



# **Migrating Legacy Software Modeling to a Simulation-Based Product Development System**

Challenges and Successes

2022

Public

# Presenters



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Cummins

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MathWorks

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# Powering a more prosperous world in 2020

**190**

Countries & territories\*

**57,825**

Global employees

**1.3M**

Engines built in 2020\*\*

**9,000**

Cummins certified  
dealer locations

**\$903M**

Invested in research  
& technology in 2020

**102**

Years of industry  
leadership

*\*Approximation of countries and territories with Cummins service*

*\*\*This includes engines from both our custodial plants and unconsolidated joint ventures.*

*As published in the 2020 10K found on cummins.com*

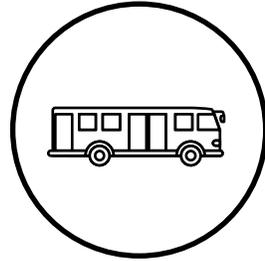
# We serve many markets and applications



Heavy-duty  
Truck



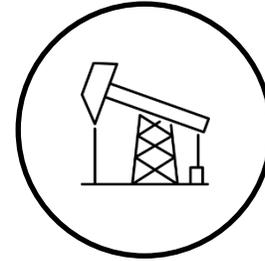
Medium-duty  
Truck



Bus



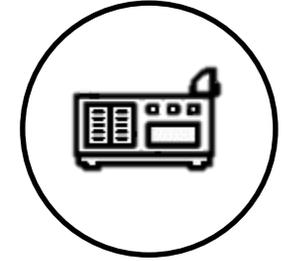
Construction



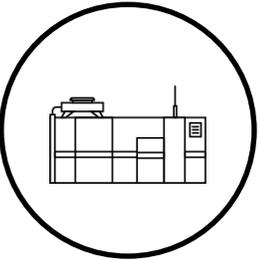
Oil & Gas



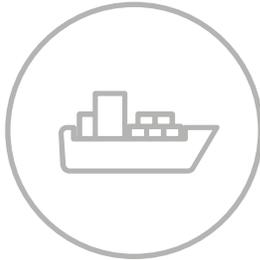
Fire &  
Emergency



Power  
Generation



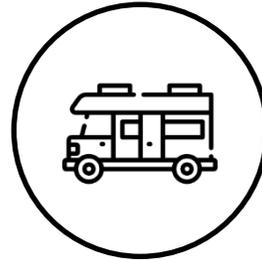
Electrolysis



Marine



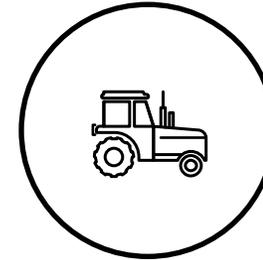
Mining



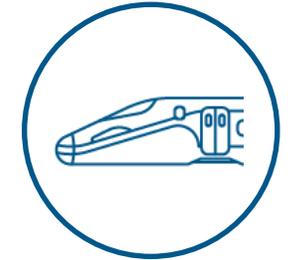
Light-duty Automotive  
& Recreational  
Vehicle



Defense



Agriculture



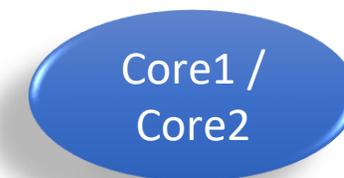
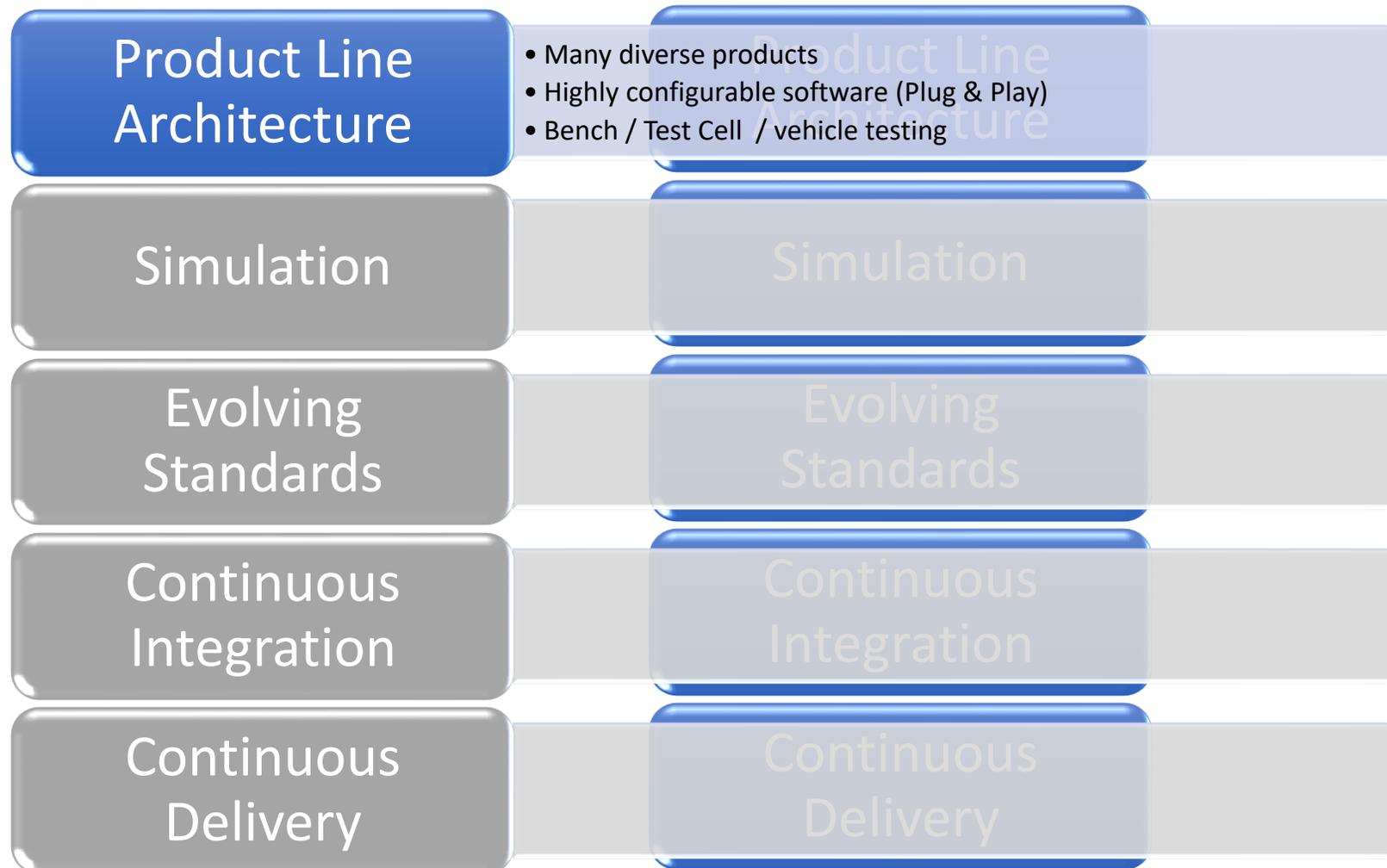
Rail

*This is not an exhaustive display of Cummins-powered markets. Please refer to [cummins.com](http://cummins.com) for the most updated product information.*





# Key Software Evolutionary Goals





# Key Software Evolutionary Goals

## Product Line Architecture

- Many diverse products
- Highly configurable software (Plug & Play)
- Bench / Test Cell / vehicle testing

## Simulation

## Evolving Standards

## Continuous Integration

## Continuous Delivery

Core1 /  
Core2

### Characteristics

- Custom code-centric design
- Custom support tooling infrastructure
- Core 2 – Model Based Code Generation

### Challenges

- High modeling effort, low return
- Quality issues found late in development

### Key Findings

- Missing: Early simulation
- Missed Value: Simulation could reduce cost of bench testing
- Issues could be found before SW build



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Core1 /  
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### Solutions

- MBD Tools team creates Model Integration Tool to automate system model stitching
- Simulation is layered over existing software structure
- Simulation-based system testing

### Successes

- Custom architectural rules respected
- Small and full builds supported for simulation tools
- Director-level sponsorship
- ROI: 6 – 10% reduction in product development cost in move to simulation

MARCI



# Key Software Evolutionary Goals

## Product Line Architecture

- Many diverse products
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- Bench / Test Cell / vehicle testing

## Simulation

- Increased virtual testing (OBD, Diag, etc.)
- Automated model integration
- System-level code generation

## Evolving Standards

## Continuous Integration

## Continuous Delivery

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### Characteristics

- Custom code-centric design
- Custom support tooling infrastructure
- Automation through MATLAB scripting

### Challenges

- Long system model integration times
- Issues still not found until integration
- Internal culture conflicts (code vs. MBD)

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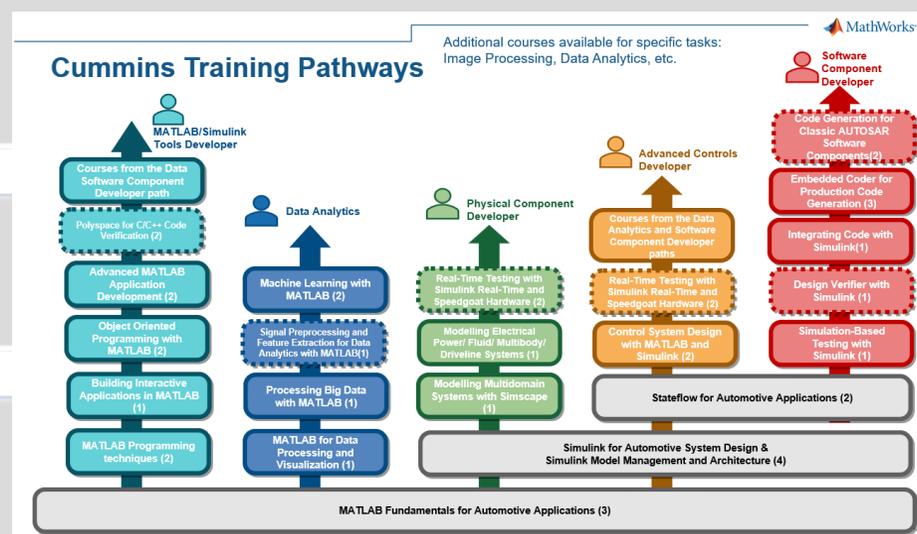
## Simulation

- Increased virtual testing (OBD, Diag, etc.)
- Automated model integration
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## Evolving Standards

## Continuous Integration

## Continuous Delivery



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## Key Events & Findings

- **MathWorks Process Assessment**
  - External expert evaluation
  - Wide industry exposure
- △ *Custom software vs simulation*

## Solutions

- C-Level Sponsorship
- Simulation Based Product Development
- AUTOSAR / CSAR Project
- Enterprise account strategic support
  - Consulting and Training

CSAR



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## Evolving Standards

- ISO 26262 / ASPICE / CMMI / Cert C / MISRA / MAAB
- Cyber Security, AUTOSAR
- “Simulation Based Product Development” (Full MBD Workflow)

## Continuous Integration

## Continuous Delivery

CSAR

### Successes

- OTS Software Architecture and Tools
- Trusted partnership with MathWorks Account Team & Consulting
- Expertise built through training
- Full MBD workflow for unit design & test
  - ~100s of pre-release issues found



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## Continuous Delivery

CSAR

### Challenges

- Cultural change for SBPD
  - Components vs. System
  - Configurability in an explicit design
    - Pushing AUTOSAR to its limits!
- OTS with legacy tool mindset
- Wanting to simulate everything

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<b>Product Line Architecture</b>	<ul style="list-style-type: none"> <li>• Many diverse products</li> <li>• Highly configurable software (Plug &amp; Play)</li> <li>• Bench / Test Cell / vehicle testing</li> </ul>	
<b>Simulation</b>	<ul style="list-style-type: none"> <li>• Increased virtual testing (OBD, Diag, etc.)</li> <li>• Automated model integration</li> <li>• System-level code generation</li> </ul>	
<b>Evolving Standards</b>	<ul style="list-style-type: none"> <li>• ISO 26262 / ASPICE / CMMI / Cert C / MISRA</li> <li>• Cyber Security, AUTOSAR</li> <li>• “Simulation Based Product Development” (Full MBD Workflow)</li> </ul>	
<b>Continuous Integration</b>	<ul style="list-style-type: none"> <li>• Automated upgrade for MBD tools (MW)</li> <li>• Unit CI pipeline (CMI, MW)</li> <li>• Composition CI pipeline (CMI, MW)</li> </ul>	<b>In Work</b>
<b>Continuous Delivery</b>	<ul style="list-style-type: none"> <li>• Automated Build, Test, Release</li> </ul>	<b>Future</b>



# Summary

- Simulation drives ROI for Model-Based Design
- Simulation finds issues early in the design phase
- MathWorks services can help overcome roadblocks and build skill sets
- Off-the-Shelf architectures and tools can lower technical debt
- Cultural changes take time to overcome!



Q & A