

78

Functional Safety and Cybersecurity

• Early Verification and Validation Using Model-Based Design

- Efficient elimination of errors at early stages
- Continuous and uninterrupted refinement of system and software requirements and architectural designs
- Complete traceability and improved consistency among requirements, architecture, design, source code, and test cases
- Certifiable tools and workflow

• Formal Code Verification

- Adhere to coding standards: safety and security, robustness checking without testing, and compliance with ISO 26262 and ISO 21434
- Integrate at different SDLC stages, intuitive and actionable presentation of results, decrease testing efforts
- Integrate into development workflows—Model-Based Design, devOps, Dockerization—and run on cloud platforms

The Three Evolutionary Forces at Play



Why are these trends important?

What are customers doing today about these trends?

How does Model-Based Design evolve to meet the needs of future mobility?

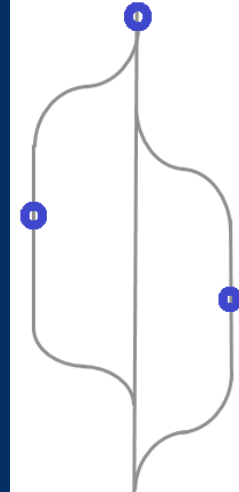
Trend: An increased demand for Agile team-based workflows



Shared team environment



Collaboration

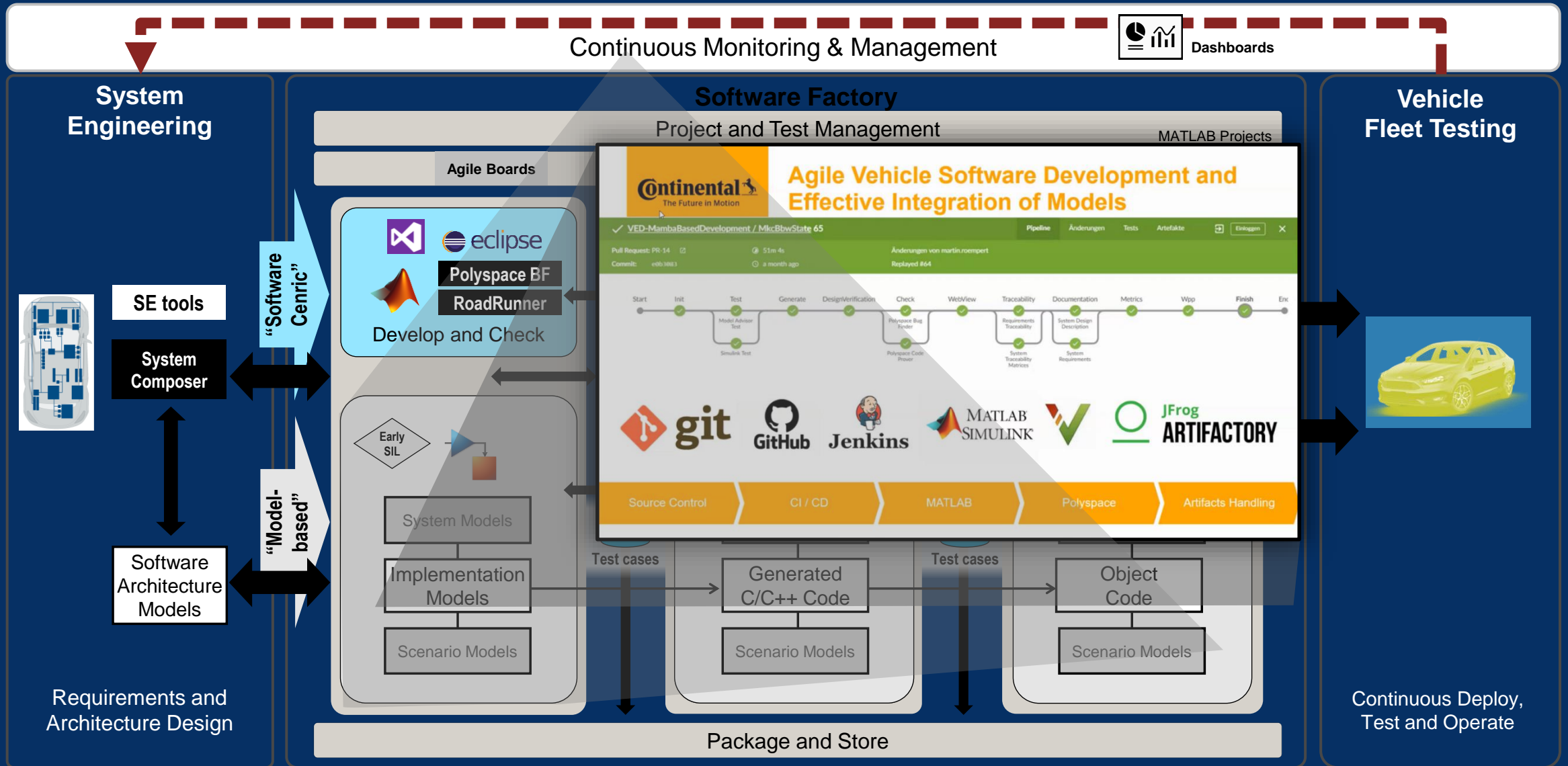


Jenkins

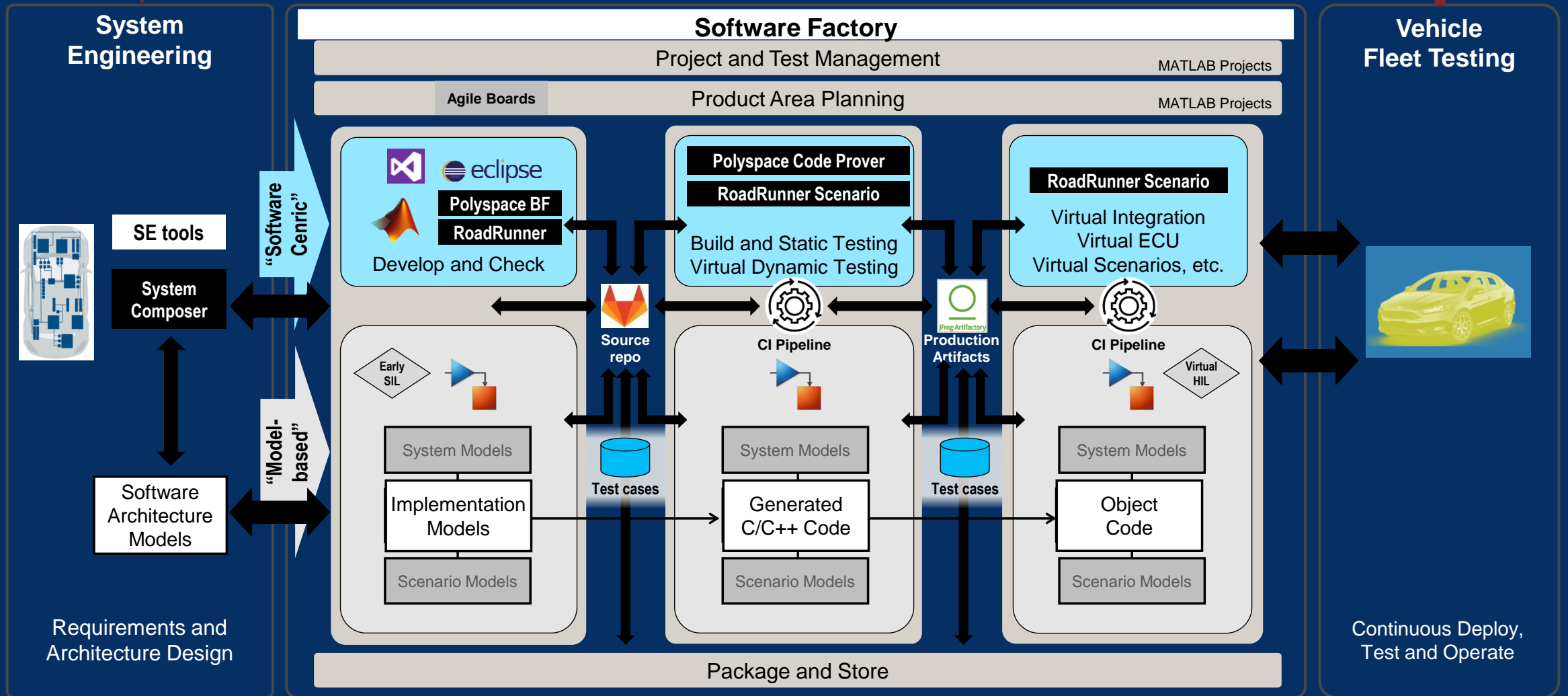
Continuous Integration & Test



Integrating model-based approaches in a Software Factory




How are MathWorks tools integrating for Continuous Development?



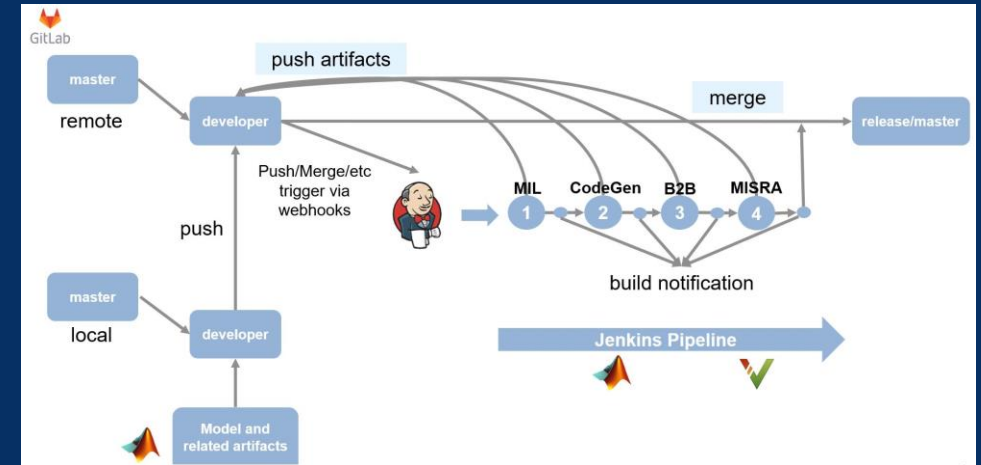
To know more :

Software-Defined Vehicles: Workflows for In-Car and Cloud Applications

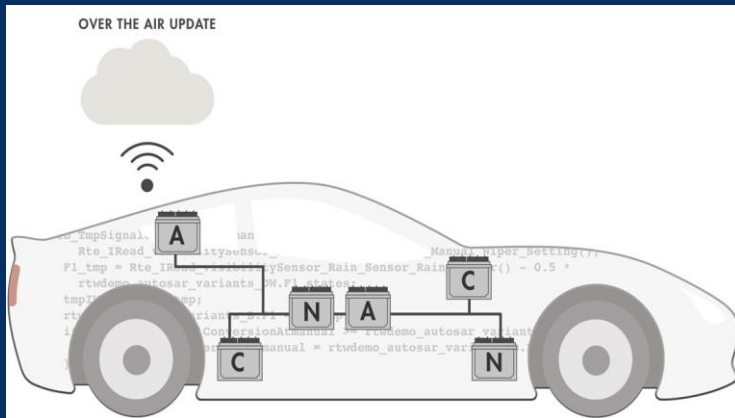
Prasanna Deshpande, MathWorks Nukul Sehgal, MathWorks



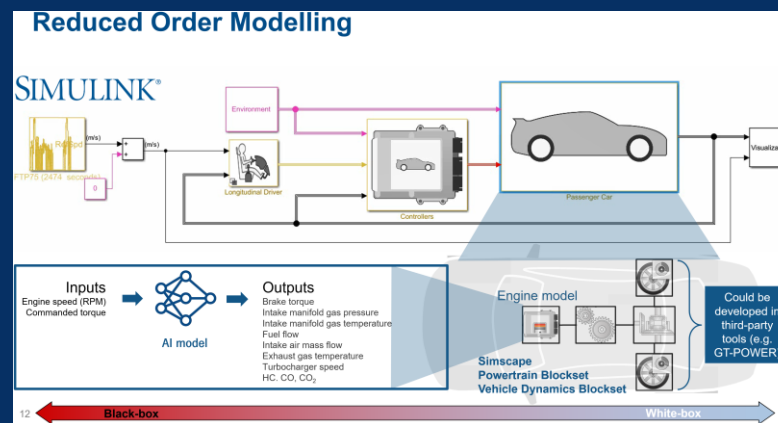
Integrating Model-Based Design with CI/CD for agile workflows



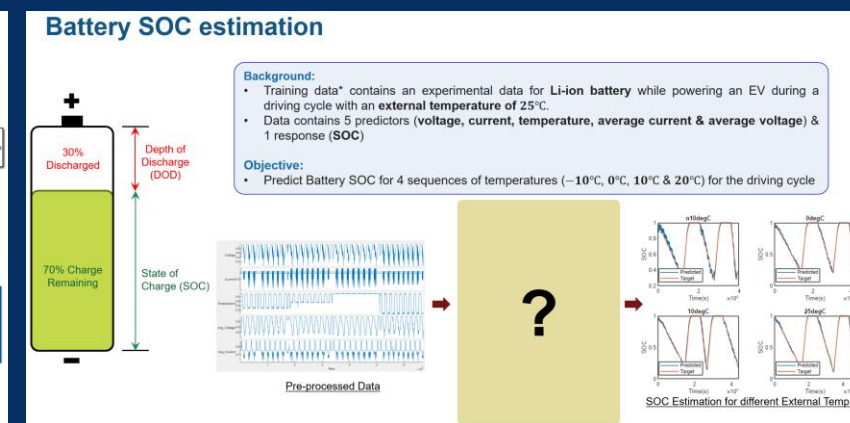
AI Deployment on Embedded Systems and Cloud



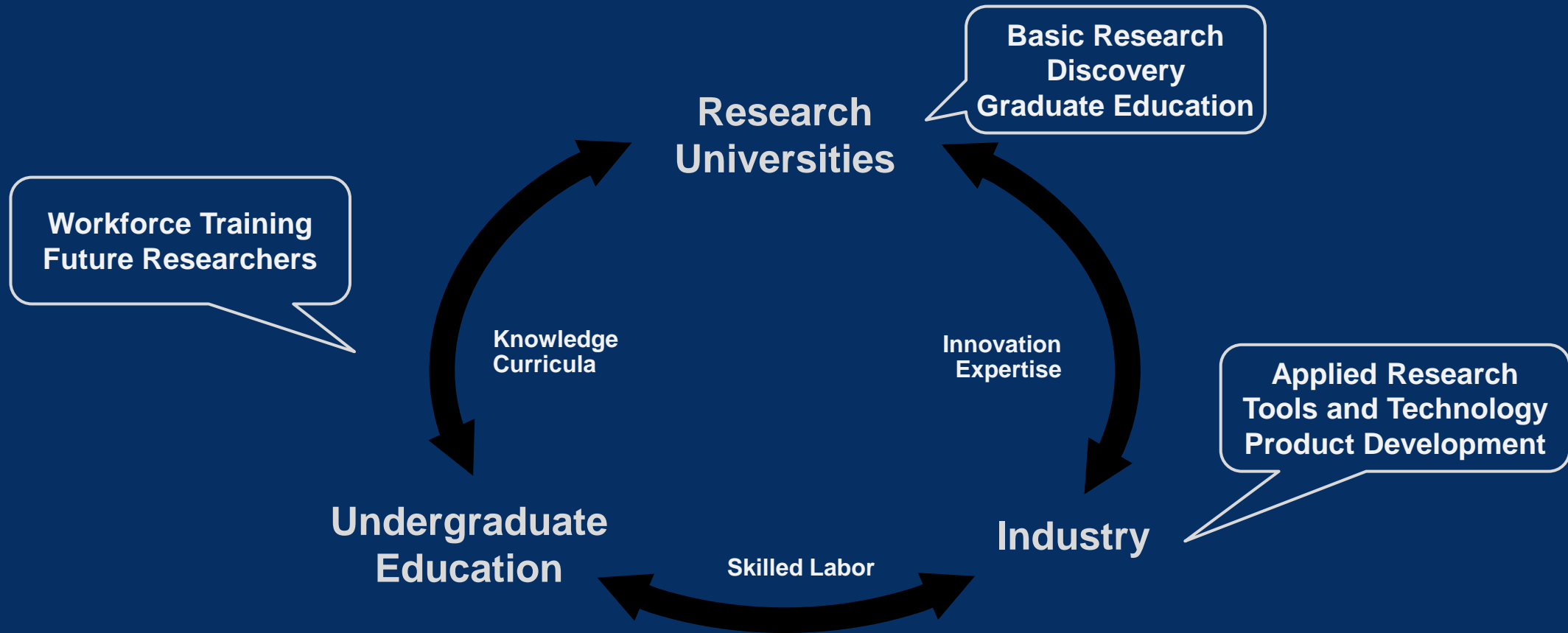
AI in Simulation : Reduced Order Modeling



AI in Electrification : Battery SOC and SOH Estimation



Trend : Bridging Gap between Industry and Academia



Bosch and National Institute of Technology Calicut Collaborate on EV Course to Prepare Students for Industry

Challenge

Address the shortage of automotive engineers with system engineering skills

Solution

Jointly create a new undergraduate course in model-based system engineering as part of a collaboration between academia and industry

Results

- Months of on-the-job training eliminated
- Enrollment increased by 250%
- 90%+ positive feedback received

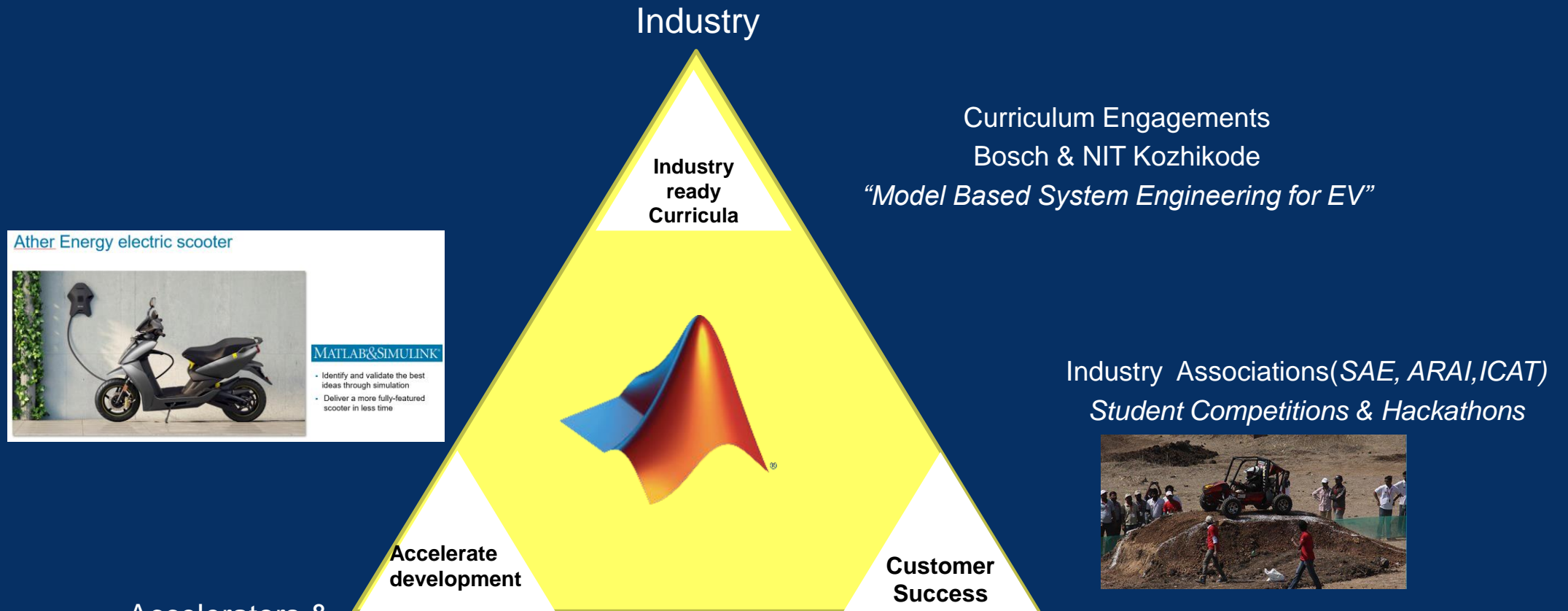


Pradeep Kumar of Bosch India lighting the ceremonial lamp with Dr. Sivaji Chakravorti of NIT Calicut before signing the agreement.

“The collaboration between NIT Calicut, MathWorks, and Bosch narrowed the gap between academia and industry, producing an electric vehicle system engineering course that has been both well received by our students and highly useful for them as well.”


- Dr. Kumaravel Sundaramoorthy, NIT Calicut

Enabling Collaboration to strengthen Mobility Eco-System



Accelerators & Startups


Anytime, Anywhere Access for Faculty, Students, and Visitors



MATLAB and Simulink for Desktops

Access MATLAB and Simulink on personal and university-owned machines


www.mathworks.com/matlab-campus



MATLAB Online and Simulink Online



Access MATLAB and Simulink with a web browser

matlab.mathworks.com



MATLAB Mobile

Access MATLAB on iOS/Android devices

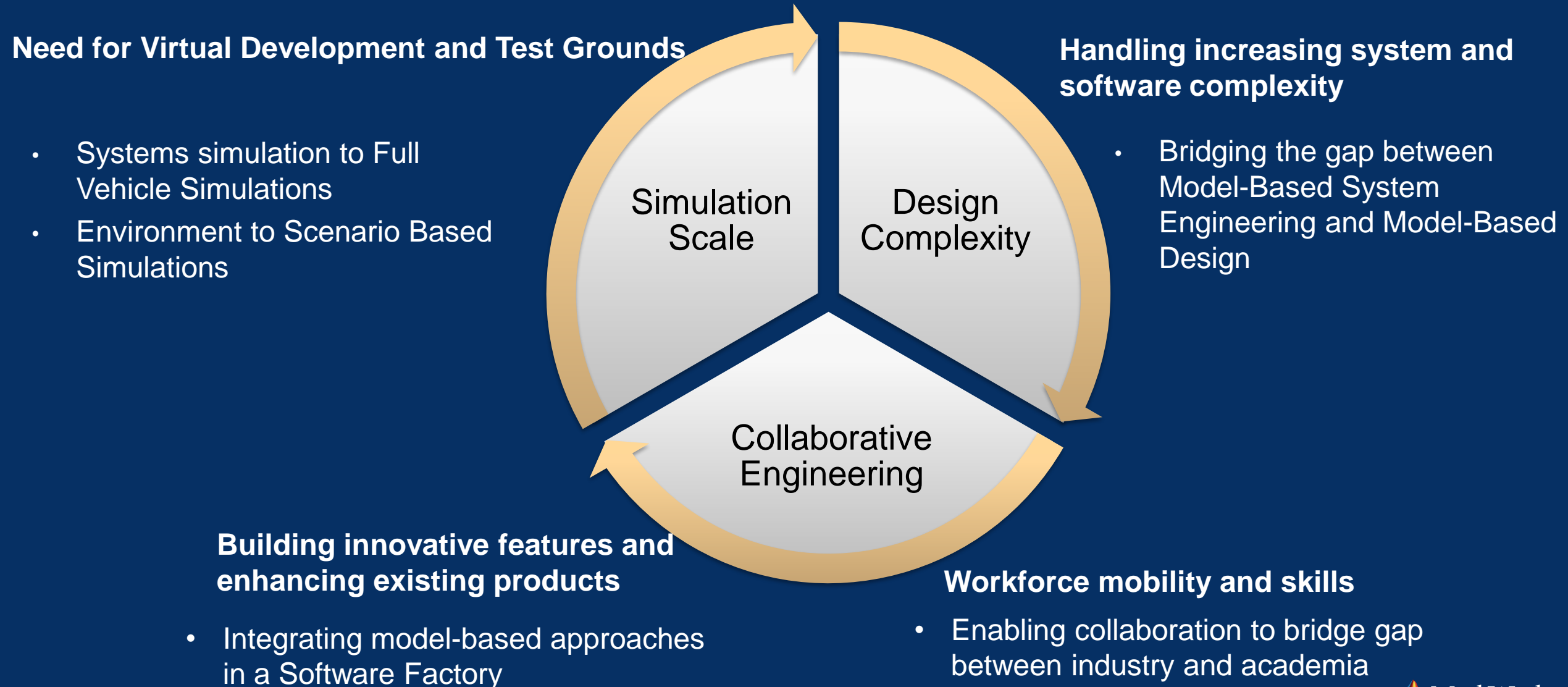
Education

Self-Paced Online Courses

Getting Started

 MATLAB Onramp	 Deep Learning Onramp	 Reinforcement Learning Onramp	 Machine Learning Onramp	 Image Processing Onramp	 Signal Processing Onramp	 Optimization Onramp	 Wireless Communications Onramp
 Simulink Onramp	 Control Design Onramp with Simulink	 Stateflow Onramp	 Simscape Onramp	 Circuit Simulation Onramp			

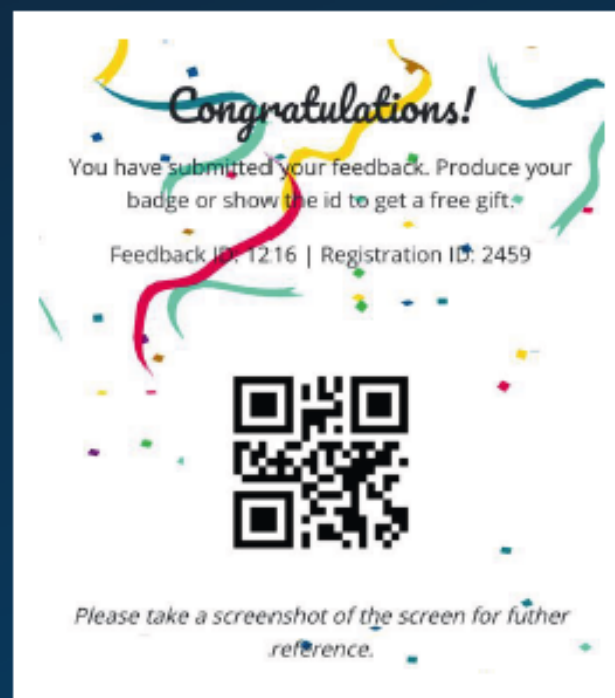
Summary :Evolution of Model-Based Design for Future Mobility



Please provide your Feedback for this Session.
You will also receive a Feedback Link via SMS on your registered Mobile Number



<https://tinyurl.com/ypr9z7rx>



Enjoy the conference