

MathWorks  
**AUTOMOTIVE  
CONFERENCE 2023**  
North America

# Accelerating Model-Based Design Through Continuous Integration



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Cummins, Inc*



*Dave Hoadley, PhD  
MathWorks*





**Powering  
a more  
prosperous  
world**

**190** Countries and territories\*

**73,600** Global employees

**104** Years of industry leadership

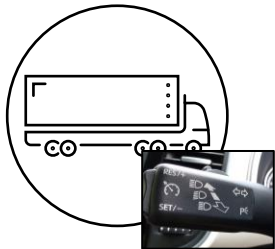
**10,600** Cummins certified dealer locations

**\$1.2B** Invested in research and technology in 2022

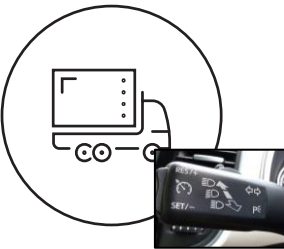
*\* Approximation of countries and territories with Cummins service*

*As published in the 2022 10K found on cummins.com.*

# Applications



Heavy-duty Truck



Medium-duty Truck



Pickup Truck



Bus



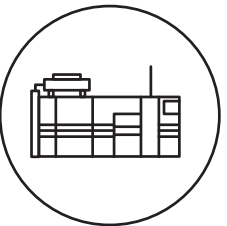
Construction



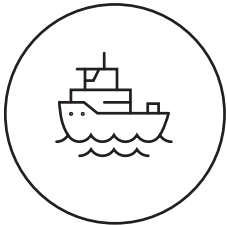
Oil & Gas



Fire & Emergency



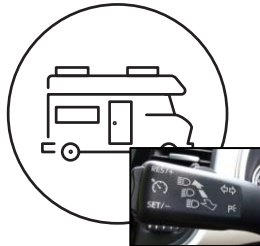
Electrolysis



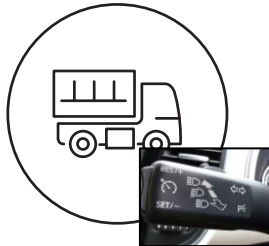
Marine



Mining



Recreational Vehicle



Defense



Agriculture



Rail

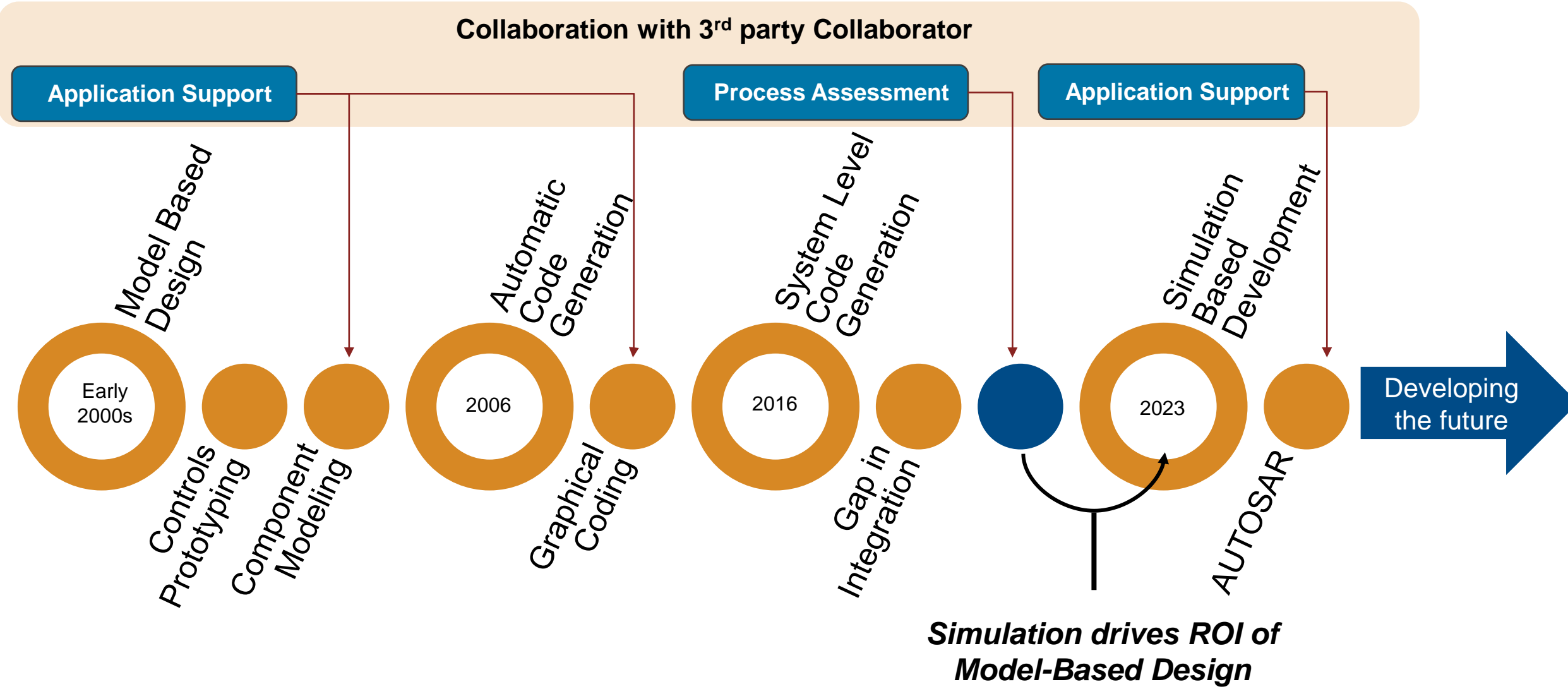


Power Generation



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

# Model-Based Design at Cummins

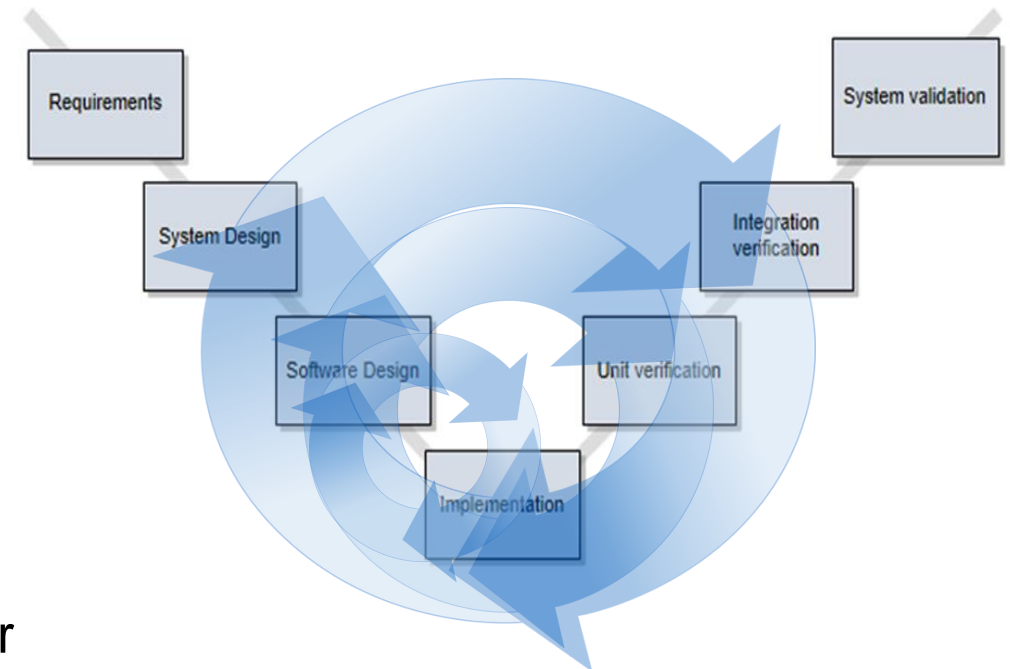


# Product Line Architecture (PLA) concept

- Families of related products (Batory, 1998)
  - Component-based software design
  - Component-based, model-based design
  - Implies/Requires software reuse while enabling product specific behaviors
- But how to test a single component across X number of products
  - 1,000s of components, 10s-100s of products!
  - Nearly infinite configurability!
  - Infinitely large tests!
  - No test team could accomplish this without CI!

# Continuous Integration System Benefits

- Scalability for breadth of applications
- Consistency of application of tools, teams
- Offloading time-consuming tasks
  - but not without prequalification
- Increased velocity of innovation
- Global SW factory scale
  - Visibility to management for the status/effectiveness
  - Coordination/trial integrations on demand; never off-the-clock



# Obstacles

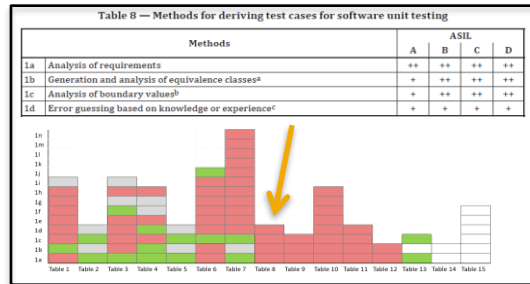
- Software development culture, organizations, and workflows must adapt
- The business must invest in the CI infrastructure
- Careful planning of the pipelines so they are implementing codified best practices
- Who, what, where, and how to get started with tools and implementation



# Cummins and MathWorks Consulting Collaborating towards CI

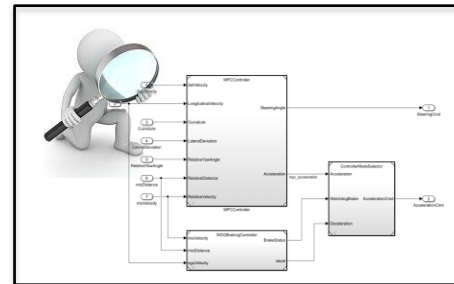
## Assess

Reviewed Process and Model



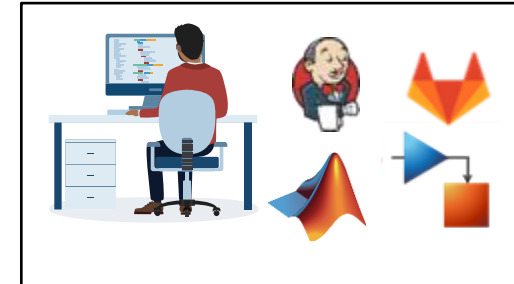
## Rearchitect

Adjusted algorithm architecture

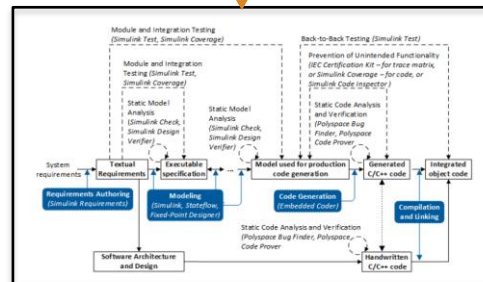


## Automate

Scripted targeted tasks for C/I automation

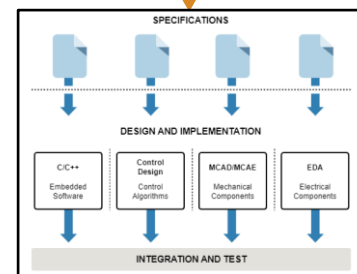


## Steps Leading to Continuous Integration



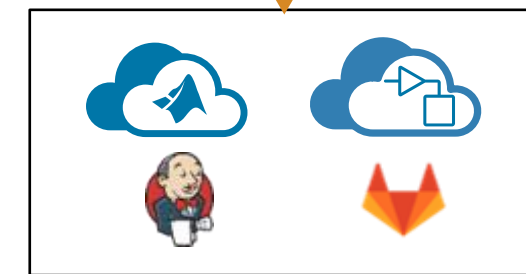
## Plan

Created plan to move to ideal state



## Adjust Process

Implemented process changes

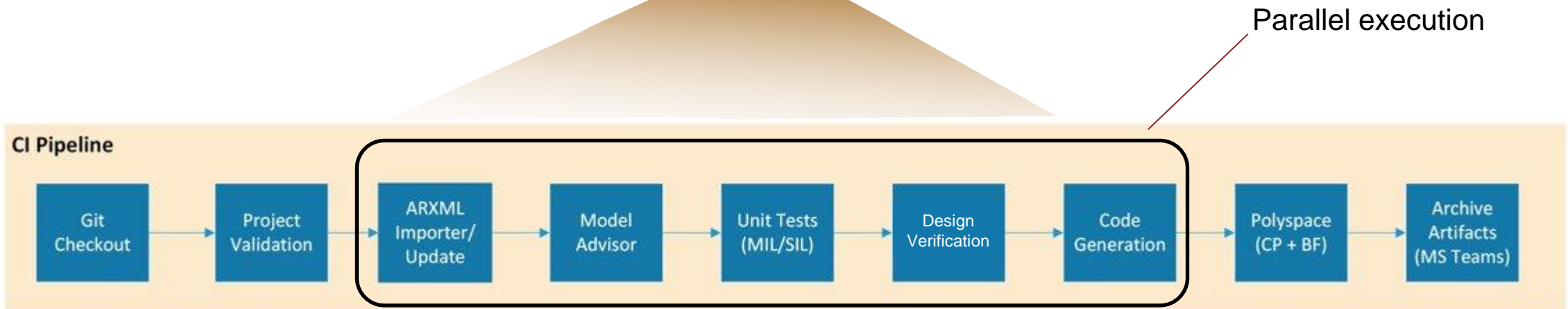
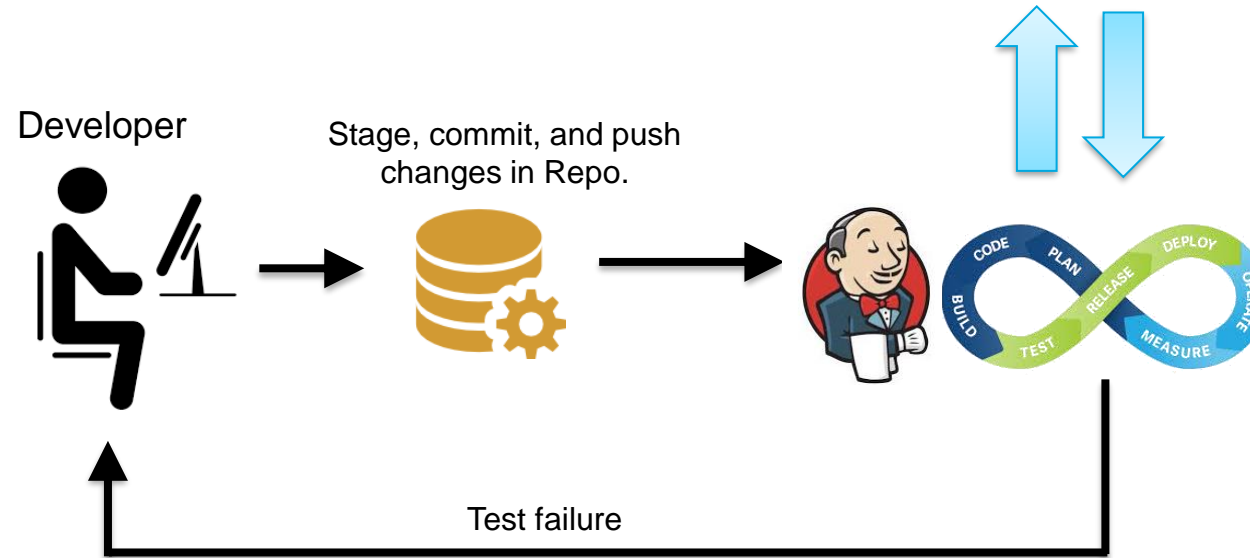


## Scale(future work)

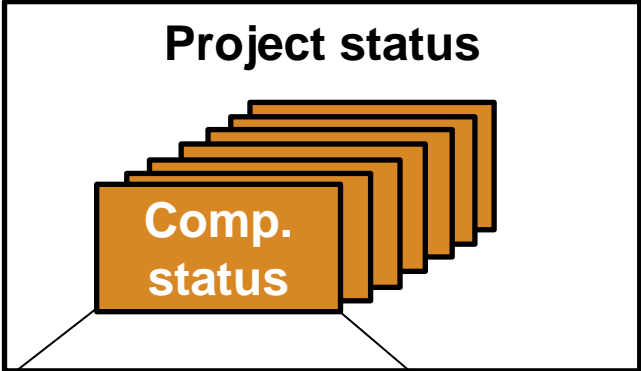
Use automation at scale in the cloud



# Jenkins pipeline implementation



# Job status dashboards



## Pipeline ModelCI

Multi-stage pipeline demo

Last Successful Artifacts  
matlabCIArtifacts.zip 11.53 MB [view](#)

Recent Changes

## Stage View

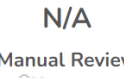
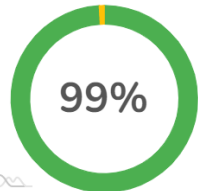
	Checkout	Project Validation	Parallel Stages	ARXML	Model Advisor	Unit Tests	SLDV	Code Generation	Polyspace	Archive Artifacts	Declarative Post Actions
Average stage times (Average full run time: ~17min 2s)	17s	39s	144ms	2min 22s	6h 52min	10min 10s	6h 53min	52s	15s	12s	18s
Apr 12 14:04	15s	39s	129ms	1min 3s	6min 27s	12min 13s	9s	1min 30s	28s	21s	1s
Apr 12 18:31	18s	42s	187ms	1min 4s	10s	12min 51s	11s	1min 30s	28s	22s	1s
Mar 22 16:34	18s	47s	192ms	5min 59s	7min 21s	13min 59s	11min 48s	1min 26s	27s	21s	27s
Mar 20 12:51	16s	39s	124ms	5min 58s	6min 42s	12min 33s	11min 45s	1min 26s	29s	11s	27s
Mar 20 11:20	17s	37s	140ms	1min 8s	6min 38s	13min 24s	11min 42s	1min 25s	20s	21s	27s
Mar 20 10:57	16s	37s	109ms	5min 57s	6min 41s	13min 32s	11min 43s	1min 24s	20s	20s	27s
Mar 20 10:30	19s	38s	126ms	52s	25min 37s	11min 21s	25min 37s	62ms	46ms	62ms	aborted

## Job Status

## MODEL QUALITY

### MODEL STANDARDS

112 Passed  
0 Failed  
1 Warning  
0 Not Run



Design Quality Dashboard

### OVERVIEW

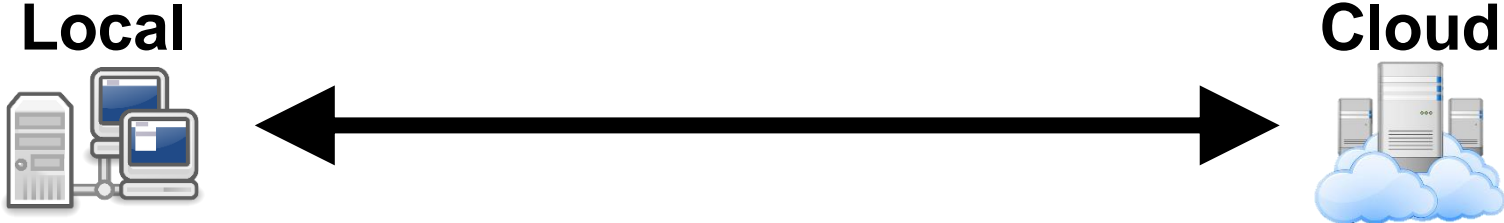
Model Name	DriverRequest
Model Version	2.1
Simulink Version	10.4 (R2021b)
Last Modified By	rsnah




### Result Summary

Model Standards (99)

Code Complexity (76)  
Model Complexity (96)  
Absence of Code Defects (100)  
Absence of Design Errors (100)  
Code Standards (100)

# Scalability



	Local CI 	Cloud CI w/ local agents 	Cloud CI 
Setup	<ul style="list-style-type: none"> <li>•Primary + Agents on your hardware</li> </ul>	<ul style="list-style-type: none"> <li>•Primary on cloud hardware</li> <li>•Agents on local hardware</li> </ul>	<ul style="list-style-type: none"> <li>•Primary + Agents on cloud hardware</li> </ul>
Pros	<ul style="list-style-type: none"> <li>•More control</li> <li>•Code privacy</li> </ul>	<ul style="list-style-type: none"> <li>•Easier to scale (less complexity)</li> <li>•Code privacy</li> </ul>	<ul style="list-style-type: none"> <li>•No installation + maintenance</li> <li>•Very easy to scale (complexity + cost)</li> </ul>
Cons	<ul style="list-style-type: none"> <li>•Harder to scale (↑ complexity)</li> <li>•Expensive to scale (hardware)</li> </ul>	<ul style="list-style-type: none"> <li>•Hardware setup + maintenance</li> <li>•Expensive to scale (hardware)</li> </ul>	<ul style="list-style-type: none"> <li>•Service costs can add up</li> <li>•Your private code sent to cloud servers</li> </ul>

# Summary

- Benefits of CI are a big win for engineering productivity
  - Reducing overhead with automation
  - Building consistency
  - Enabling a cultural shift to early verification and collaboration
  - Enabling PLA approach at scale
- Plus, we are improving our native support in this area

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**Thank you**

