

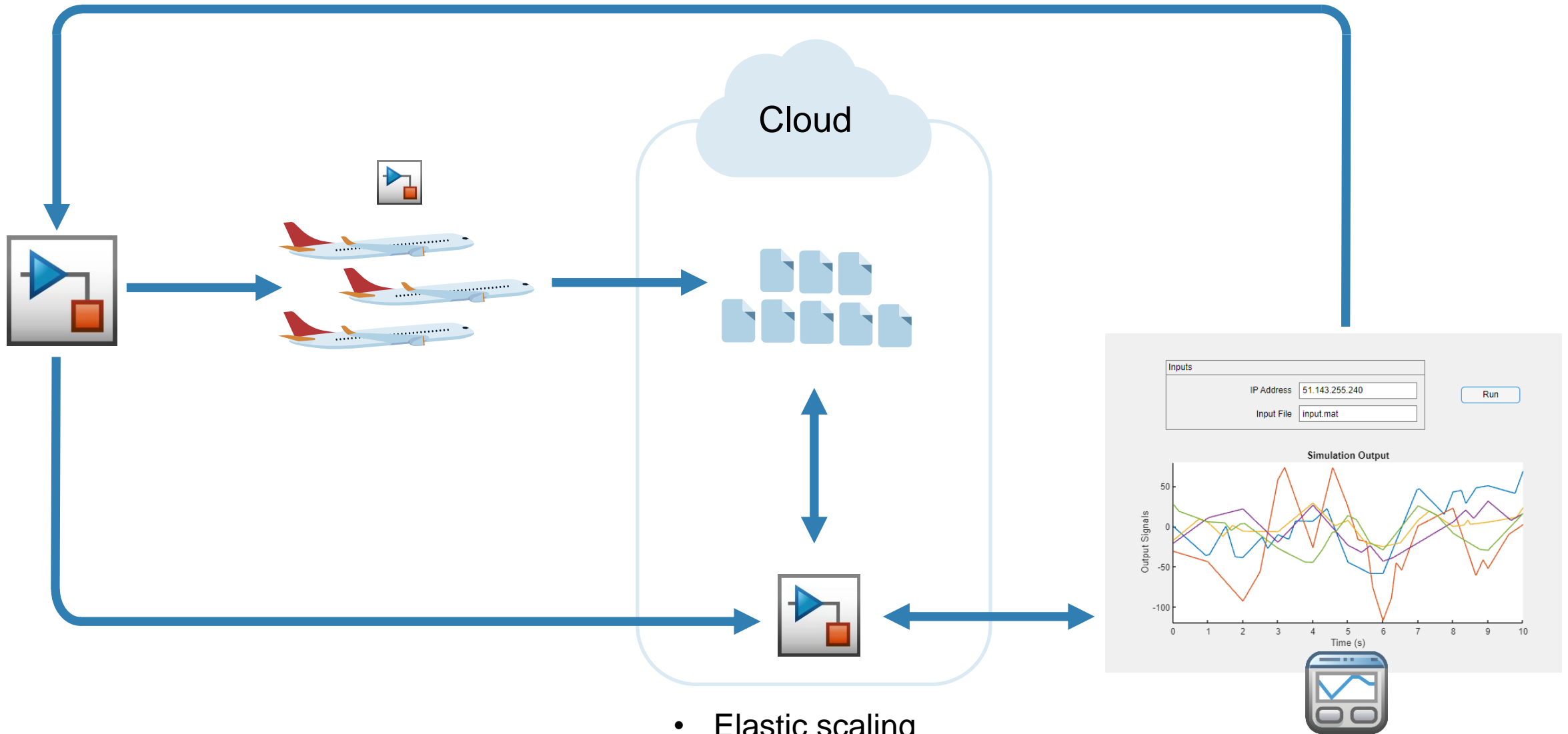
# Developing, Testing and Deploying Models and Algorithms in the Cloud

*Jean-Baptiste Lanfrey, MathWorks*



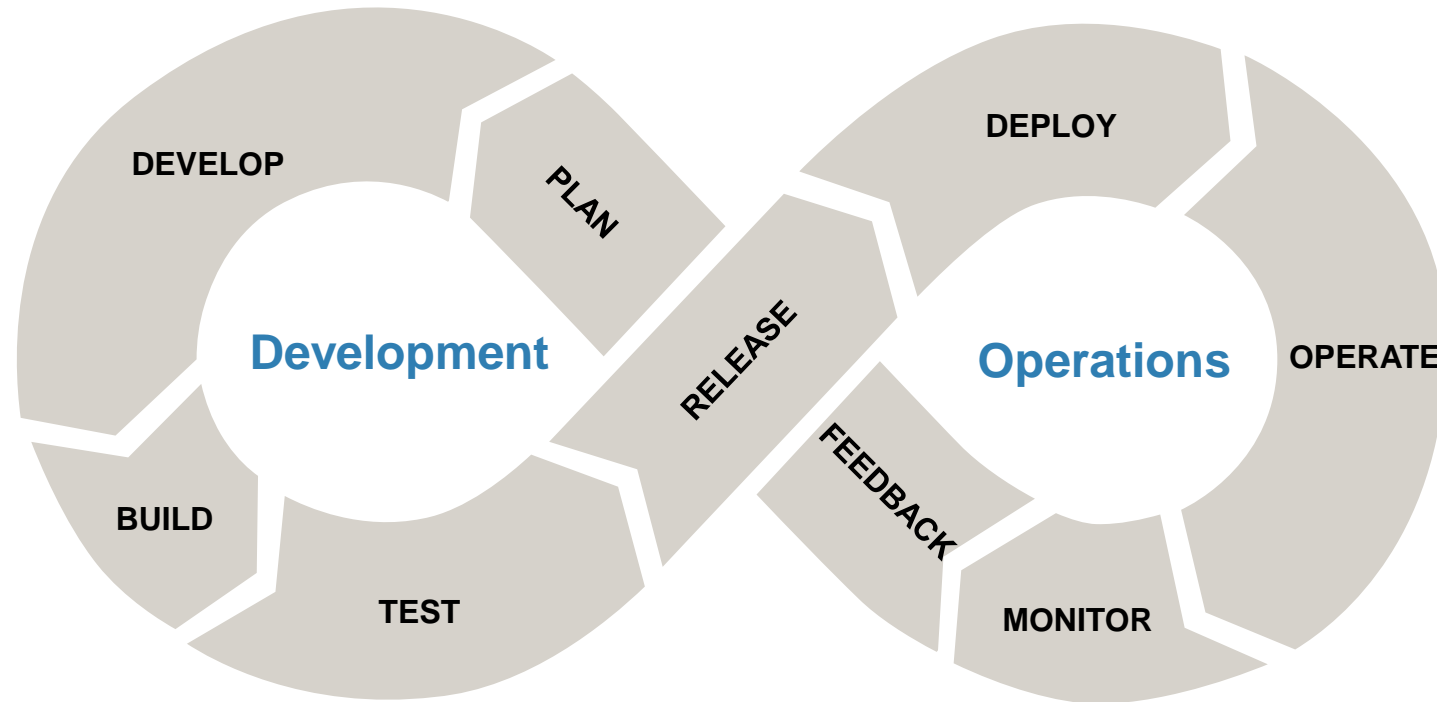
# What Will You Learn Today?

- We are making it easier for you to:
  - Implement MBD workflows in CI systems
  - Access cloud data directly from MATLAB
  - Create a microservice with MATLAB Compiler SDK

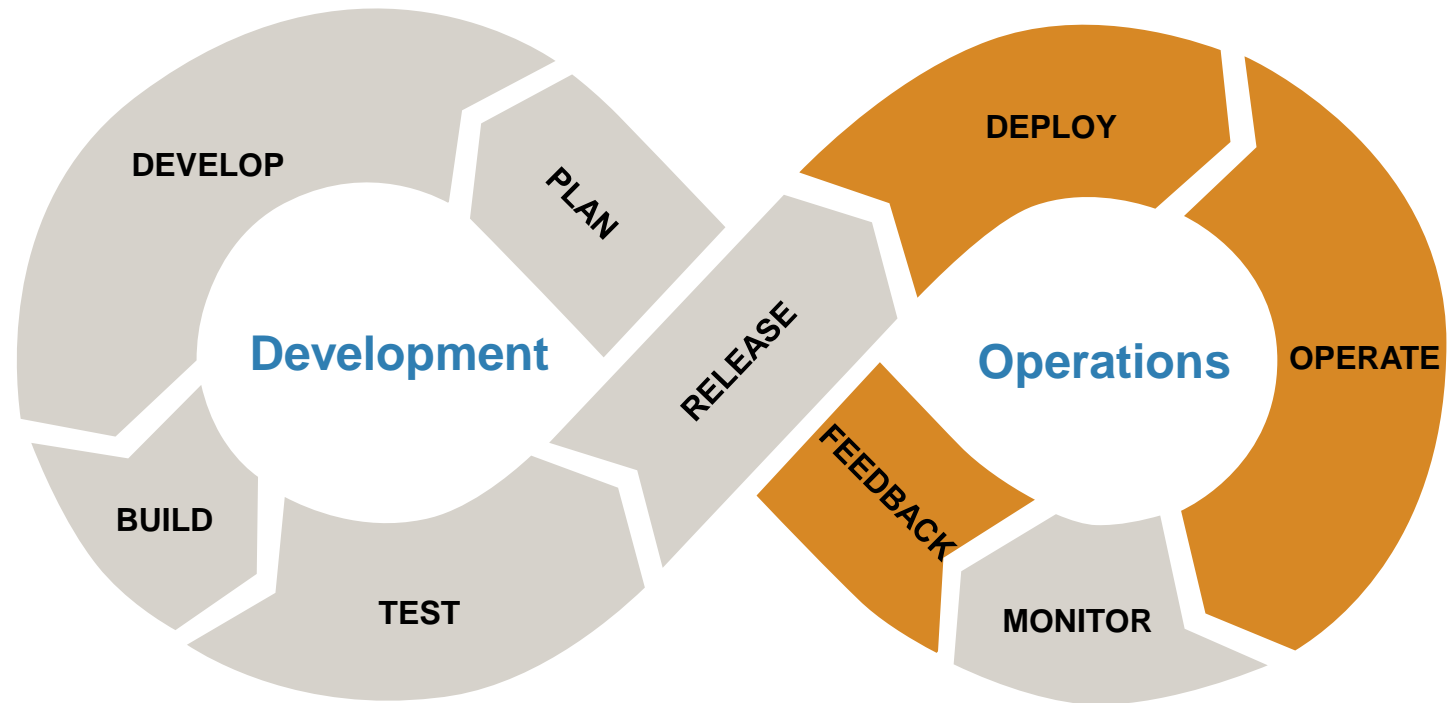


- Elastic scaling
- Data sovereignty
- Automation
- Multiple uses

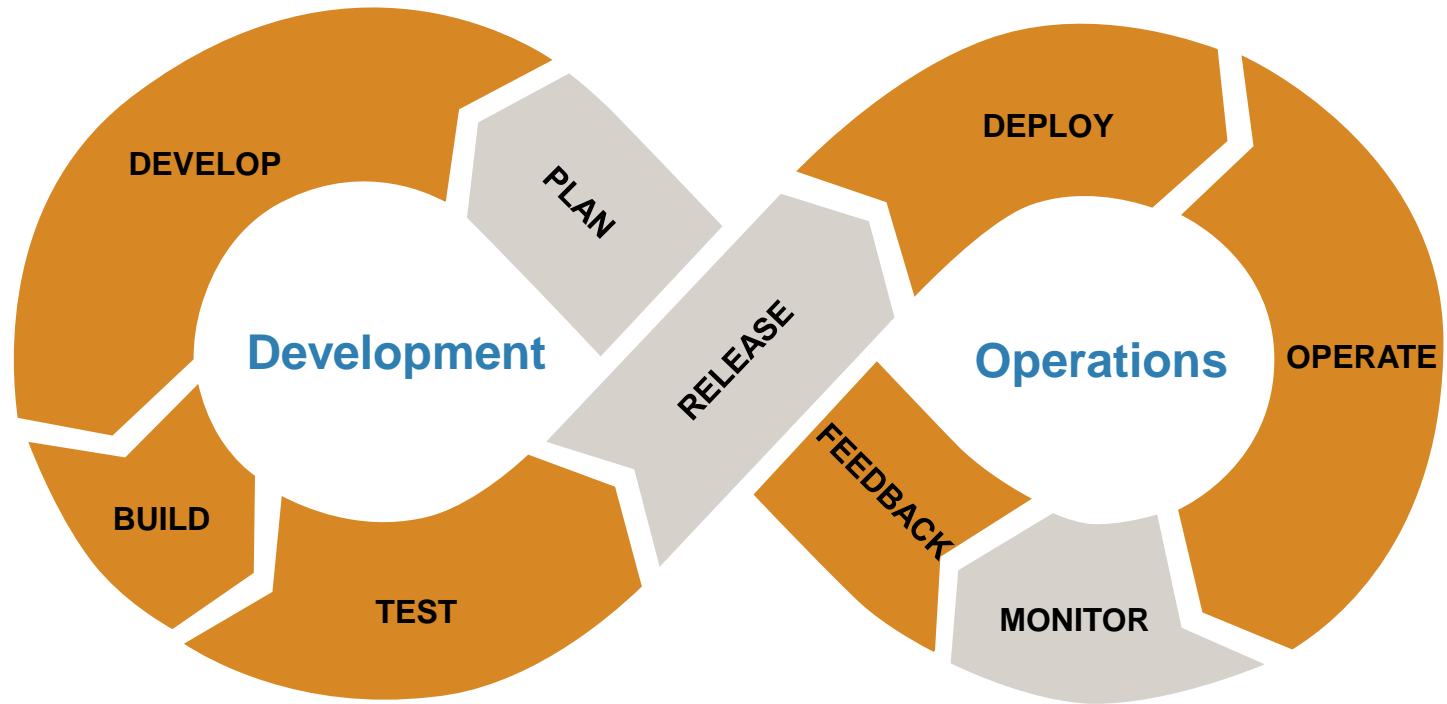
# DevOps Lifecycle



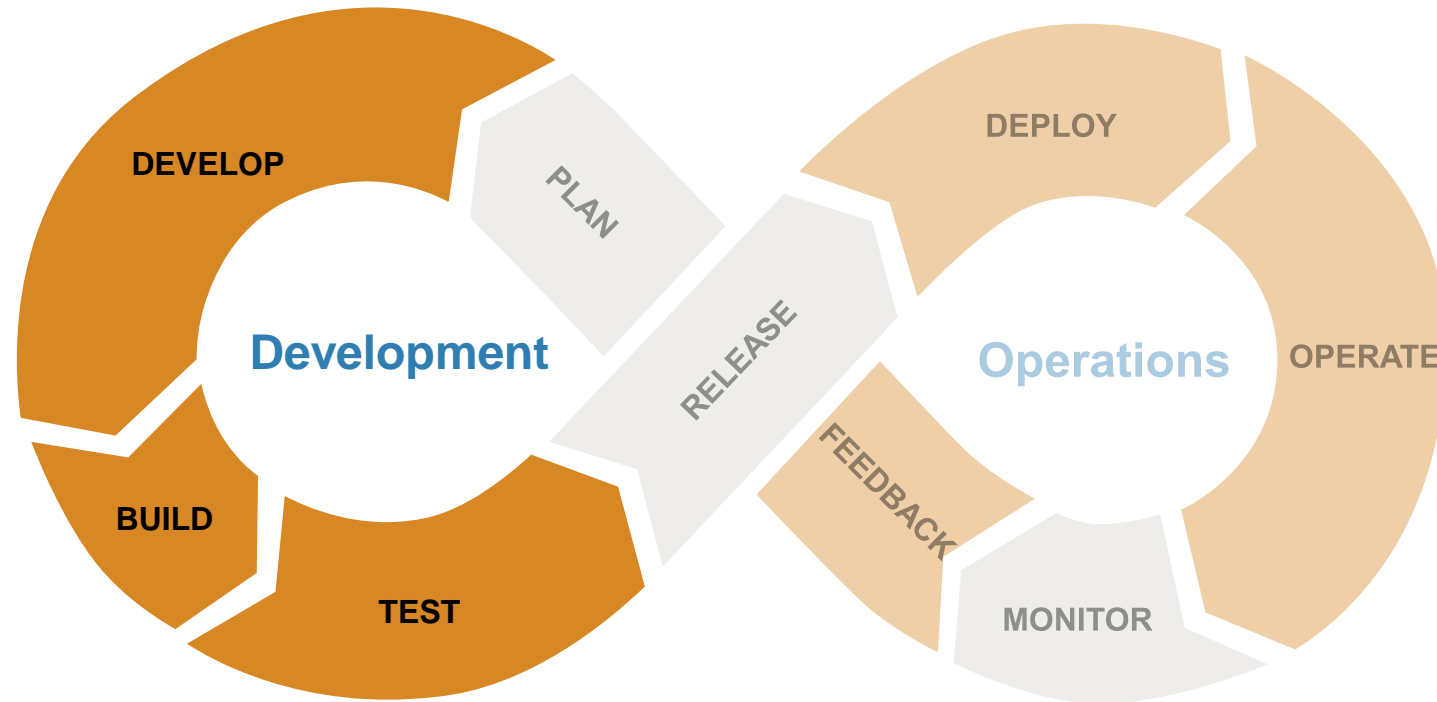
# DevOps Lifecycle



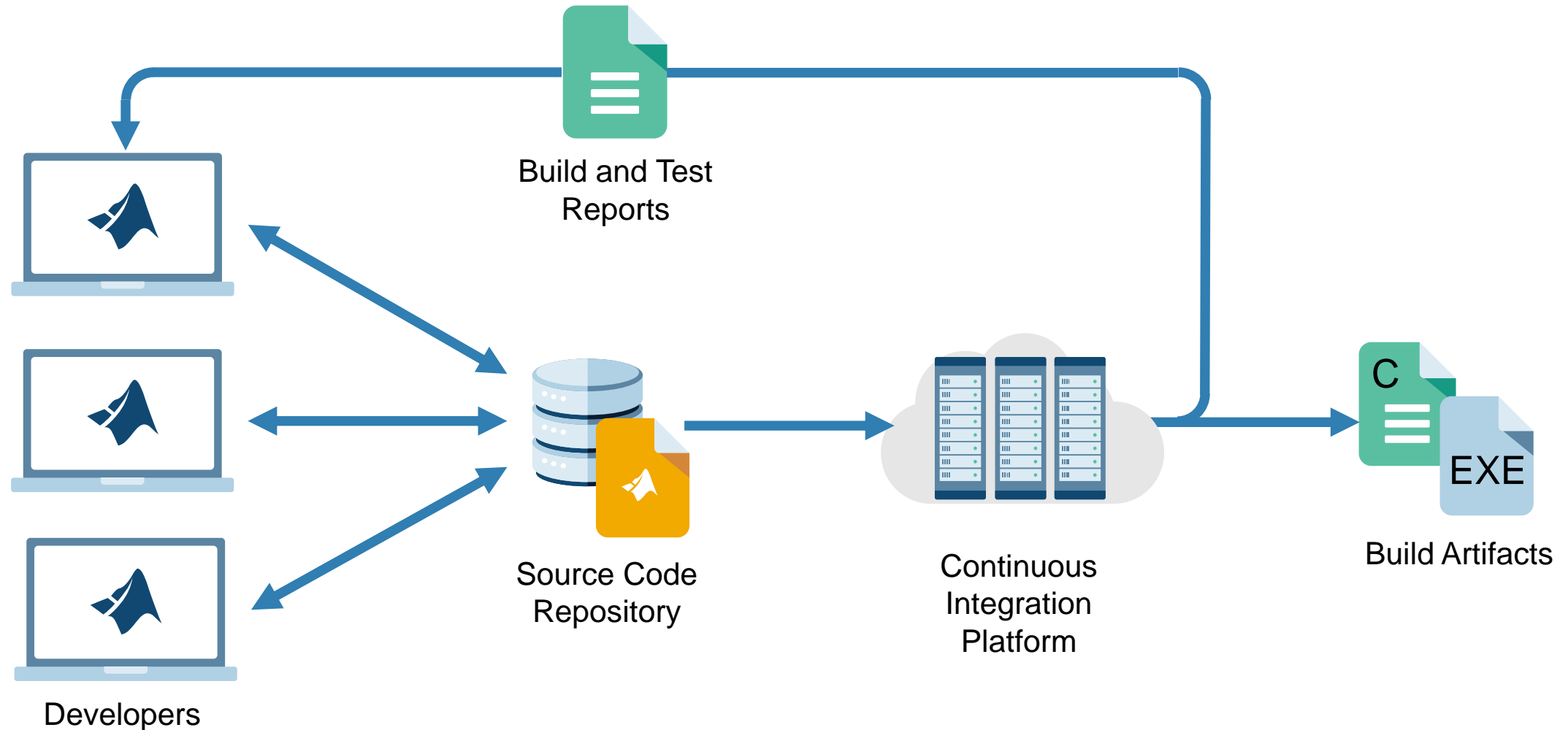
# DevOps Lifecycle



# DevOps Lifecycle

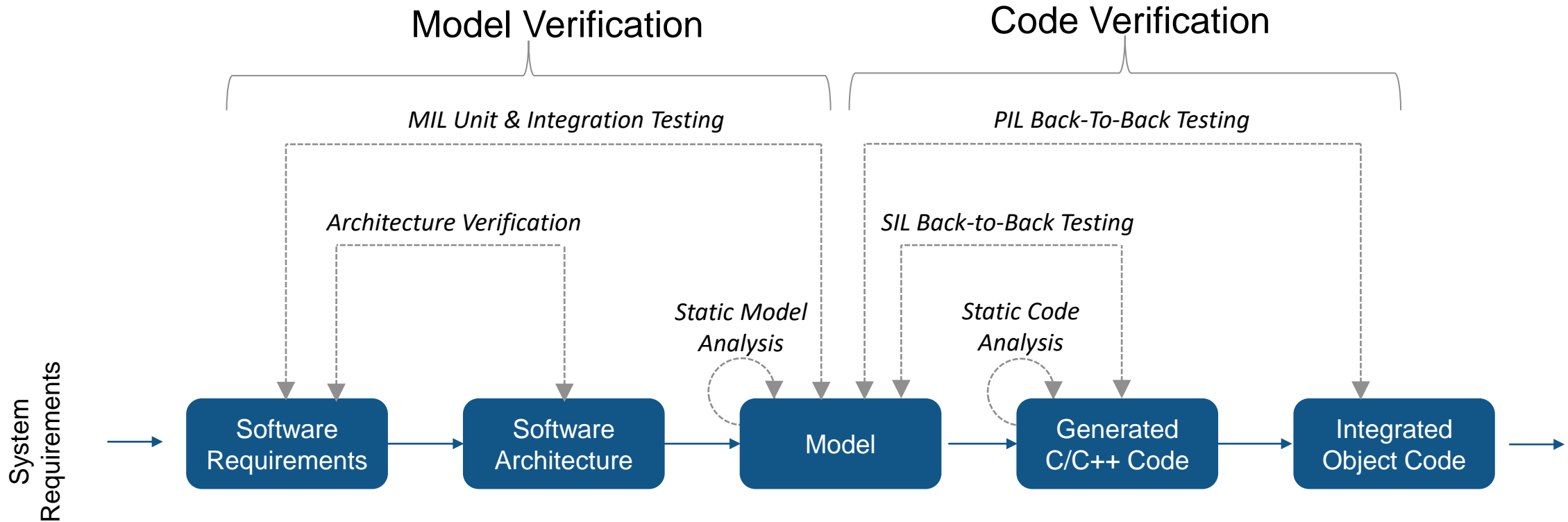


# What does a CI-based workflow look like?

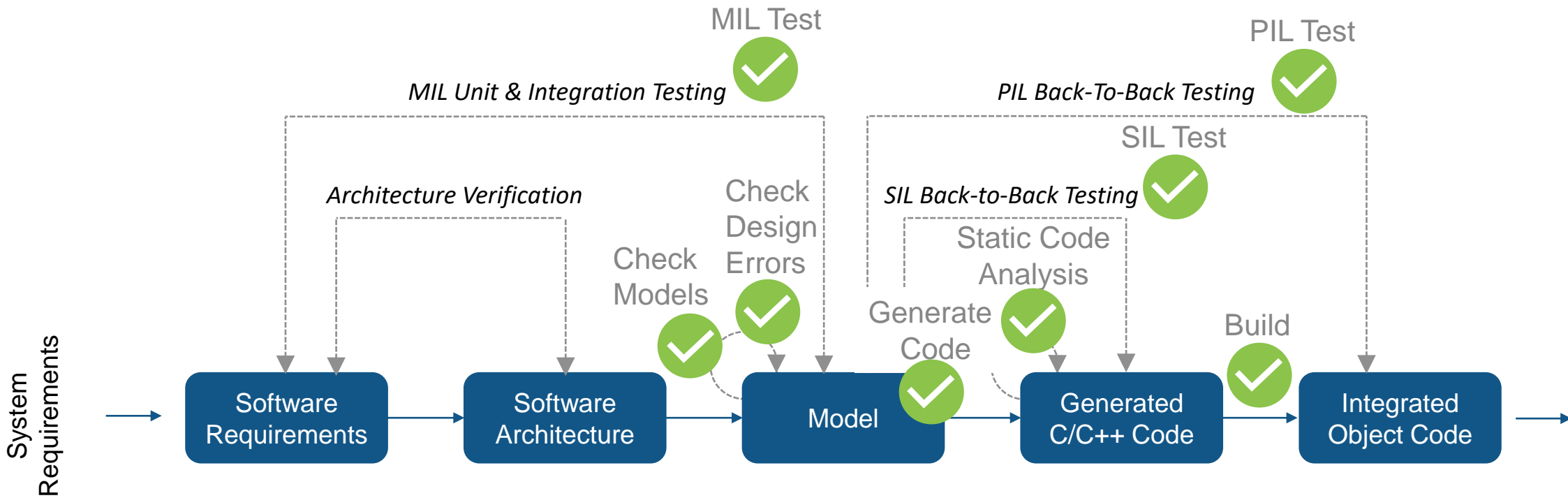




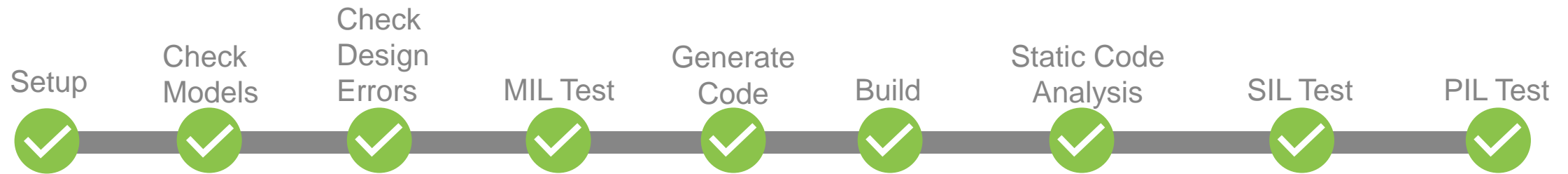
# Model-Based Design Reference Workflow



# Model-Based Design Reference Workflow



# Model-Based Design Reference Workflow



- Define Process and Automate

- Identify Tasks
- Define Sequence
- Define Outputs
- Script the Tools



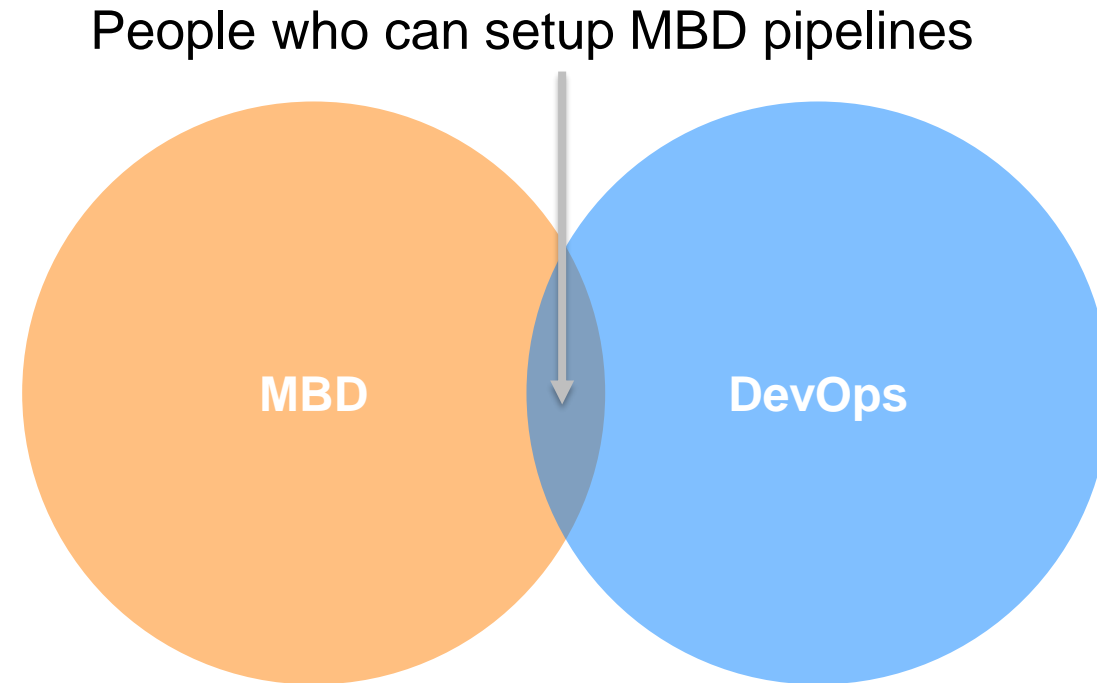
build.m



genCode.m



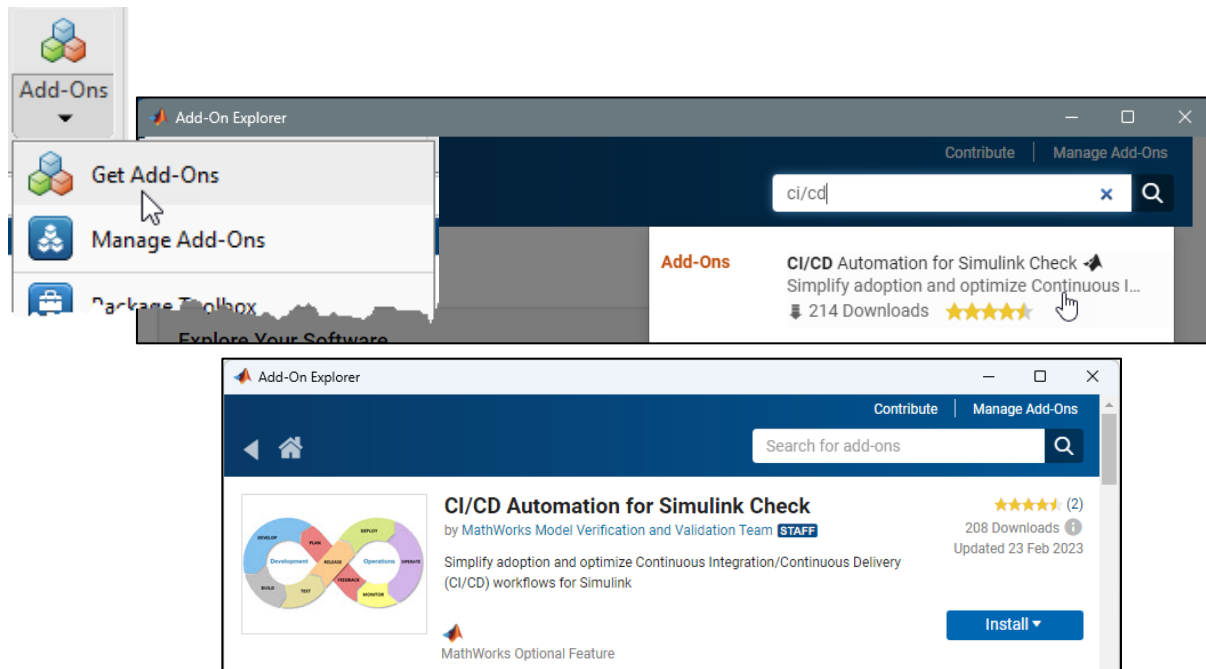
# Simplifying Continuous Integration for Model-Based Design



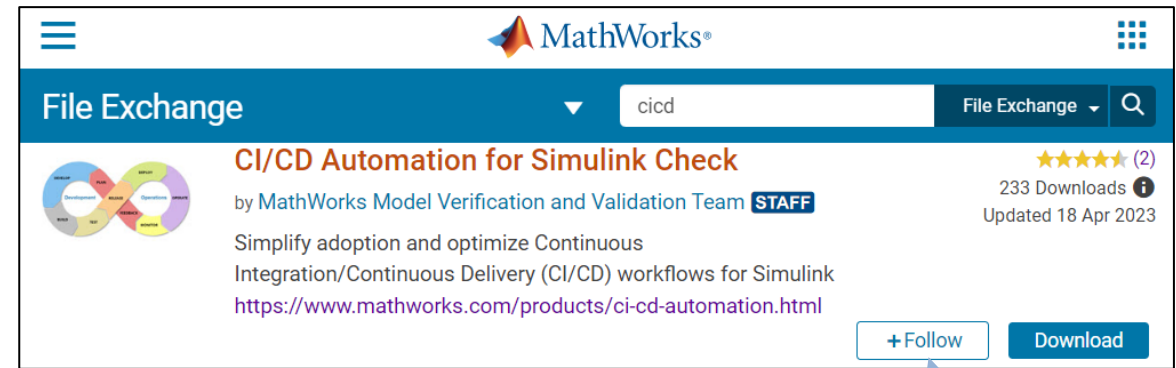
- Enable MBD users to model pipeline inside MATLAB
- Create single integration point for DevOps engineers
- Empower MBD users to maintain and debug pipeline

# Get the CI/CD Automation for Simulink Check Support Package

## From MATLAB with Add-On Manager



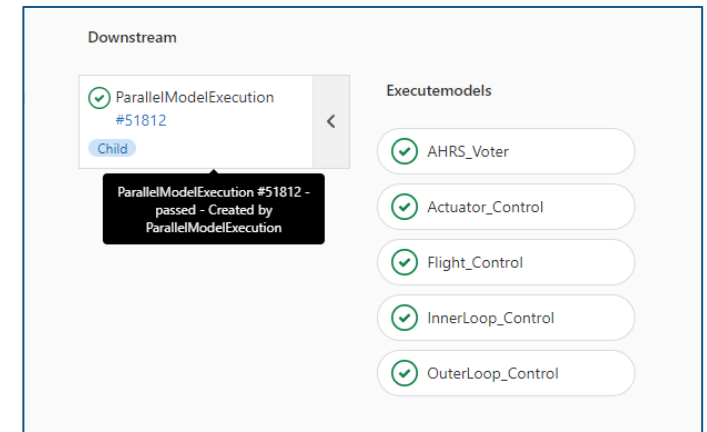
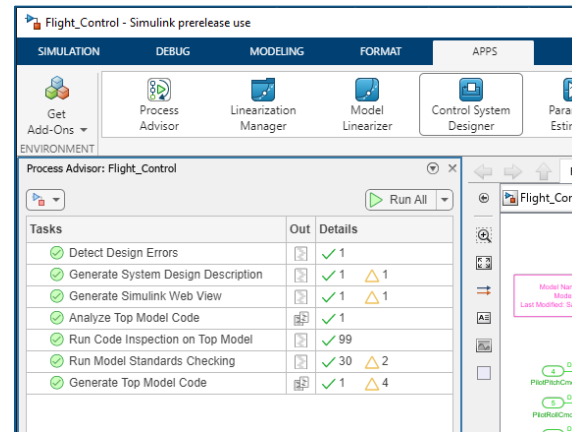
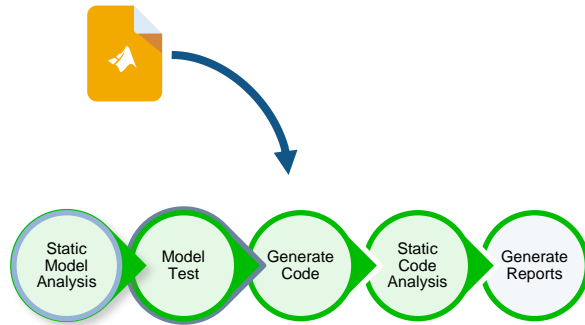
## Download from [File Exchange](#)



Follow to get notified of updates

Supports MATLAB R2022a and later

# Support Package : CI/CD Automation for Simulink Check



## 1) Simple Setup

- ✓ Prebuilt MBD pipeline
- ✓ Built-in MBD tool support
- ✓ Tailorable

## 2) Desktop Integration with Process Advisor app

- ✓ Local testing
- ✓ Local debugging
- ✓ Local execution

## 3) 3<sup>rd</sup> Party CI Integration

- ✓ e.g. GitLab/GitHub
- ✓ Auto-generate config files

# Prebuilt & Tailorable MBD Pipeline

## Built-in Library of Tasks

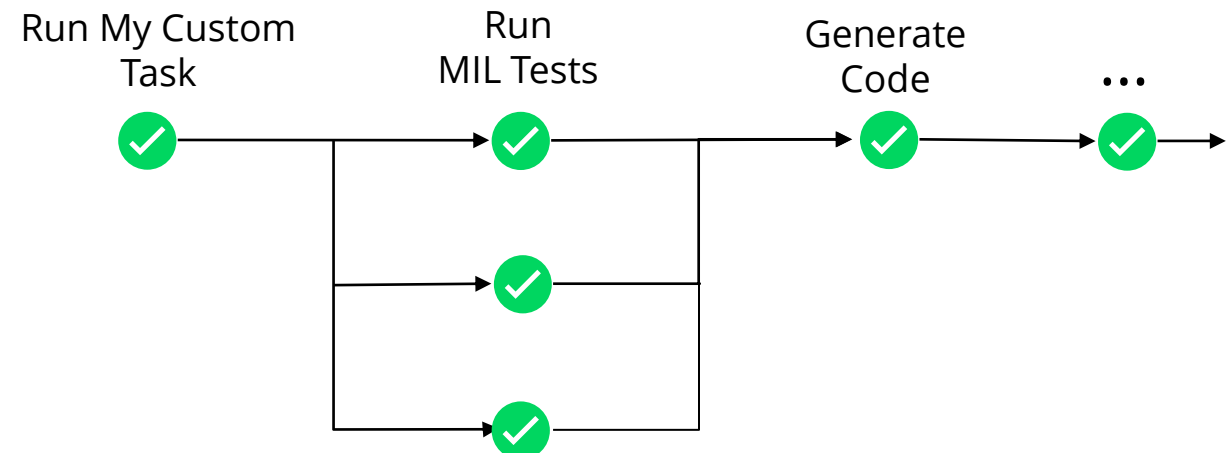
- Static Analysis
- Code Generation
- Testing

## Zero Upfront Code

## Fully Tailorable

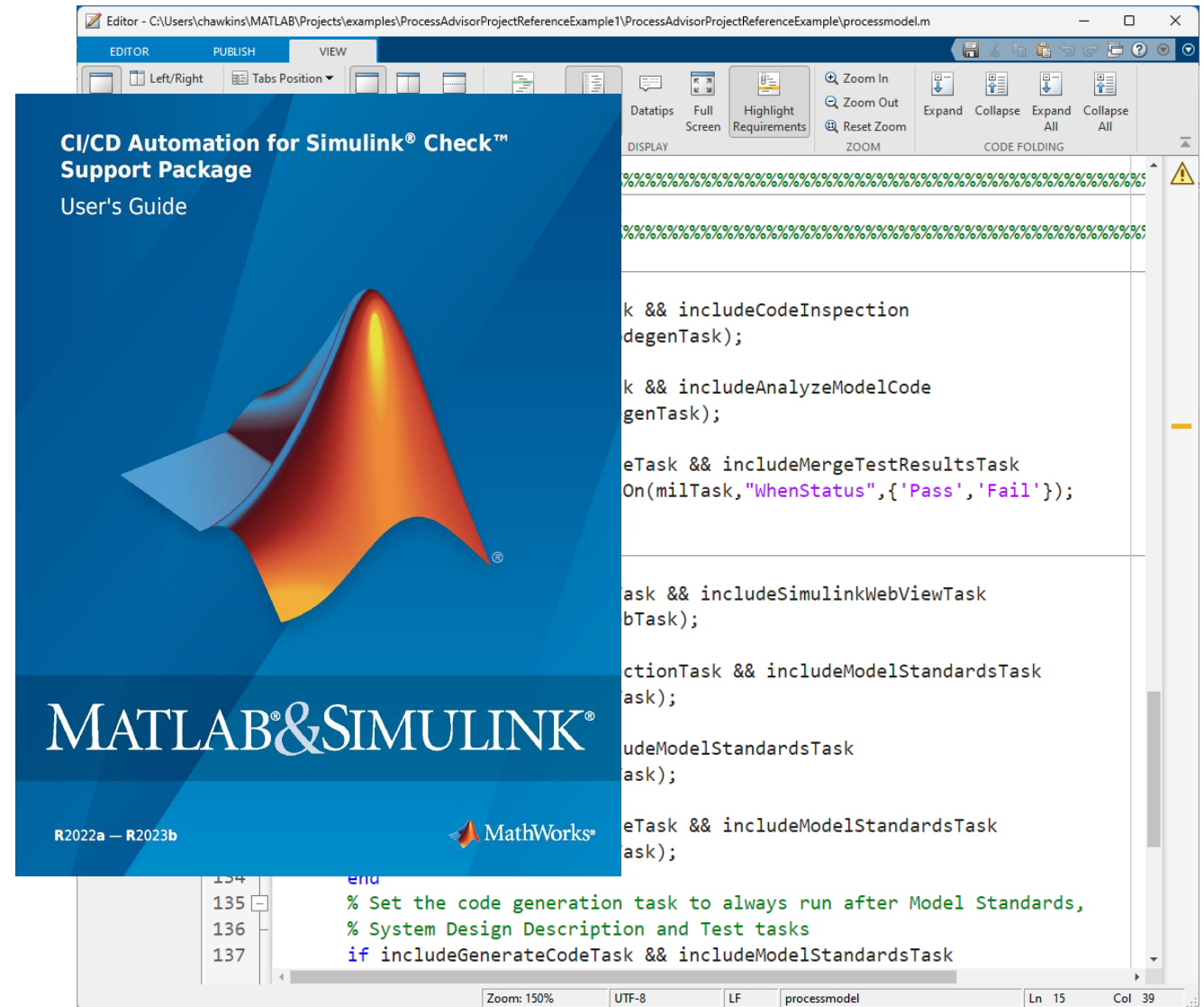
- Create custom tasks
- Modify existing steps
- Add and remove steps

TASKS	TOOLS
Check Model Standards Compliance	Simulink Check
Run Tests	Simulink Test
Generate Source Code	Embedded Coder
Check Code Standards Compliance	Polyspace Bug Finder
Generate Software Design Description	Simulink Report Generator
Design Error Detection	Simulink Design Verifier
Verify Model Update & Simulation	Simulink
Check Model Metrics	Model Advisor



# Pipeline Definition – The Process Model

- MATLAB code file
- Automatically generated
- Register tasks
- Set task dependencies
- Set task run order
  
- Full documentation



The screenshot displays the MATLAB Editor interface. A large blue overlay on the left side of the editor window features the Simulink logo and the text: "CI/CD Automation for Simulink® Check™ Support Package User's Guide" and "MATLAB® & SIMULINK® R2022a — R2023b MathWorks®". The editor window title is "Editor - C:\Users\chawkins\MATLAB\Projects\examples\ProcessAdvisorProjectReferenceExample1\ProcessAdvisorProjectReferenceExample\processmodel.m". The editor shows a MATLAB script with the following code:

```
task && includeCodeInspection
(degenTask);

task && includeAnalyzeModelCode
(degenTask);

eTask && includeMergeTestResultsTask
On(milTask,"WhenStatus",{ 'Pass', 'Fail' });

task && includeSimulinkWebViewTask
(bTask);

actionTask && includeModelStandardsTask
(task);

includeModelStandardsTask
(task);

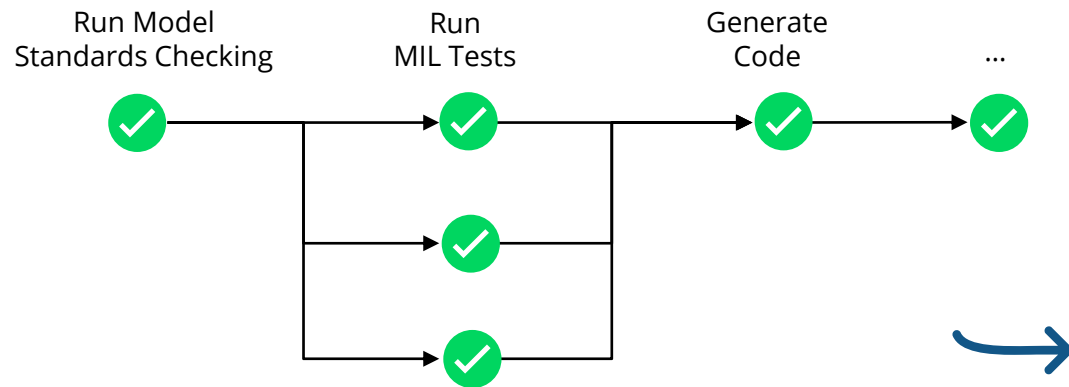
eTask && includeModelStandardsTask
(task);

end
% Set the code generation task to always run after Model Standards,
% System Design Description and Test tasks
if includeGenerateCodeTask && includeModelStandardsTask
```

The status bar at the bottom indicates "Zoom: 150%", "UTF-8", "LF", "processmodel", "Ln 15", and "Col 39".

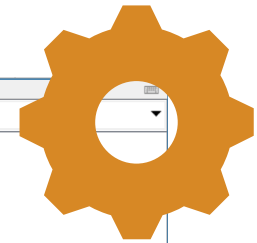


# Pipeline Testing & Pre-qualification - Process Advisor



Process Model

Tasks	Out	Results
<ul style="list-style-type: none"> <li>Run Code Generator               <ul style="list-style-type: none"> <li>db_ControlMode</li> <li>db_Controller</li> <li>db_DriverSwRequest</li> <li>db_TargetSpeedThrottle</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>20</li> <li>10</li> <li>2</li> <li>3</li> <li>5</li> </ul>	<ul style="list-style-type: none"> <li>2</li> <li>1</li> <li></li> <li>1</li> <li>1</li> </ul>
<ul style="list-style-type: none"> <li>Run Model Standards Checking               <ul style="list-style-type: none"> <li>db_ControlMode</li> <li>db_Controller</li> <li>db_DriverSwRequest</li> <li>db_TargetSpeedThrottle</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>60</li> <li>15</li> <li>15</li> <li>15</li> <li>15</li> </ul>	<ul style="list-style-type: none"> <li>1</li> <li></li> <li></li> <li></li> <li>1</li> </ul>
Run Design Error Detection	93	7

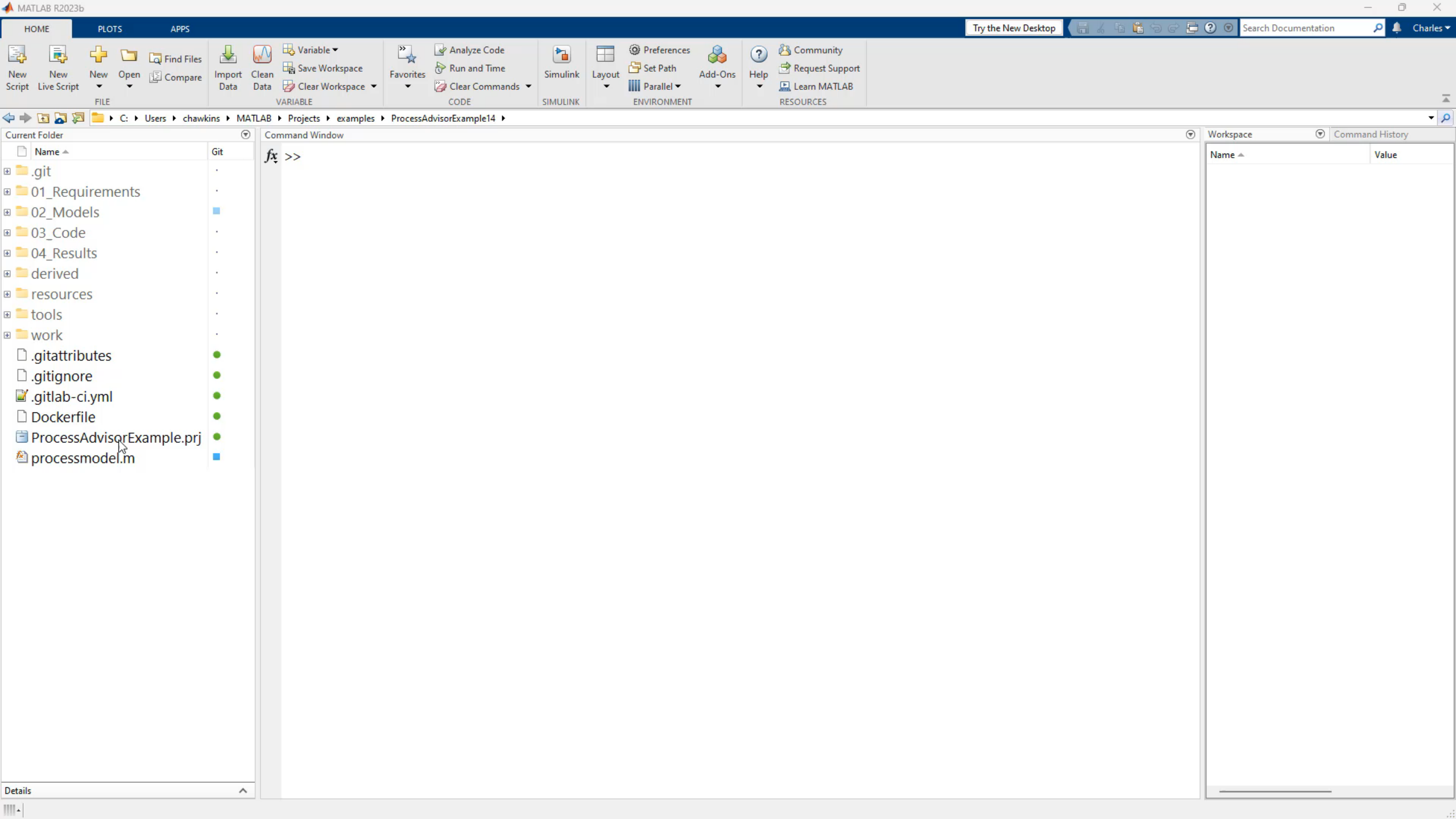


MBD Build Tool

Process Advisor



Local Desktop Workflow



# Pipeline Configuration Generation Simplified

## 1) Configure your options

```
>> opt = padv.pipeline.GitLabOptions
opt =
  GitLabOptions with properties:
    Tags: ""
    EnableArtifactCollection: 1
    ArtifactZipFileName: "padv_artifacts.zip"
    ArtifactsExpireIn: "30 days"
    ArtifactsWhen: "always"
    GeneratedYMLFileName: "simulink_pipeline"
    PipelineArchitecture: SingleStage
    ForceRunAllTasks: 0
    ExitInBatchMode: 1
    RerunFailedTasks: 0
    RerunErroredTasks: 0
    MatlabLaunchCmd: "matlab"
    MatlabStartupOptions: "-nodesktop -logfile output.log"
    AddBatchStartupOption: 1
    GeneratedPipelineDirectory: "derived\pipeline"
    GenerateUnitRorProcess: 1
```

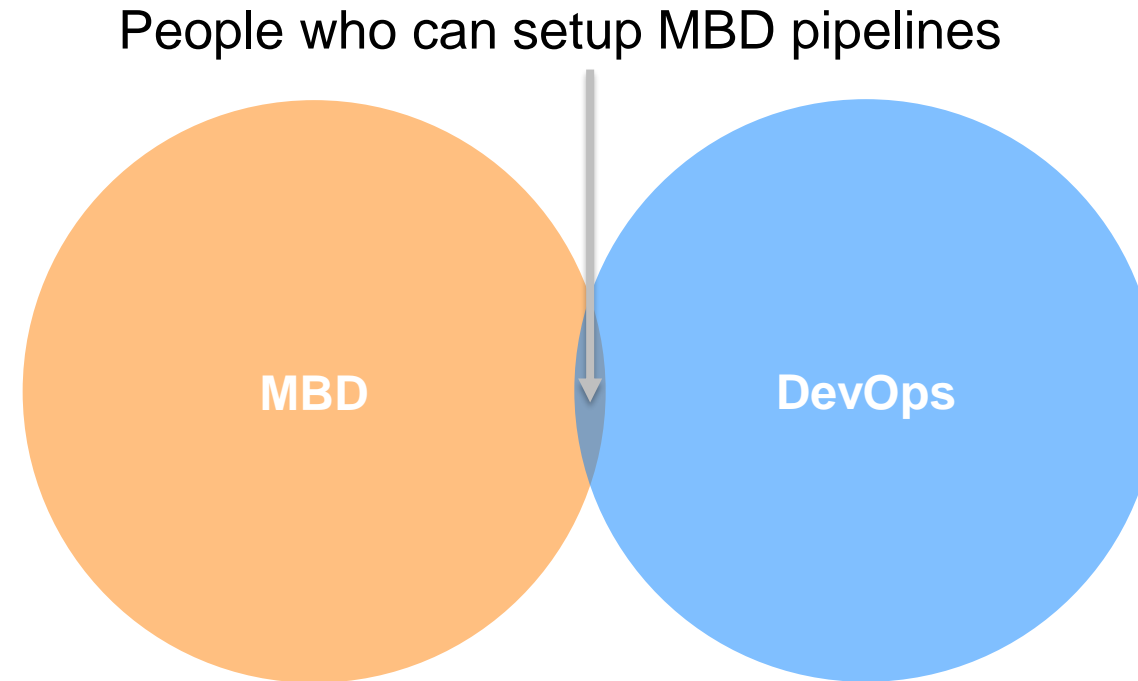
## 2) Generate your pipeline

```
>> padv.pipeline.generatePipeline(opt)
#####
## Getting details about the current project
## Resolving pipeline architecture 'SingleStage'
## Generating internal pipeline
## Generating 'GitLab' pipeline
### Creating pipeline: 'simulink_pipeline.yml'
### Adding 'stages' information
### Adding 'jobs':
### Adding job: 'Runprocess'
### Adding job to collect artifacts
## Writing pipeline content into 'simulink_pipeline.yml'
#####
```

## 3) Integrate the output

```
41 SimulinkPipelineExecution:
42
43   stage: SimulinkPipelineExecution
44
45   trigger:
46
47     include:
48       artifact: derived/pipeline/simulink_pipeline.yml
49
50
51     job: SimulinkPipelineGeneration
52
53   strategy: depend
54
55   # Do not change the name of this variable
56   variables:
57     PADV_ROOT_PIPELINE_ID: $CI_PIPELINE_ID
```

# Automatic Pipeline Generation



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

# Automatic Pipeline Generation



## People who can setup MBD Pipelines

- Enable
- Create
- **Empower**

```
11 stage: SimulinkPipelineGeneration
12
13 tags:
14   - padv_demo_ci
15
16 script:
17   # Open the project and generate the pipeline using
18   # appropriate options in project root
19   - >
20     matlab
21     -nodesktop
22     -logfile "$MATLAB_LOG_FILE"
23     -batch "
24     cp = openProject(pwd);
25     padv.pipeline.generatePipeline(
26     padv.pipeline.GitLabOptions(
27     PipelineArchitecture = padv.pipeline.Architecture.SerialStagesGroupPerTask,
28     GeneratedYMLFileName = 'simulink_pipeline.yml',
29     GeneratedPipelineDirectory = fullfile('derived','pipeline'));
30     "
```

- ProcessAdvisorProject23b
- Project information
- Repository
- Files
- Commits
- Branches
- Tags
- Contributor statistics
- Graph
- Compare revisions
- Issues 0
- Merge requests 0
- CI/CD
- Security and Compliance
- Deployments
- « Collapse sidebar

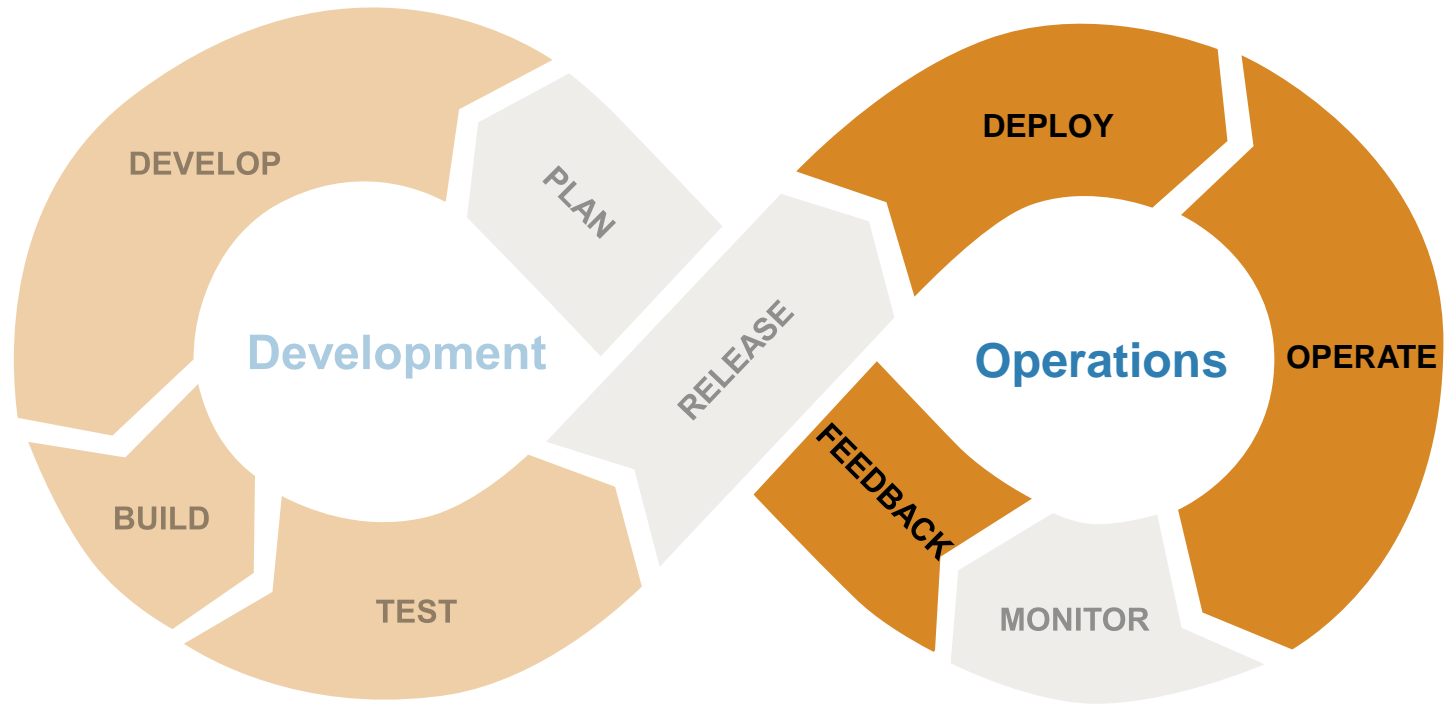
Charles Hawkins > ProcessAdvisorProject23b > Repository

 **Update GitLab options** ✔ b3e278f7   
Charles Hawkins authored 2 hours ago

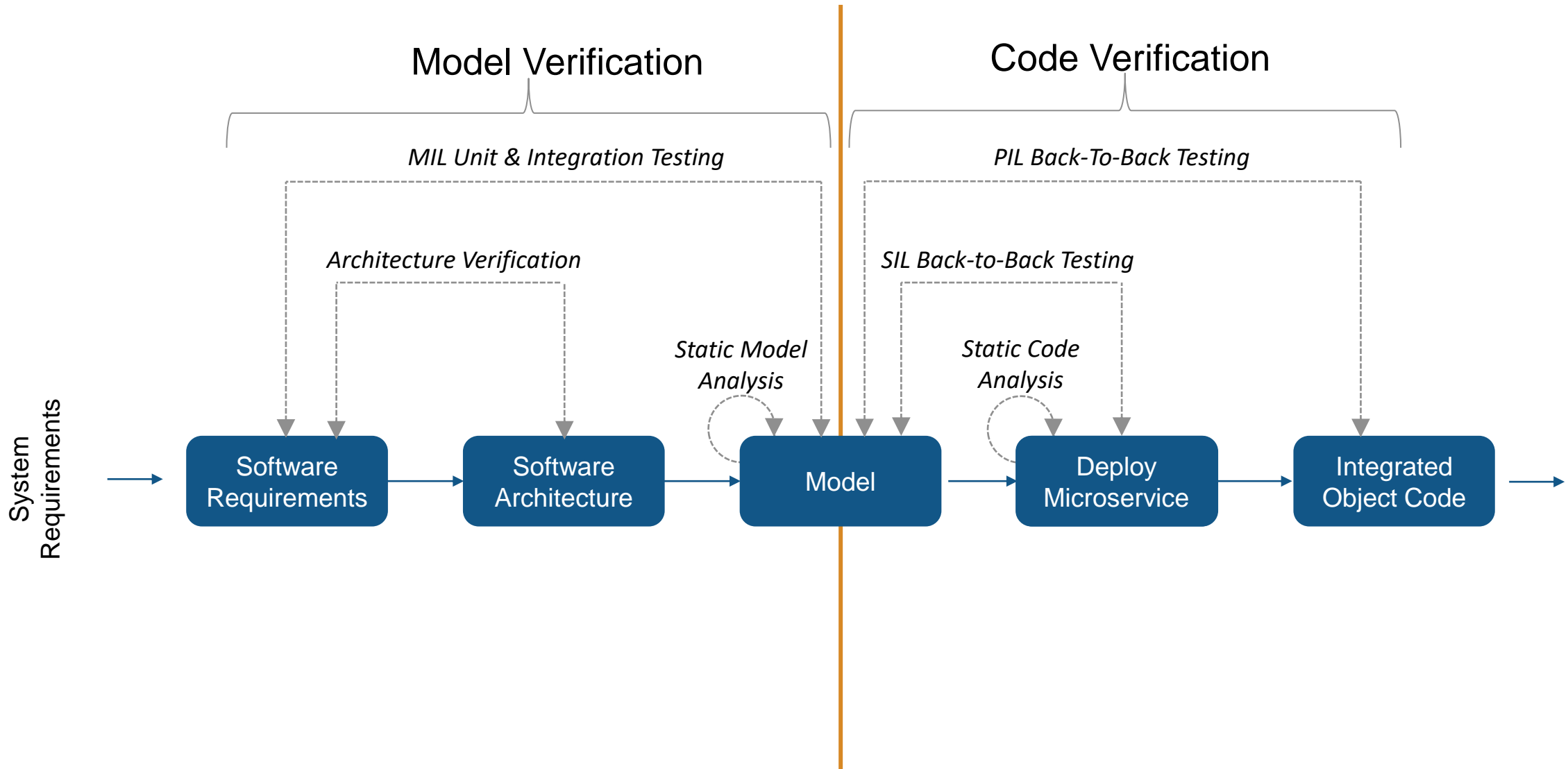
master processadvisorproject23b / + History Find file Web IDE  Clone 

Name	Last commit	Last update
01_Requirements		
02_Models		
03_Code		
04_Results		
resources/project		
tools		
work/cache		
.gitattributes		

# DevOps Lifecycle

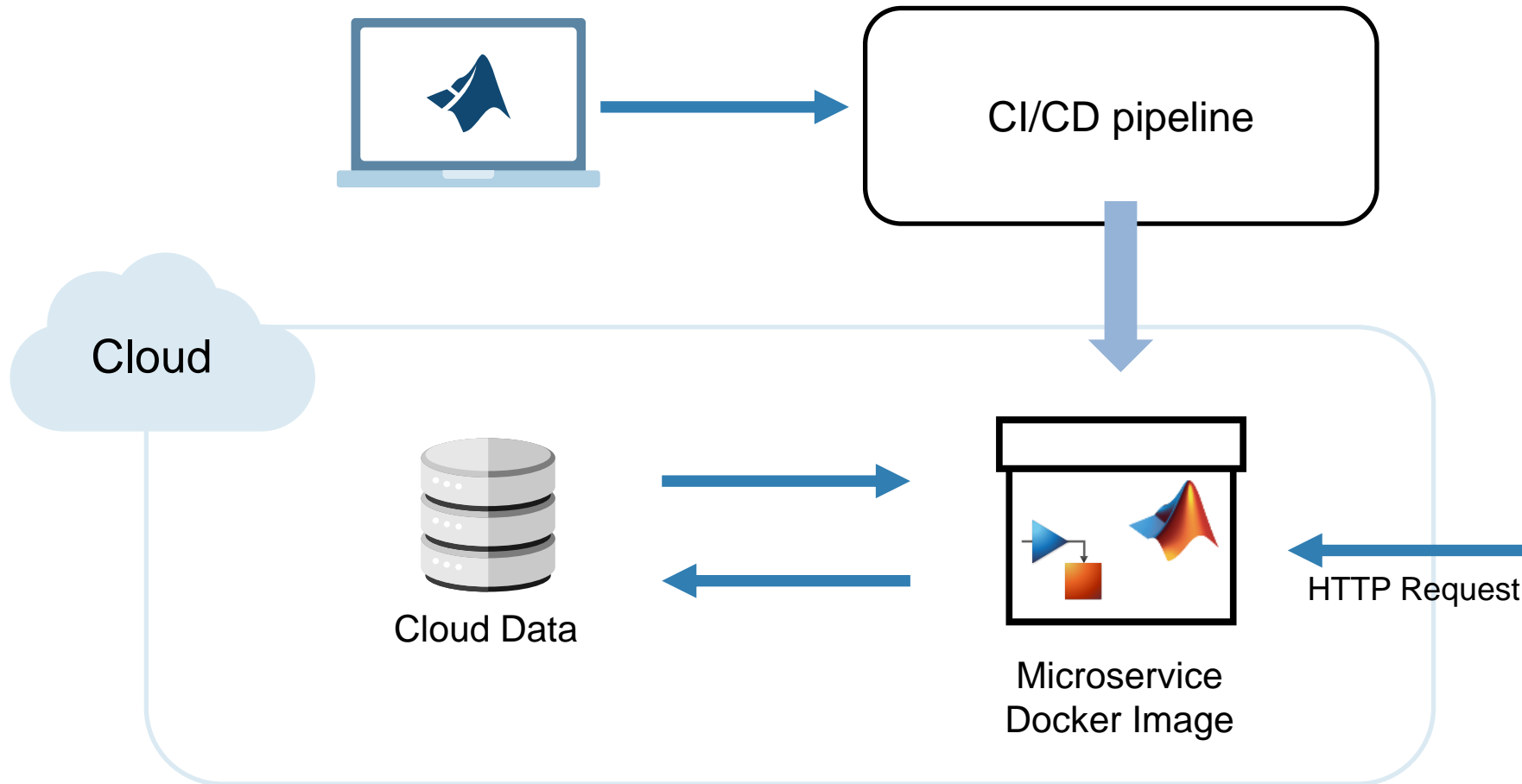
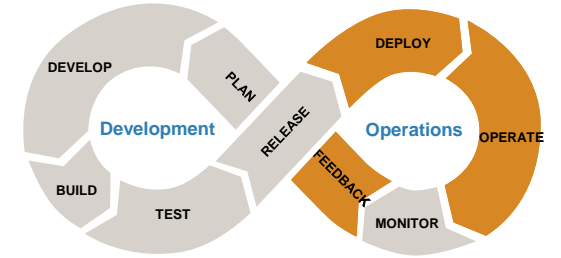


# Model-Based Design Reference Workflow

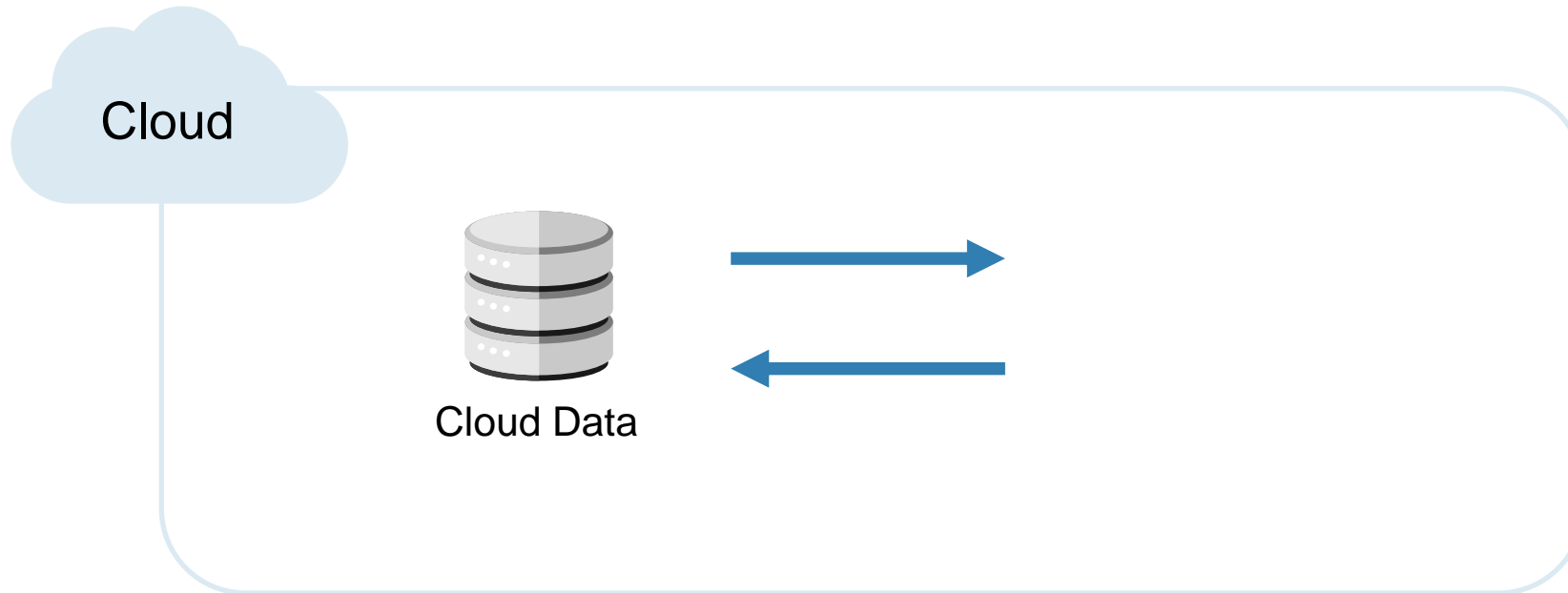
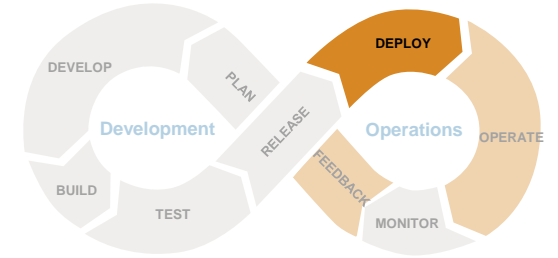




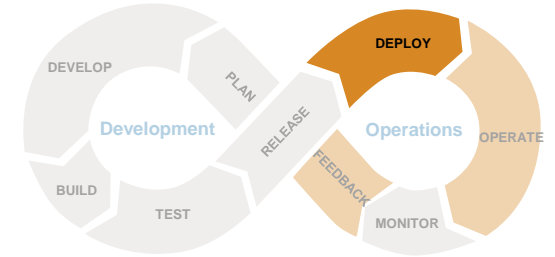
# Workflow



# Workflow



# Deploy – Read/Write Cloud Data from MATLAB



## Local Data

```
fileName = "path/to/file.mat";  
load(filename, "var");  
save("path/to/newfile.mat", "var", "-v7.3")
```

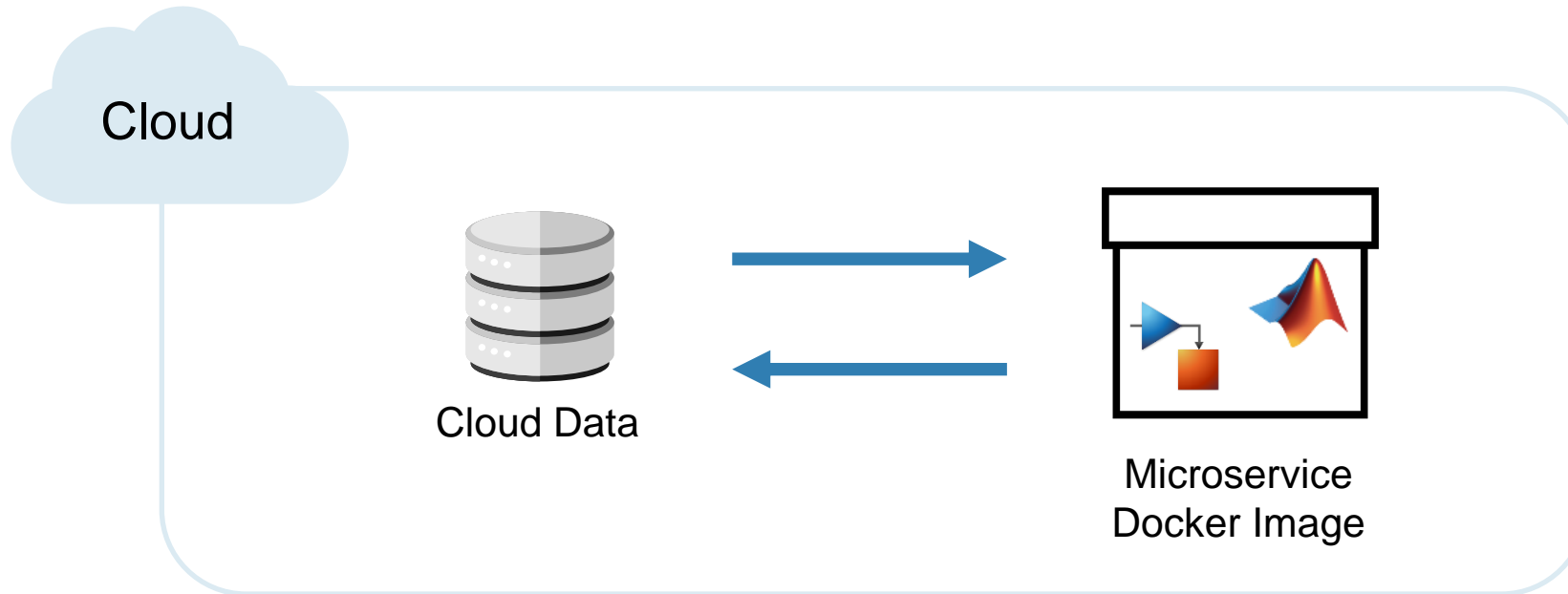
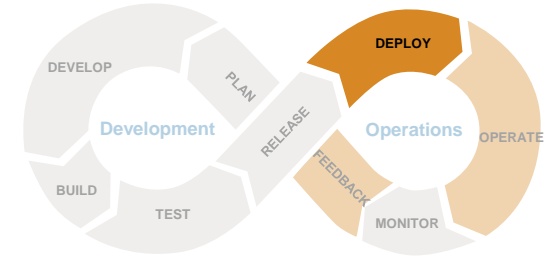


## Remote Data

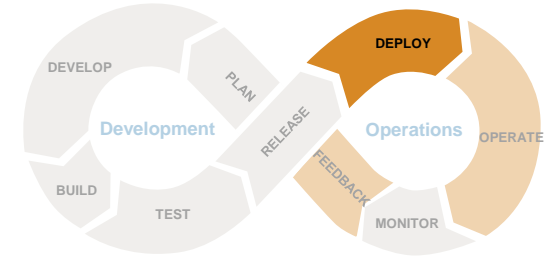
```
loadenv("secrets.env")
```

```
fileName = "wasbs://container@account/path/to/file.mat";  
load(filename, "var");  
save("wasbs://container@account/path/to/newfile.mat", "var", "-v7.3")
```

# Workflow



# Deploy – Microservice Docker Image



```
function playSimulation(inputFile, outDir)
```

```
% Load input file
```

```
load(inputFile, 'AHRs1', 'AHRs2', 'AHRs3');
```

Read Data

```
% Define the input data
```

```
inputData = Simulink.SimulationData.Dataset;  
inputData = addElement(inputData, AHRs1, 'AHRs1');  
inputData = addElement(inputData, AHRs2, 'AHRs2');  
inputData = addElement(inputData, AHRs3, 'AHRs3');
```

Define Input

```
% Set input data as external data
```

```
in = Simulink.SimulationInput('AHRs_Voter');  
in = setExternalInput(in, inputData);  
% Configure for deployed simulation  
in = simulink.compiler.configureForDeployment(in);
```

Prepare Simulation

```
% Run the simulation
```

```
simOut = sim(in);
```

Simulate

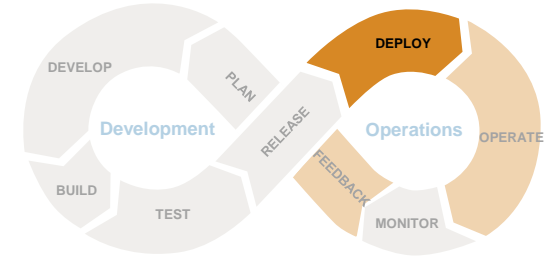
```
% Write results in the output folder
```

```
out = simOut.yout{1}.Values;  
save(outDir+"output.mat", "out", '-v7.3')
```

Save Data

```
end
```

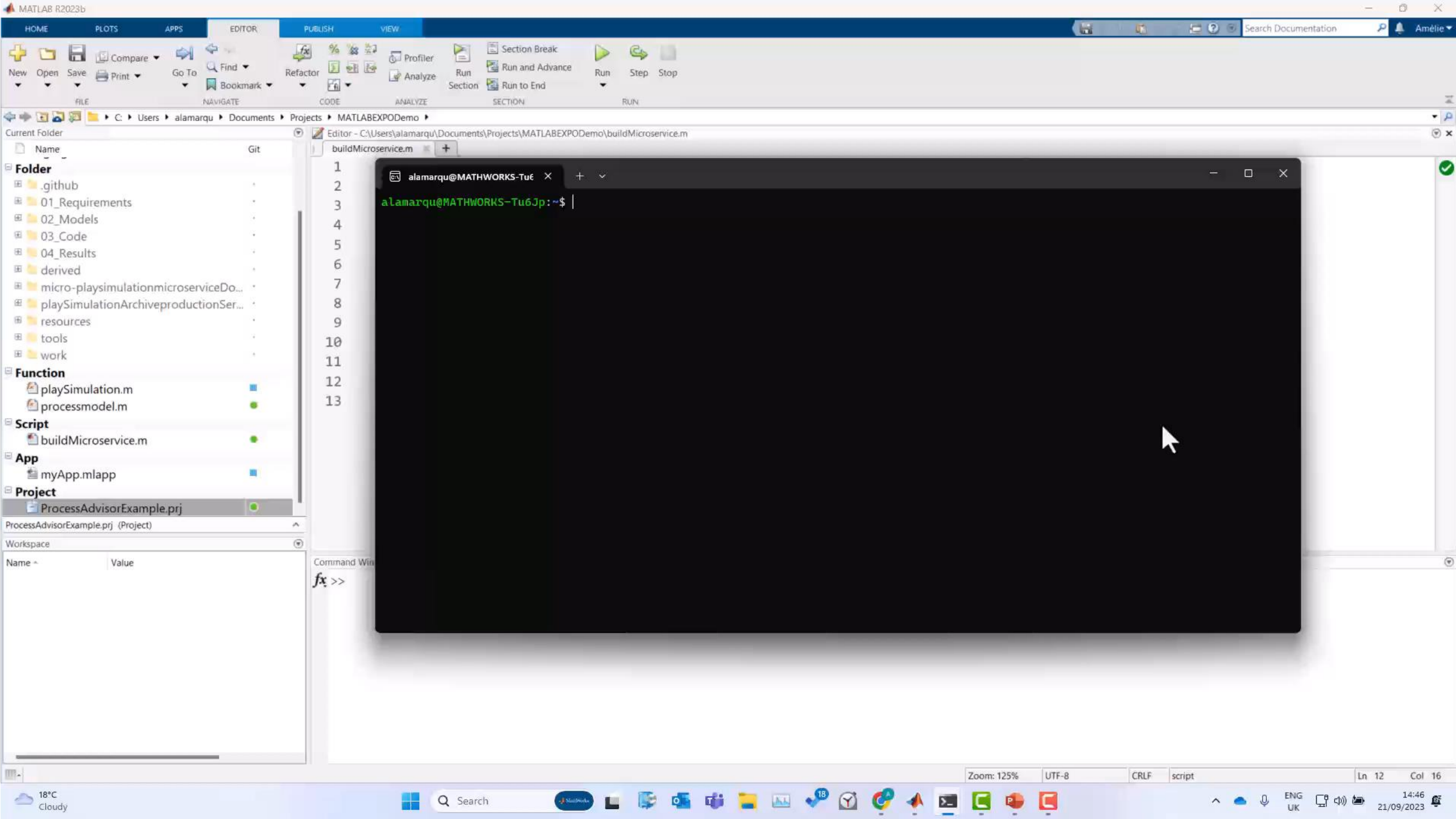
# Deploy – Create a Microservice in MATLAB



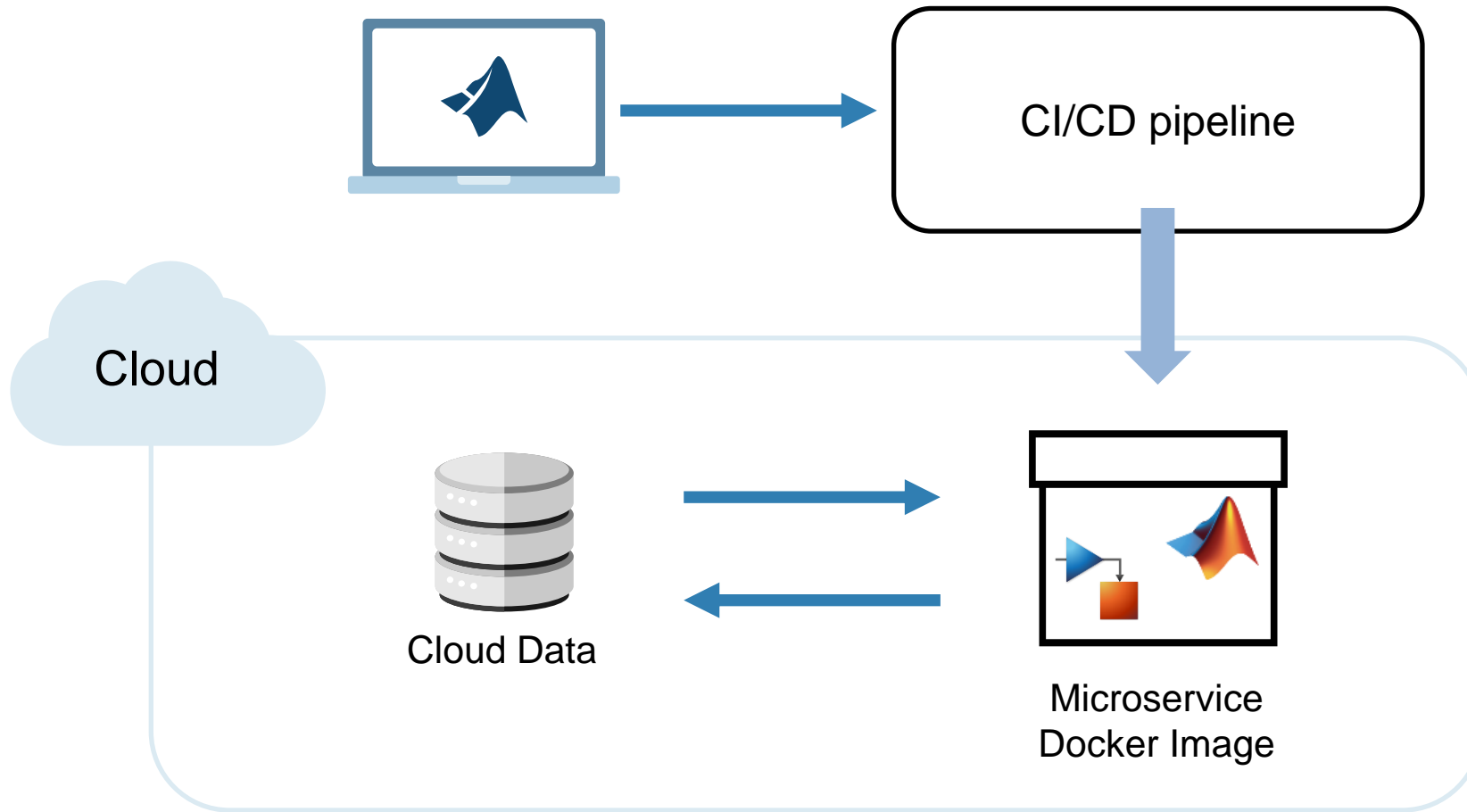
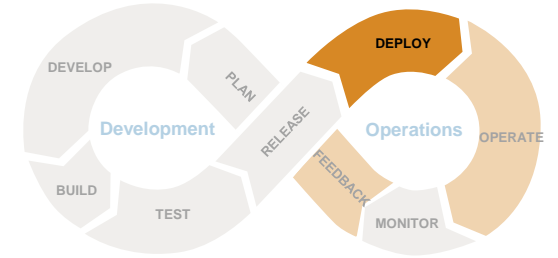
- Requirements:
  - Docker
  - MATLAB Compiler
  - MATLAB Compiler SDK
  - Simulink Compiler

- Code:

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

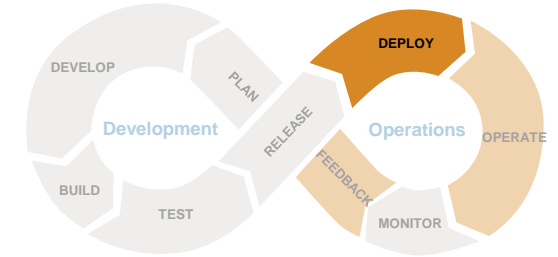


# Workflow





# Deploy – Integration with the DevOps Pipeline



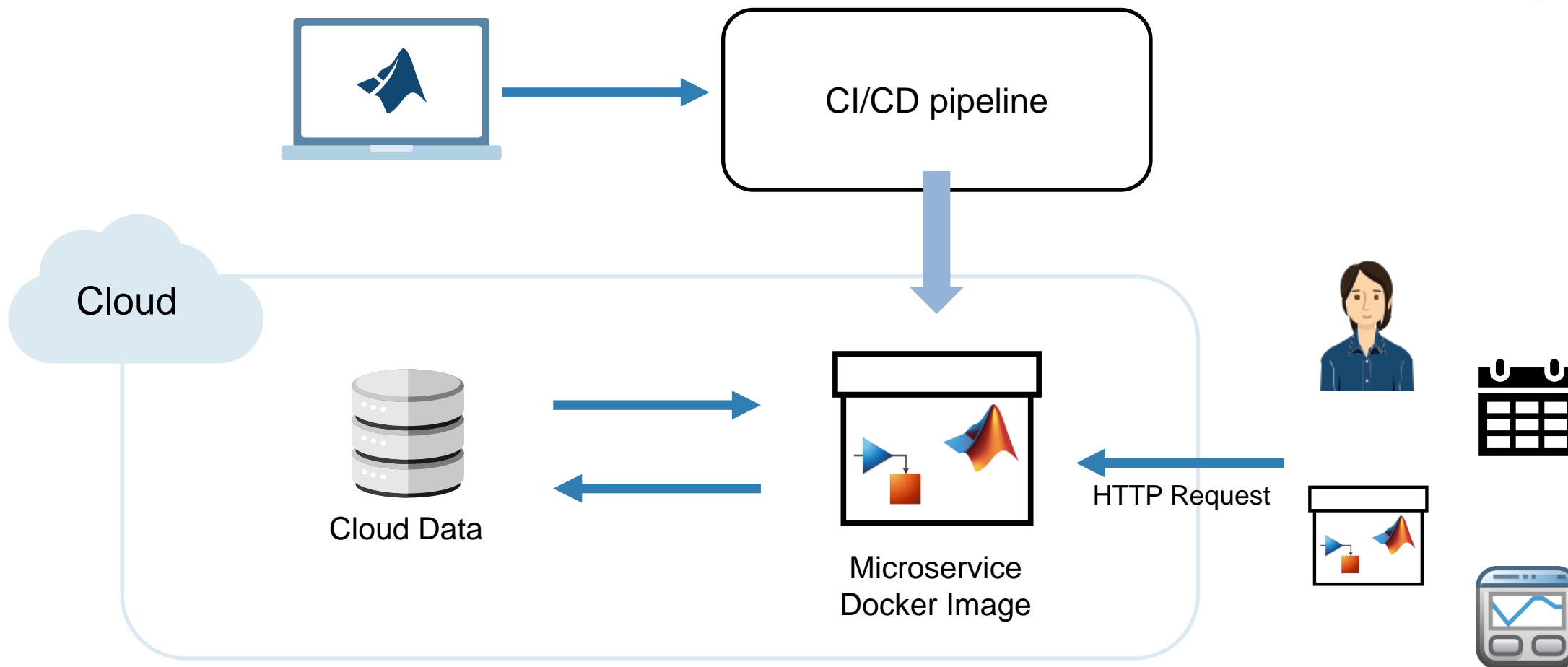
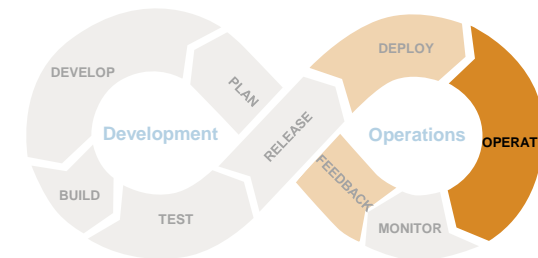
- How to use it in pipeline

**build-and-deploy**  
succeeded 18 hours ago in 25m 51s

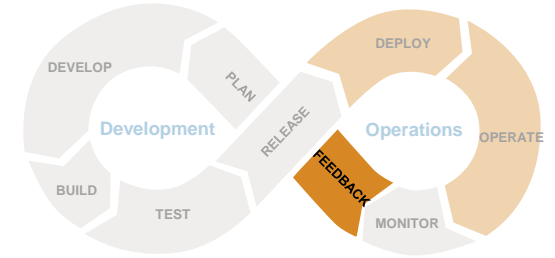
Search logs

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

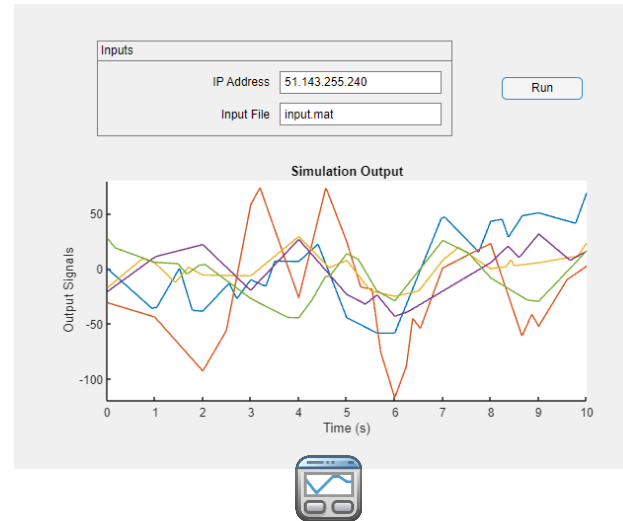
# Operate – Sending Requests



# Feedback – Visualise Data

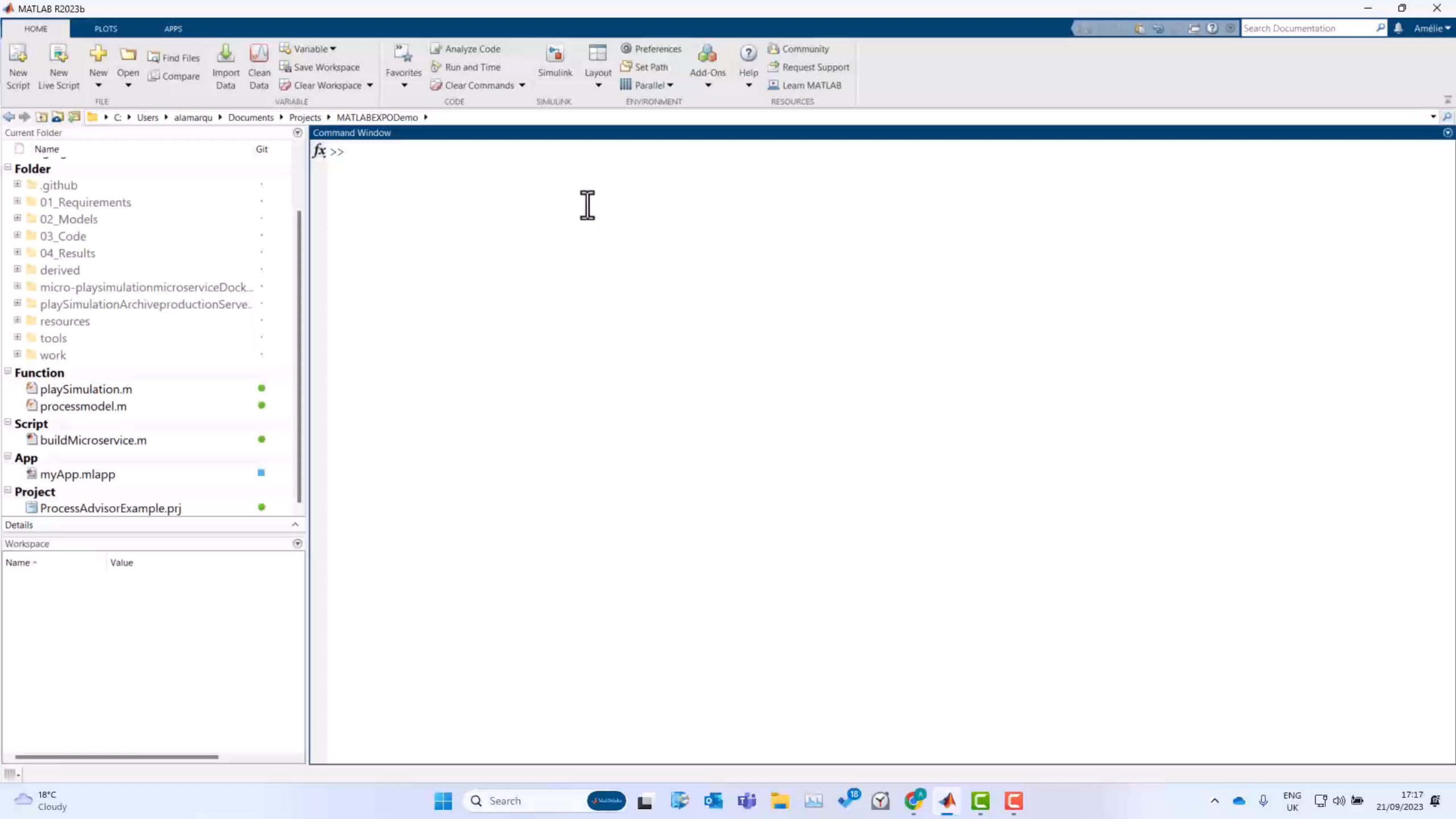


- Application e.g. using microservices



- Dashboards





HOME PLOTS APPS

New Script New Live Script New Open Compare Import Data Clean Data Variable Save Workspace Clear Workspace Favorites Run and Time Clear Commands Simulink Layout Set Path Parallel Add-Ons Help Community Request Support Learn MATLAB

FILE VARIABLE CODE SIMULINK ENVIRONMENT RESOURCES

C:\Users\alamarqu\Documents\Projects\MATLABEXPODemo

Current Folder

Name	Git
Folder	
.github	.
01_Requirements	.
02_Models	.
03_Code	.
04_Results	.
derived	.
micro-playsimulationmicroserviceDock...	.
playSimulationArchiveproductionServe...	.
resources	.
tools	.
work	.
Function	
playSimulation.m	●
processmodel.m	●
Script	
buildMicroservice.m	●
App	
myApp.mlapp	■
Project	
ProcessAdvisorExample.prj	●

Command Window

```
fx >>
```

I

Details

Workspace

Name	Value

# The Cloud and MathWorks Products



MathWorks Cloud



Private Cloud



Public Clouds



Microsoft Azure



**MATLAB Online**  
**Simulink Online**  
**MATLAB Drive**

**Reference Architectures**

**Cloud Data Services**

**Cloud Center**

**MathWorks Server Products**

**Microservices**

# What Will You Learn Today?

- We are making it easier for you to:
  - Implement MBD workflows in CI systems
    - Go try the CI/CD Support Package for Simulink Check
  - Access cloud data directly from MATLAB
    - It's just like accessing files on your PC
  - Create a microservice with MATLAB Compiler SDK
    - Two MATLAB commands is all it takes

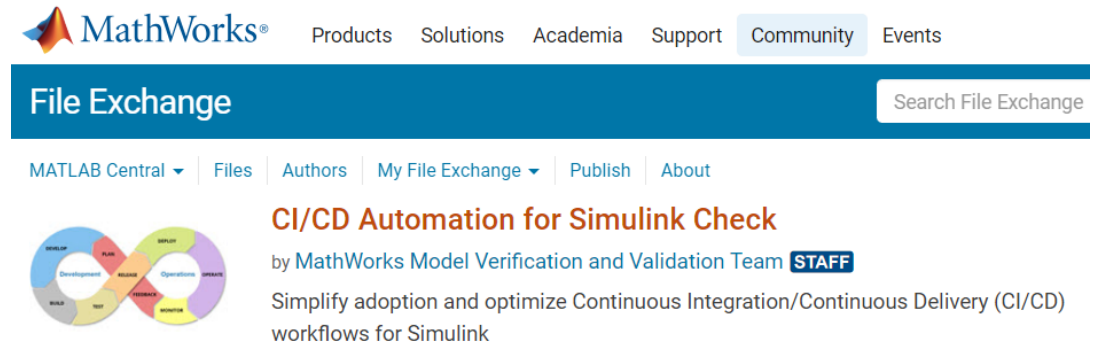
# Additional Resources

## ■ Email

- [continuous-integration@mathworks.com](mailto:continuous-integration@mathworks.com)
- [cloud@mathworks.com](mailto:cloud@mathworks.com)

## ■ Web


- [File Exchange](#)
- <https://mathworks.com/cloud>
- [https://www.mathworks.com/help/compiler\\_sdk/microservice.html](https://www.mathworks.com/help/compiler_sdk/microservice.html)

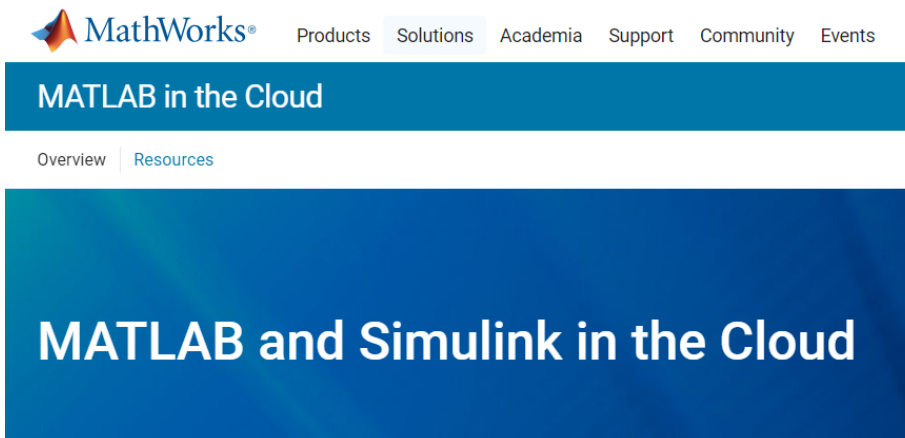


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File Exchange

MATLAB Central ▾ Files Authors My File Exchange ▾ Publish About

 **CI/CD Automation for Simulink Check**  
by MathWorks Model Verification and Validation Team **STAFF**  
Simplify adoption and optimize Continuous Integration/Continuous Delivery (CI/CD) workflows for Simulink



MathWorks® Products Solutions Academia Support Community Events

MATLAB in the Cloud

Overview Resources

**MATLAB and Simulink in the Cloud**

# Thank you



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