Enabling MATLAB and Simulink for Use in the Cloud

Loren Dean, MathWorks

- Senior director of MATLAB development. ~30 years with MathWorks
- Responsibilities include
  - Parallel computing, controls and test and measurement
  - Online Products Development: MATLAB Online, MATLAB Mobile, Cloud Platform integration and general infrastructure
- B.S. and an M.S. in aeronautical engineering from Purdue University and an M.B.A. from Northeastern University.

Leslie Mehrez, MathWorks

- Senior manager, technical marketing. 15+ years with MathWorks
- Responsibilities include
  - Technical marketing of online products
  - Bringing MATLAB and Simulink products to cloud, web and mobile platforms
- B.S.E.E. from Lafayette College and an M.B.A. from Babson College

MathWorks
AUTOMOTIVE CONFERENCE 2024
North America

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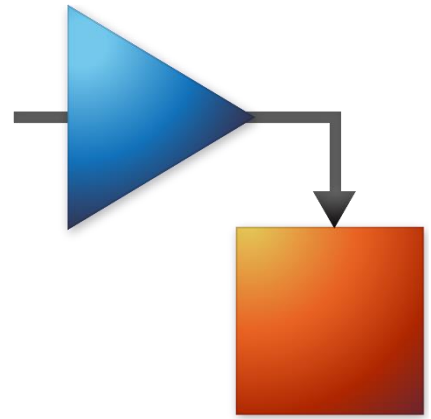
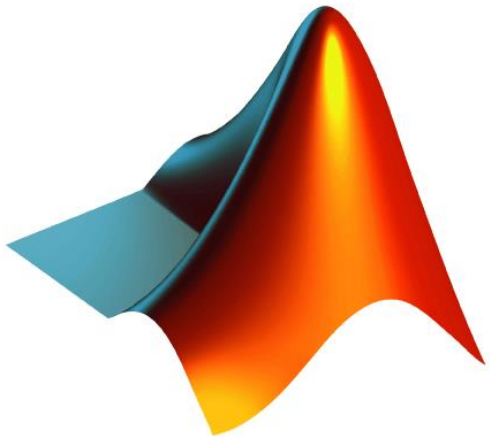
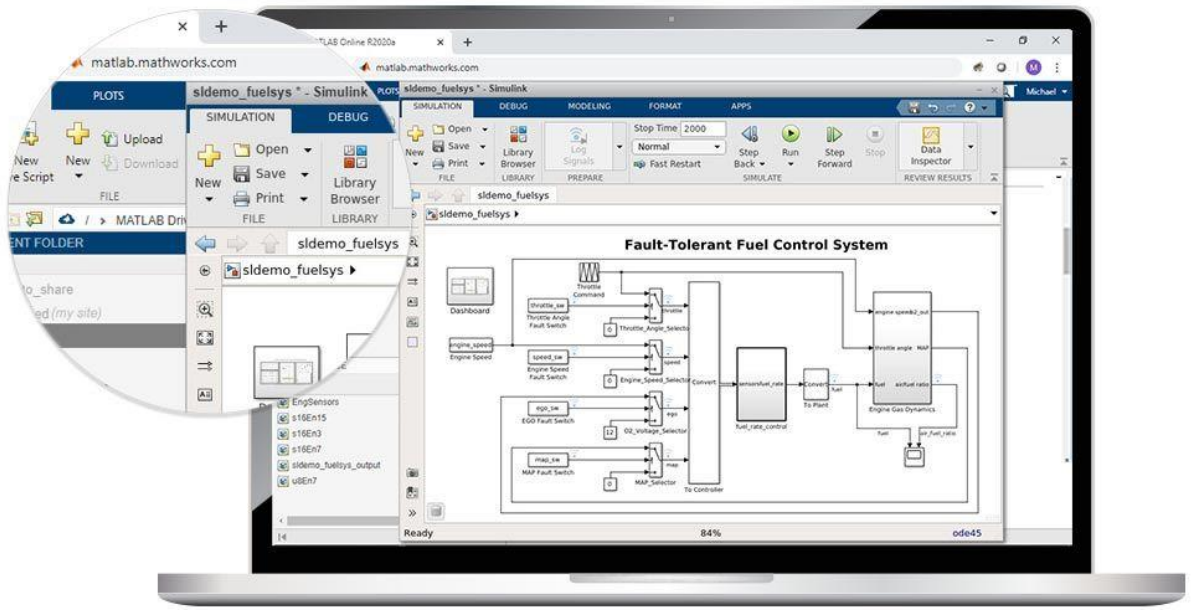
Leslie Mehrez
Sr. Manager Technical Marketing
Online Products

Loren Dean
Senior Director of Engineering,
Online Products and Technical Computing


aws







MATLAB Online (2010)

Containers

Cloud Center

Cloud Data Services

Cloud Marketplace Offerings

Reference Architectures

Infrastructure as Code

Cloud Plays a Critical Role in Automotive Transformations

Software complexity and data growth

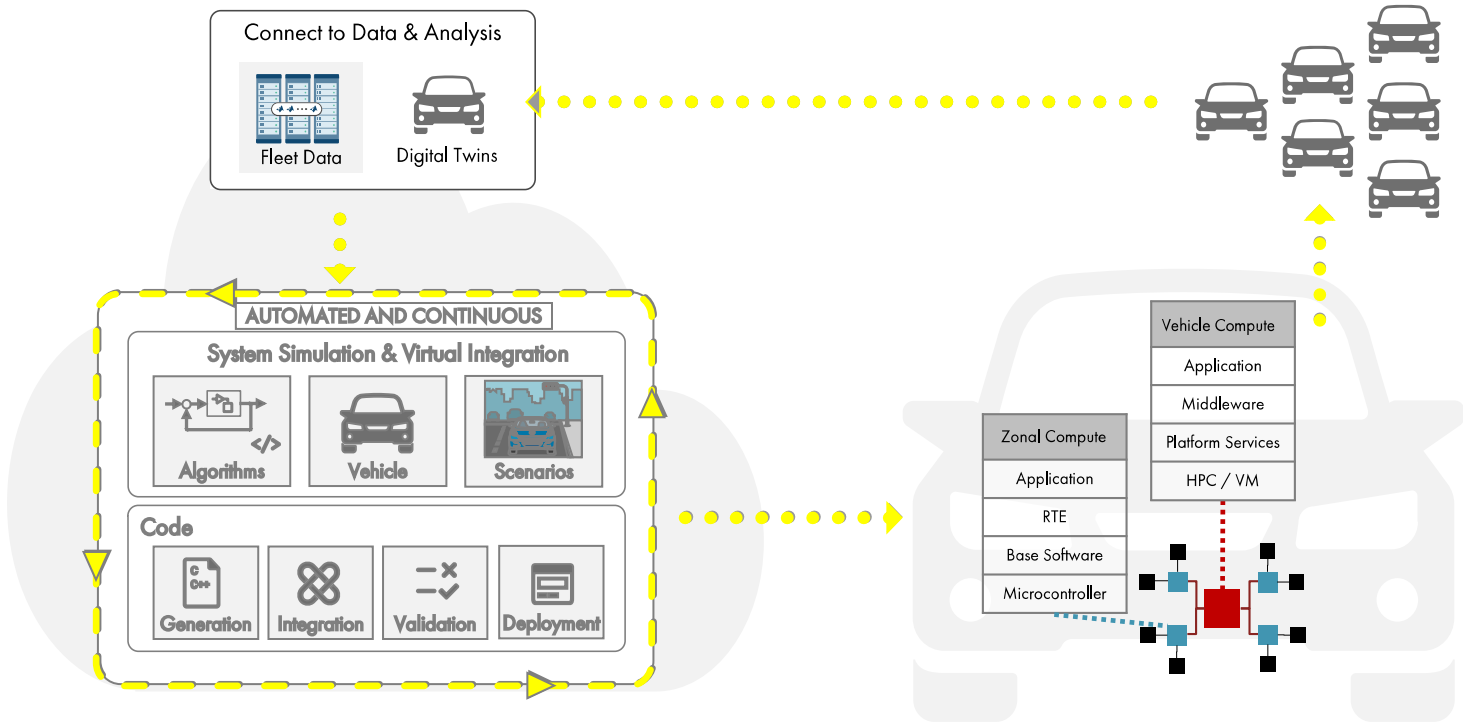
- Connectivity V2X (Vehicle to Infrastructure, Vehicle to Vehicle, etc.)

Shorter development times

- New models every 2 years vs 5 years

Consumer expectations

- Digital continuity from phone to car, Immediate OTA (Over the Air) fixes



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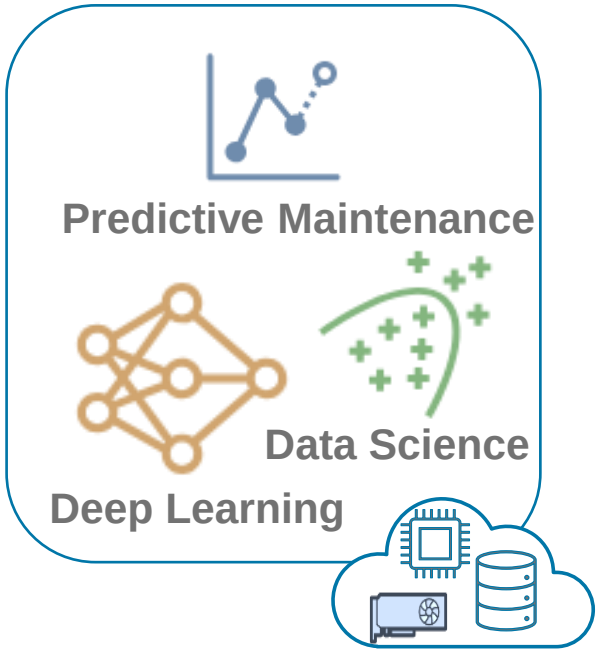
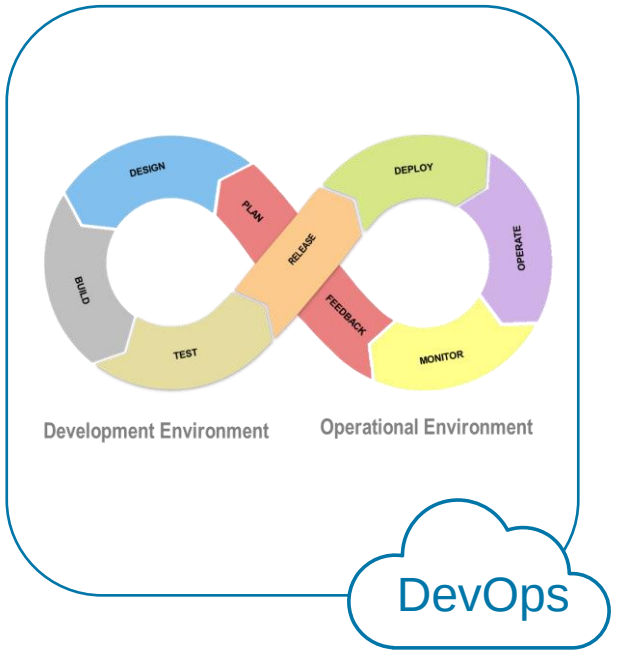
Key reasons engineering workflows move to the Cloud



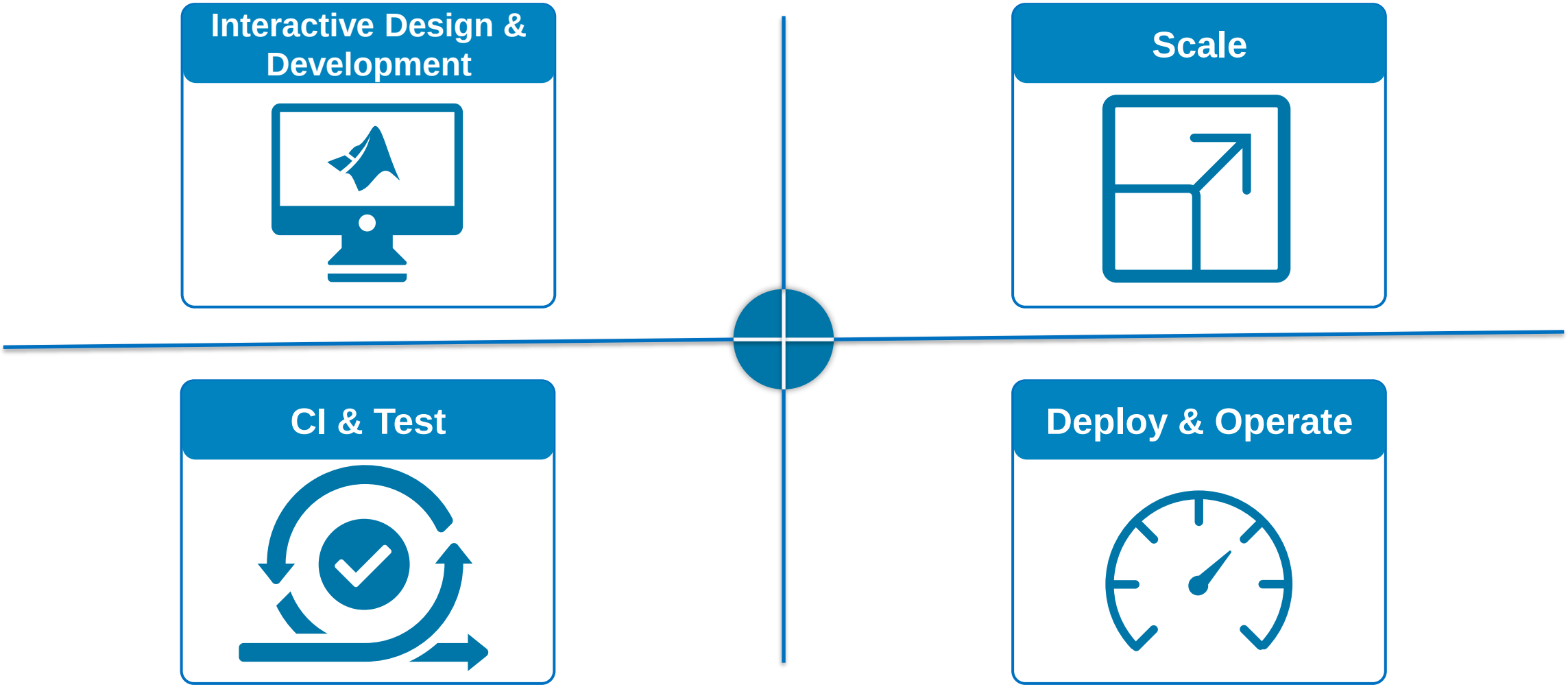
Data Growth

IT Evolution

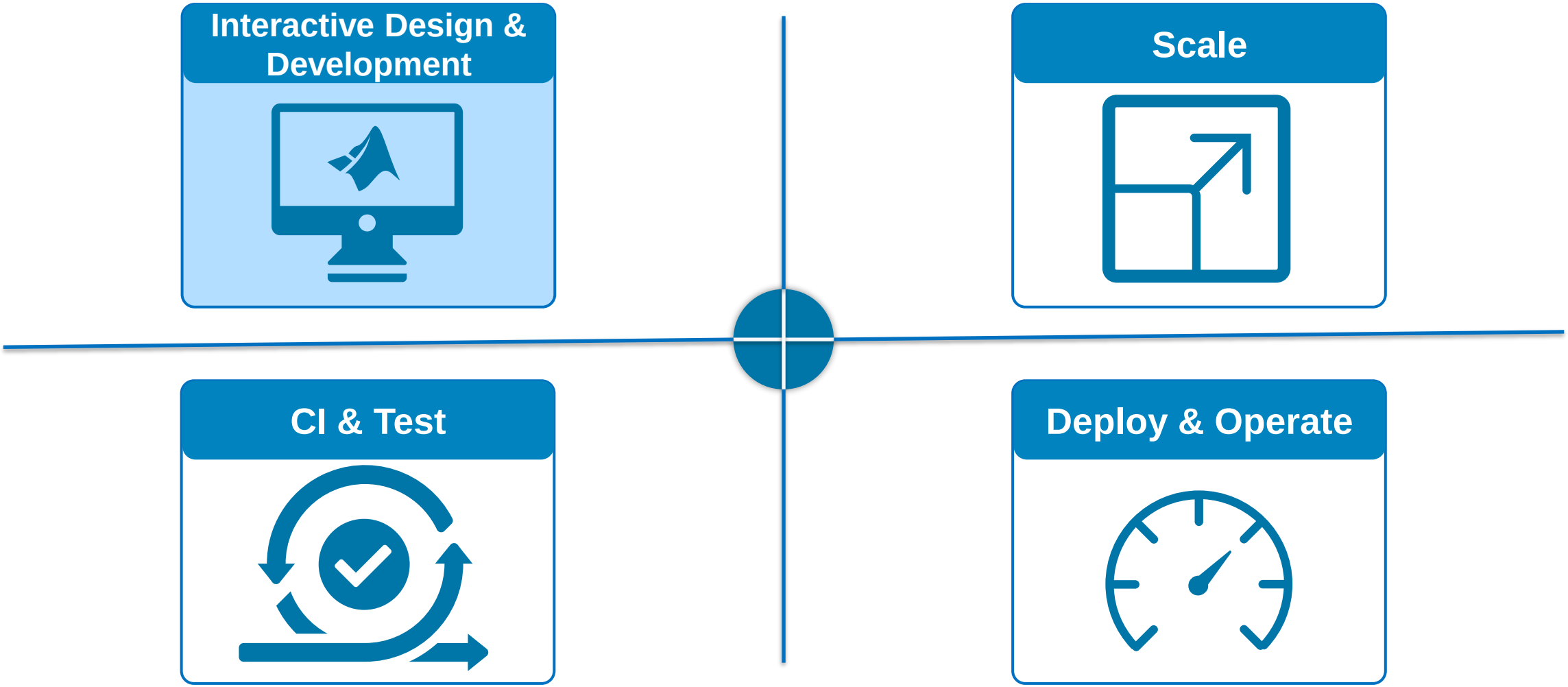


Operationalize Code and Realize Value

Start with the Cloud Usage Framework



Start with the Cloud Usage Framework



Run MATLAB & Simulink in any Cloud Context

Azure

aws

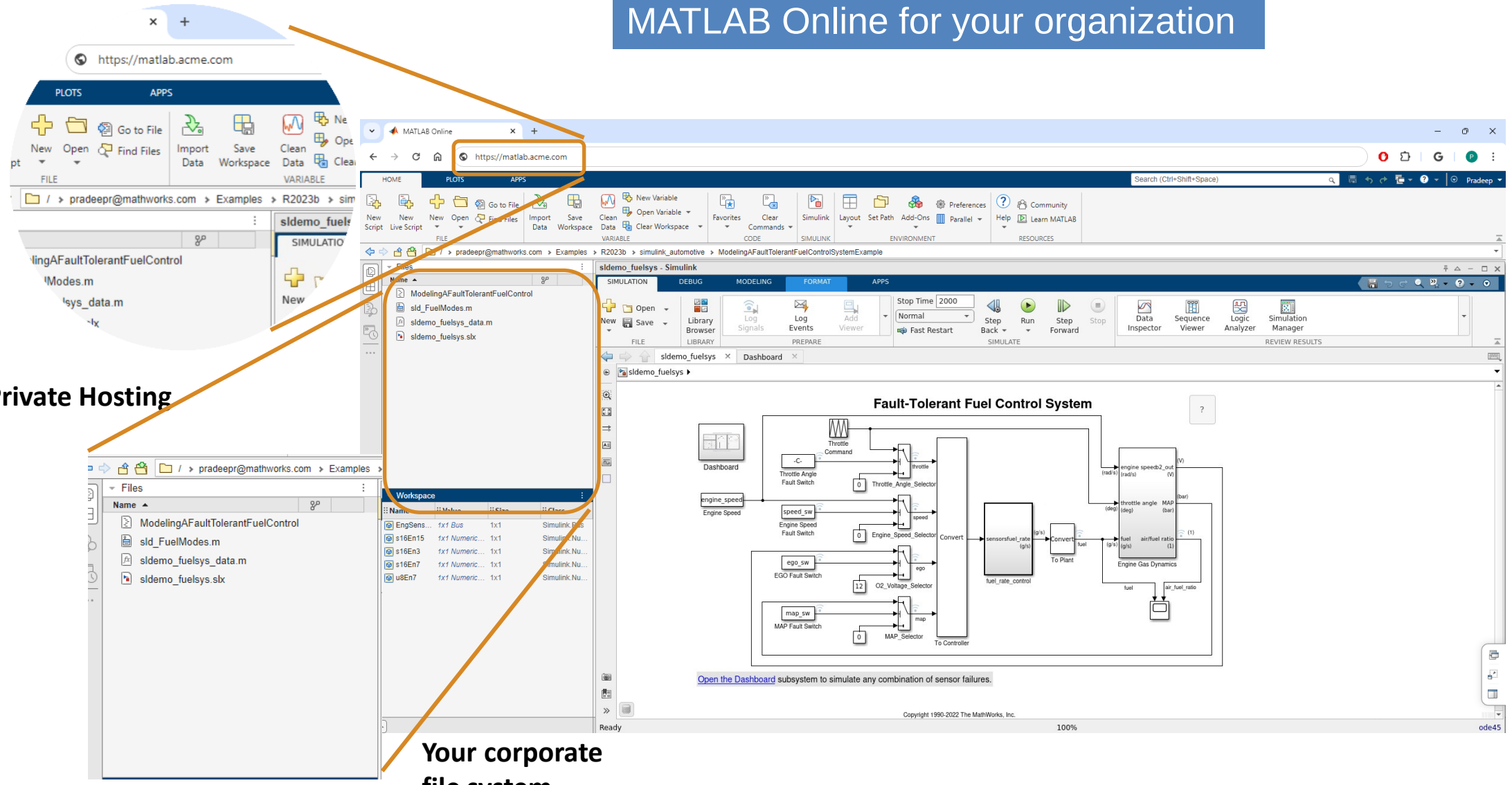
jupyter

Google Cloud Platform

databricks

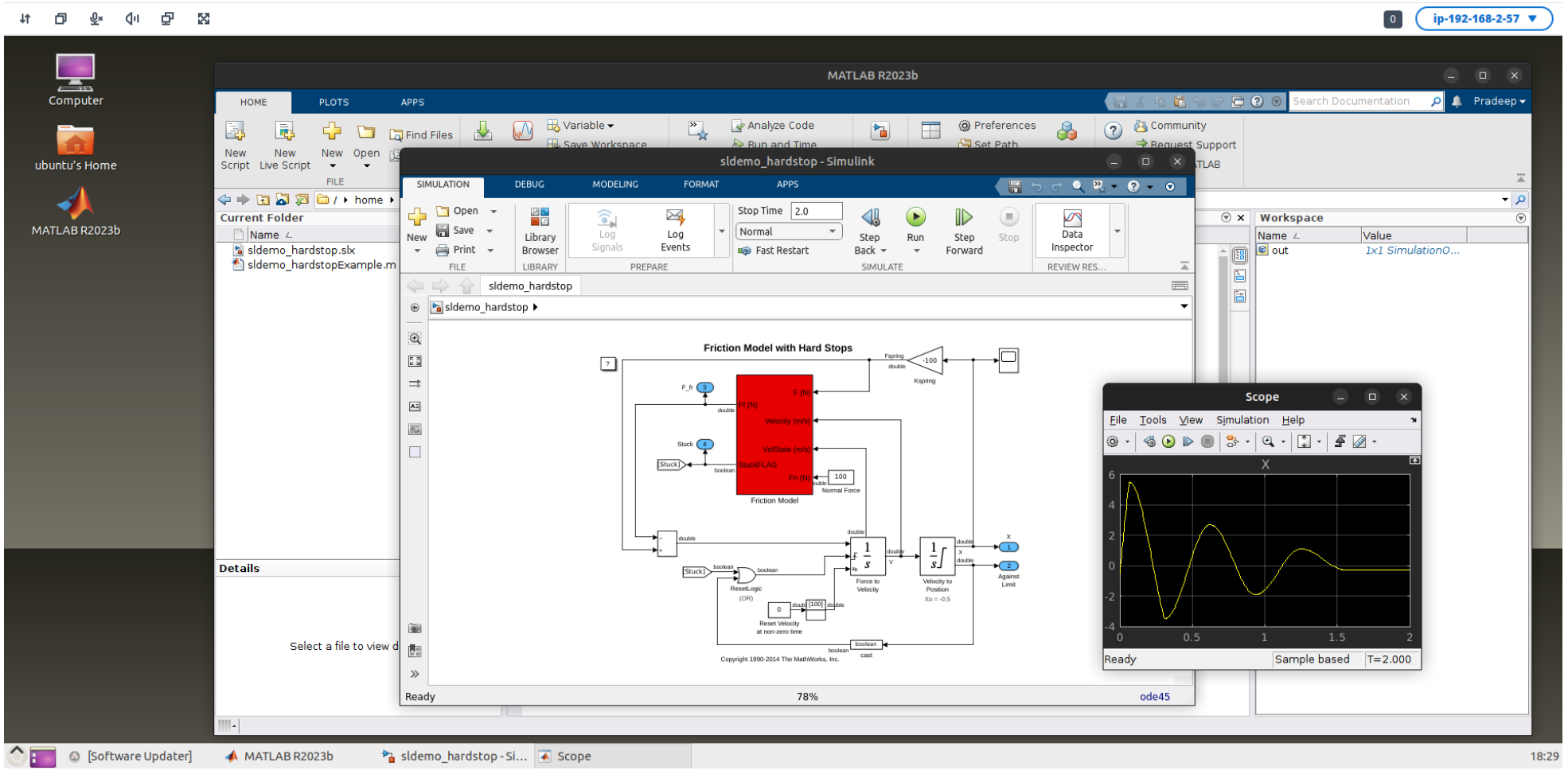
Run MATLAB & Simulink in any cloud context

MATLAB Online for your organization

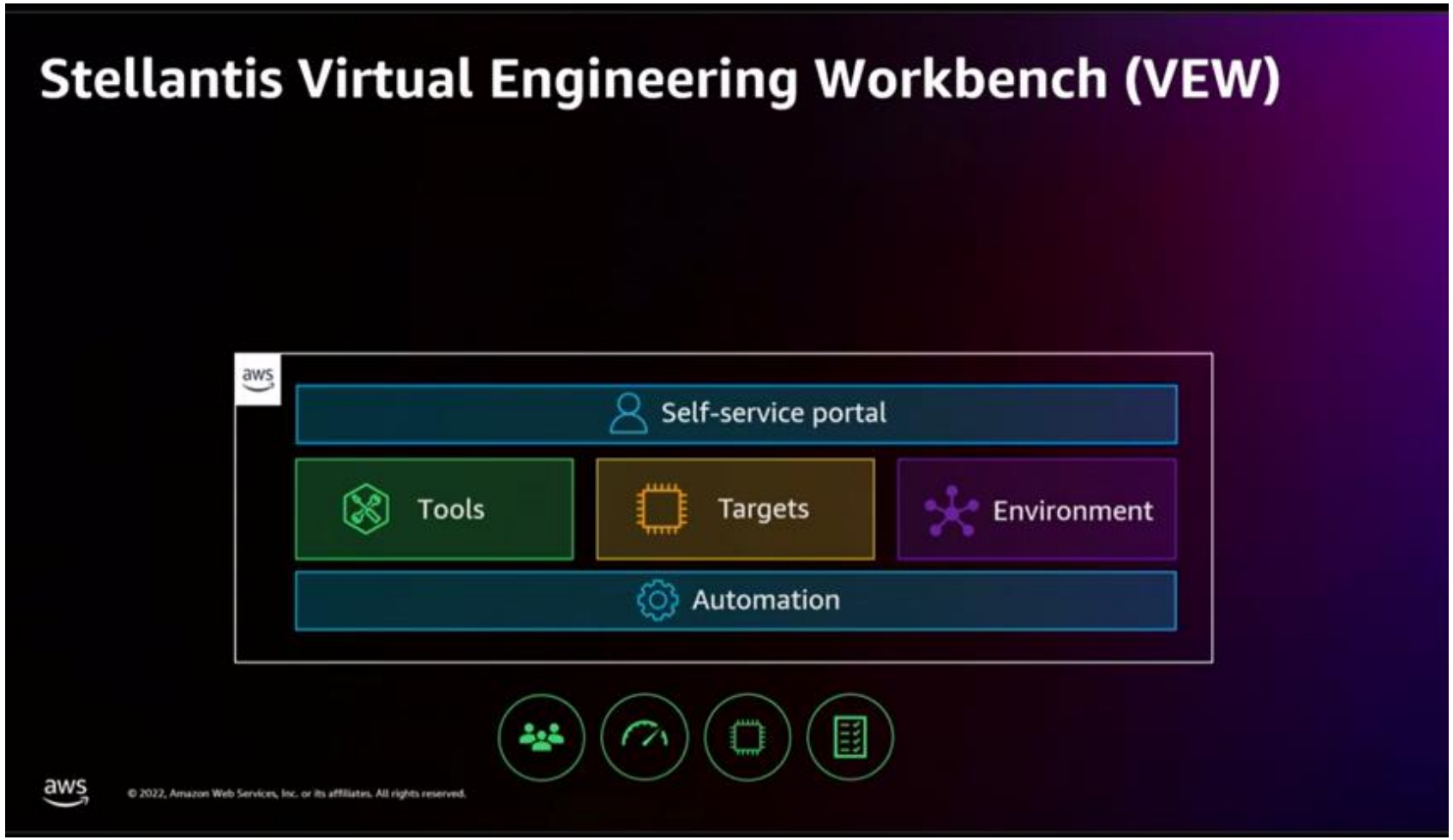


Run MATLAB & Simulink in any Cloud Context

MATLAB in a Virtual Machine or container



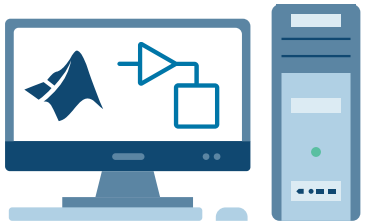
Stellantis Virtual Engineering Workbench Will Streamline Software Development Workflows



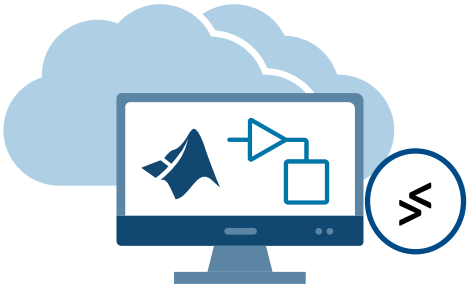
Presented at AWS Re:Invent 2023

New Considerations for Interactive Design and Development on the Cloud

- MathWorks
  - Common user experience for all contexts
- You
  - What is the right cloud context?
    - Control and flexibility



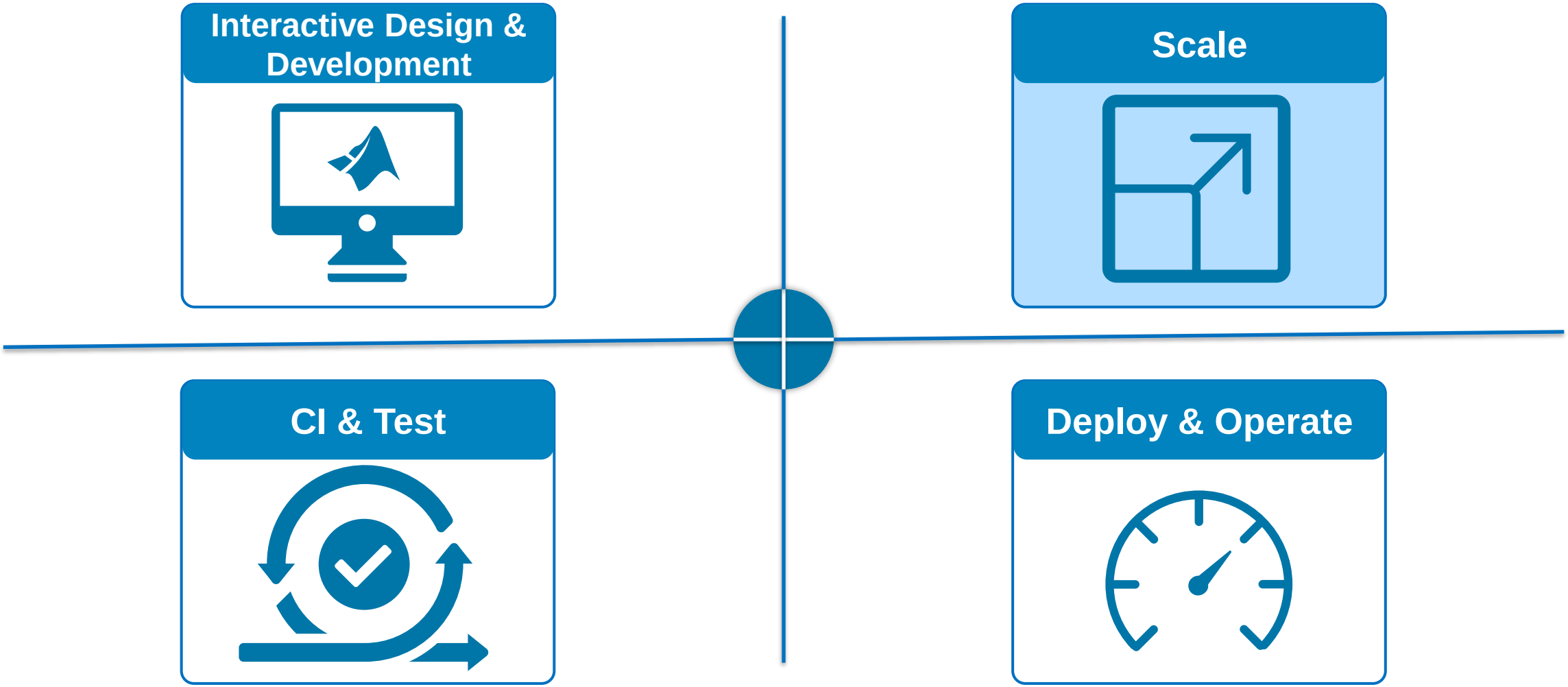
Local PC



Virtual Desktop

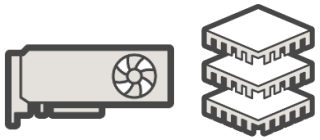
Browser-based

MATLAB and Simulink Cloud Usage Framework



Scaling Compute and Data

Compute

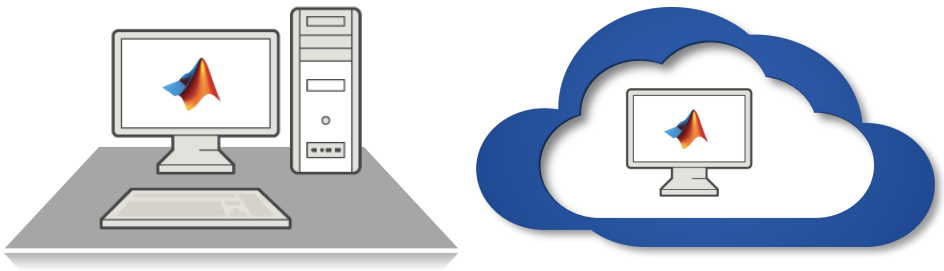


Scale locally with GPU or multi-core

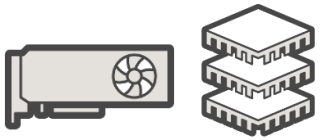
Data

Connect to cloud data

Scaling Compute and Data



Compute



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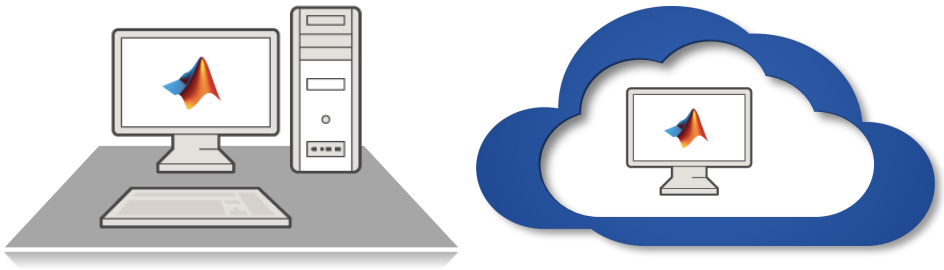
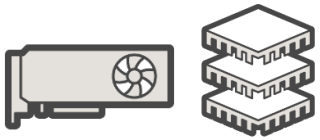


Compute



Scale locally with GPU or multi-core

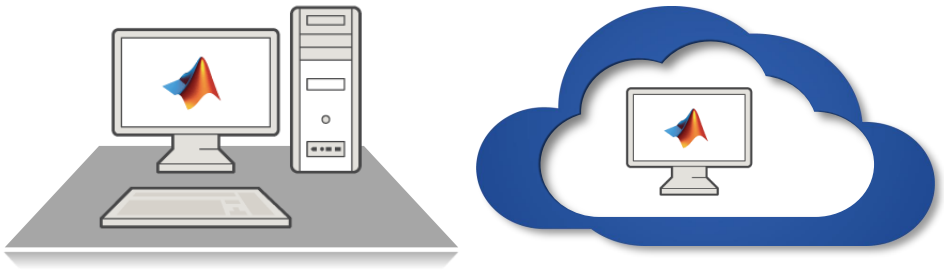
Data

Connect to cloud data

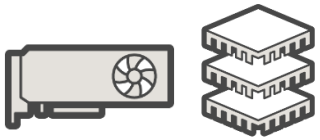
Access more capable compute resources at scale

Connect to cloud data

Scaling Compute and Data



Compute



Scale locally with GPU or multi-core

Data

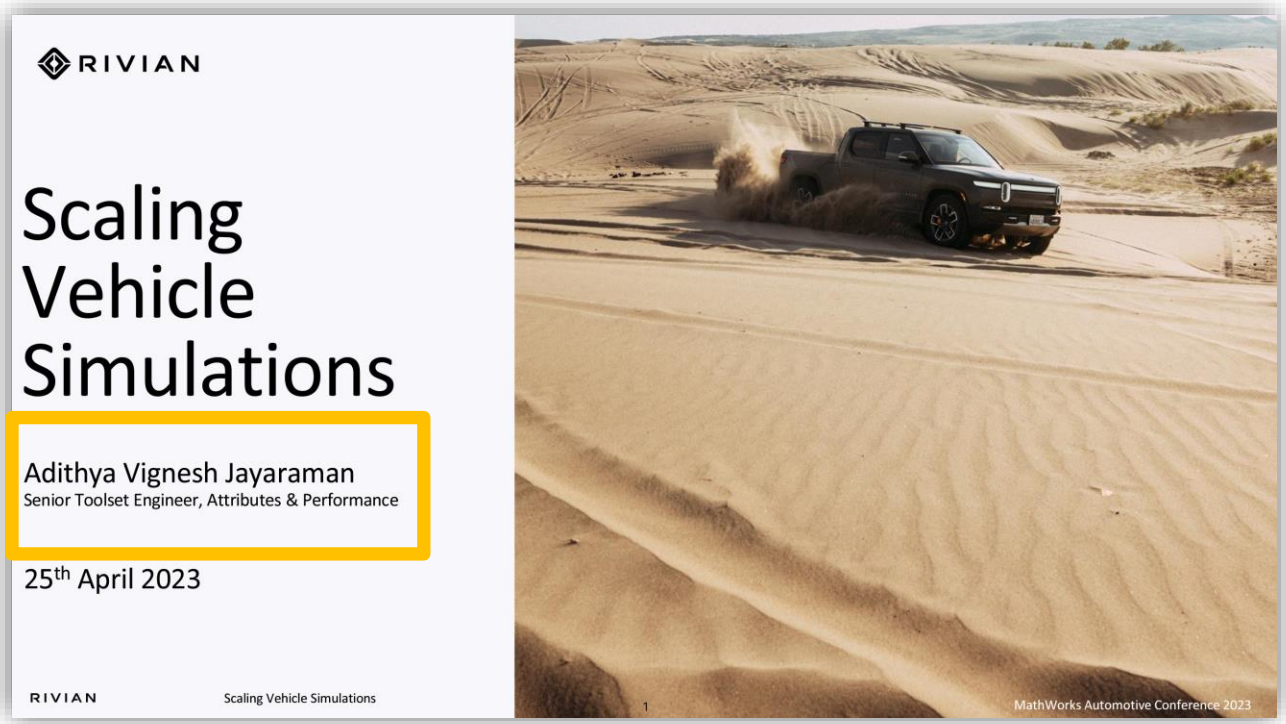
Connect to cloud data

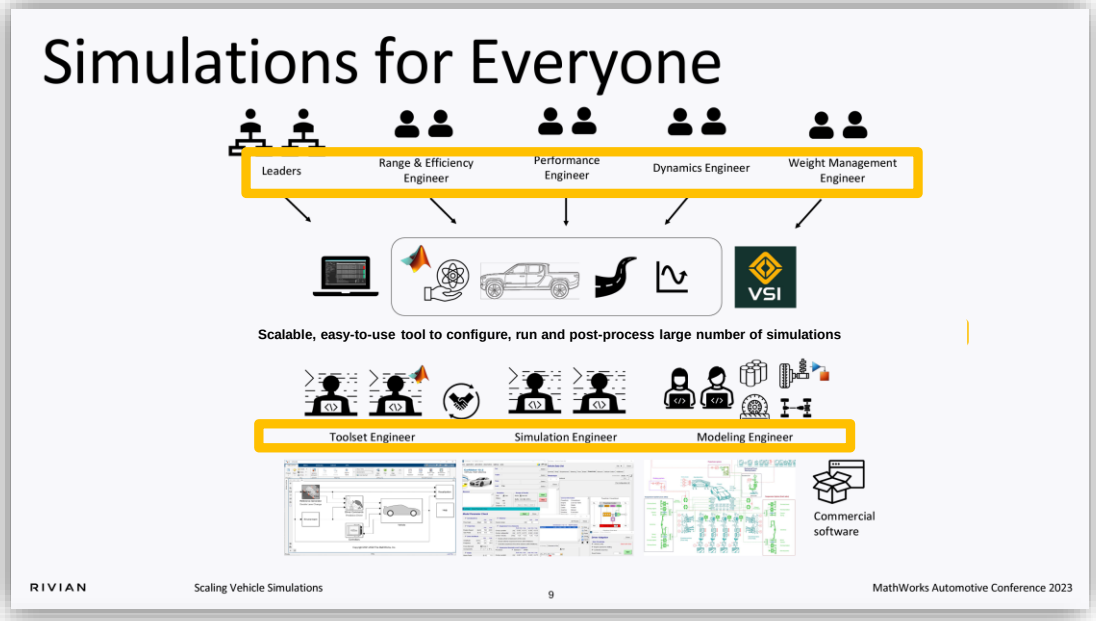
Access more capable compute resources at scale

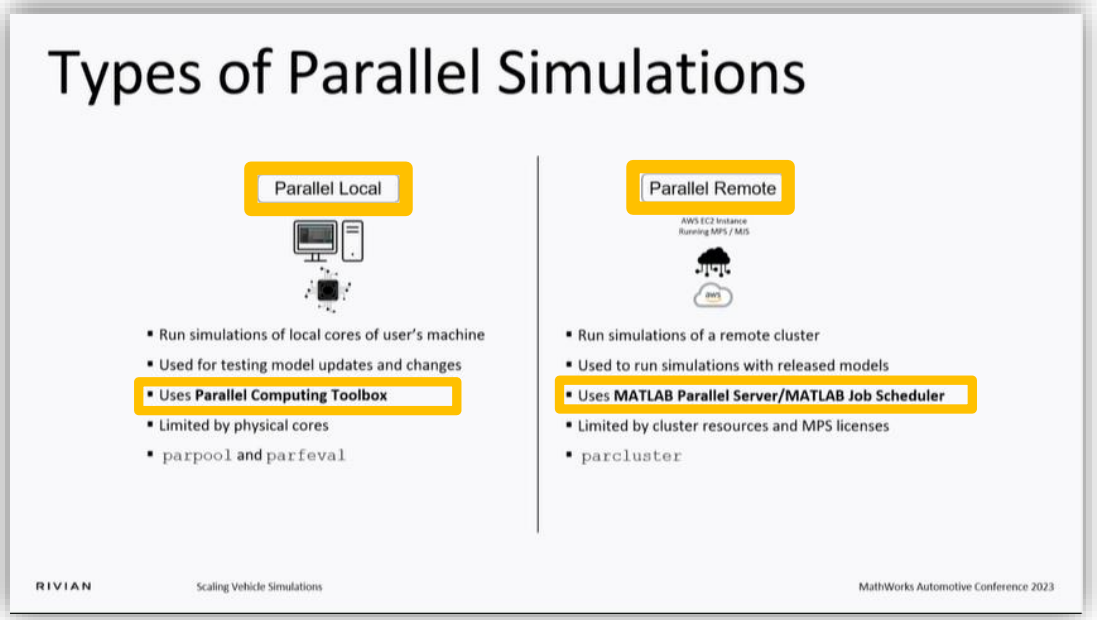
Connect to cloud data

Orchestration required

Scaling Vehicle Simulations

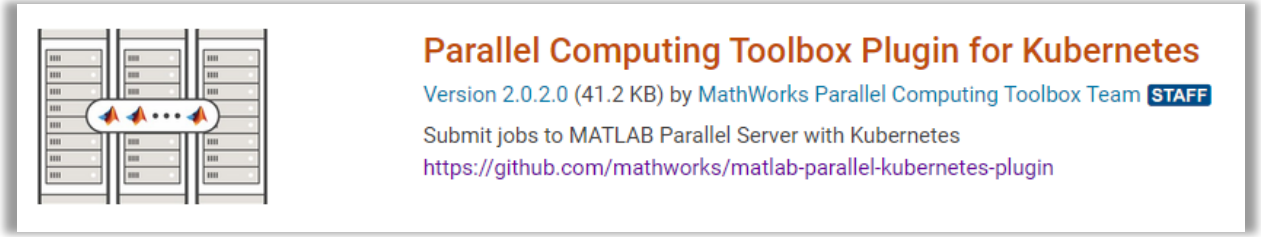






[Link to user story](#) (search MathWorks Rivian)

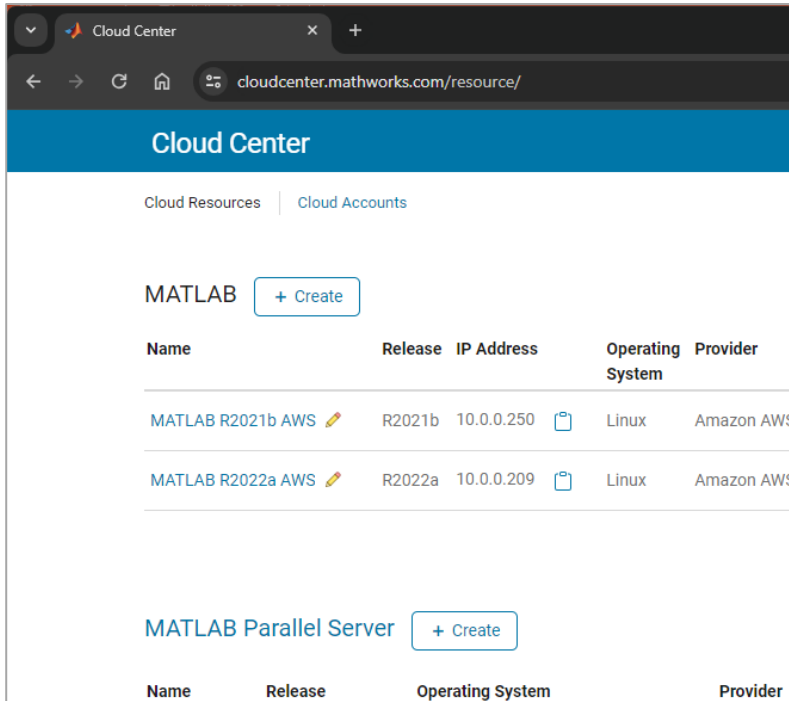
New Requirements for Scaling



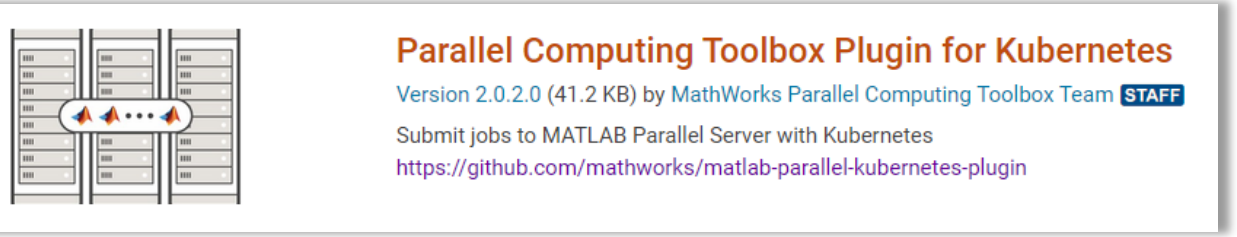
- MathWorks
  - Building tools that can scale on any cloud environment while providing a common user experience
    - Parallel Language for end users
    - Technology and licensing to scale

10,000 Workers with 64 Threads each – 640,000 cores of computation

R2023a



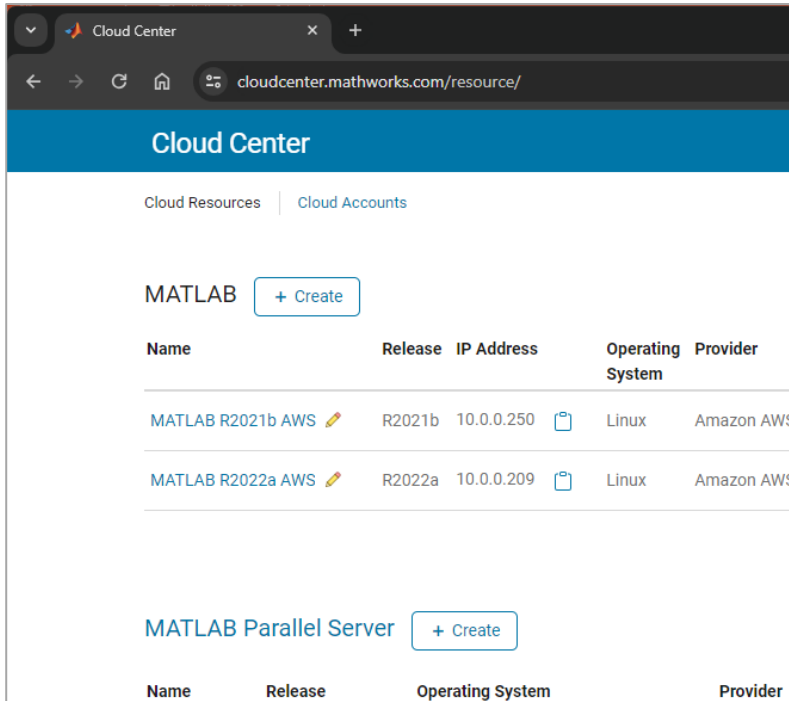
New Requirements for Scaling



- MathWorks
  - Building tools that can scale on any cloud environment while providing a common user experience
    - Parallel Language for end users
    - Technology and licensing to scale
- You
  - Running at scale is a journey, not a “one and done” activity.
  - Building processes that let you scale from desktop to cloud
  - Working across the organization with other teams, including IT, and departments

10,000 Workers with 64 Threads each – 640,000 cores of computation

R2023a

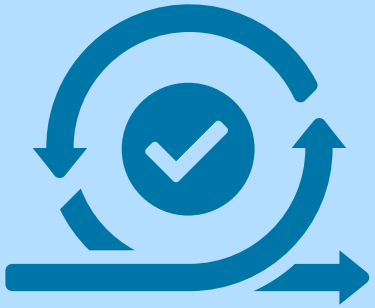


MATLAB and Simulink Cloud Usage Framework

Interactive Design & Development

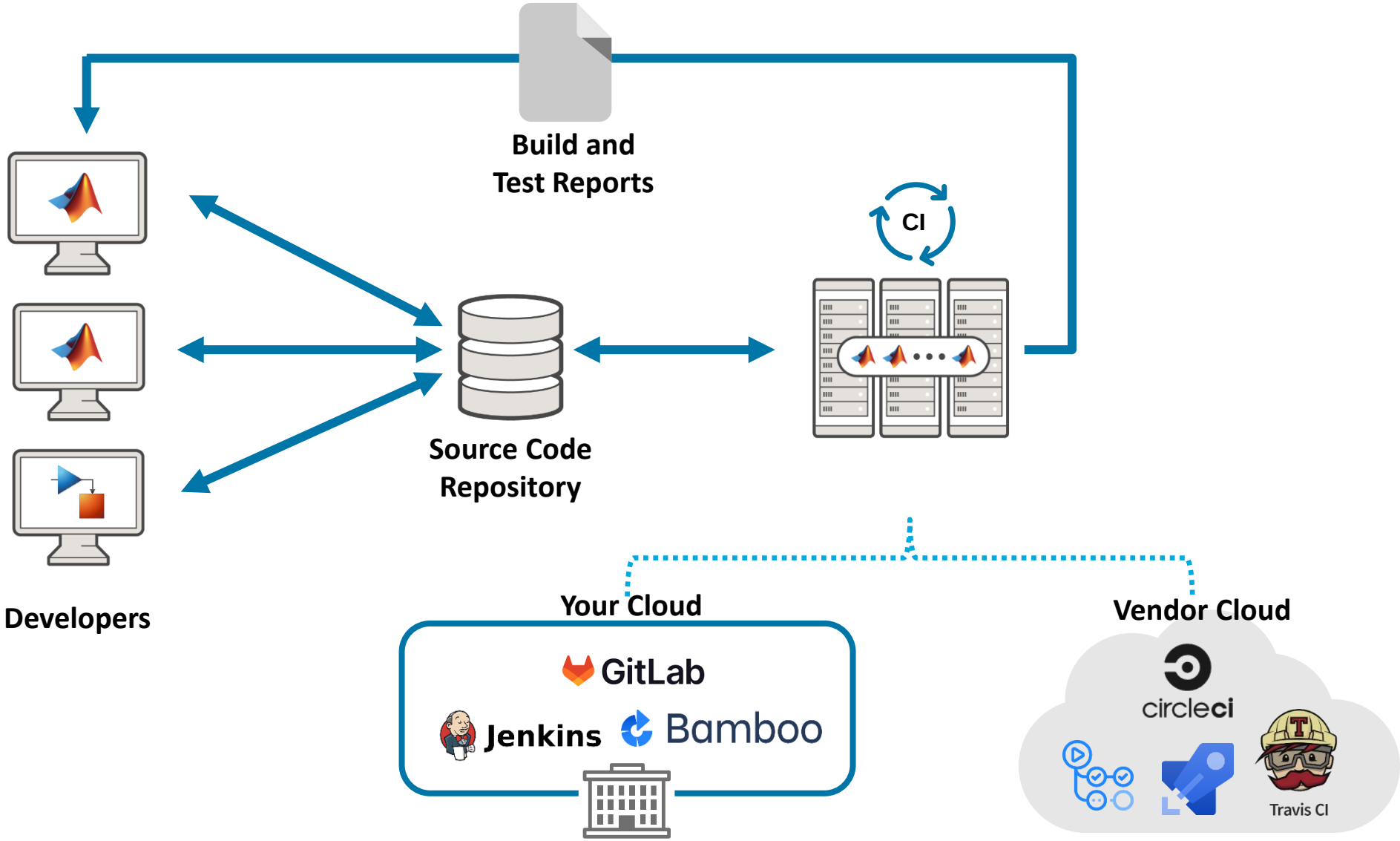
Scale

CI & Test

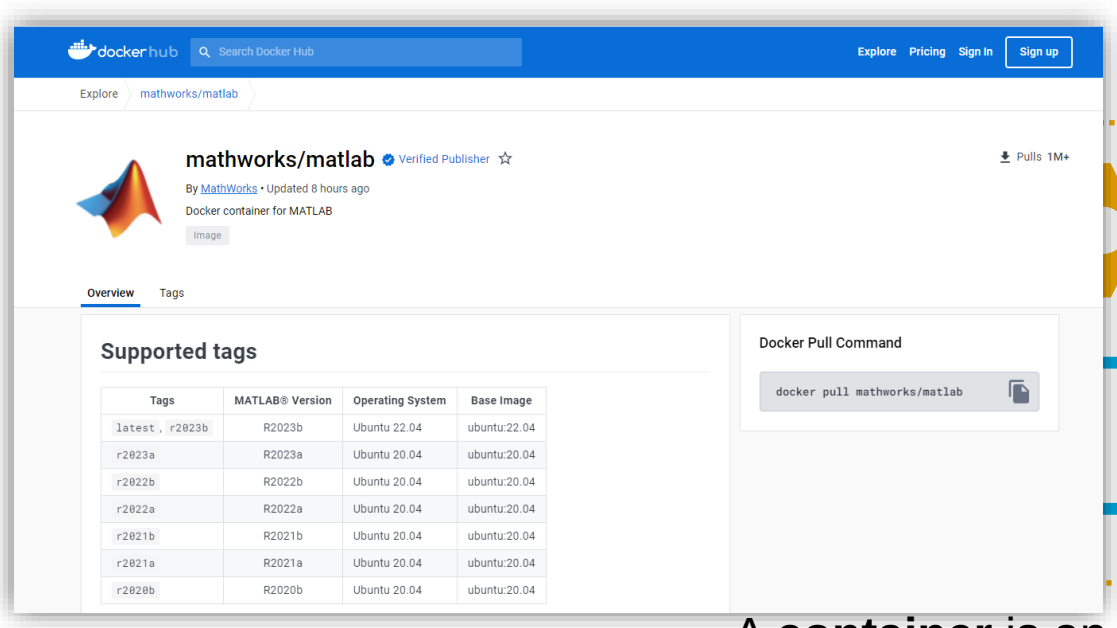


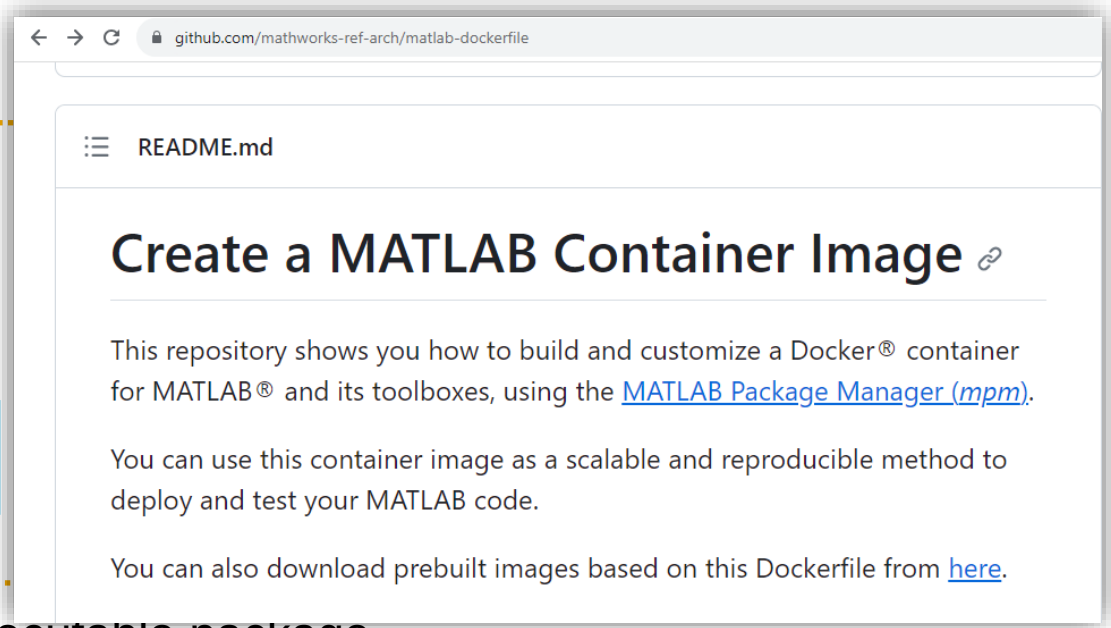
Deploy & Operate

CI & Test involves automating the build and test of MATLAB code and Simulink models



Containers are the basis for CI build agents and environments



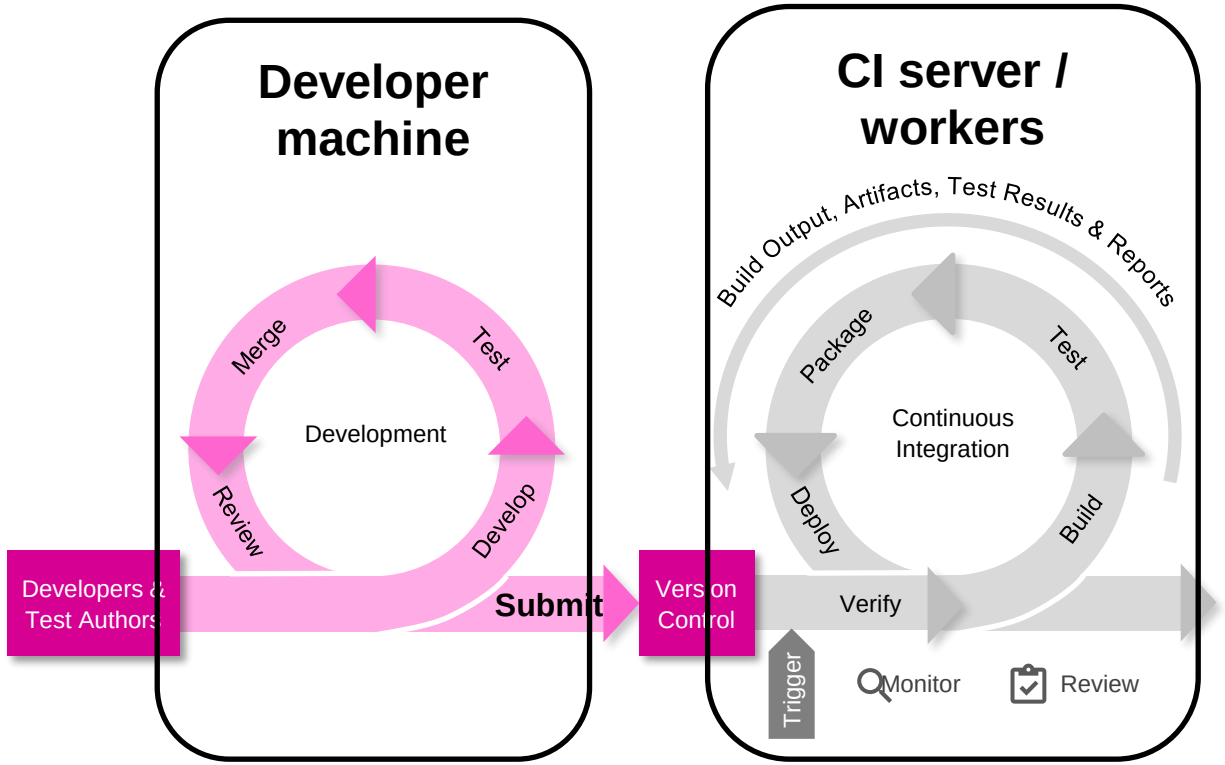


A **container** is an executable package
lication and all its

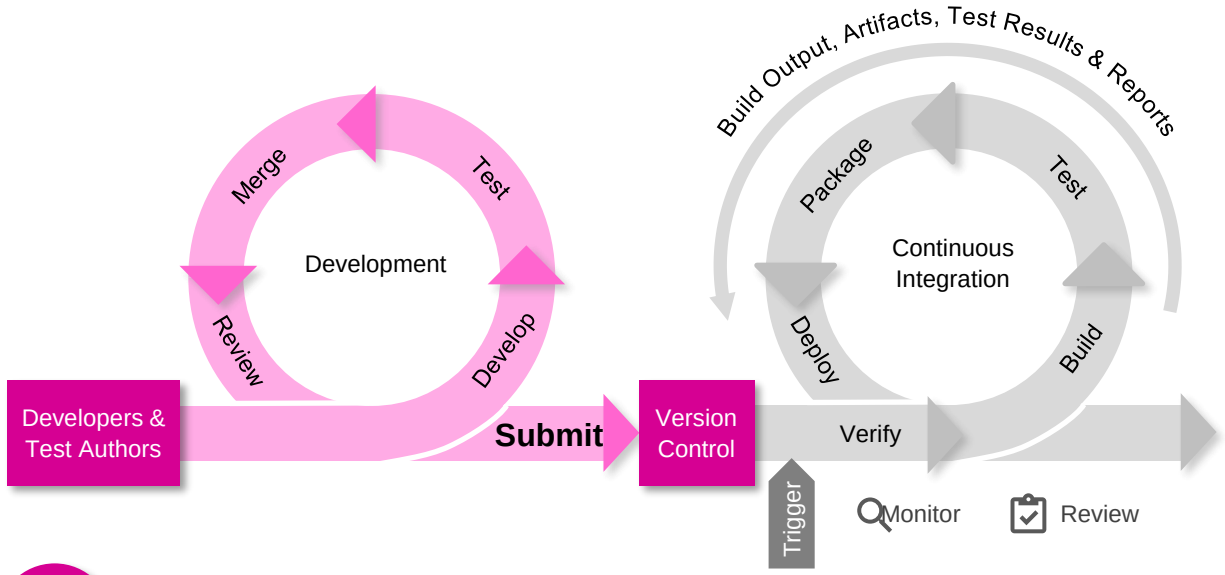
MATLAB & Simulink Containers on Dockerhub

Docker files on GitHub

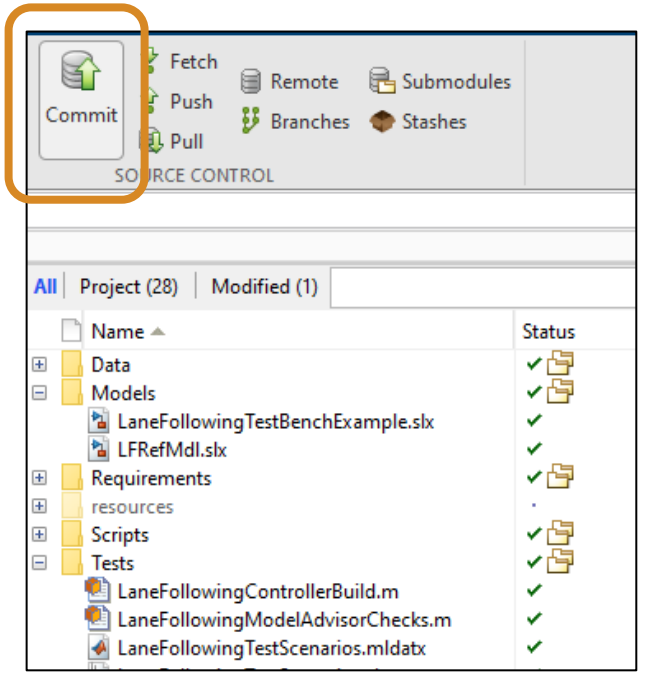
Continuous Integration workflow with Model-Based Design



Continuous Integration workflow with Model-Based Design

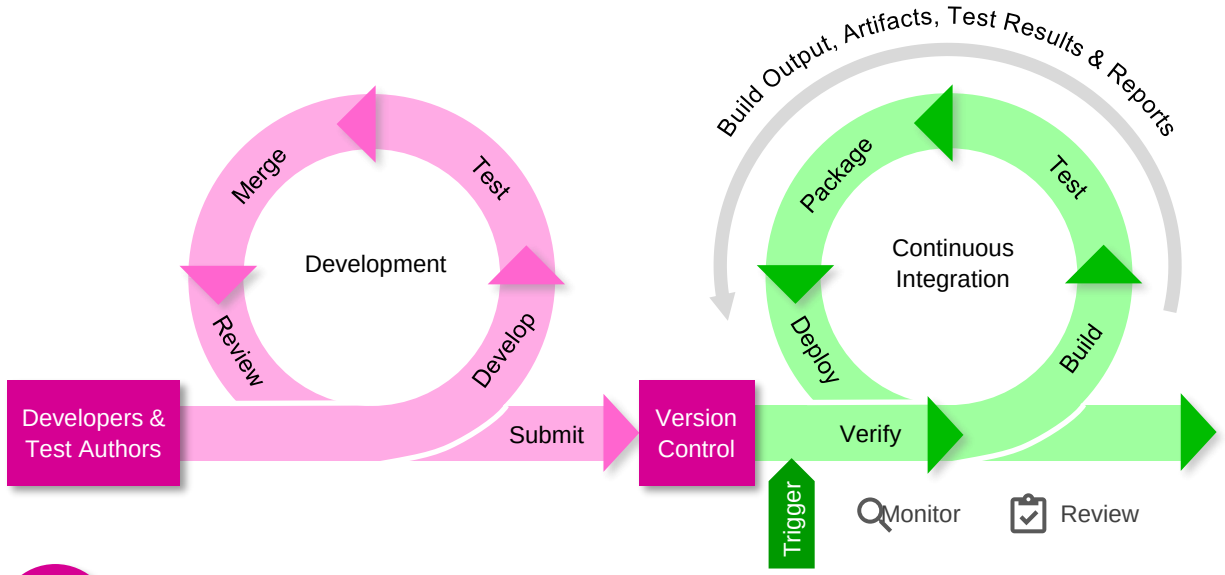


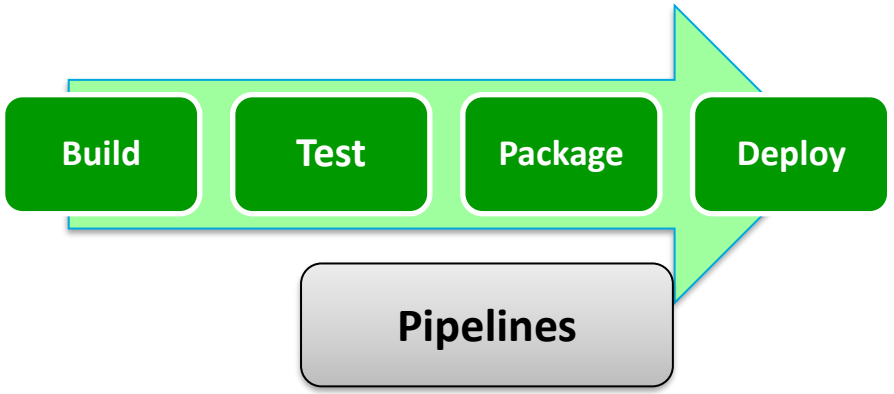
1 **Development**



Manage using Projects

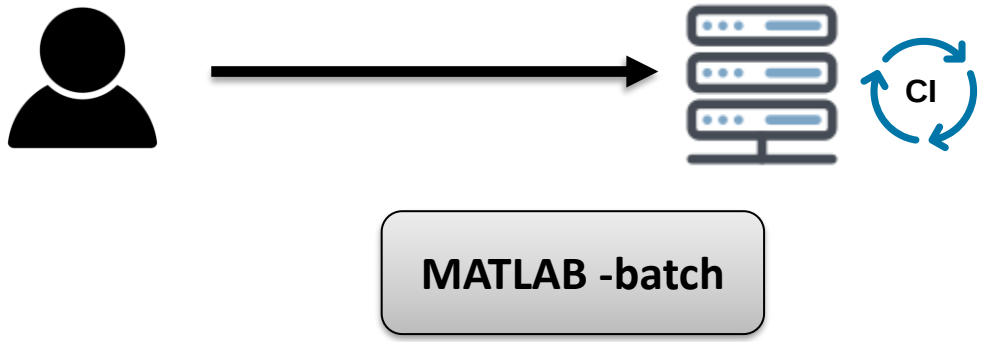
Continuous Integration workflow with Model-Based Design





1 **Development**

2 **Continuous Integration**



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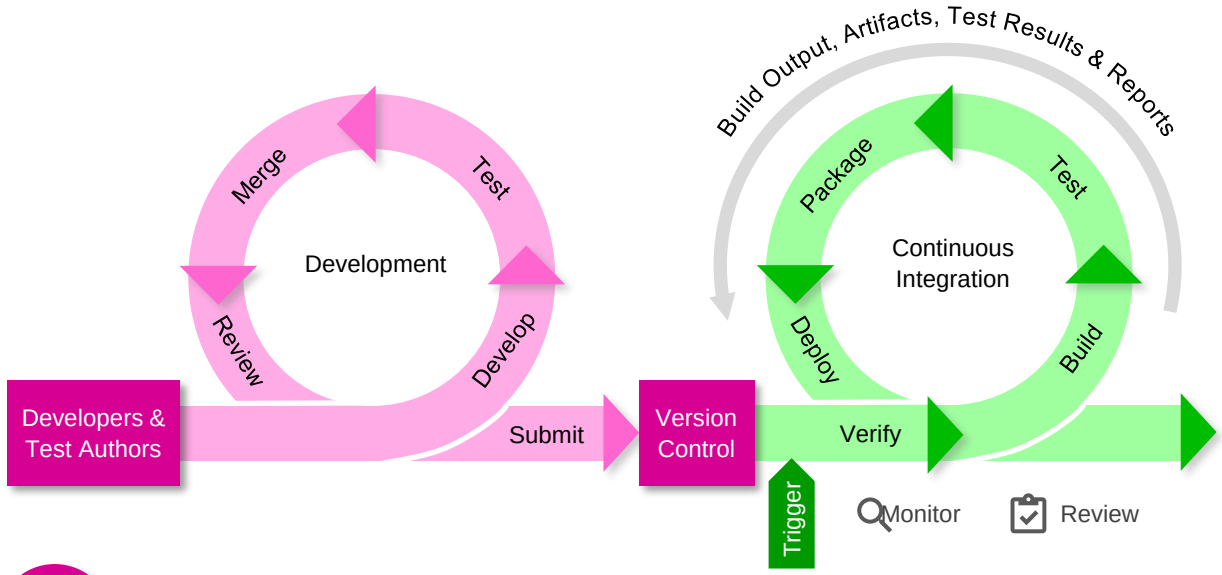
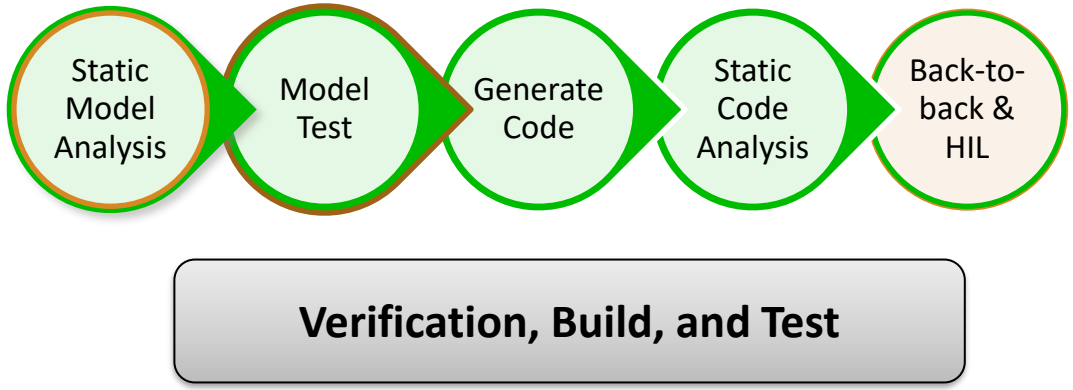
Continuous Integration workflow with Model-Based Design



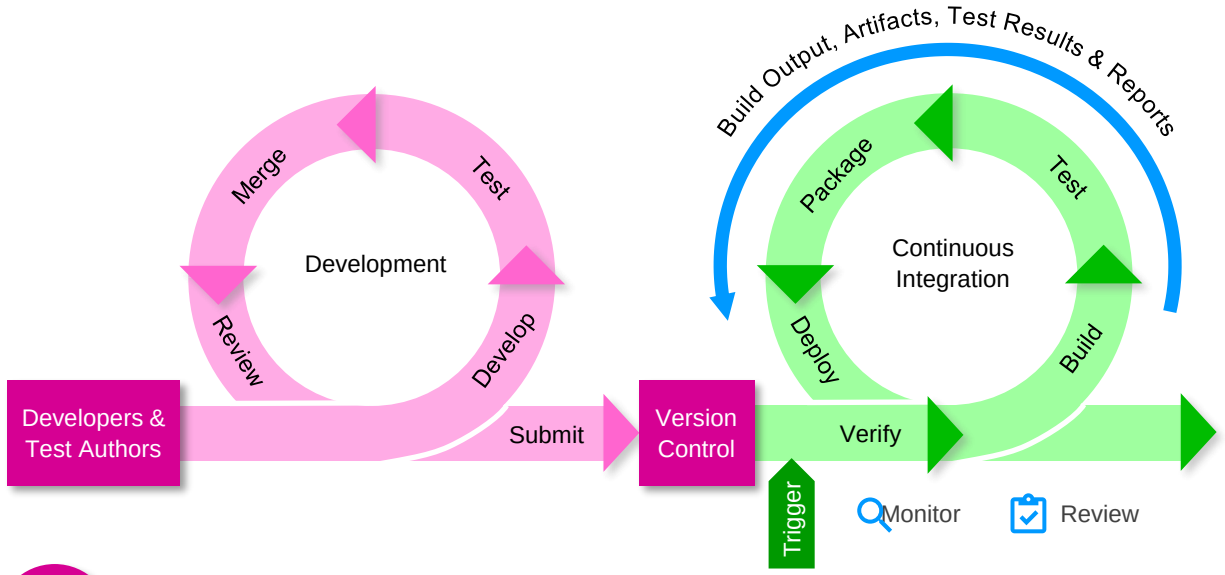
1 **Development**

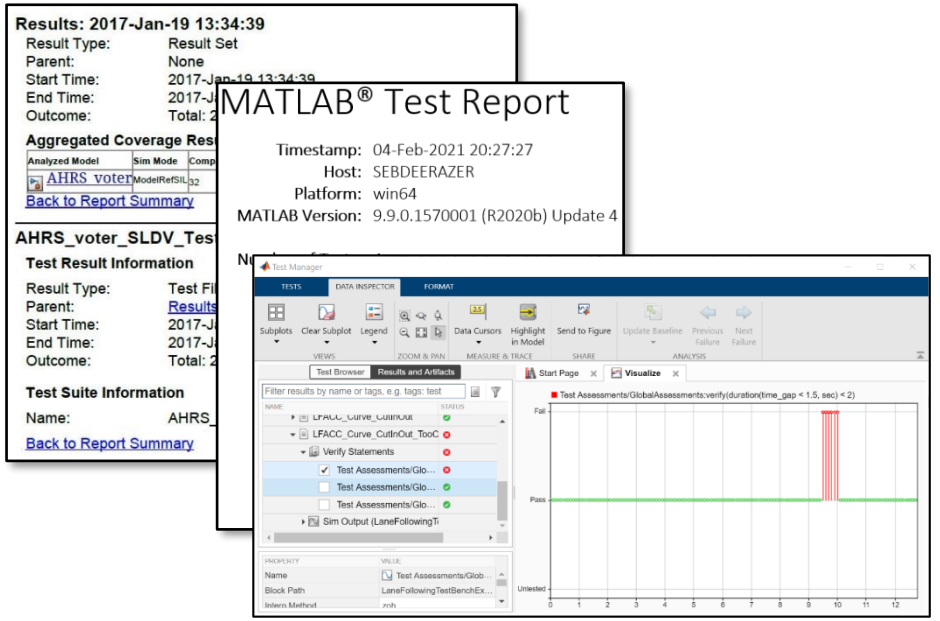
2 **Continuous Integration**



Verification, Build, and Test

Continuous Integration workflow with Model-Based Design





Test and Code Coverage Reports
Simulink Test Results

1. **Development**
2. **Continuous Integration**
3. **Results Monitor and Review**

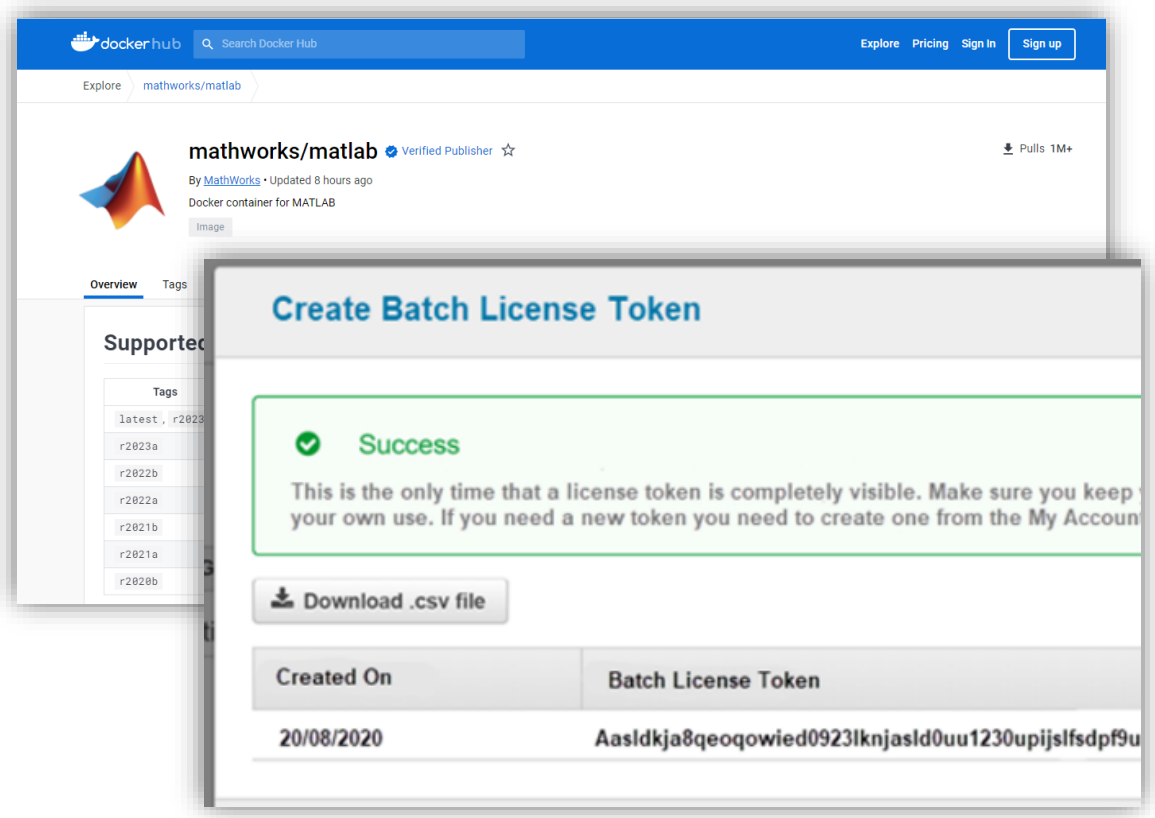
ISO 26262 — Functional Safety

ISO/SAE 21434 — Cybersecurity for Road Vehicles

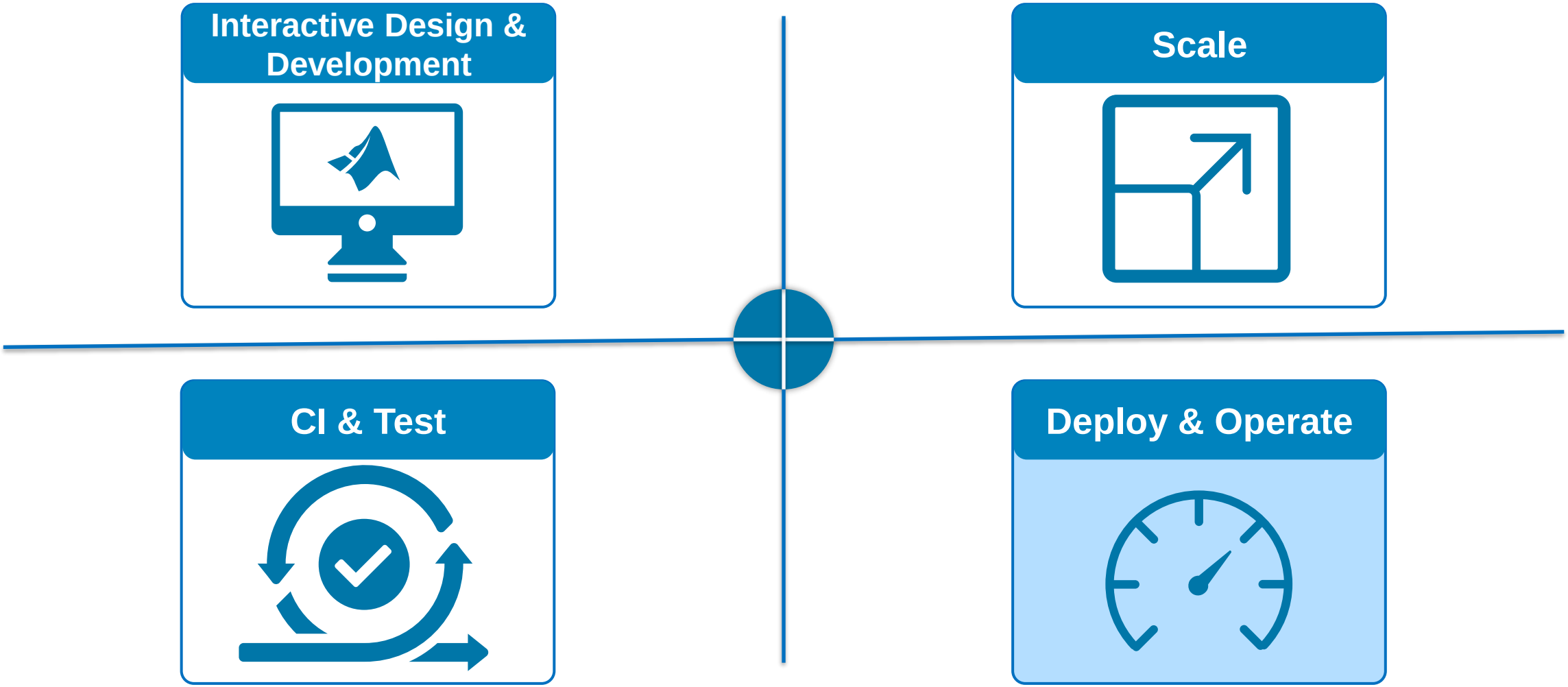
ISO 21448 — Safety of the intended functionality (SOTIF)

Considerations for CI and Test on the Cloud

- MathWorks
  - Container ecosystem
  - Batch (non-interactive) licensing
- You
  - Evolving software development practices



MATLAB and Simulink Cloud Usage Framework

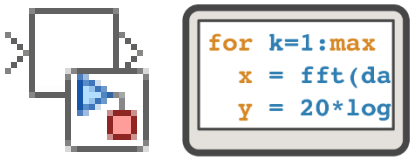


What is a microservice?

"Microservices are an architectural and organizational approach to software development where software is composed of **small independent services that communicate over well-defined APIs**."

aws.amazon.com/microservices

Creating a microservice from MATLAB/Simulink in 2 steps



1

Compile your code/model into a **CTF archive**

```
>> compiler.build.productionServerArchive
```

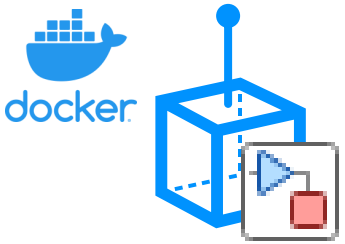
2

Create a **Docker container** that has:

1. Ubuntu
2. MATLAB Runtime (optimized for size)
3. Your code
4. An HTTP server to respond to the API

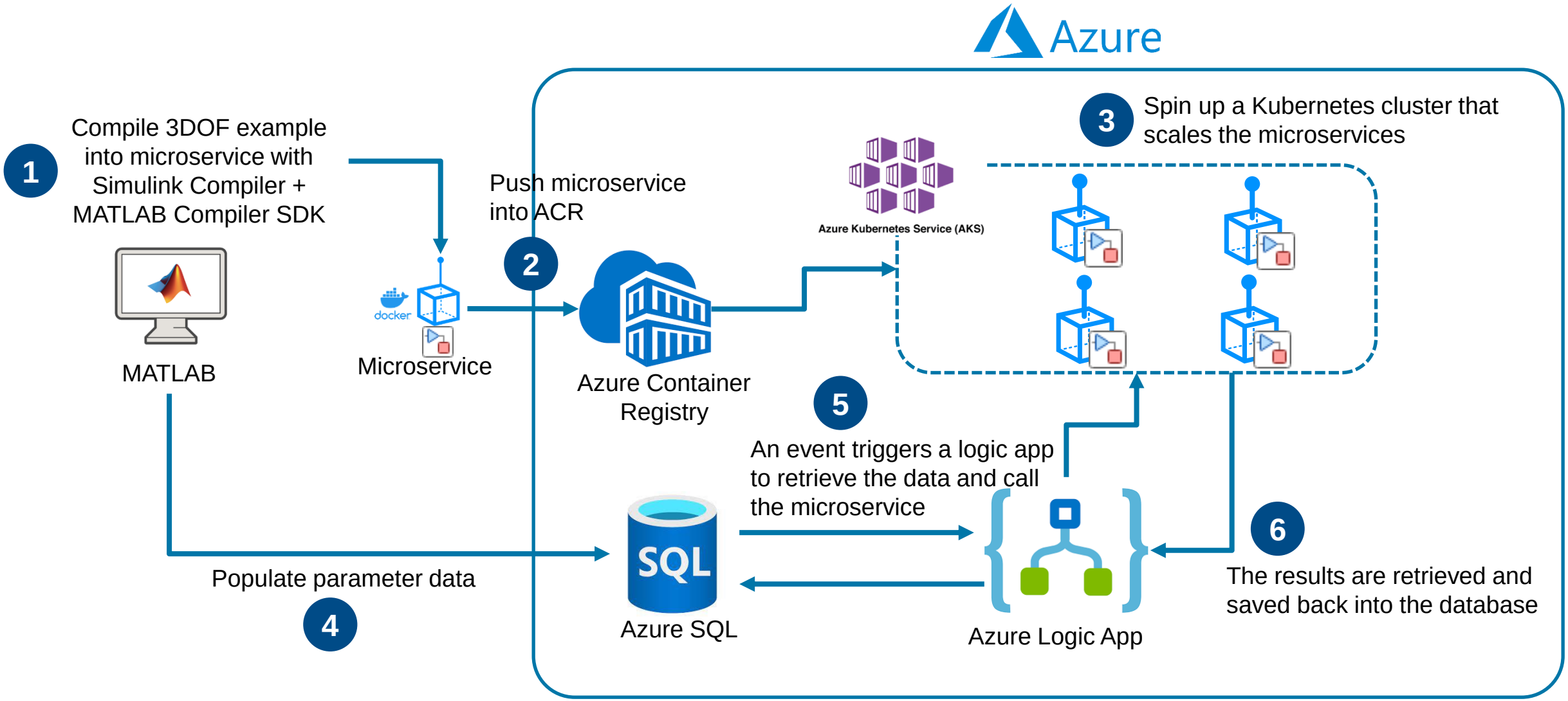
```
>> compiler.package.microserviceDockerImage
```

HTTP RESTful Endpoint



Microservice container can be shared/hosted royalty-free

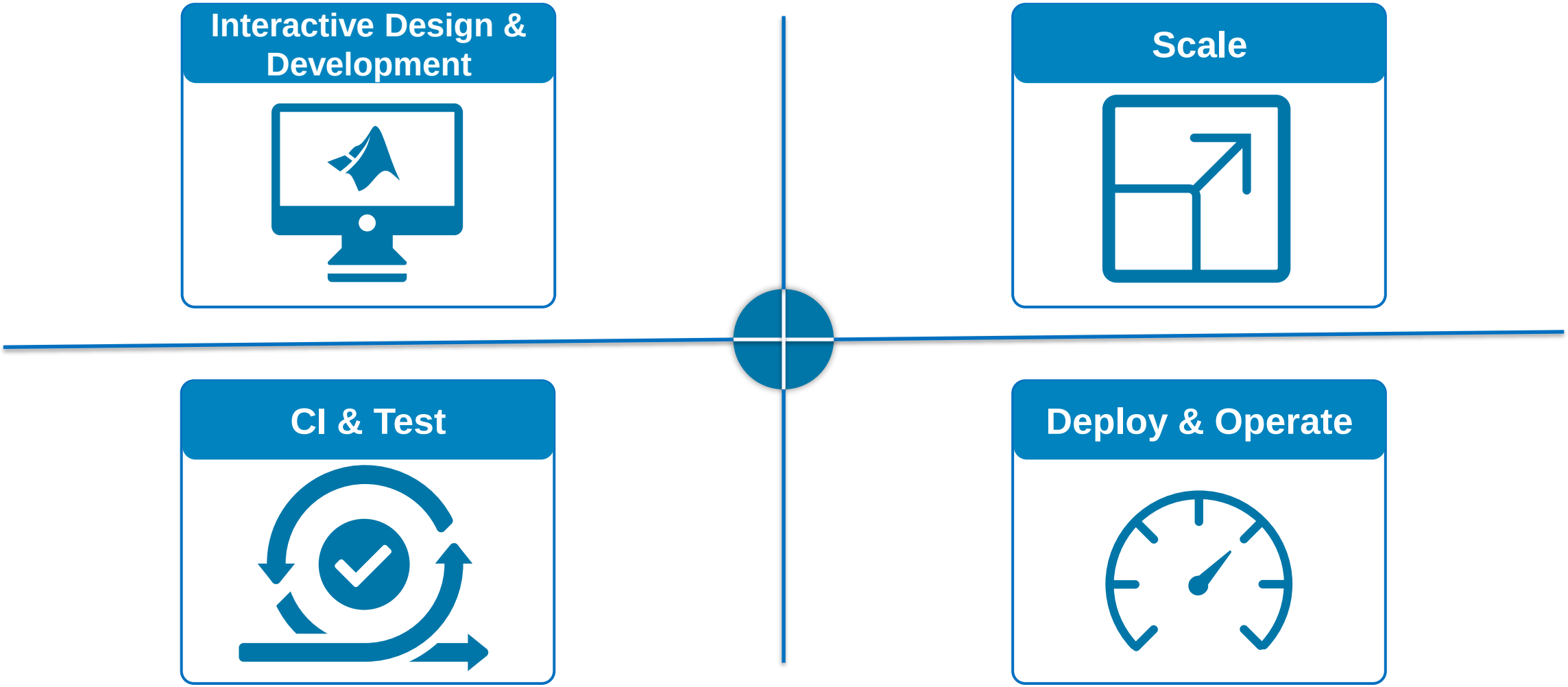
Using a Simulink microservice



New Requirements for Deploying and Operating MATLAB/Simulink Models on the Cloud

- MathWorks
  - Enabling MATLAB and Simulink code/models as microservices
  - Integration with Cloud technologies like Docker/Kubernetes
  - Logging/monitoring for observability
  - Footprint reduction
- You
  - Working with IT and others in the organization to build the right architecture and infrastructure or learning how you plug into what exists
  - Learning how to do 24x7 operation and to meet SLAs
  - Building observability into your applications
  - Measuring reliability and responding to outages (DORA, etc.)

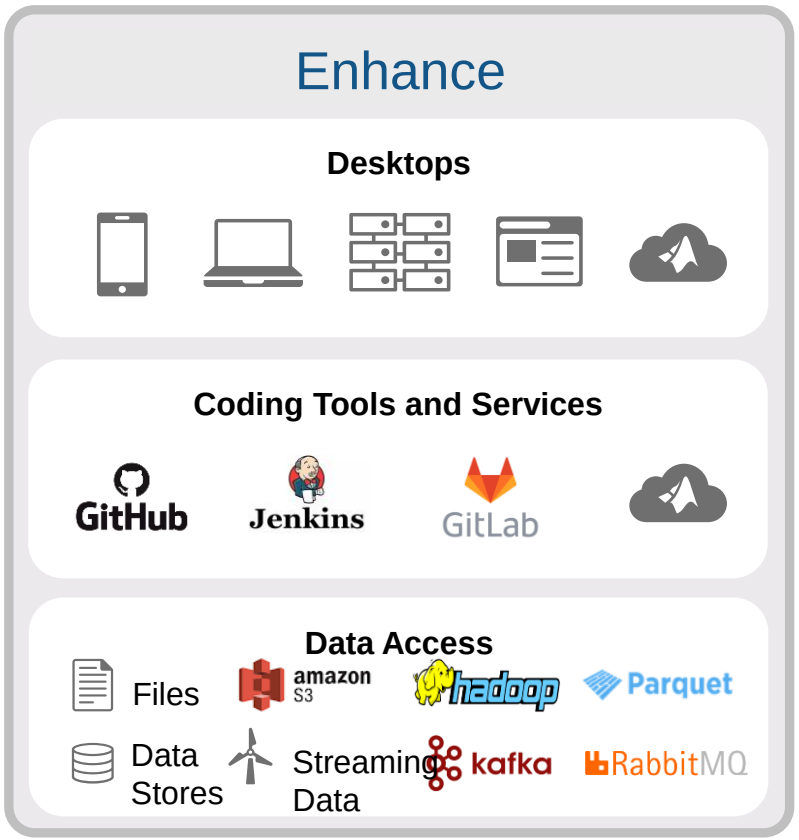
MATLAB and Simulink Cloud Usage Framework

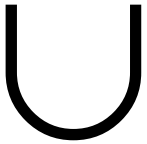


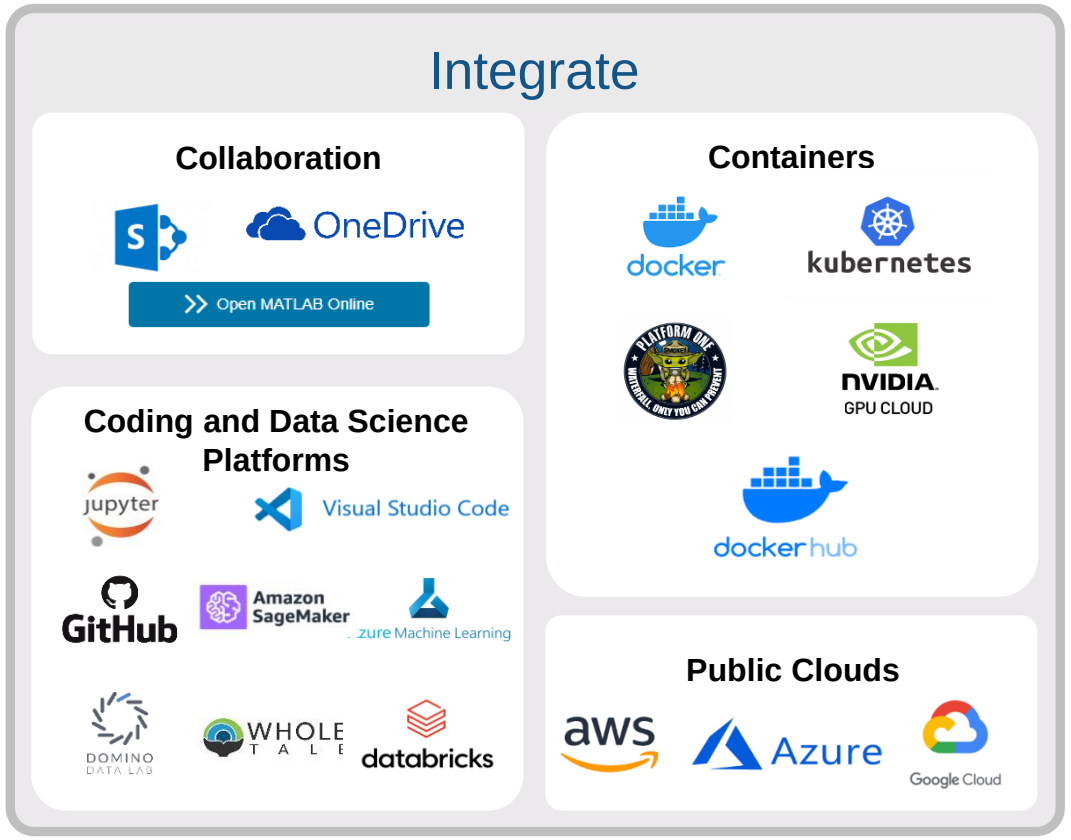
Our Cloud Philosophies

- Enhancing and integrating are equally important
- Cloud represents a new platform (like Win/Mac/Linux)
- Evolving our own software for cloud involves significant evolution of MATLAB/Simulink
- Evolving MATLAB to support your online workflows

Enhancing and Integrating are equally Important







Usage starts from MATLAB

MATLAB needs to be *enhanced* to access online technologies

MATLAB is started by somebody else

MATLAB needs to be *integrated into these environments*

Integrating four widely used toolchains for SDV

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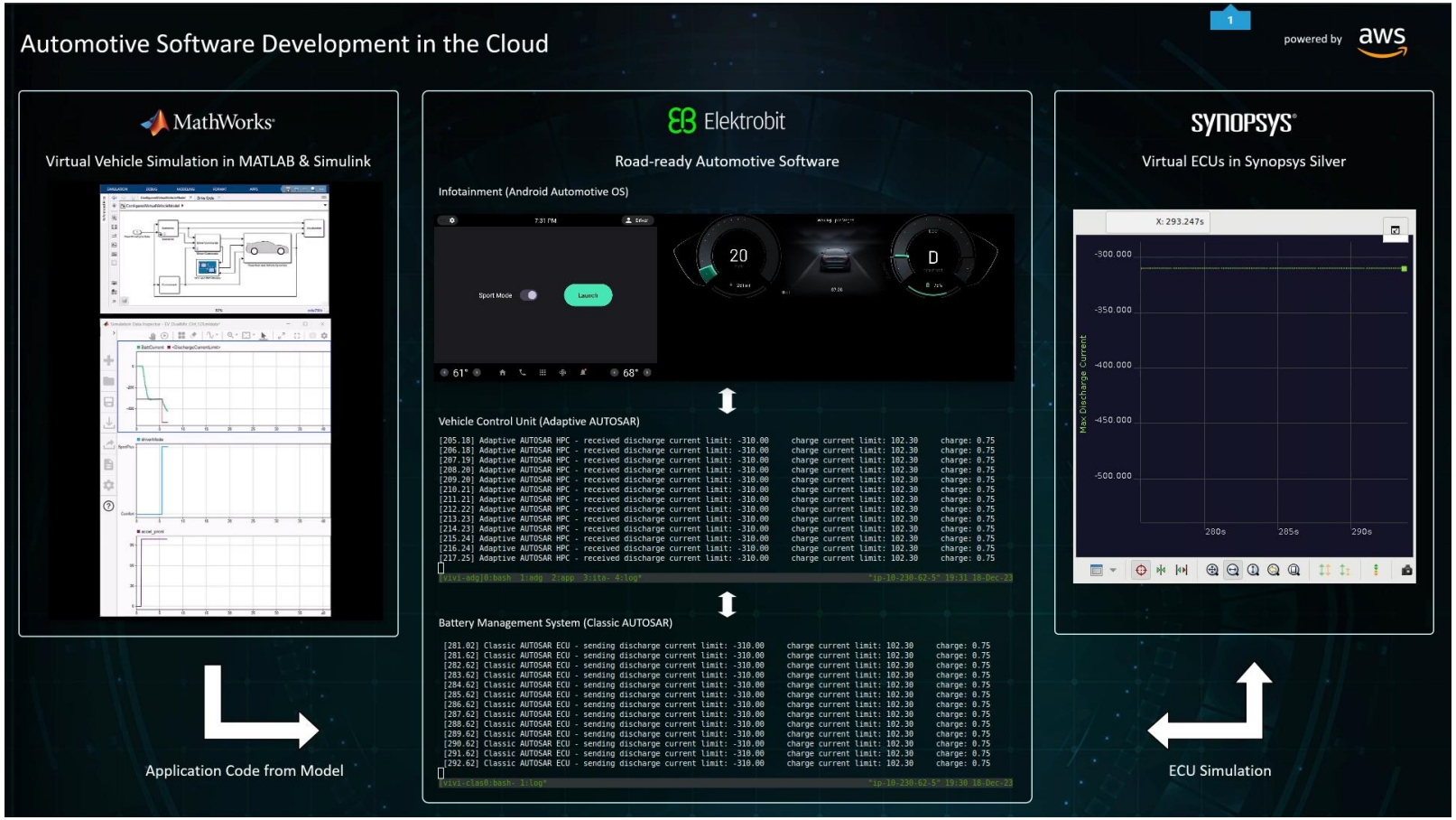
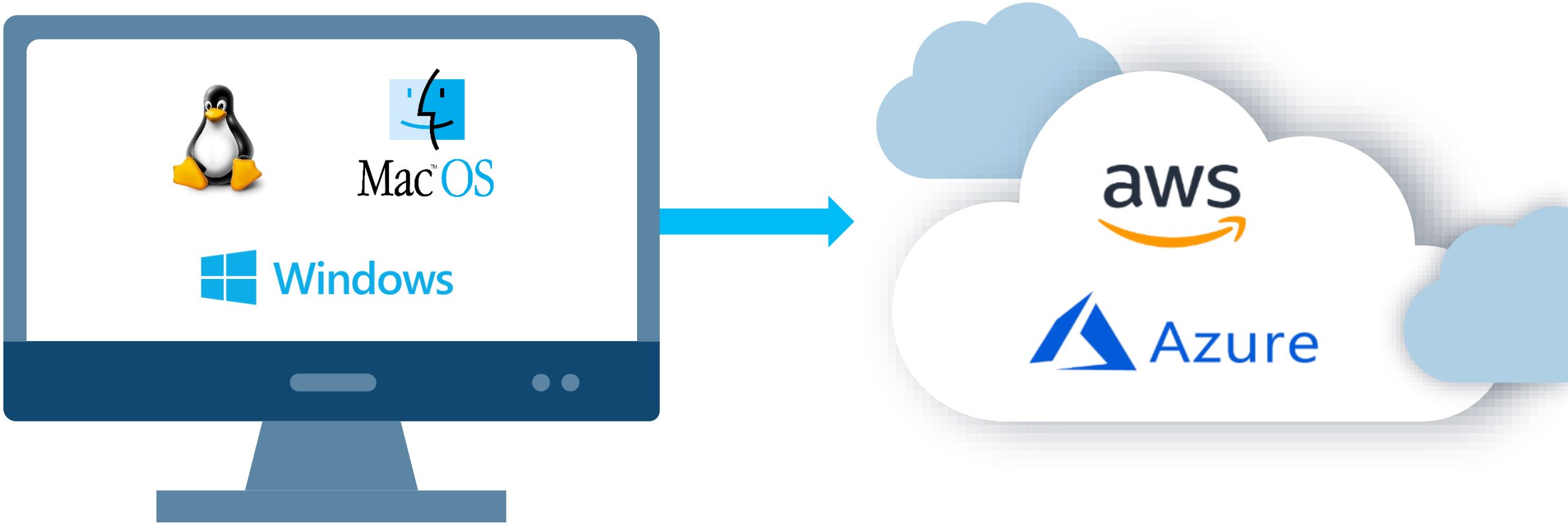


Stop by the booth to see it in action!

Cloud represents a new platform (like Win/Mac/Linux)

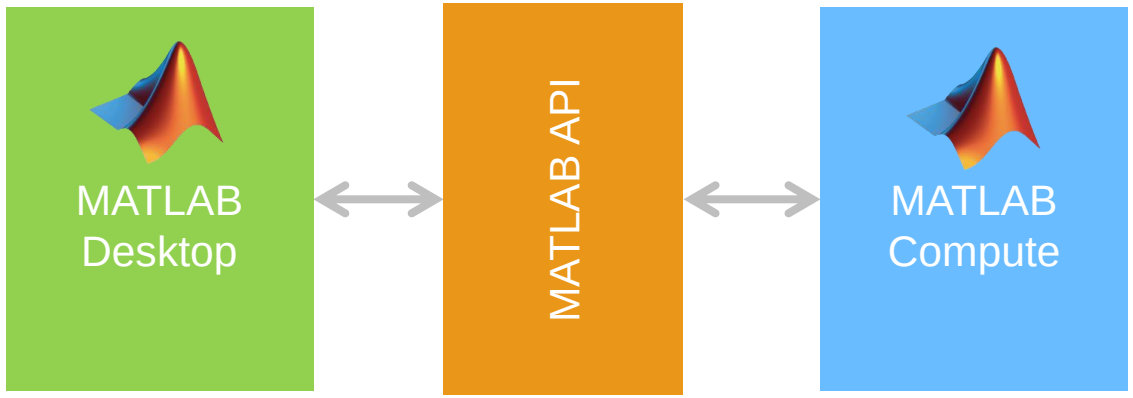
and should be treated like one

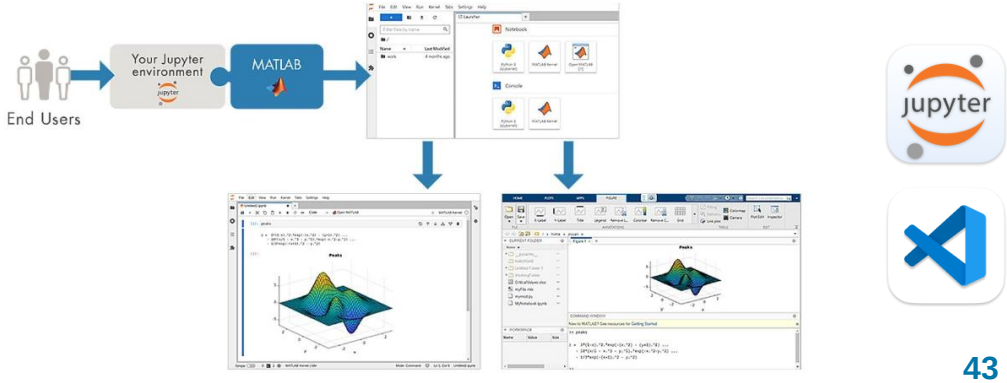


Evolving our own software for cloud involves significant evolution of MATLAB/Simulink

MATLAB

Evolving our own software for cloud involves significant evolution of MATLAB/Simulink





Evolving MATLAB to support your online workflows

Collaboration and Integration	Cloud Center	Docker / Kubernetes	VS Code	MATLAB Production Server
	MATLAB Online Server	Connected Desktop	JupyterHub	MATLAB Parallel Server
Software Development Workflows	MATLAB Test	MATLAB / Simulink Compiler	MATLAB / Simulink Coder	GitHub / GitLab
	Build Tool	MATLAB / Simulink Projects	Toolbox Standards	Package Management
Foundations	Modular Execution	Code Analysis	Extension Points	Apps
	Performance	Desktop and Editor	Language	Graphics

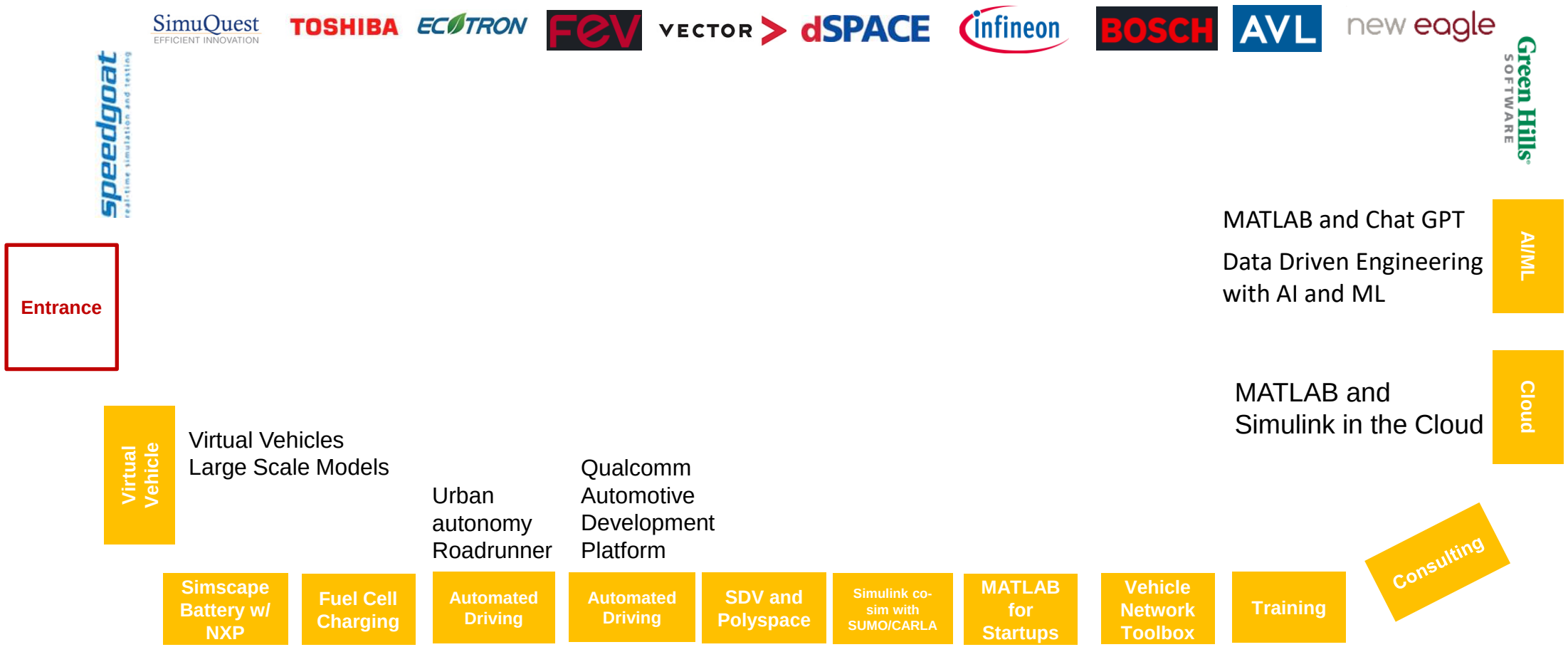
Our Cloud Philosophies

- Enhancing and integrating are equally important
- Cloud represents a new platform (like Win/Mac/Linux)
- Evolving our own software for cloud involves significant evolution of MATLAB/Simulink
- Evolving MATLAB to support your online workflows

We're Ready When You Are….

- Not sure where to start?
  - Cloud usage framework
  - mathworks.com/cloud
- We can help
  - Account team
  - cloud@mathworks.com
- Tech showcase
- Soft Dev Session at 4:15
  - "How Cloud-Based Virtual Vehicles Can Help You Build Your Next-Gen Software"

Technology Showcase



Next presentation starts at 10:30 AM

MathWorks
AUTOMOTIVE CONFERENCE 2024
North America

Enabling MATLAB and Simulink for use on the cloud

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