

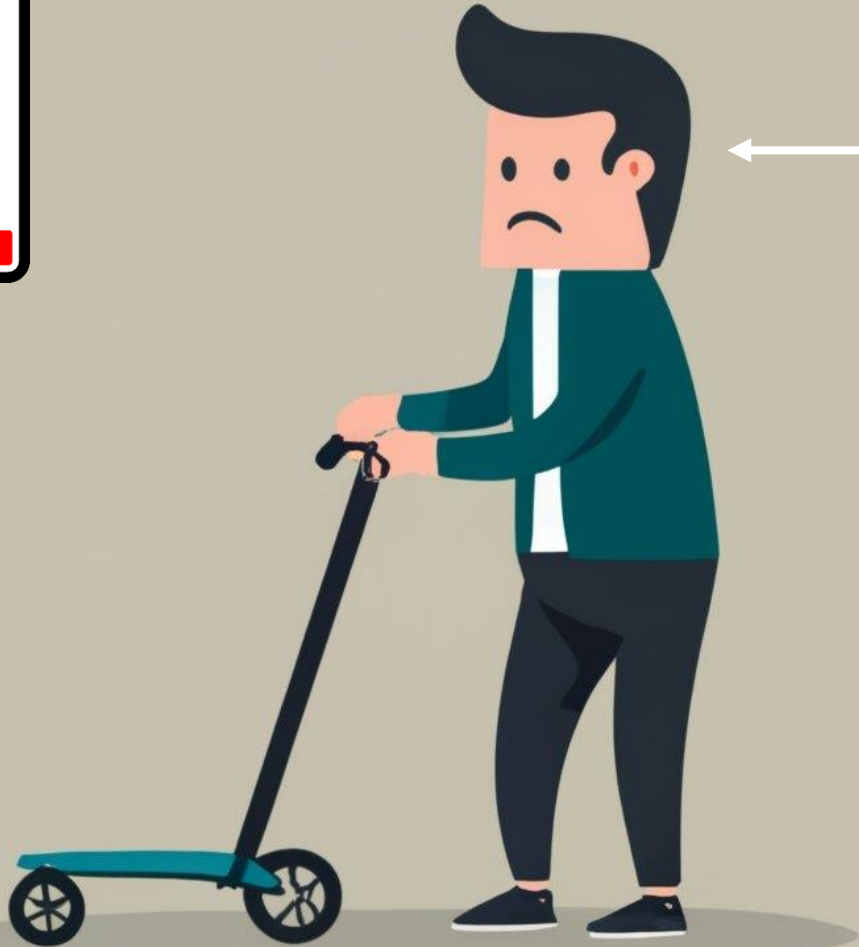
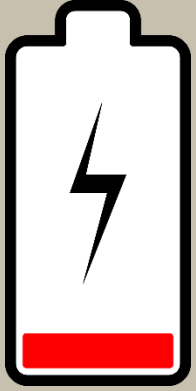
# MATLAB EXPO

FRANCE

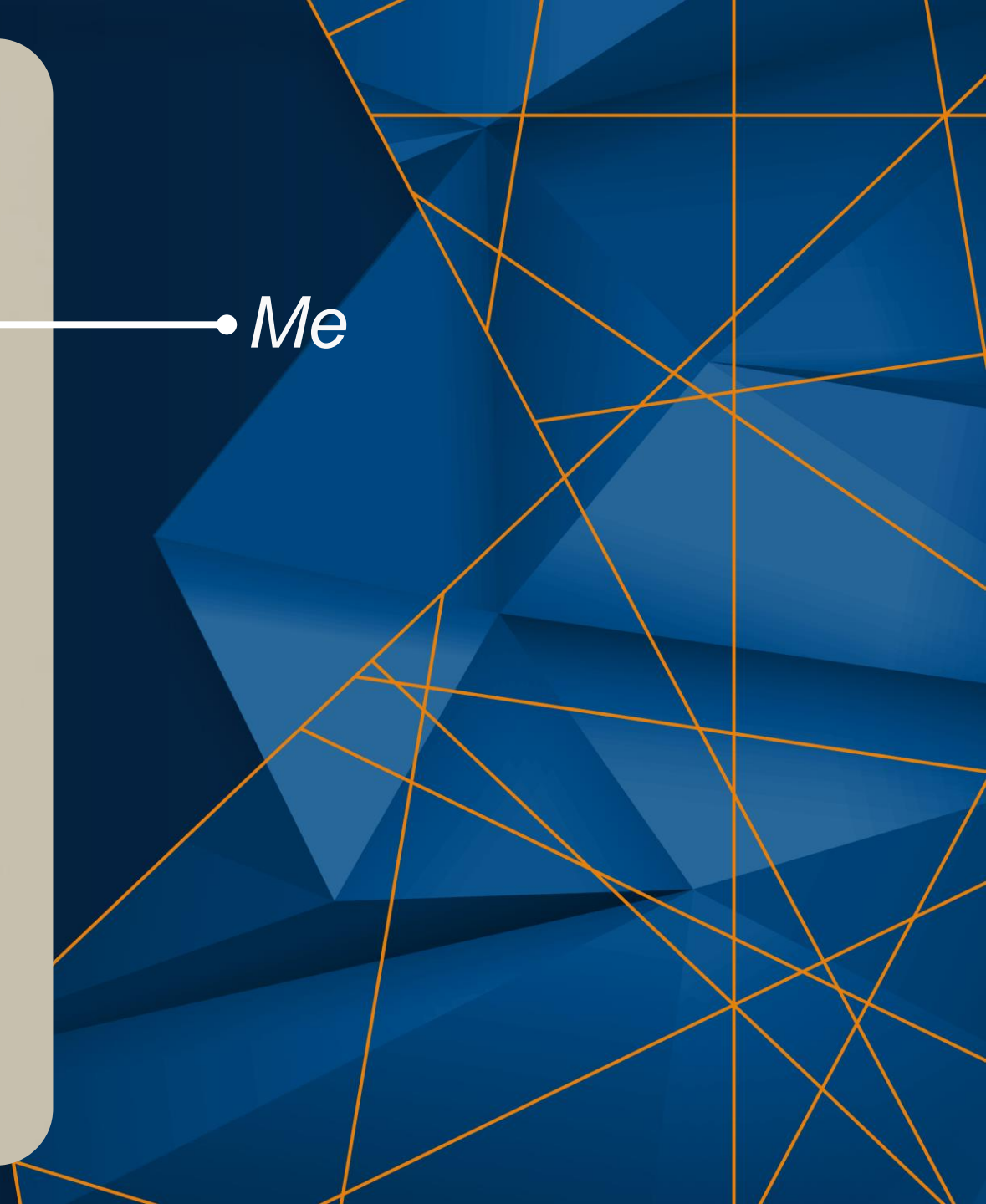
## Déploiement d'algorithmes de dérive de données et de modèles dans le cloud

*Pierre Harouimi, MathWorks*





← • Me

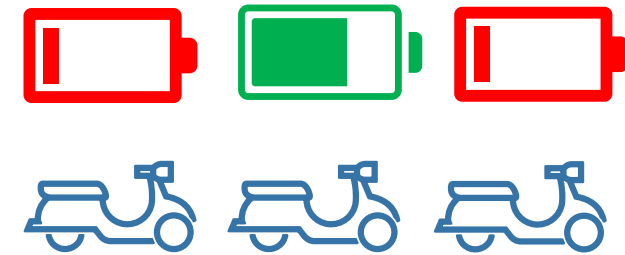
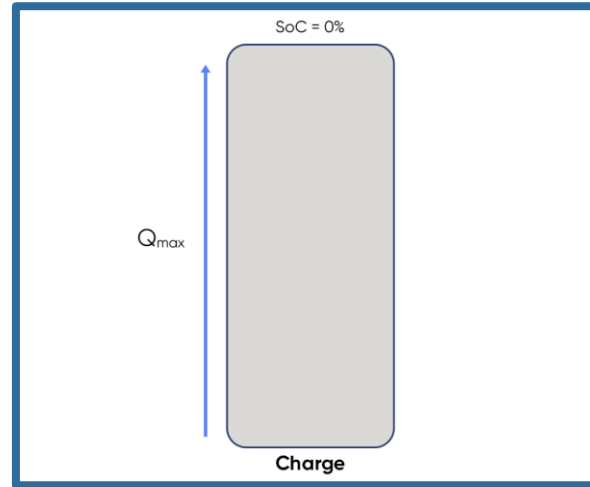
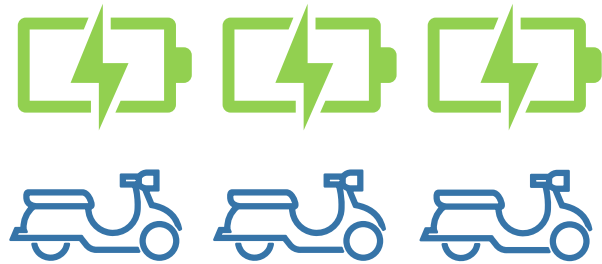


*“More than **half** of AI  
Models Never Make It To  
Production”*

*Source: Gartner 2021*



# How much longer can you drive before recharging?



State of Charge (SoC) *cannot be directly measured* x

*No observed data* x

Need to *embed* model for real-time data x

How to handle *data drifting* from baseline x

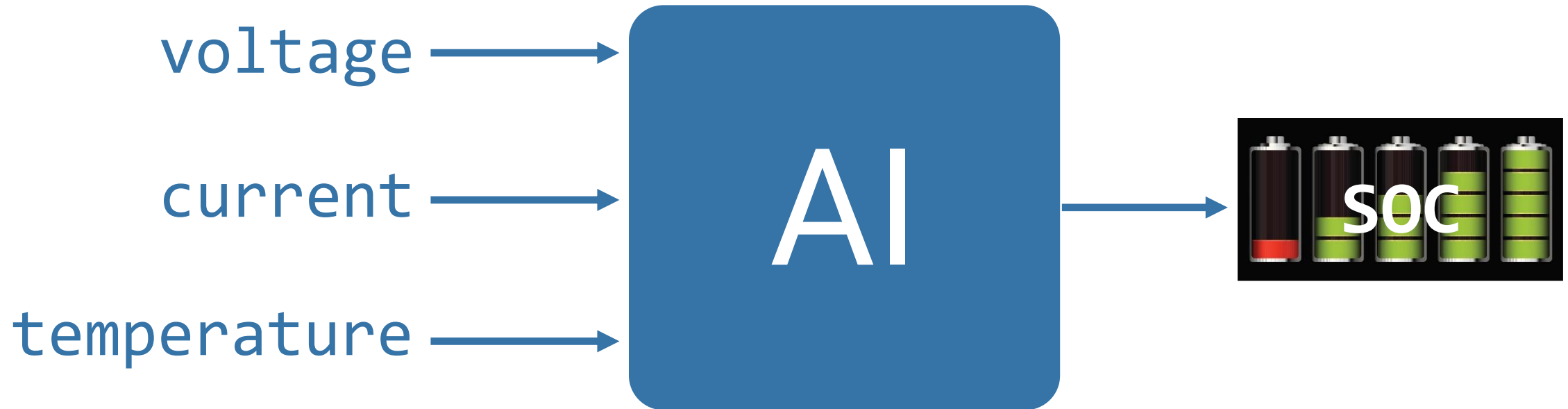
✓ *Predict battery SoC using AI with MATLAB & python*

✓ *Generate realistic data with Simulink*

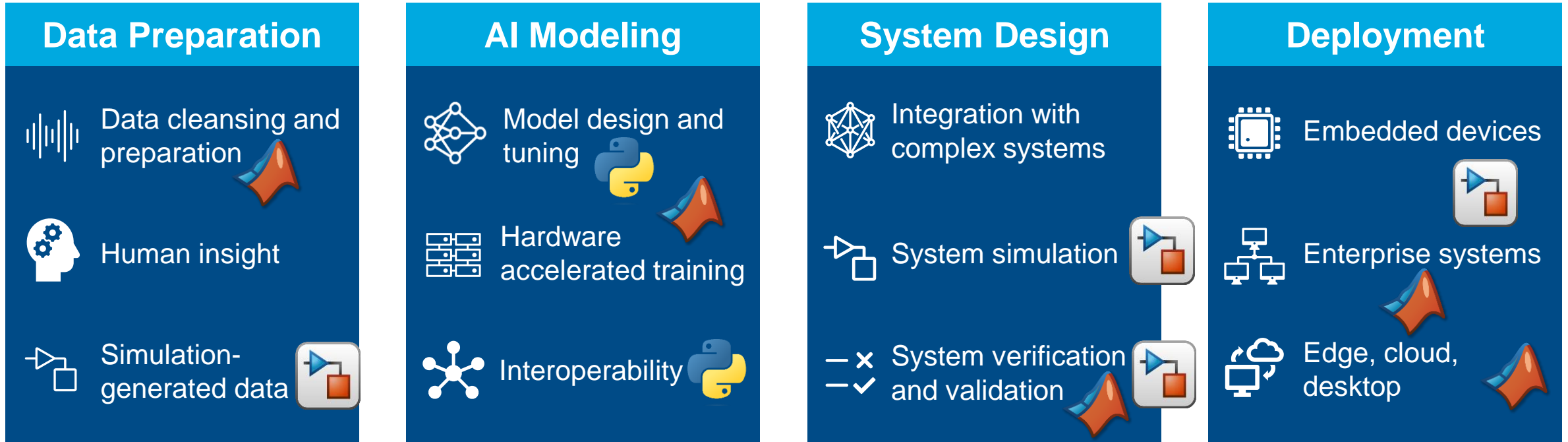
✓ *Convert python model into MATLAB to generate code*

✓ *Deploy MATLAB algos and Simulink model in the cloud*

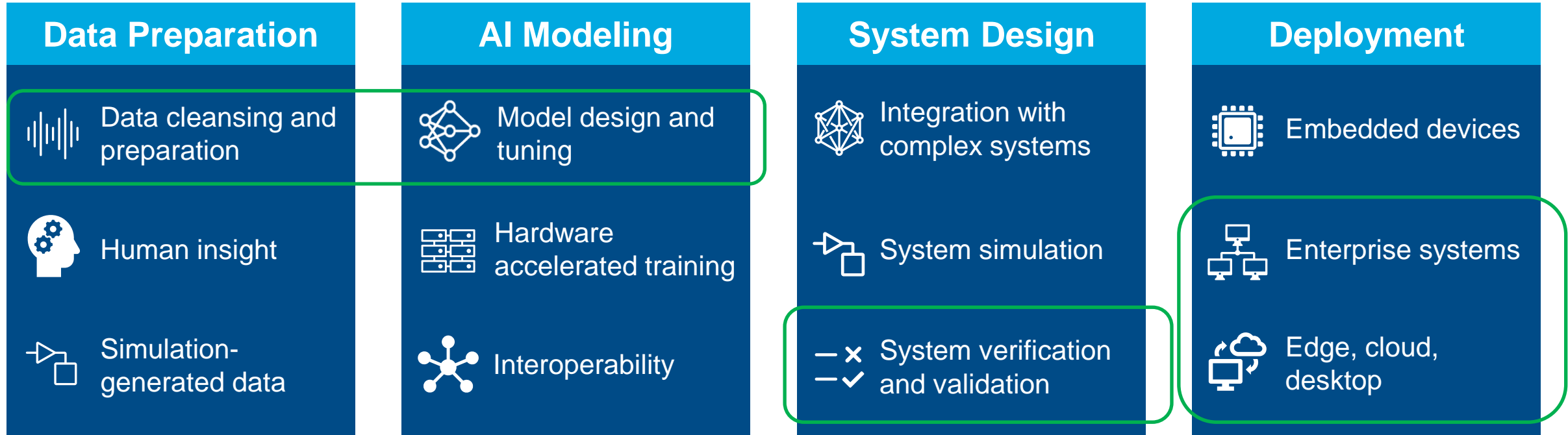
# Battery State-of-Charge (SoC) estimation using AI

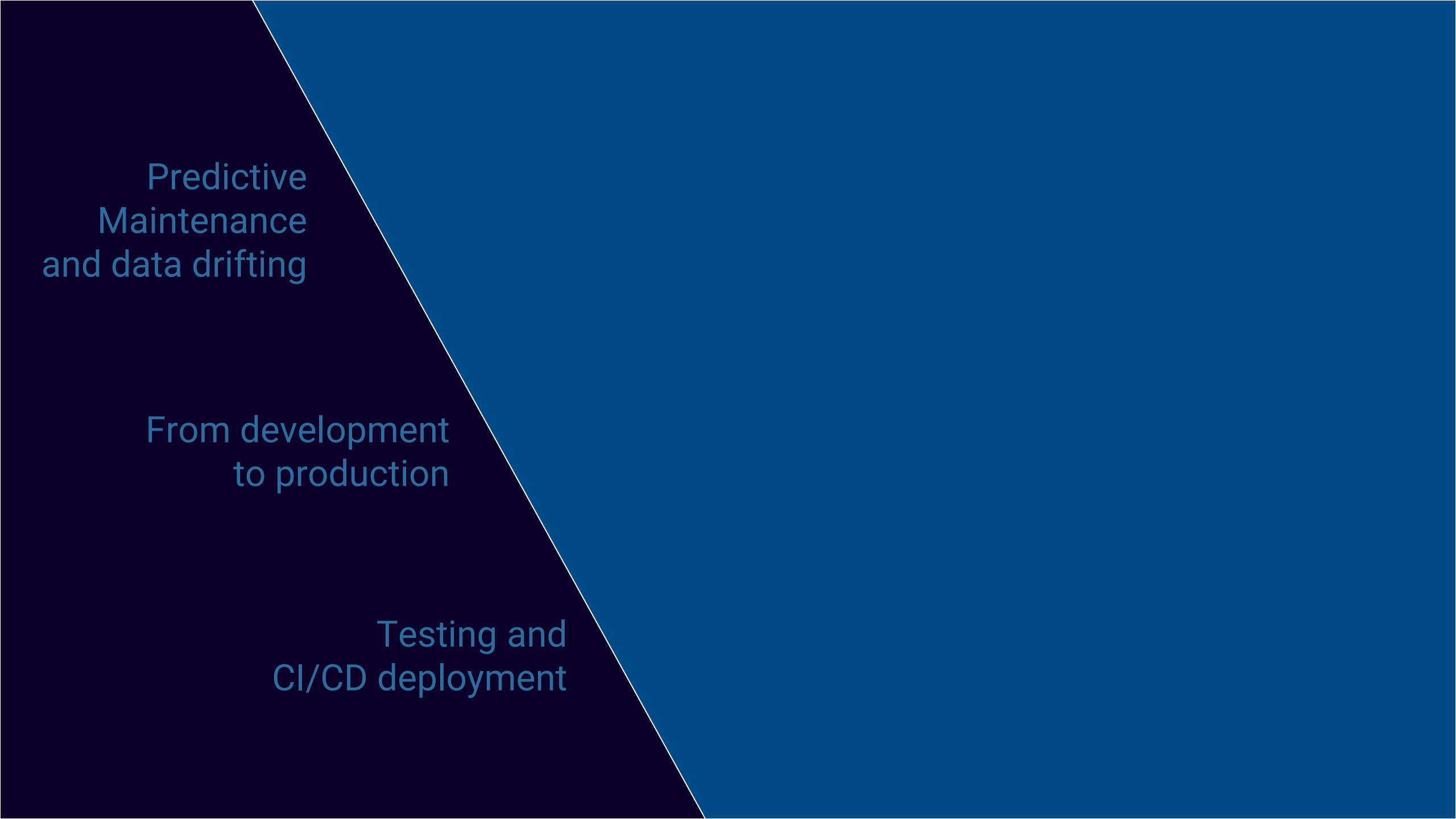


# AI-driven system design and collaboration



# AI-driven system design and collaboration





Predictive  
Maintenance  
and data drifting

From development  
to production

Testing and  
CI/CD deployment



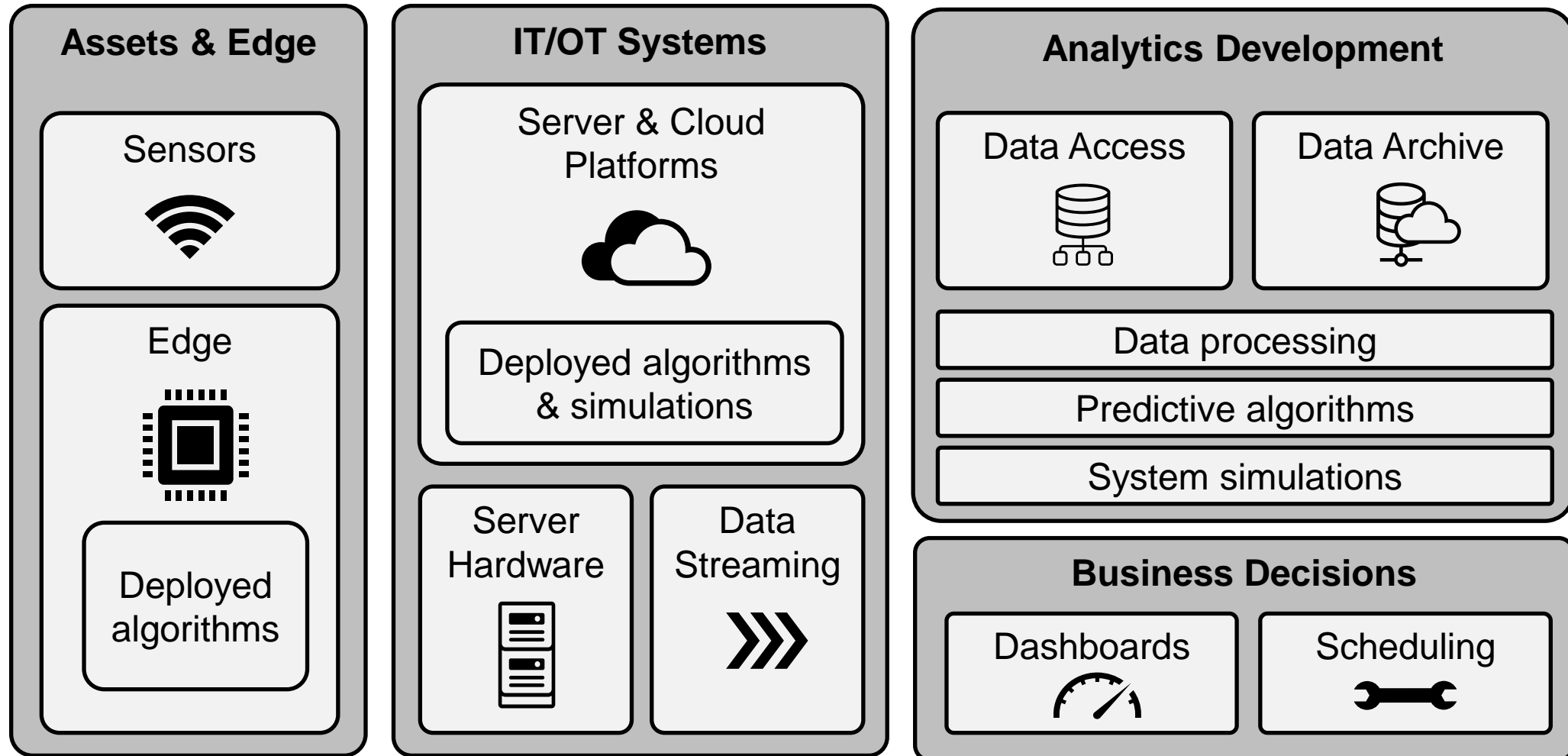
**Predictive  
Maintenance  
and data drifting**

How to use MATLAB® for predictive  
maintenance applications

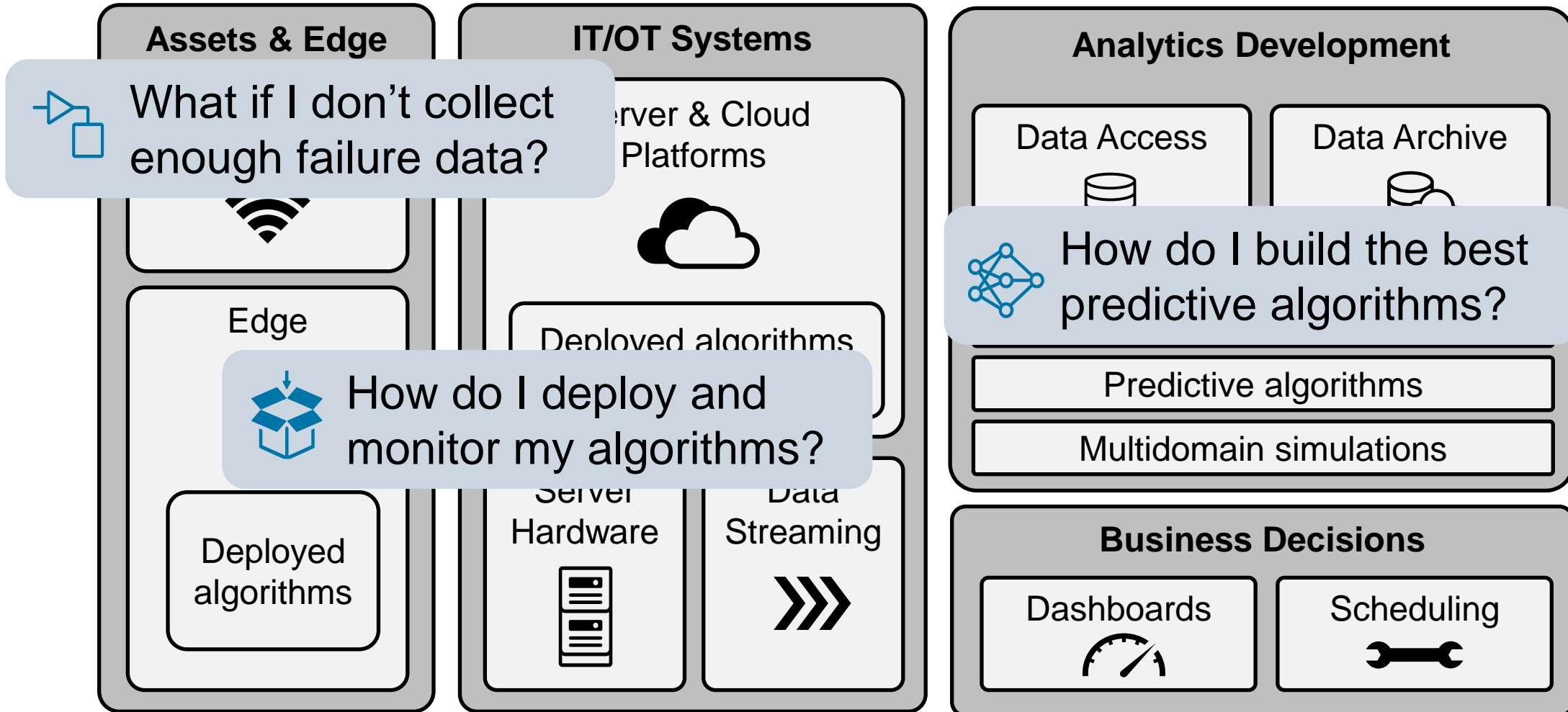
From development  
to production

Testing and  
CI/CD deployment

# A predictive maintenance solution is more than an algorithm



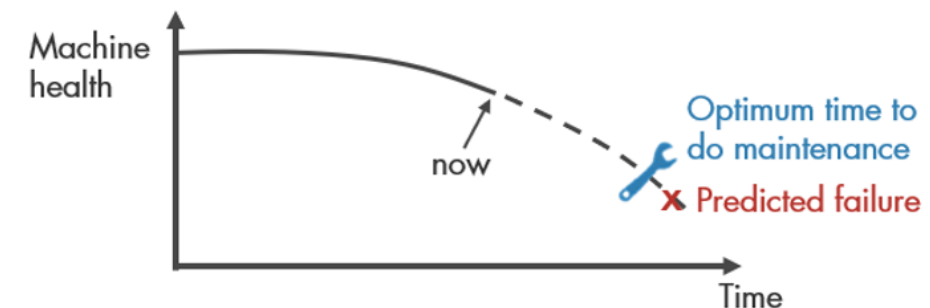
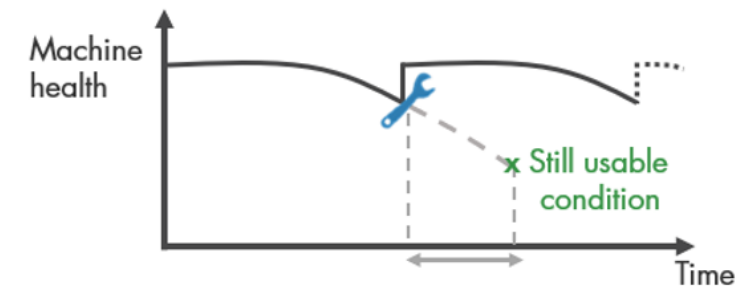
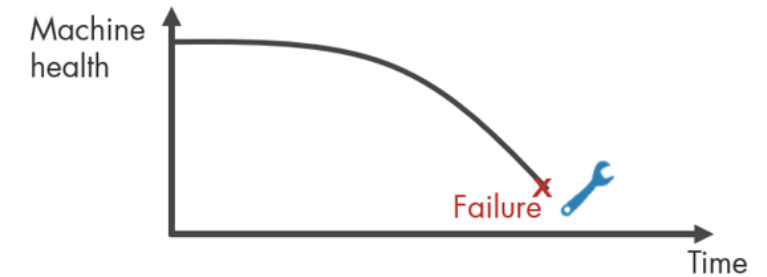
# Many challenges



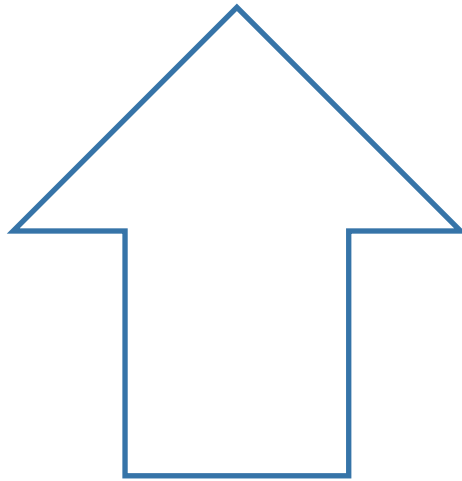


# Types of Maintenance

- **Reactive** – Do maintenance once there's a problem
  - Problem: unexpected failures can be expensive and potentially dangerous
- **Scheduled** – Do maintenance at a regular rate
  - Problem: unnecessary maintenance can be wasteful; may not eliminate all failures
- **Predictive** – Forecast when problems will arise
  - Problem: difficult to make accurate forecasts for complex equipment

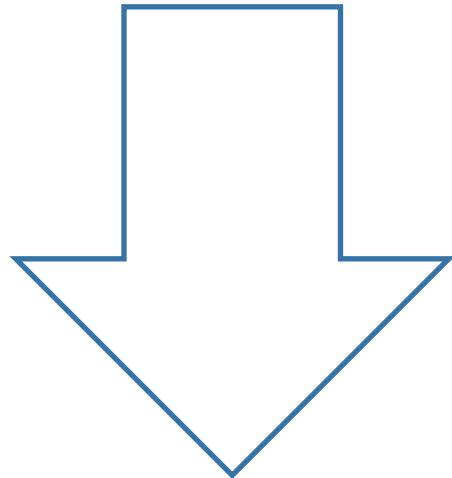


# Why perform predictive maintenance?



## Increase

- Service life of parts
- Equipment safety
- Overall profitability



## Reduce

- Downtime
- Maintenance costs
- Equipment failures

# What does a predictive maintenance algorithm do?

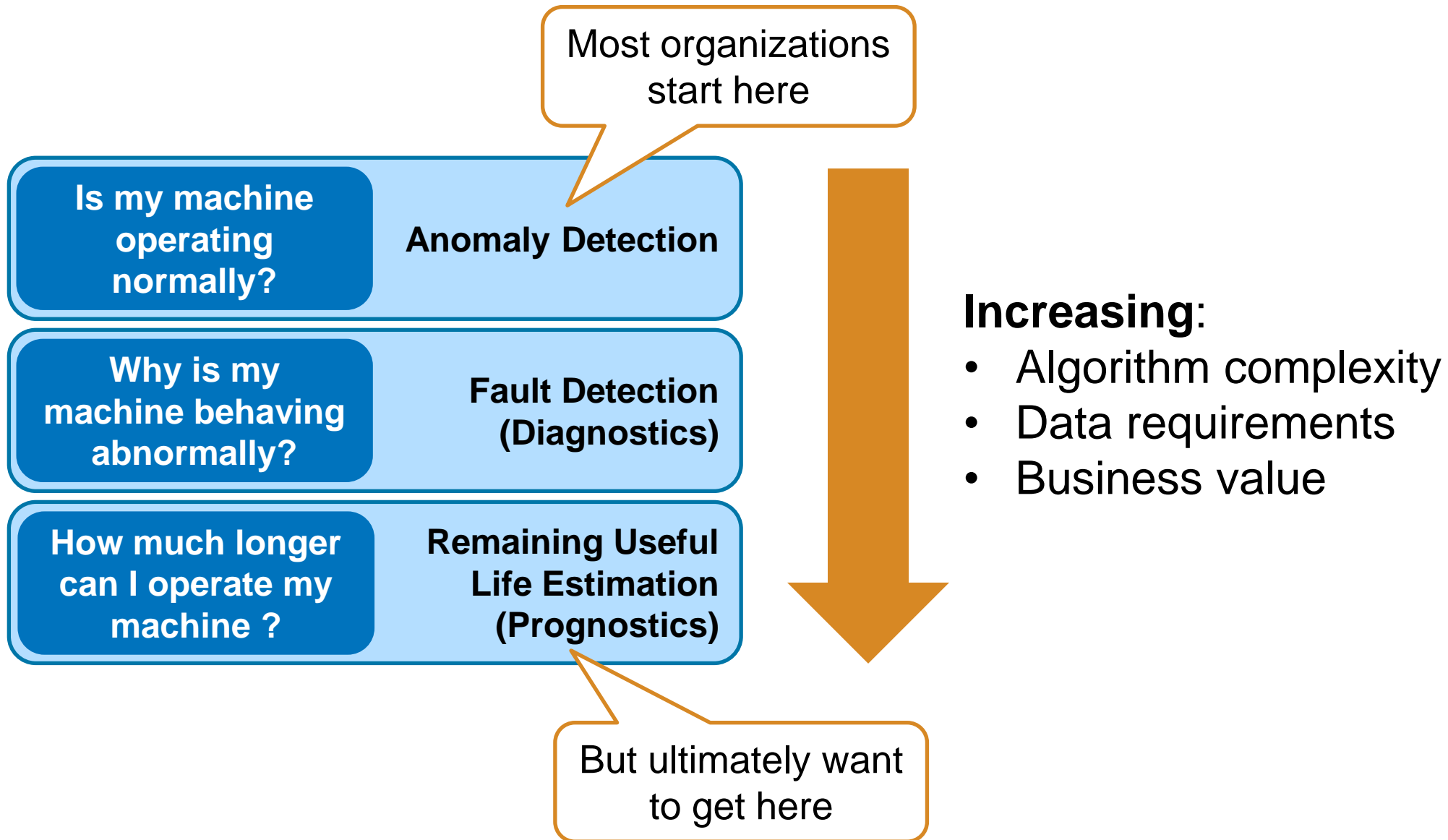
<p><b>Is my machine operating normally?</b></p>	<p><b>Anomaly Detection</b></p>
<p><b>Why is my machine behaving abnormally?</b></p>	<p><b>Fault Detection (Diagnostics)</b></p>
<p><b>How much longer can I operate my machine ?</b></p>	<p><b>Remaining Useful Life Estimation (Prognostics)</b></p>

**I need help.**

**One of my cylinders is blocked.**

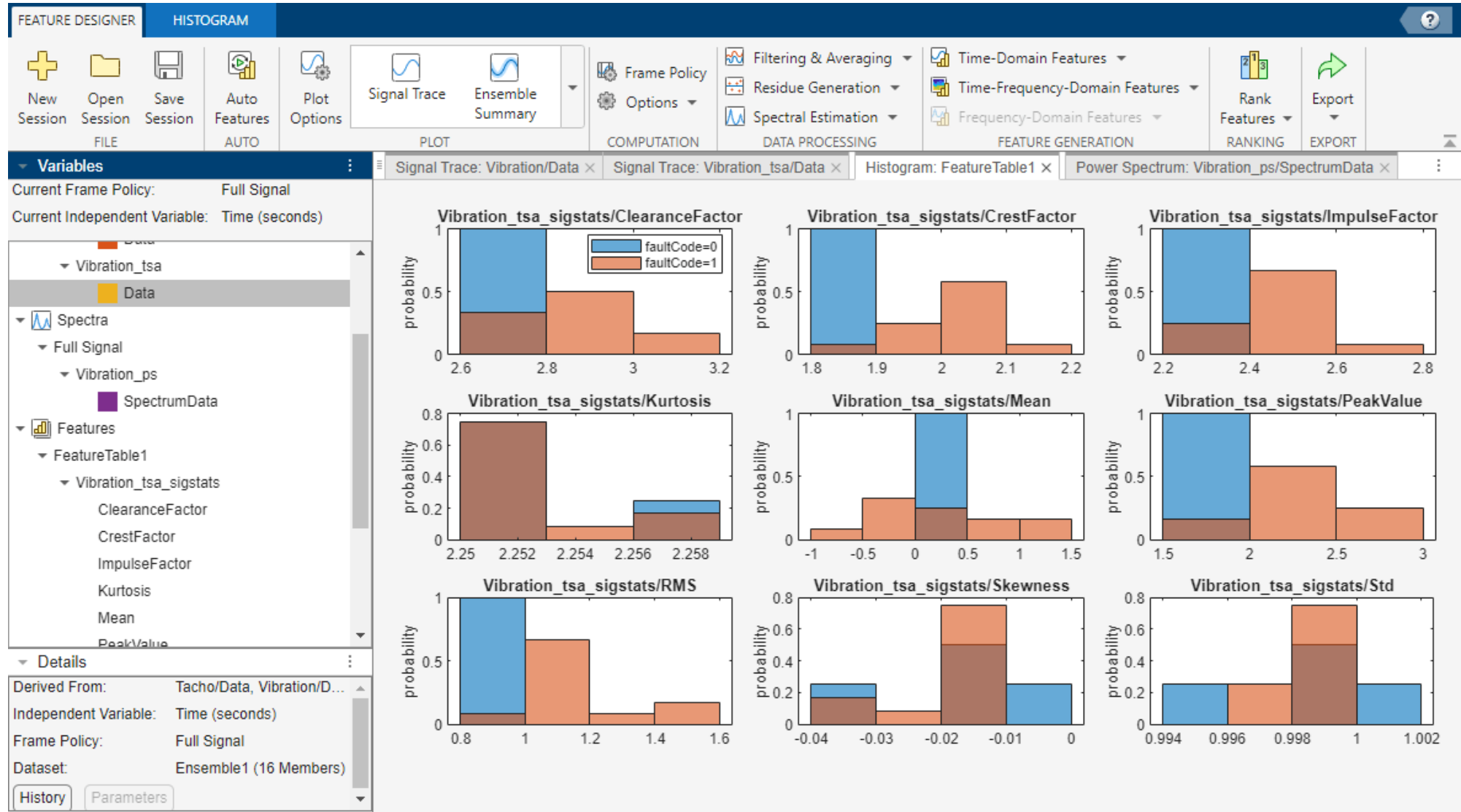
**I will shut down your line in 15 hours.**

# What does a predictive maintenance algorithm do?





# MATLAB apps to extract and generate new features



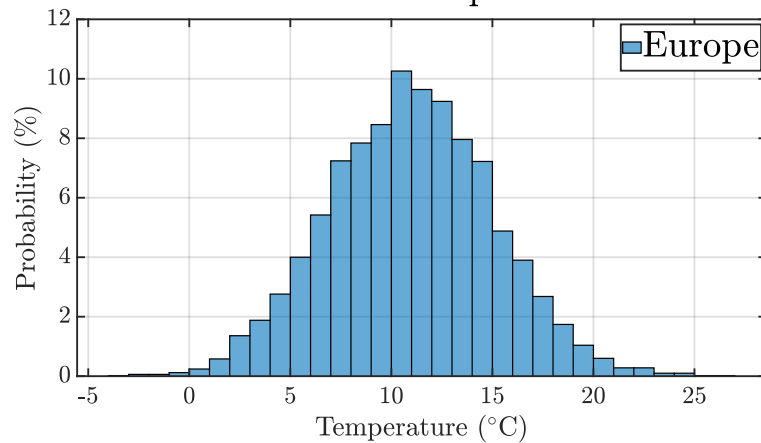
# MATLAB for Predictive Maintenance

## Data and concept drifting

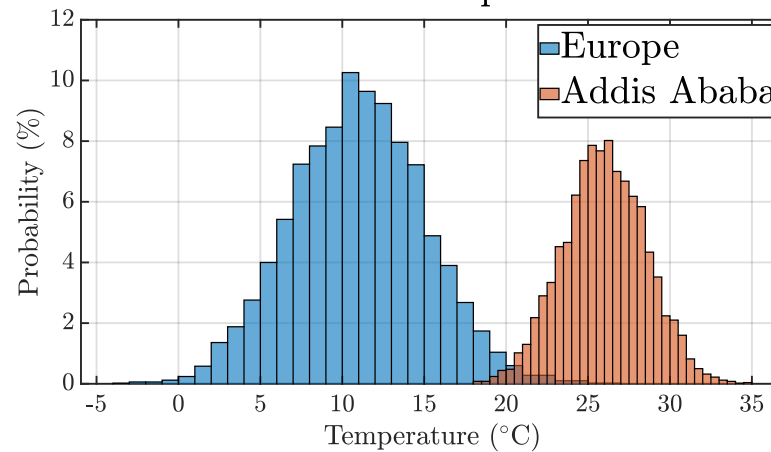
Why data/concept drift? Because static data/model assumption rarely holds in the real world



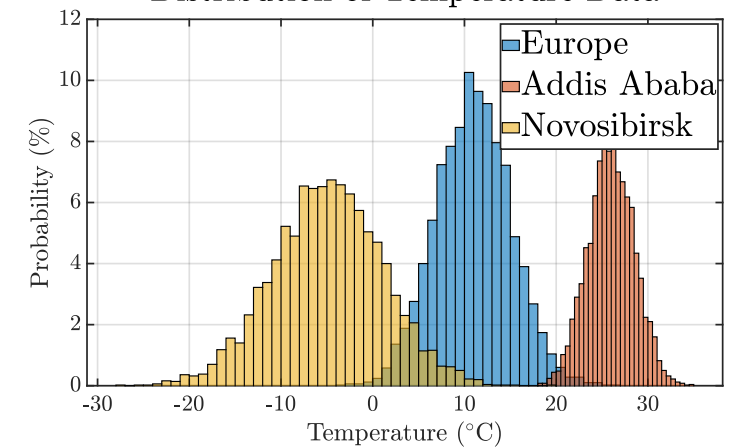
Distribution of Temperature Data



Distribution of Temperature Data

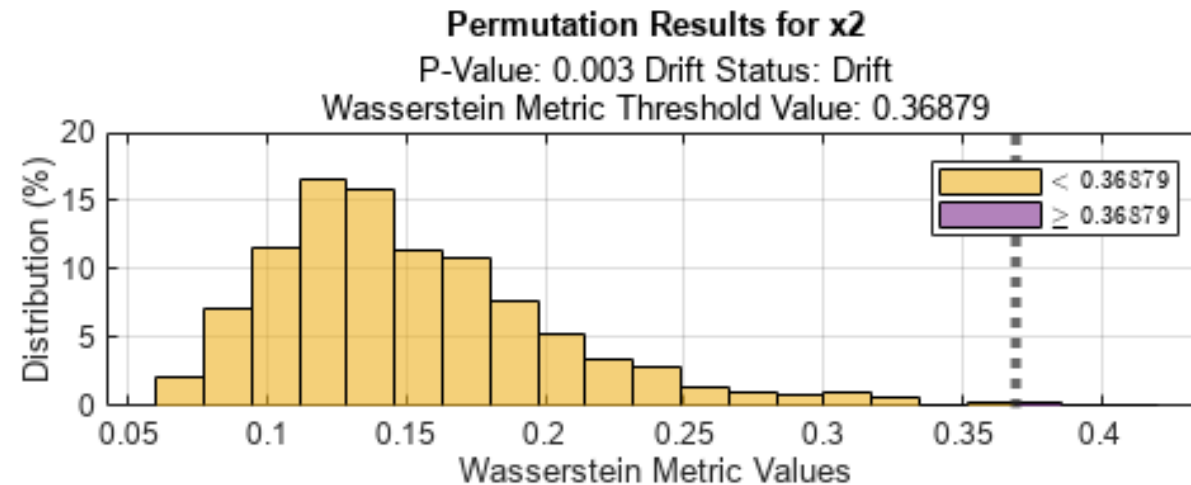
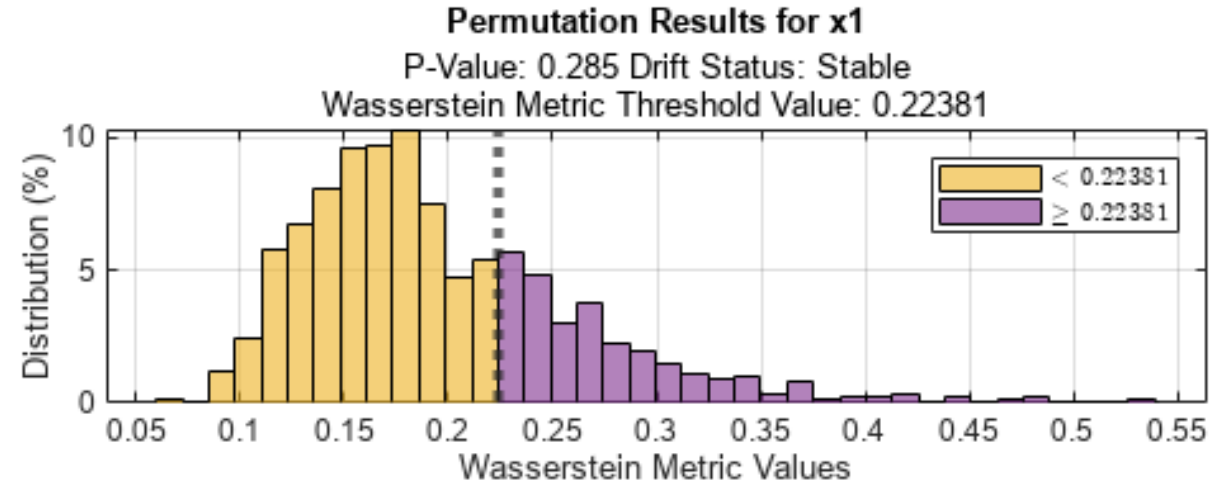


Distribution of Temperature Data



# MATLAB for Predictive Maintenance

## Data drifting: detect drift from baseline



*“More than **half** of AI Models Never Make It To Production”*

Source: Gartner 2021



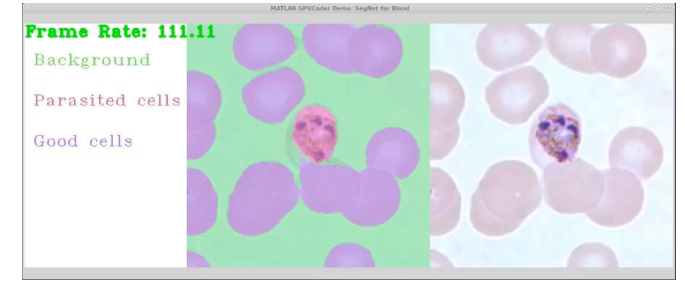
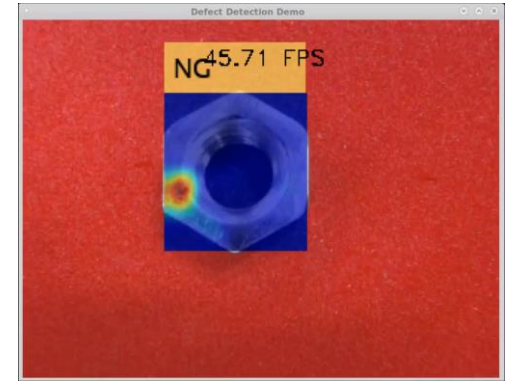
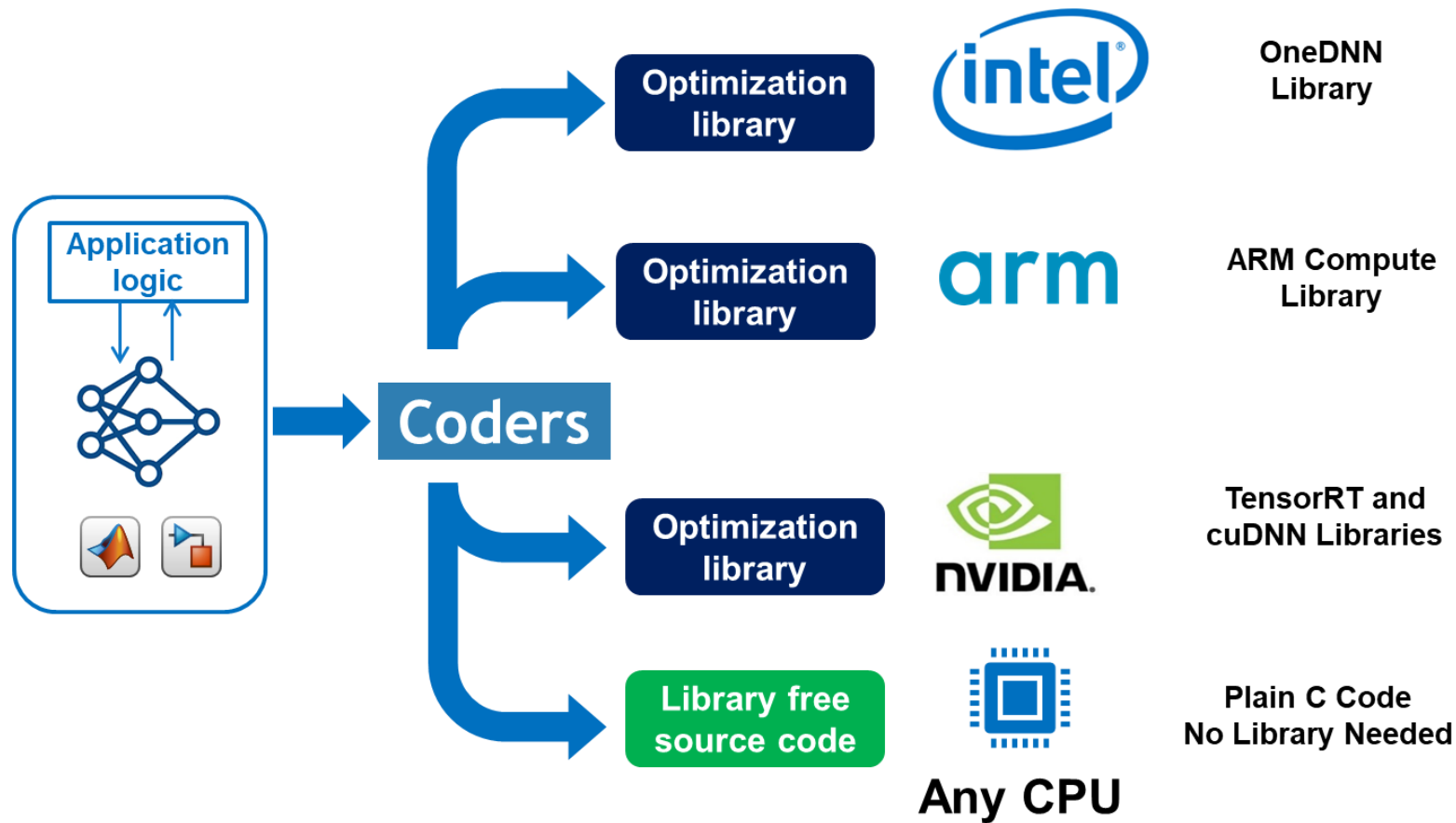
Predictive  
Maintenance  
and data drifting

**From development  
to production**

How to deploy applications and  
integrate them in an IT ecosystem

Testing and  
CI/CD deployment

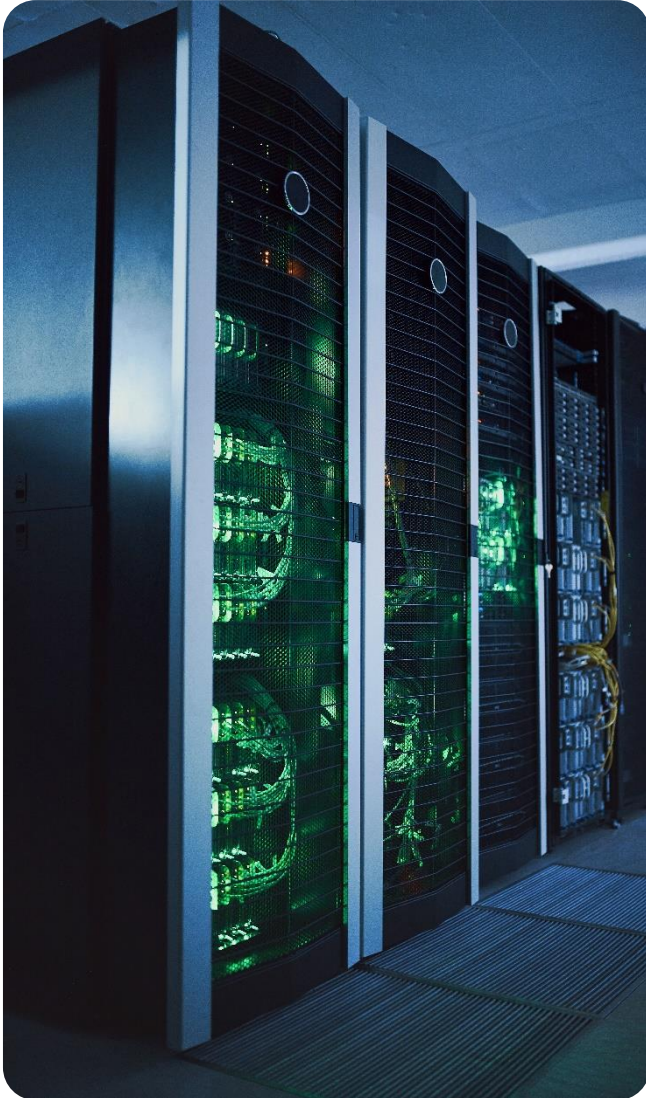
# Other deployment - Code generation for Machine/Deep Learning



  
 TensorFlow Lite  
 Support for TFLite

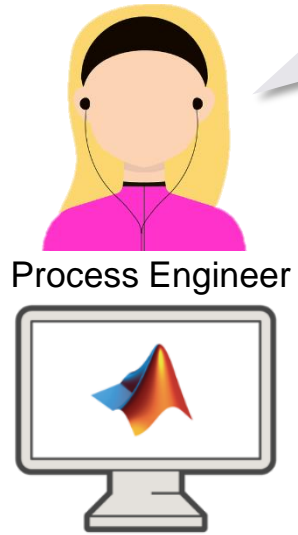
R2022a

## Integrate functions and applications in an IT ecosystem



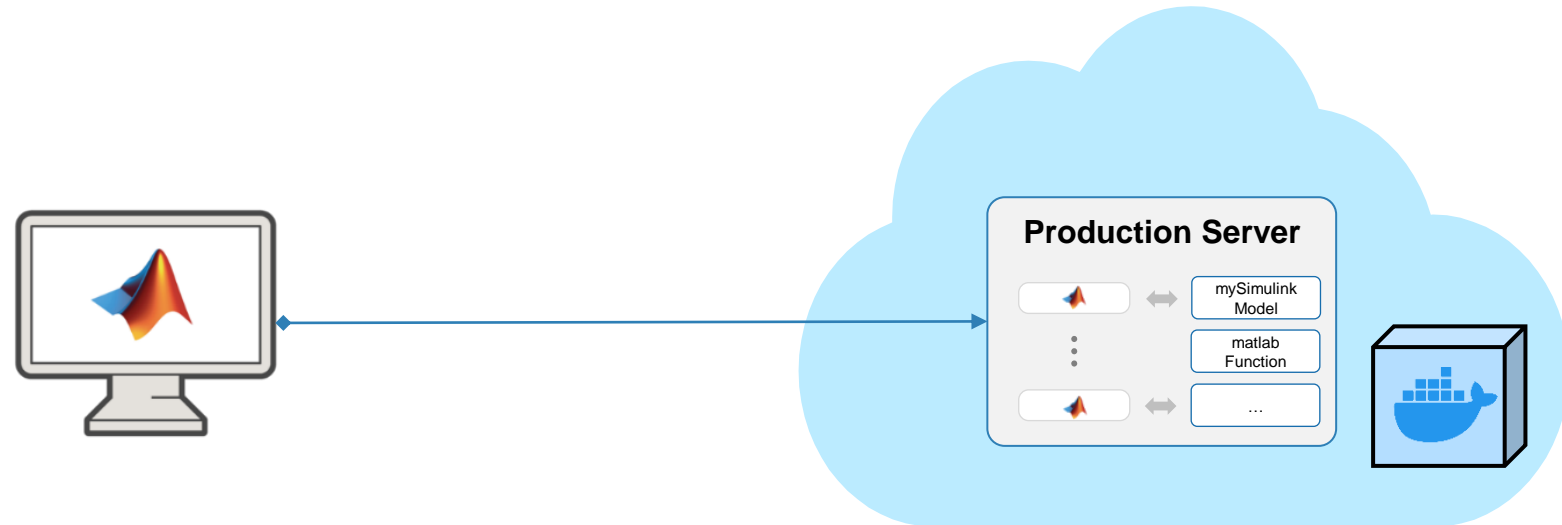
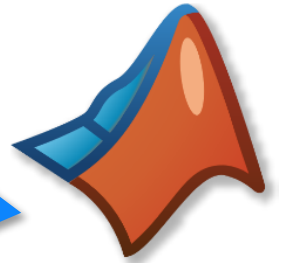
- ▶ Ease-to-use functions and apps allow you to deploy applications without any IT skills
- ▶ Integrate MATLAB & Simulink into your enterprise applications with an endpoint HTTPS and REST API
- ▶ Many different ways to deploy your algorithms

# Generate web services and microservices

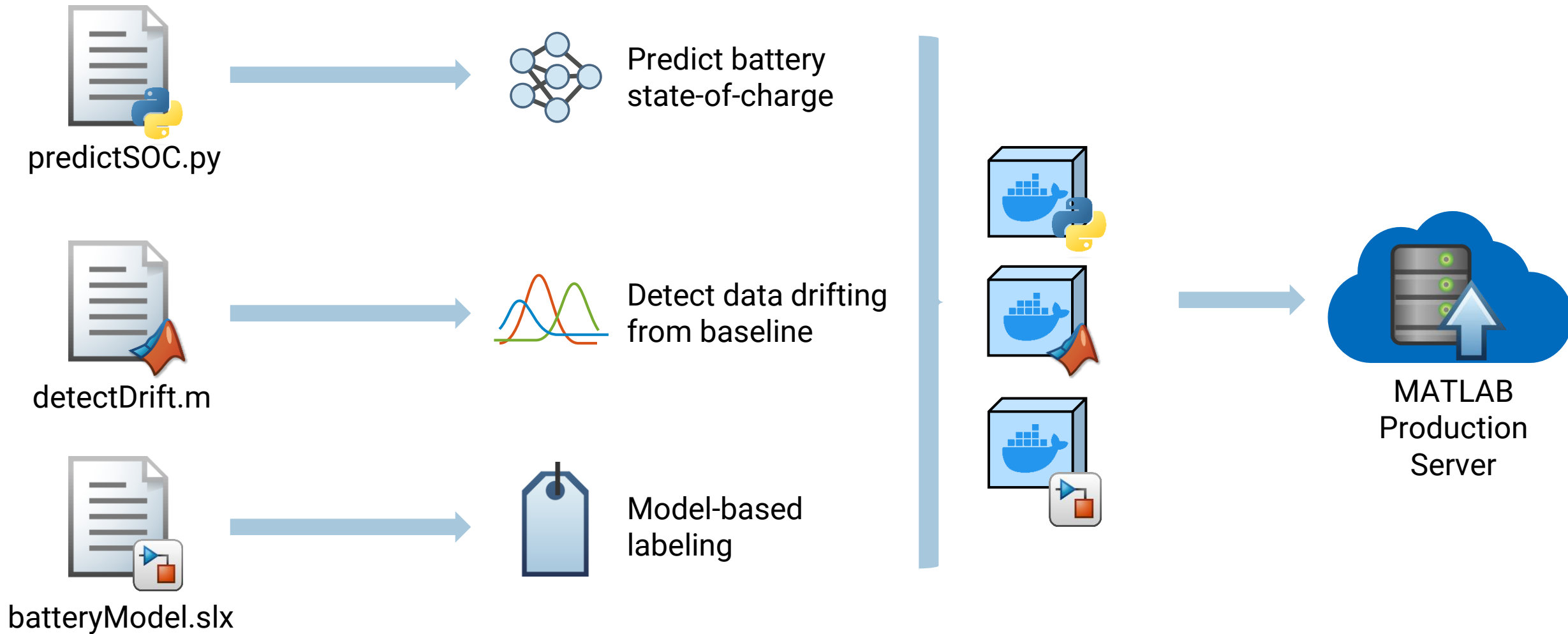


I need to put my MATLAB algo in production for streaming and asynchronous analysis

You can easily integrate your MATLAB functions in production, onprem or in the cloud

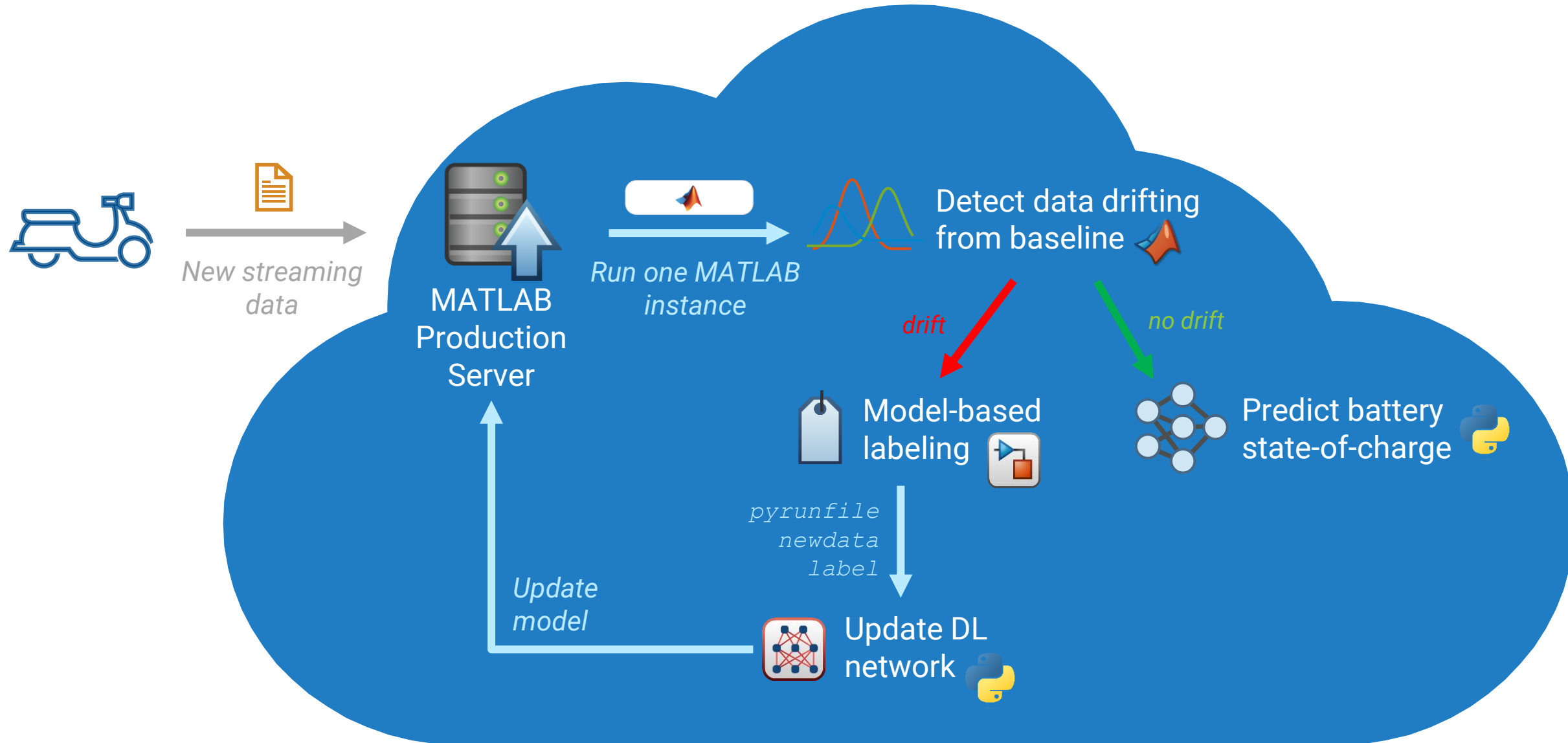


# Models' deployment for data drifting

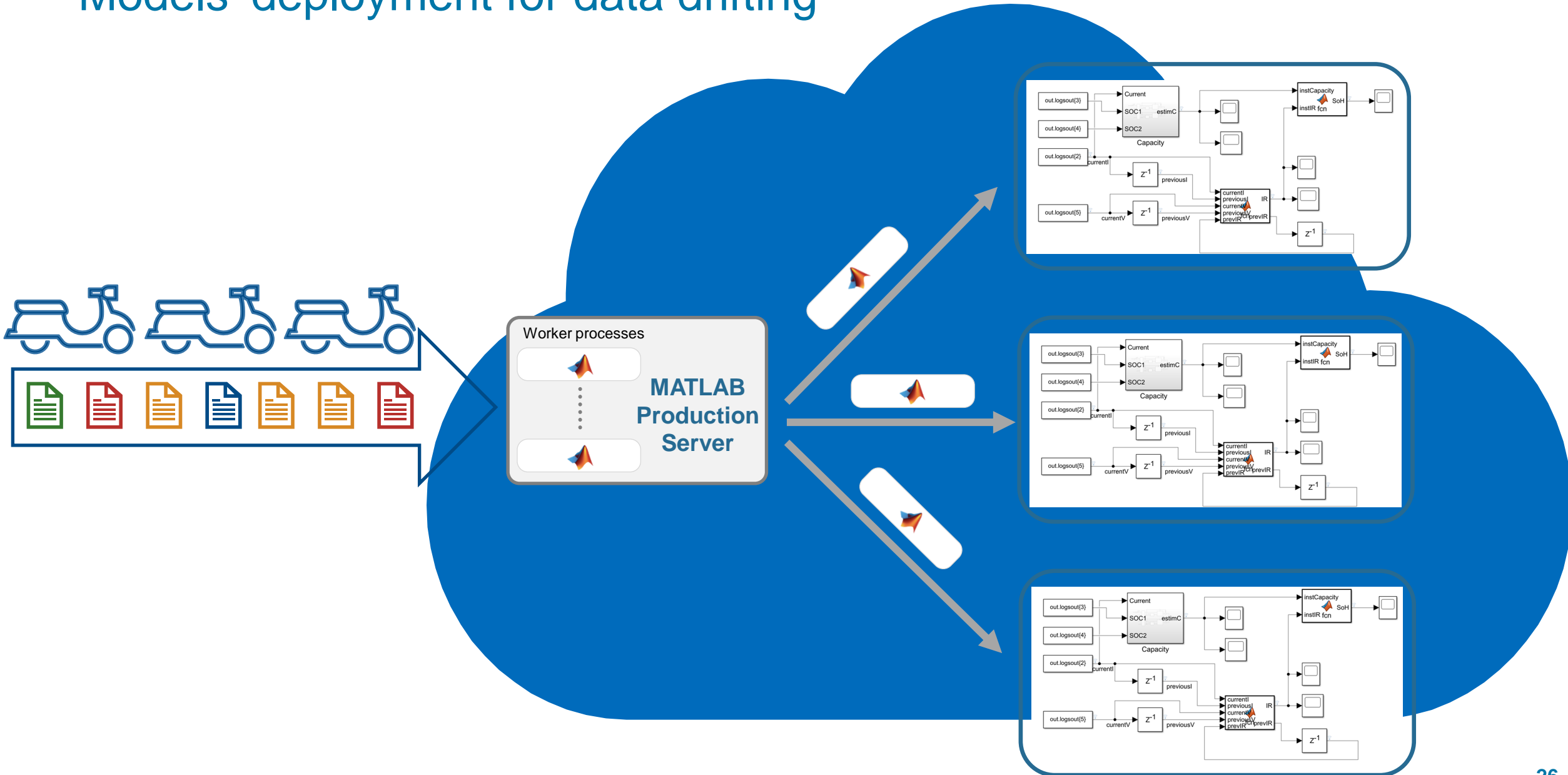




# Models' deployment for data drifting



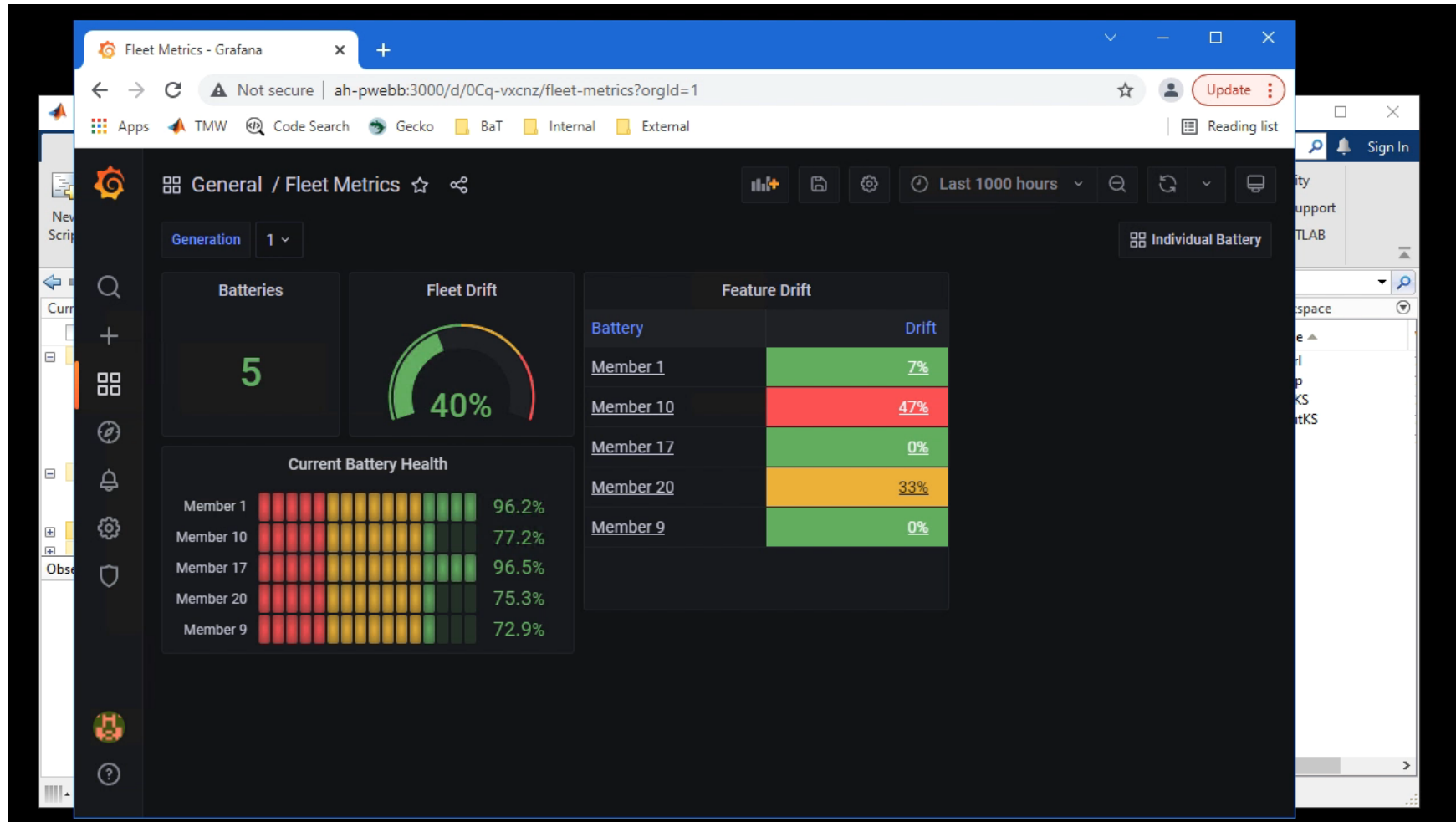
# Models' deployment for data drifting



# Deployment for streaming analysis

## Models' deployment for data drifting

### Case study: Step 6 – Integrate algorithms in Grafana



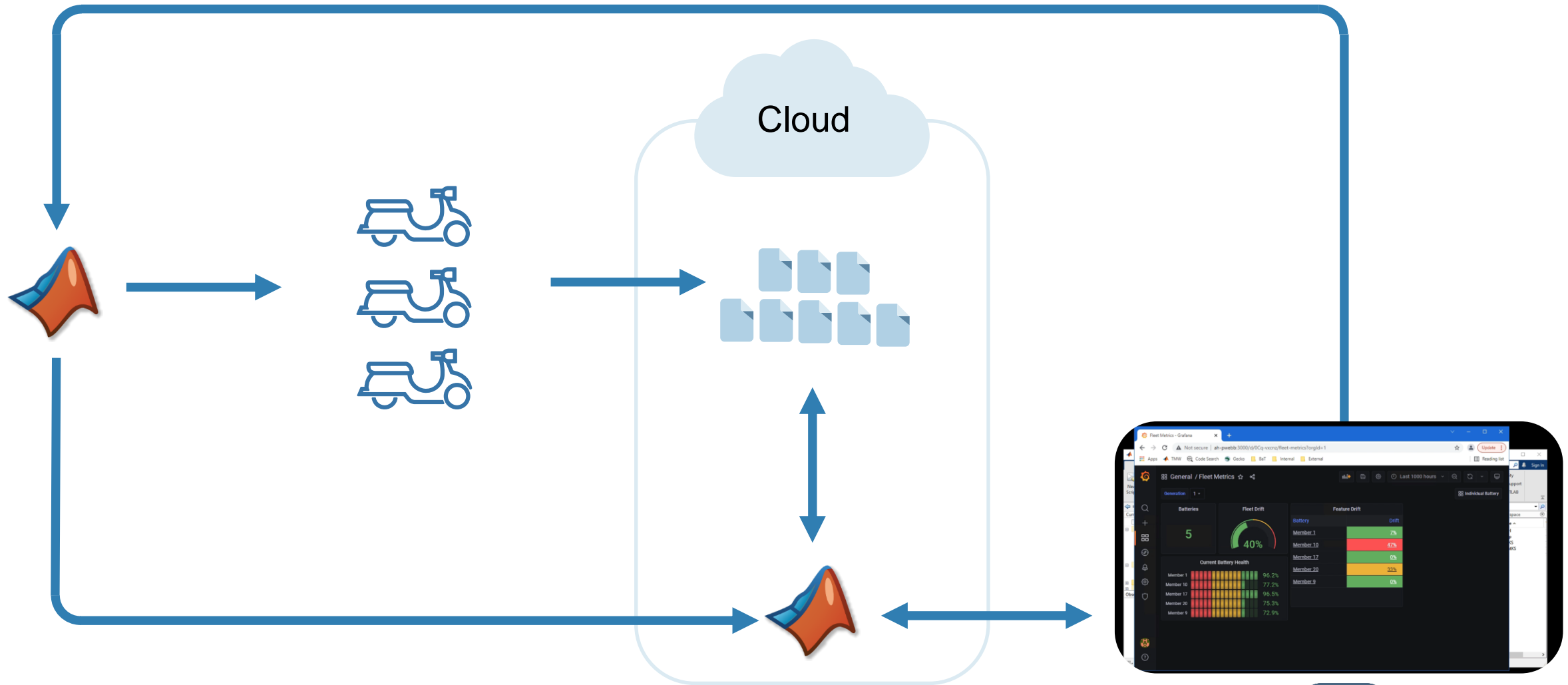
MBD meets AI

Predictive  
Maintenance and  
data drifting

From development  
to production

Testing and  
CI/CD deployment

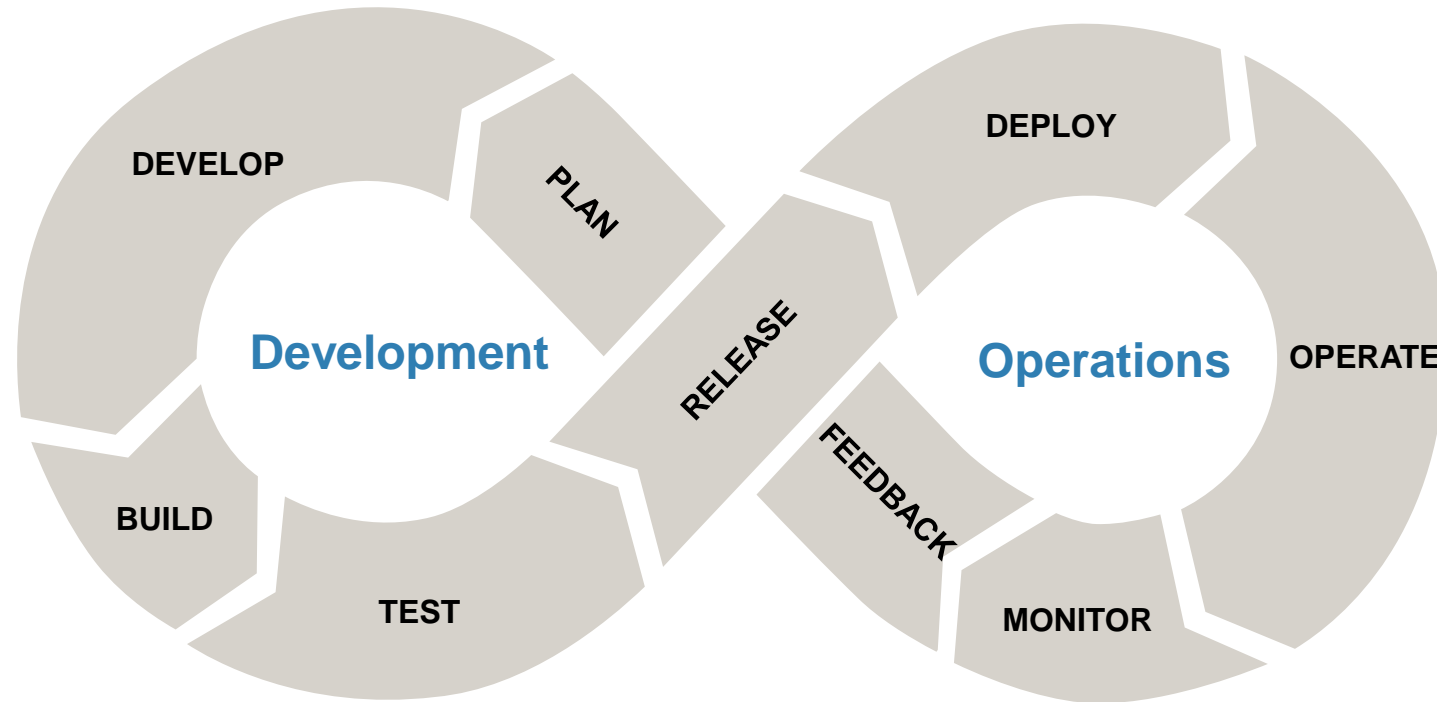
How to integrate your whole workflow  
in a local testing and a CI/CD pipeline



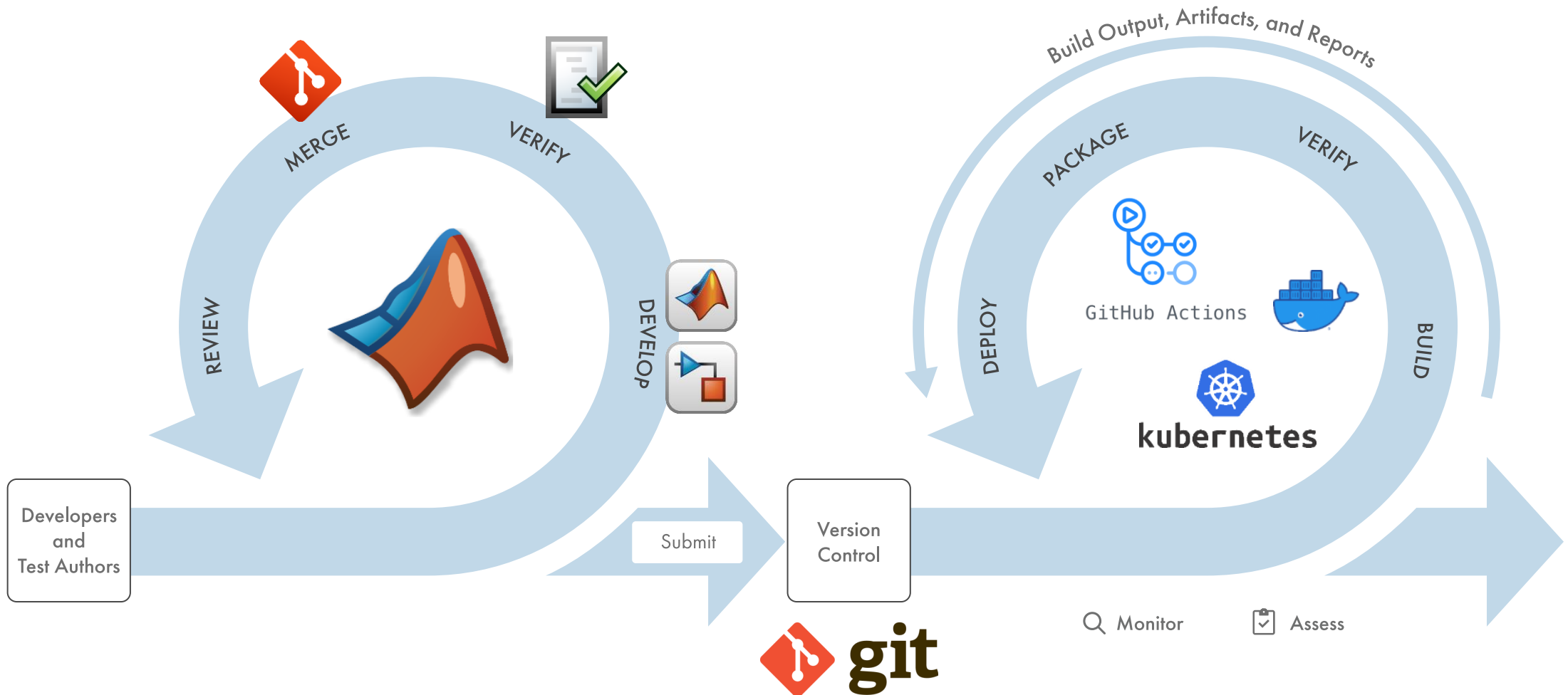
- Elastic scaling
- Data sovereignty
- Automation
- Multiple uses



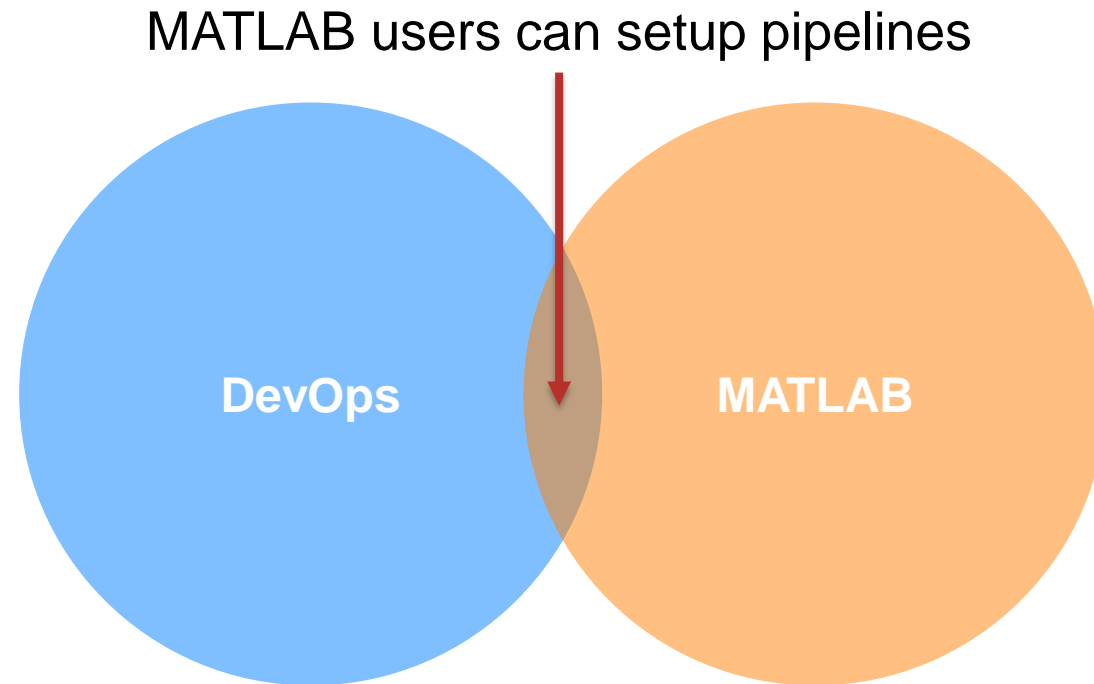
# DevOps Lifecycle



# DevOps Lifecycle



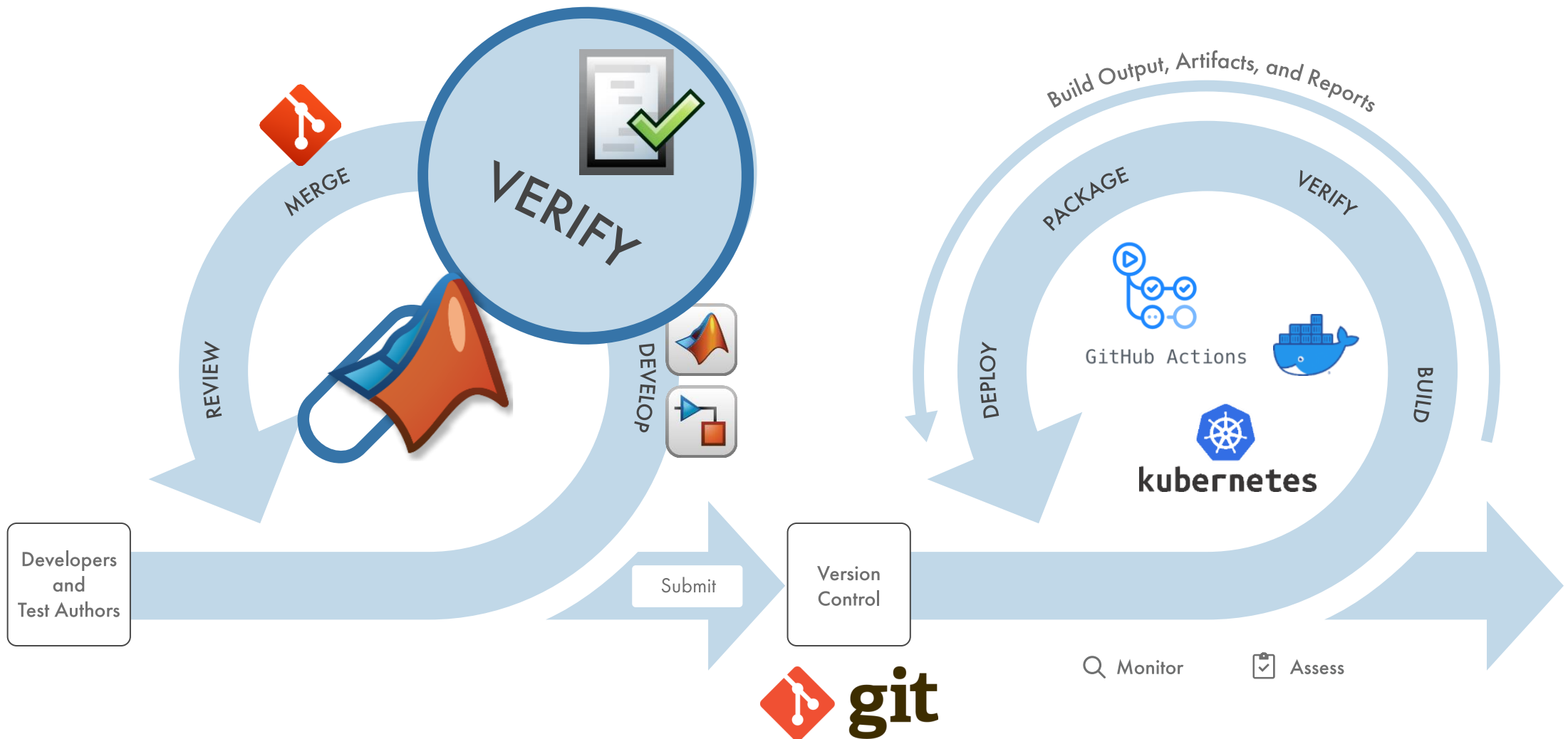
# Simplifying Continuous Integration for MATLAB & Simulink users



- Enable users to model pipeline inside MATLAB
- Create single integration point for DevOps engineers
- Empower users to maintain and debug pipeline



# Write and run your tests locally



# 1 – Write and manage test locally

Open project

The screenshot shows the MATLAB Test Manager interface. The 'Test Manager' icon in the top toolbar is highlighted with a green box. A callout box points to it with the text 'Enable coverage and view report'. The main window displays 'Test Manager: All Tests in Current Project' with a summary of test results: 70 Total Tests, 0 Passed, 0 Failed, and 0 Incomplete. A callout box points to this summary with the text 'Summary of tests and results'. Below the summary is a 'Test Details' section with a table of tests and results. A callout box points to this table with the text 'Table of tests and results'. Another callout box points to the table with the text 'Test suite being viewed'. A final callout box at the bottom states 'Results are persisted in project, can close/reopen Test Manager or MATLAB'.

**Enable coverage and view report**

**Test suite being viewed**

**Summary of tests and results**

**Table of tests and results**

**Results are persisted in project, can close/reopen Test Manager or MATLAB**

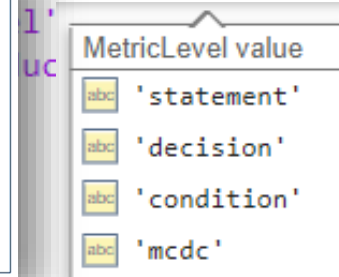
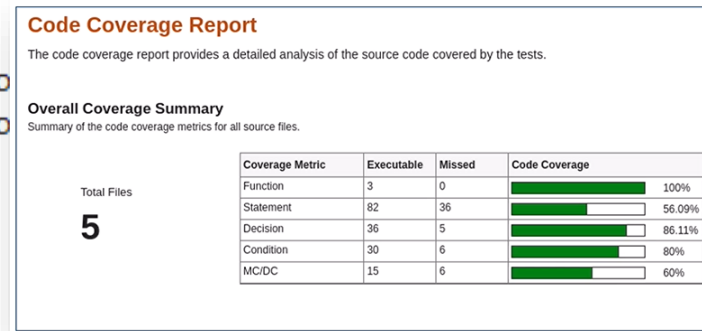
Test	Dagnostic	Time
<input type="radio"/> <a href="#">SmokeTests/smokeTest1.m</a>		
<input type="radio"/> <a href="#">SmokeTests/smokeTest2.m</a>		
<input type="radio"/> <a href="#">UnitTests/backendTests.m</a>		
<input type="radio"/> <a href="#">UnitTests/uiTests.m</a>		
<input type="radio"/> <a href="#">uiTestA (s=1+d)</a>		
<input type="radio"/> <a href="#">uiTestA (s=1+a+b)</a>		
<input type="radio"/> <a href="#">uiTestB</a>		



# Coverage metrics: tells you what you have tested

`% Advanced Metrics`

```
format = matlab.unittest.plugins.Co
plugin = matlab.unittest.plugins.Co
```



MATLAB

Statement  
& Function  
Coverage

R2022a

MATLAB Test

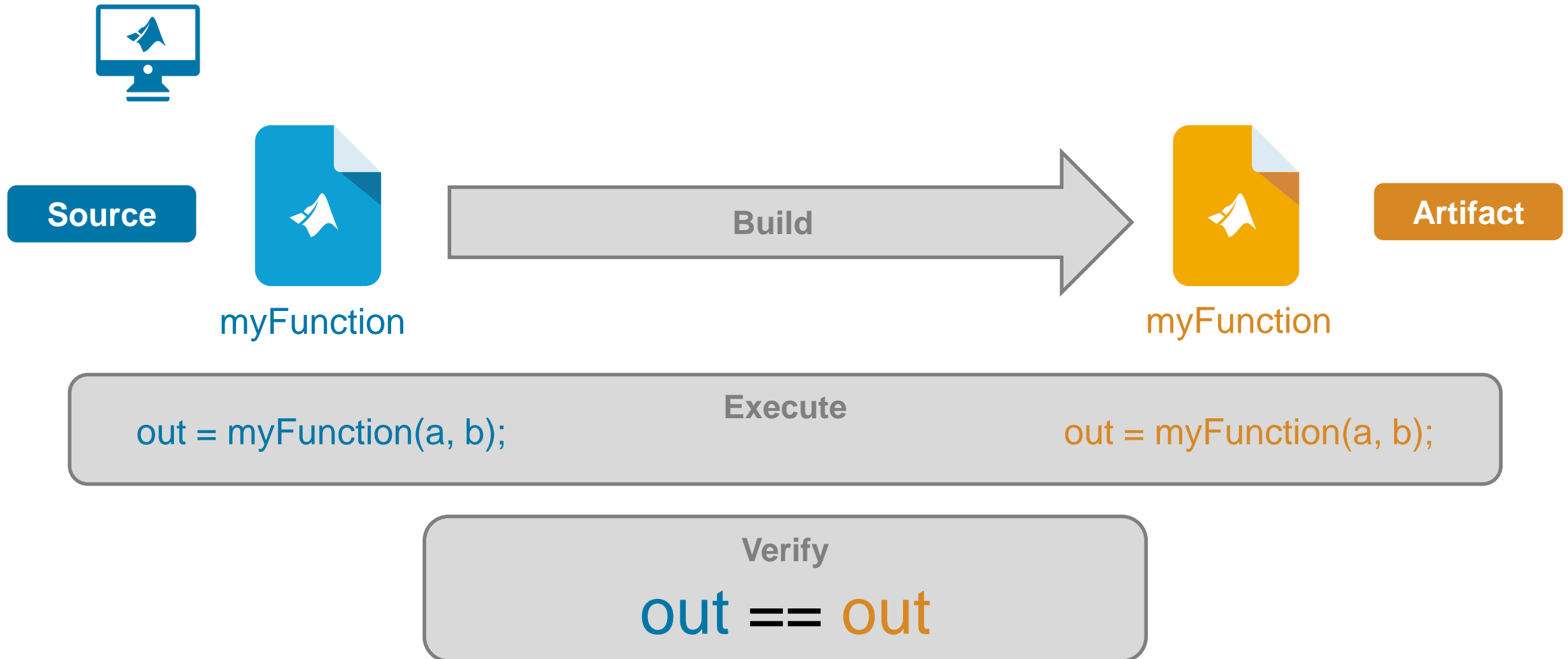
Decision  
Coverage

Condition  
Coverage

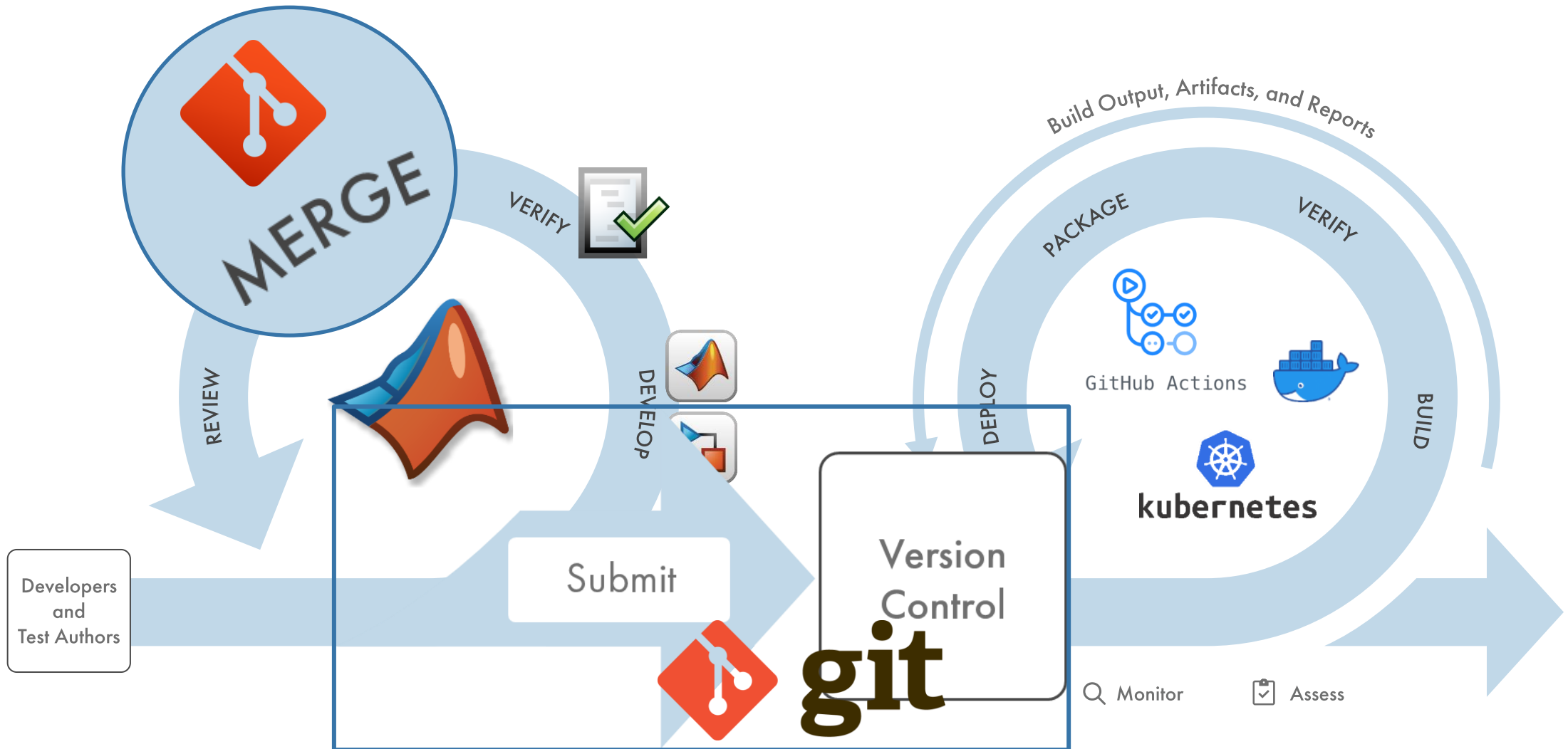
Modified  
Condition/  
Decision  
Coverage

R2023a

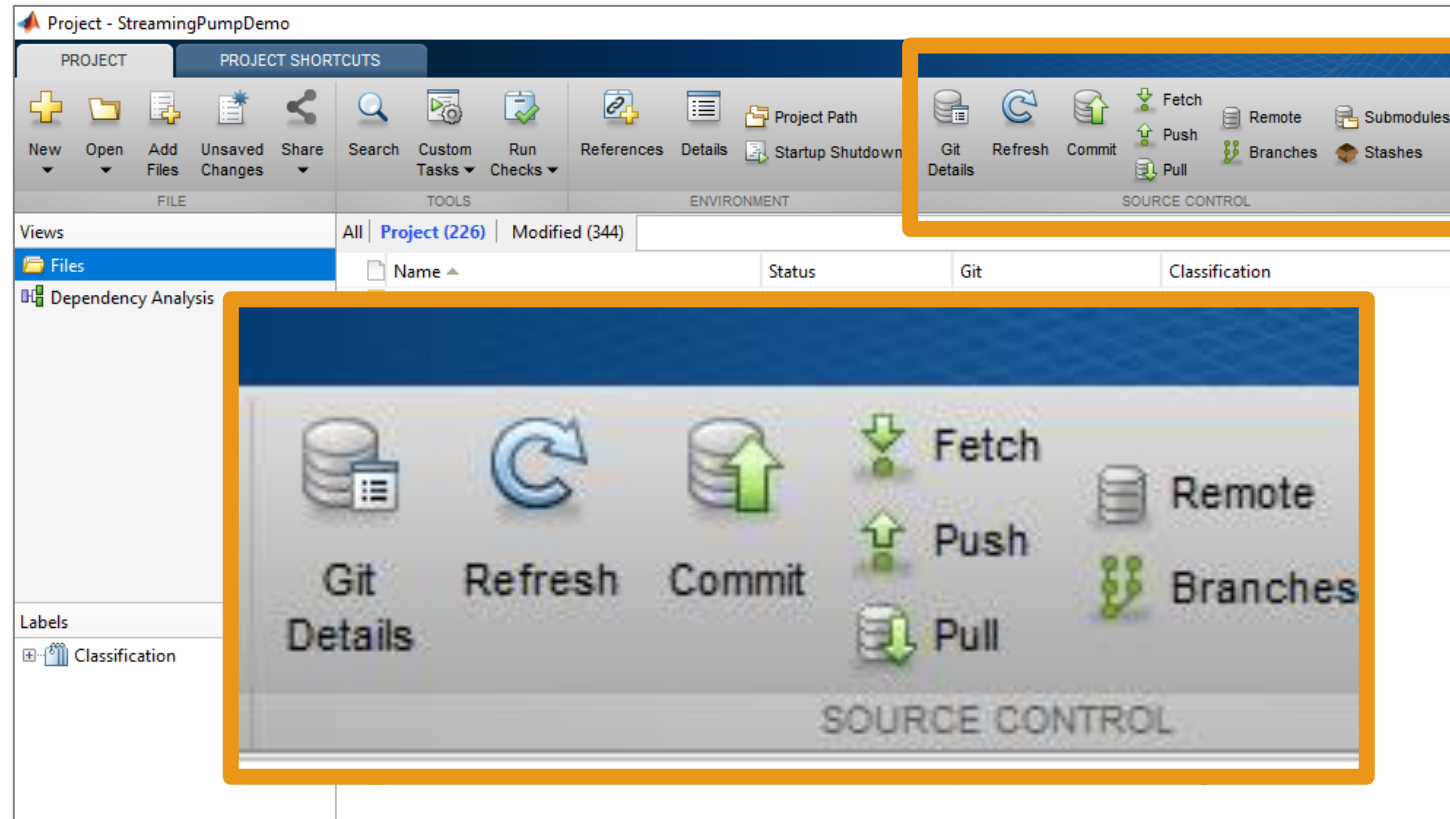
# Equivalence testing feature: Catch issues before leaving MATLAB



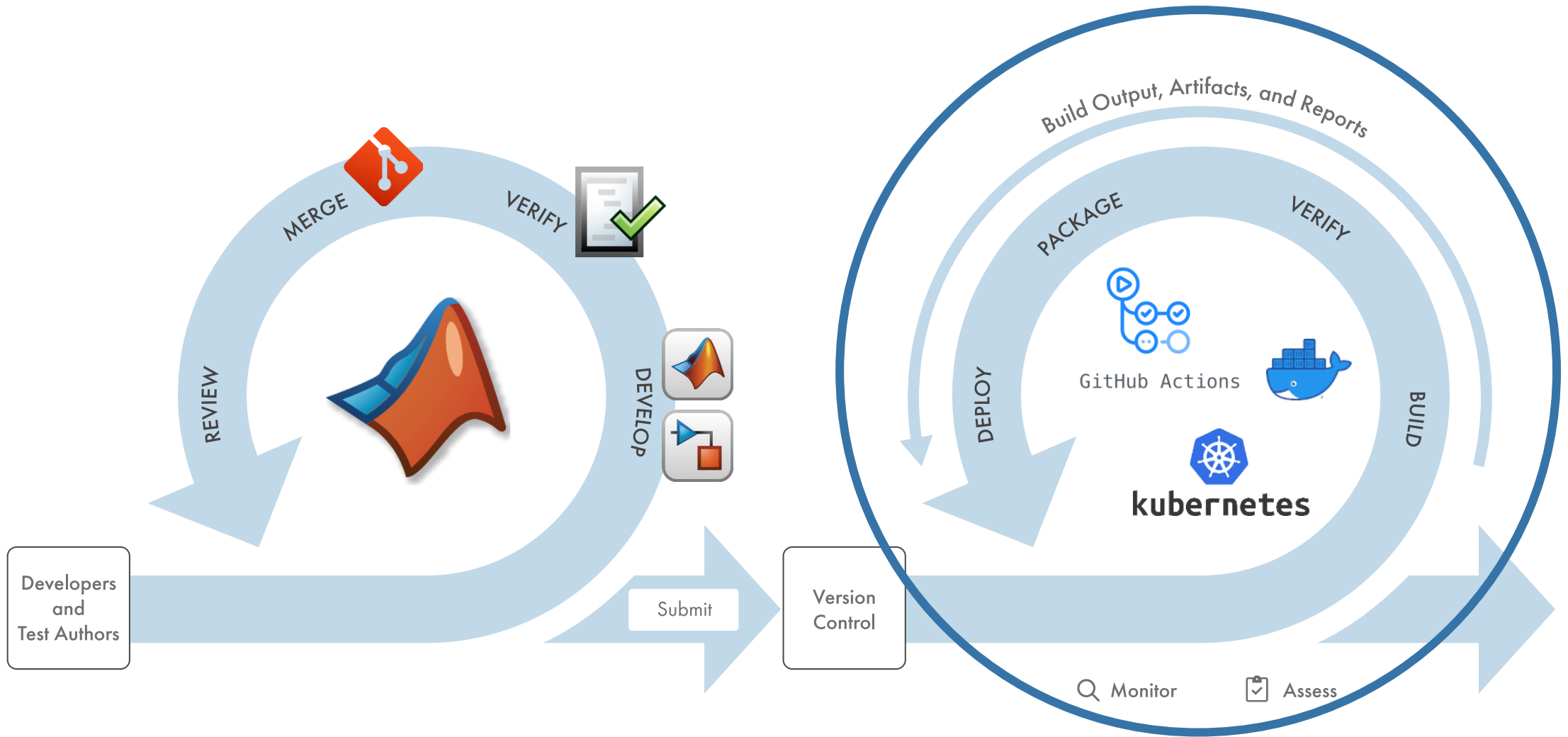
# Version control



## 2 – Version your code locally and directly from MATLAB

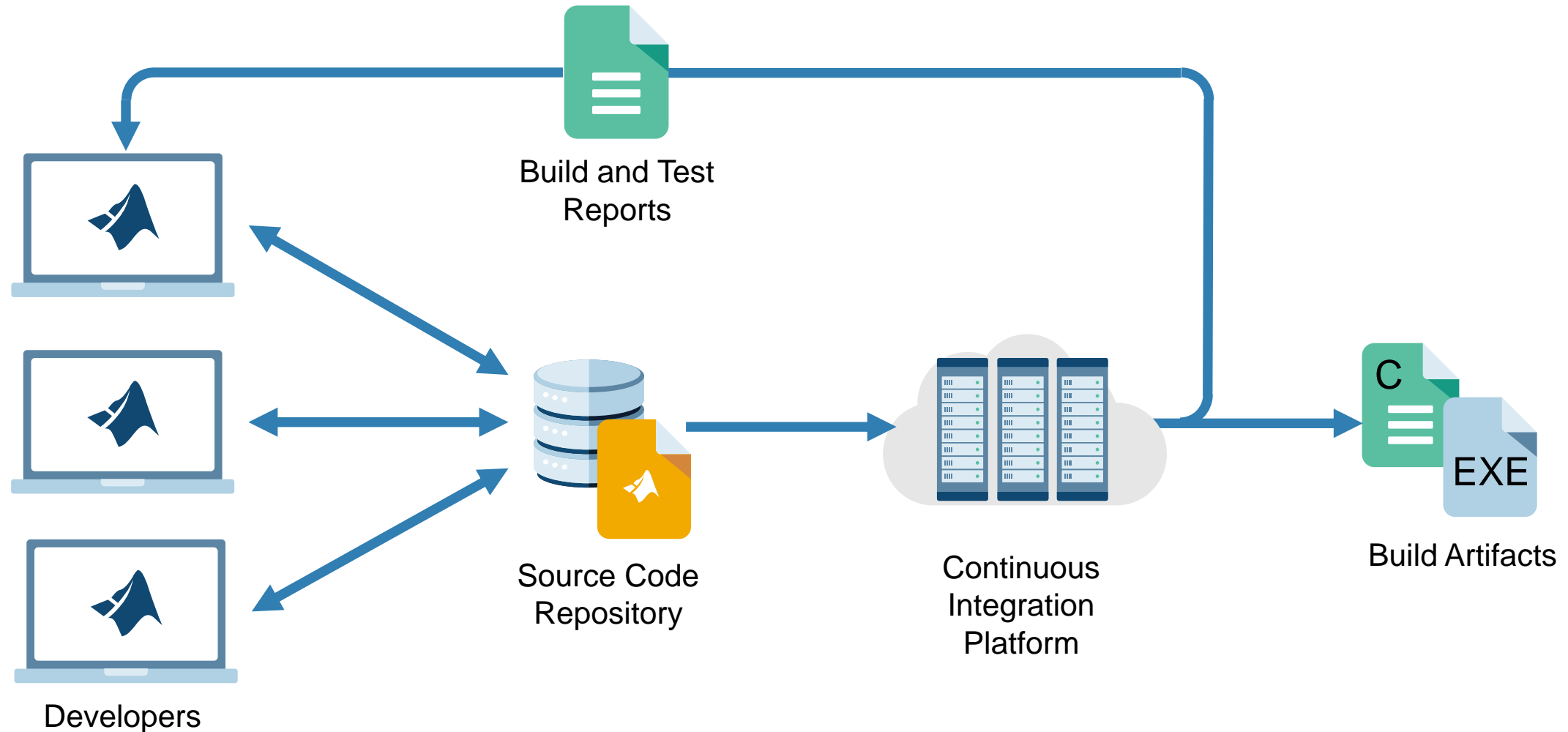


# Version control





# What does a CI-based workflow look like?



# Deploy – Create a Microservice in MATLAB

- Requirements:
  - Docker
  - MATLAB Compiler
  - MATLAB Compiler SDK
  - Simulink Compiler
  
- Code:

```
mpsResults = compiler.build.productionServerArchive("myFunction.m");  
  
compiler.package.microserviceDockerImage(mpsResults, ...  
                                         "ImageName", "micro-myfunction");
```

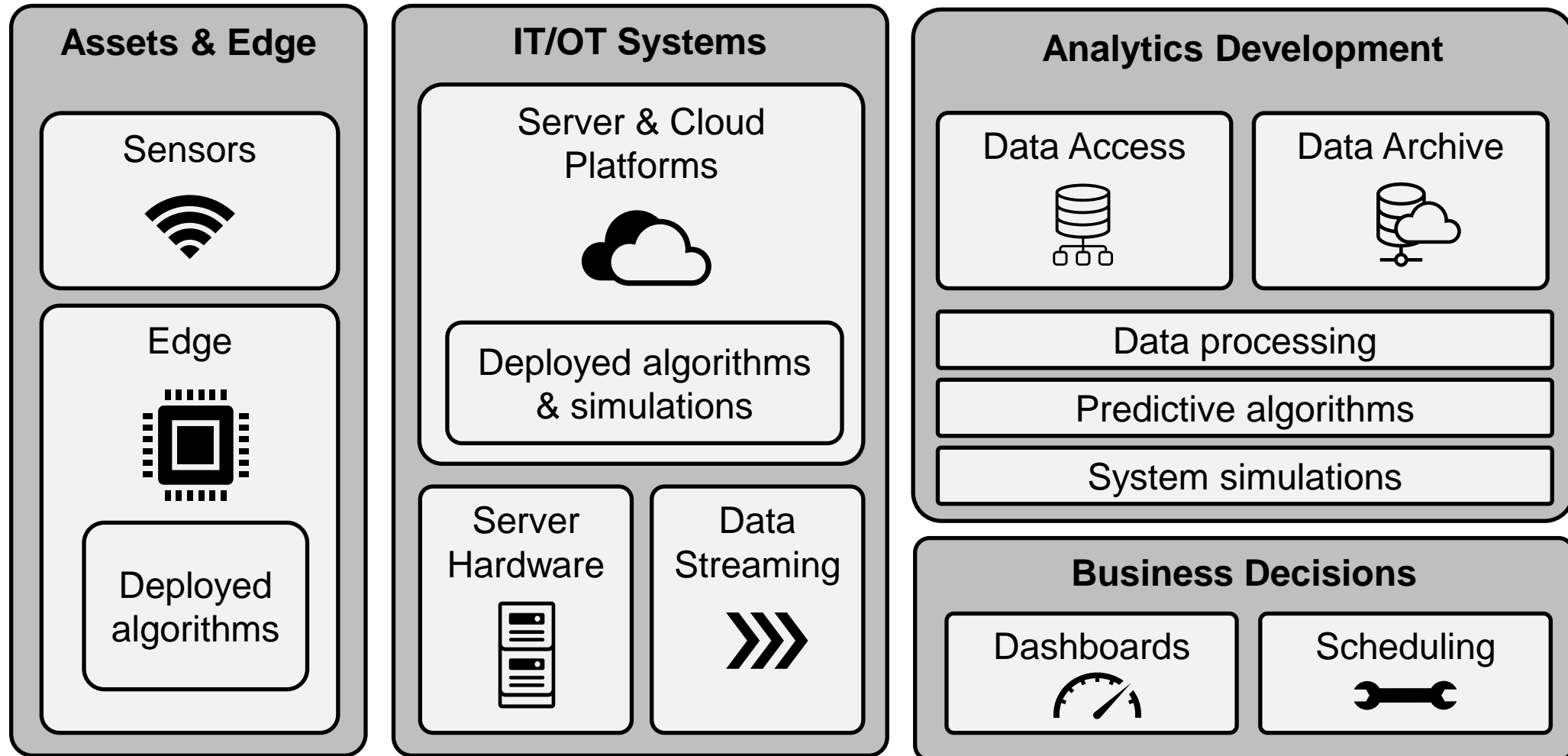
# Deploy – Integration with the DevOps Pipeline

- How to use it in pipeline

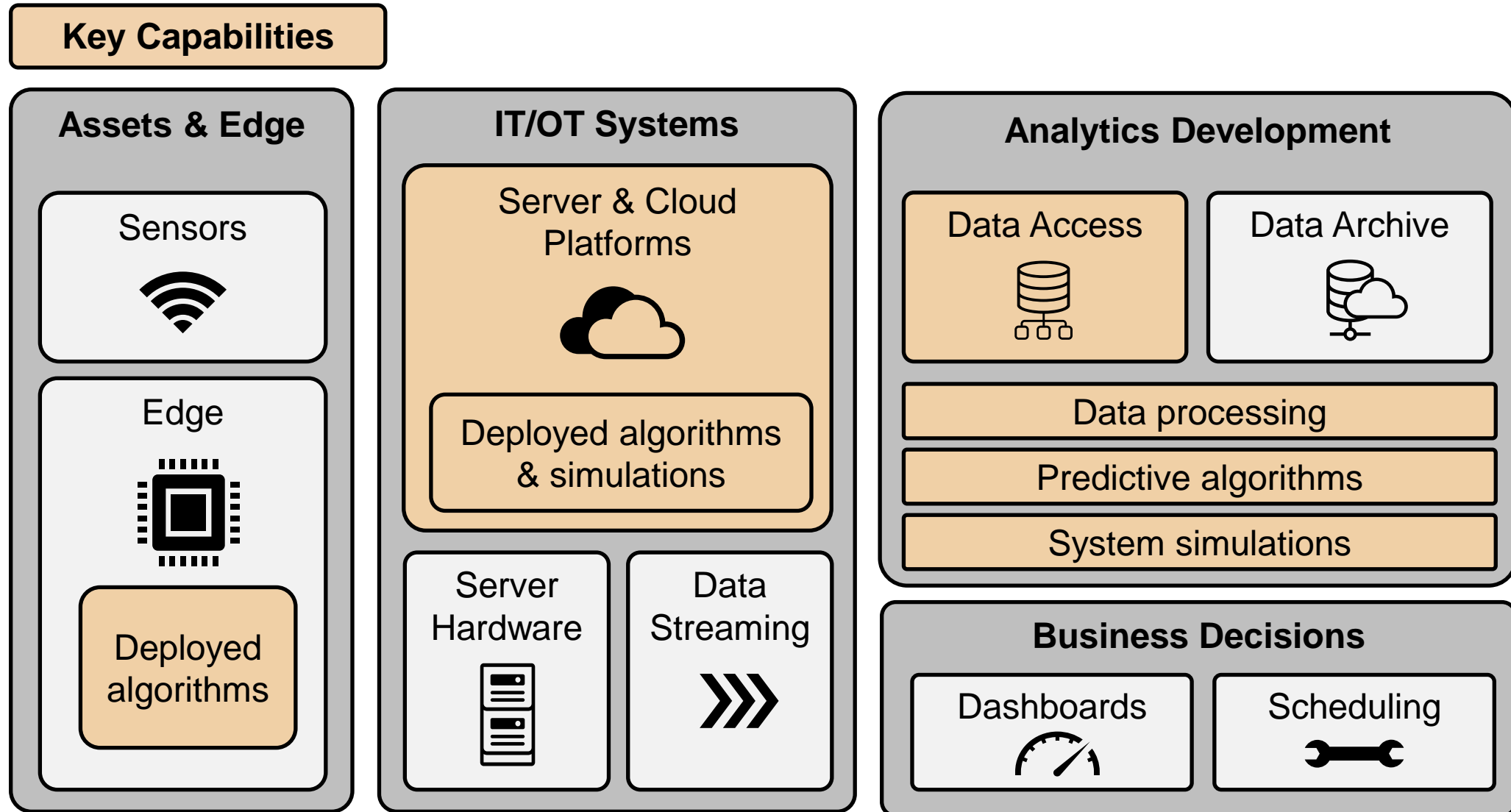
The screenshot shows a pipeline run for 'build-and-deploy' that succeeded 18 hours ago in 25m 51s. The pipeline consists of several steps grouped into three phases: 'Set up', 'Microservice build', and 'Clean up'. Each step is marked with a checkmark and a duration.

Phase	Step	Duration
Set up	Set up job	5s
	Check-out repository	1s
	Setup MATLAB	31s
	Set up Docker	19s
Microservice build	Create the microservice	22m 13s
	Connect to Azure registry	0s
	Tag and push the Docker image to Azure	2m 36s
Clean up	Post Check-out repository	0s
	Complete job	0s

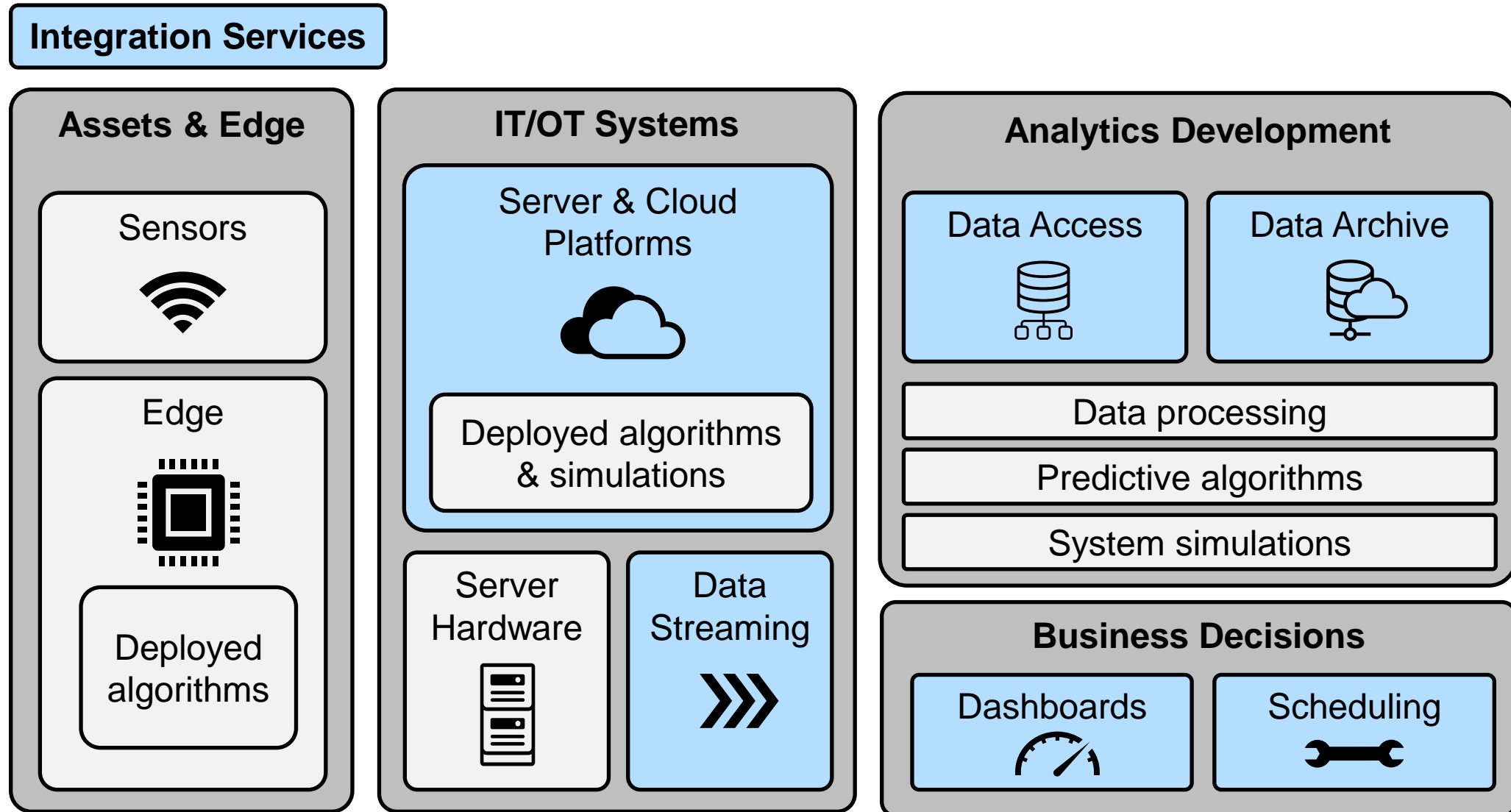
# A predictive maintenance solution is more than an algorithm



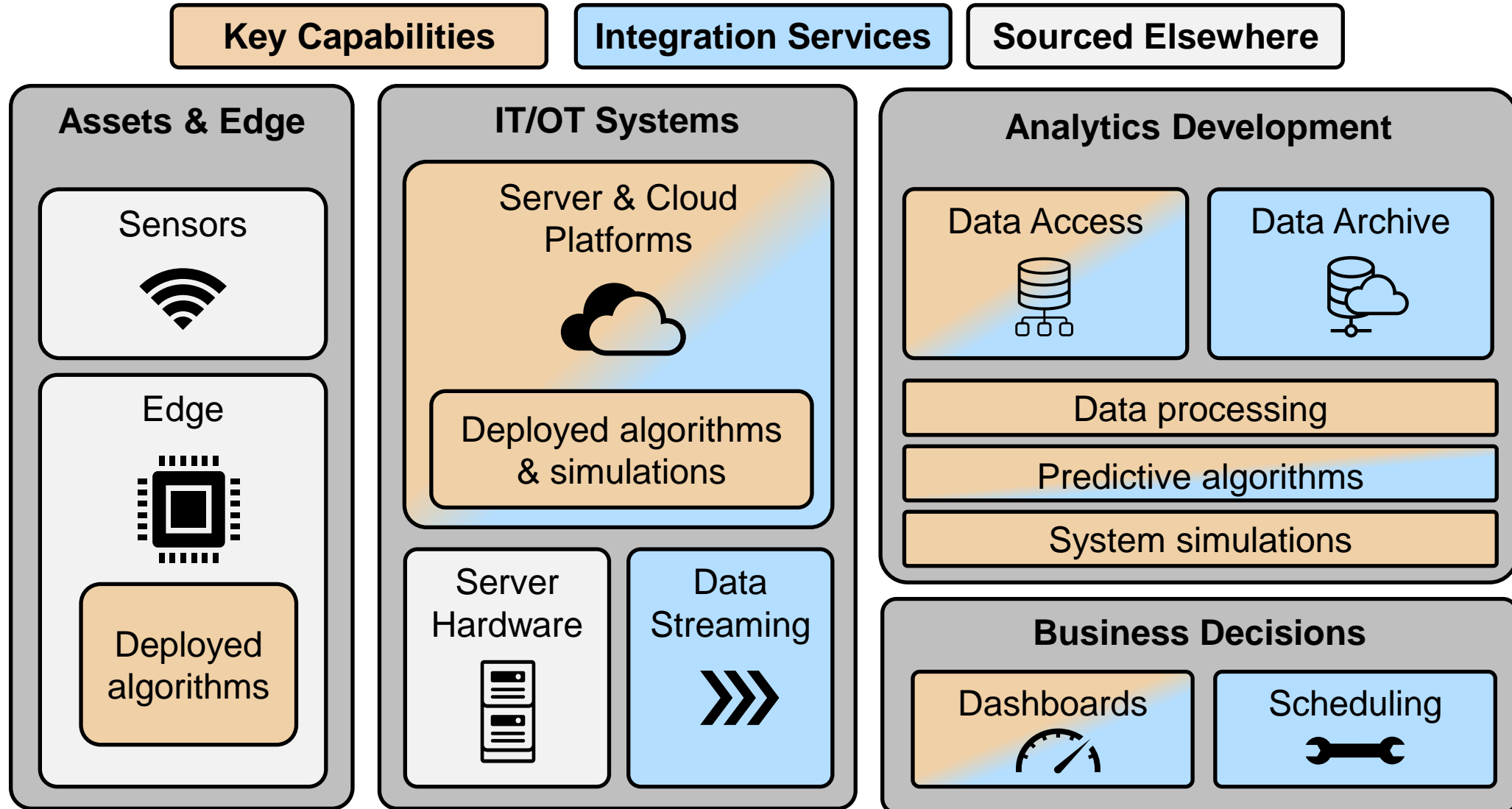
# A predictive maintenance solution is more than an algorithm



# A predictive maintenance solution is more than an algorithm



# A predictive maintenance solution is more than an algorithm





Not Me





# MATLAB EXPO

FRANCE

Thank you!  
Questions?



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