MathWorks
AUTOMOTIVE CONFERENCE 2023
North America

MATLAB and Simulink in Continuous Integration

MathWorks

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MATLAB and Simulink in Continuous Integration

Need

Innovation, speed, repeatability, and compliance

Solution

- Innovate with Model-Based Design
- Run Model-Based Design in CI, for speed and repeatability

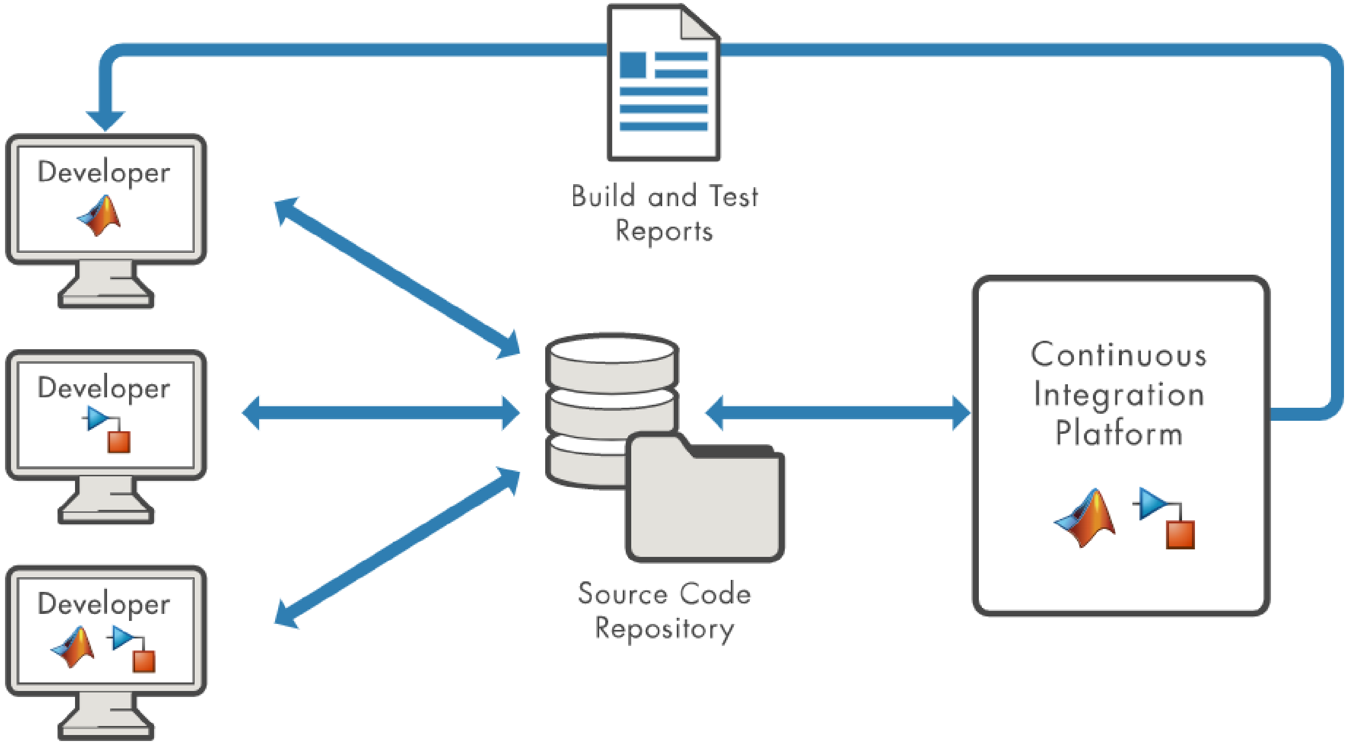
Key Takeaways

1. Iterate locally to innovate and prequalify before submitting to CI pipeline
2. Extend Model-Based Design Workflows into CI Platforms
3. Simplify adoption by using the CI Automation Support Package

CI enables team collaboration

Case Study Team

- **Team leader**, Source Control, & Integration
- **Controls Engineer** for Prevent Enable
- **Controls Engineer** for Disable
- **Test Engineer**

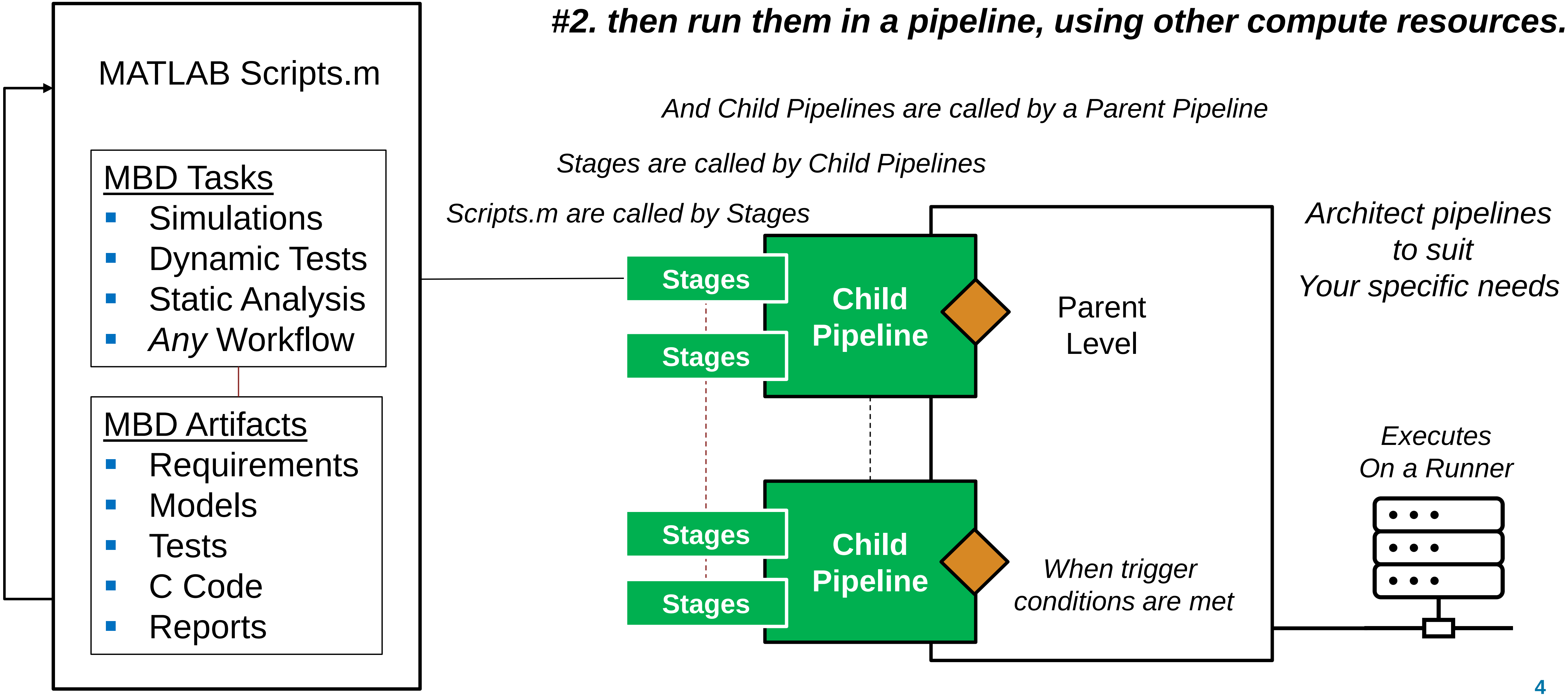


What does pipeline mean in the context of Model-Based Design?

Automation

#1. Exercise automation, Artifacts, and Scripts on your desktop,

#2. then run them in a pipeline, using other compute resources.



MATLAB Scripts.m

MBD Tasks
- Simulations
- Dynamic Tests
- Static Analysis
- *Any* Workflow

MBD Artifacts
- Requirements
- Models
- Tests
- C Code
- Reports

And Child Pipelines are called by a Parent Pipeline

Stages are called by Child Pipelines

Scripts.m are called by Stages

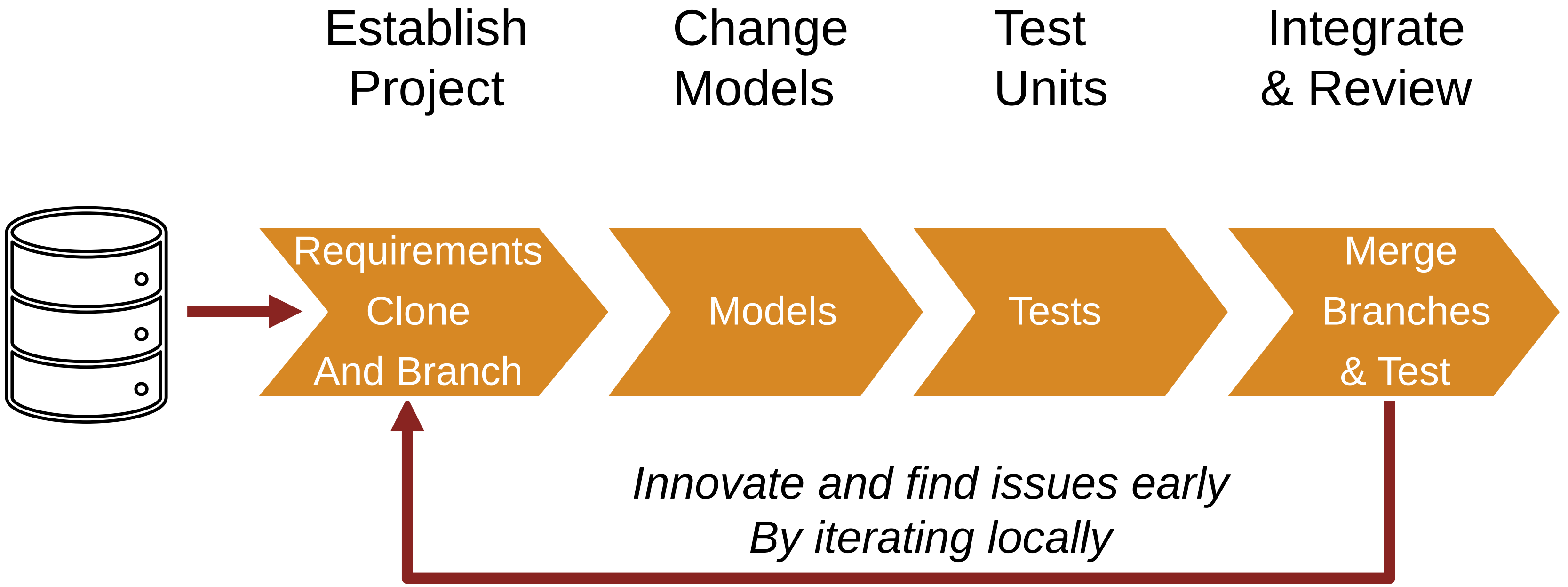
Architect pipelines to suit Your specific needs

Executes On a Runner

When trigger conditions are met

Takeaway #1: Iterate locally to innovate and prequalify

General Example



Establish Project

Change Models

Test Units

Integrate & Review

Requirements
Clone
And Branch

Models

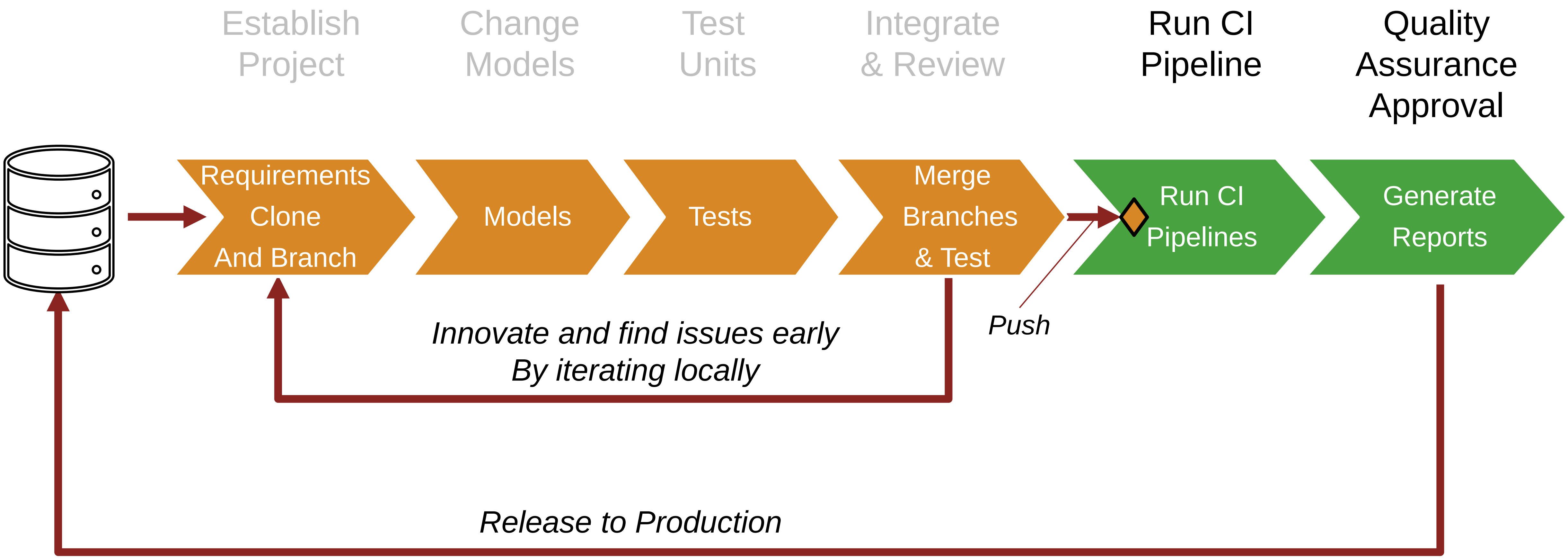
Tests

Merge
Branches
& Test

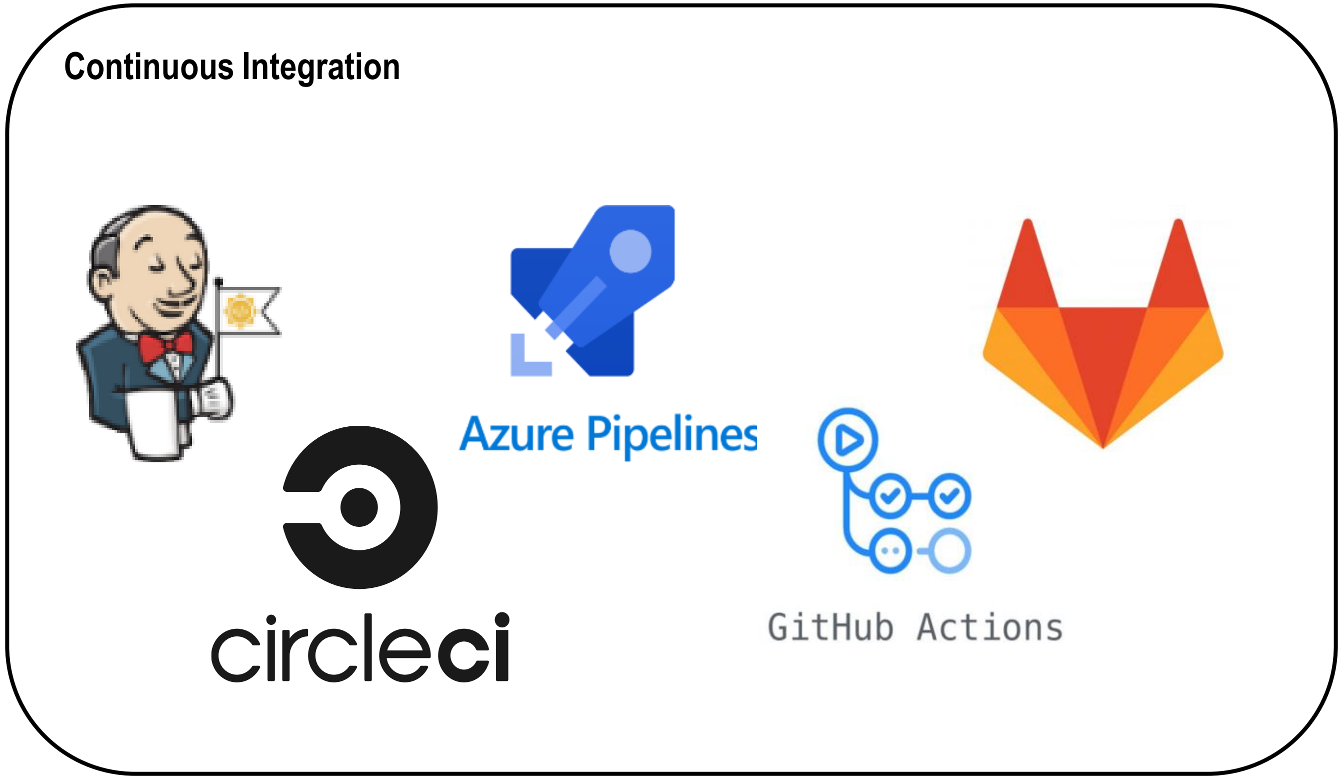
Innovate and find issues early
By iterating locally

Takeaway #2: Extend Model-Based Design Workflows into CI Platforms

General Example

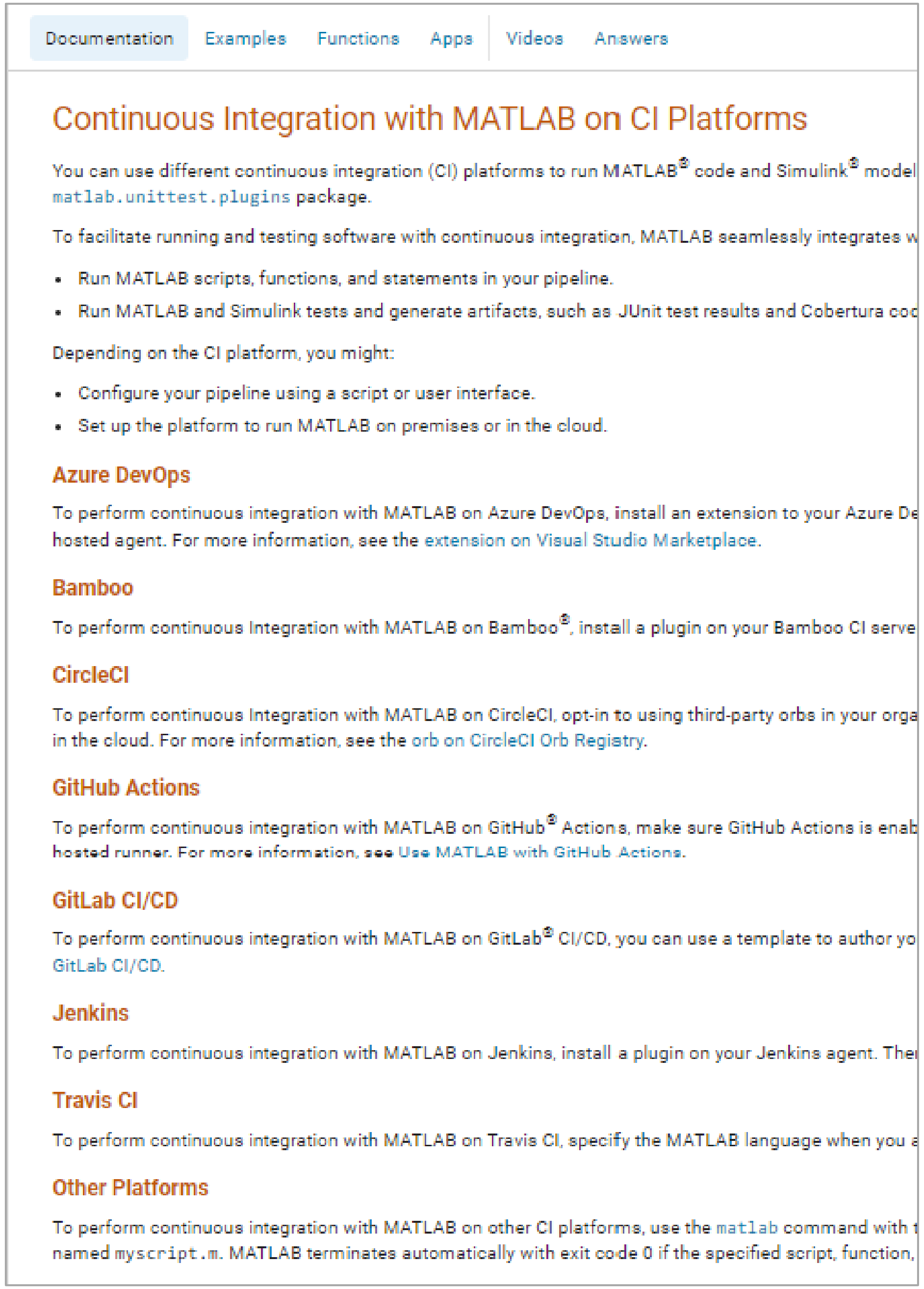


MathWorks Supports popular CI platforms



The case study

- Will clone from GitHub
- Execute a Model-Based Design workflow
- Then push to GitLab
- Other CI apps could be used



Continuous Integration with MATLAB on CI Platforms

You can use different continuous integration (CI) platforms to run MATLAB® code and Simulink® model
matlab.unittest.plugins package.

To facilitate running and testing software with continuous integration, MATLAB seamlessly integrates w

- Run MATLAB scripts, functions, and statements in your pipeline.
- Run MATLAB and Simulink tests and generate artifacts, such as JUnit test results and Cobertura coc

Depending on the CI platform, you might:

- Configure your pipeline using a script or user interface.
- Set up the platform to run MATLAB on premises or in the cloud.

Azure DevOps

To perform continuous integration with MATLAB on Azure DevOps, install an extension to your Azure De
hosted agent. For more information, see the extension on Visual Studio Marketplace.

Bamboo

To perform continuous Integration with MATLAB on Bamboo®, install a plugin on your Bamboo CI serve

CircleCI

To perform continuous Integration with MATLAB on CircleCI, opt-in to using third-party orbs in your orga
in the cloud. For more information, see the orb on CircleCI Orb Registry.

GitHub Actions

To perform continuous integration with MATLAB on GitHub® Actions, make sure GitHub Actions is enab
hosted runner. For more information, see Use MATLAB with GitHub Actions.

GitLab CI/CD

To perform continuous integration with MATLAB on GitLab® CI/CD, you can use a template to author yo
GitLab CI/CD.

Jenkins

To perform continuous integration with MATLAB on Jenkins, install a plugin on your Jenkins agent. The

Travis CI

To perform continuous integration with MATLAB on Travis CI, specify the MATLAB language when you a

Other Platforms

To perform continuous integration with MATLAB on other CI platforms, use the `matlab` command with t
named `myscript.m`. MATLAB terminates automatically with exit code 0 if the specified script, function,

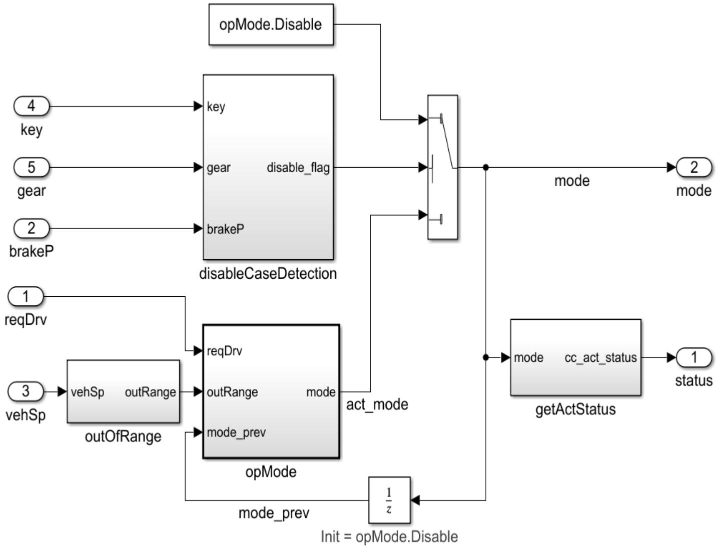
[Link to Supported CI platforms](#)

Case Study: Cruise Control System

A Cruise Control Product must meet a new Driver Awareness requirement:

If the "Driver Awareness" signal is false, then:

1. ***Cruise control function shall be disabled.***
2. ***Enable shall be prevented.***



Is the driver aware?

Modify logic and tests

Production

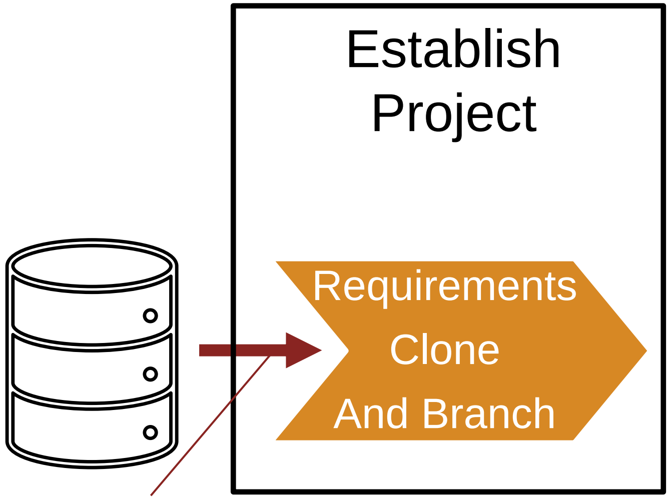
[Link: Case Study Model-Based Design and YAML files can be found here]()

Case Study: Plan

- A team is formed
- The new feature must be released within weeks
- Fortunately, the process had been automated → speed and quality
- The GitHub and GitLab repositories are already established
  - Original project will be cloned from GitHub
  - The production release will be to GitLab
  - MathWorks supports all popular CI platforms

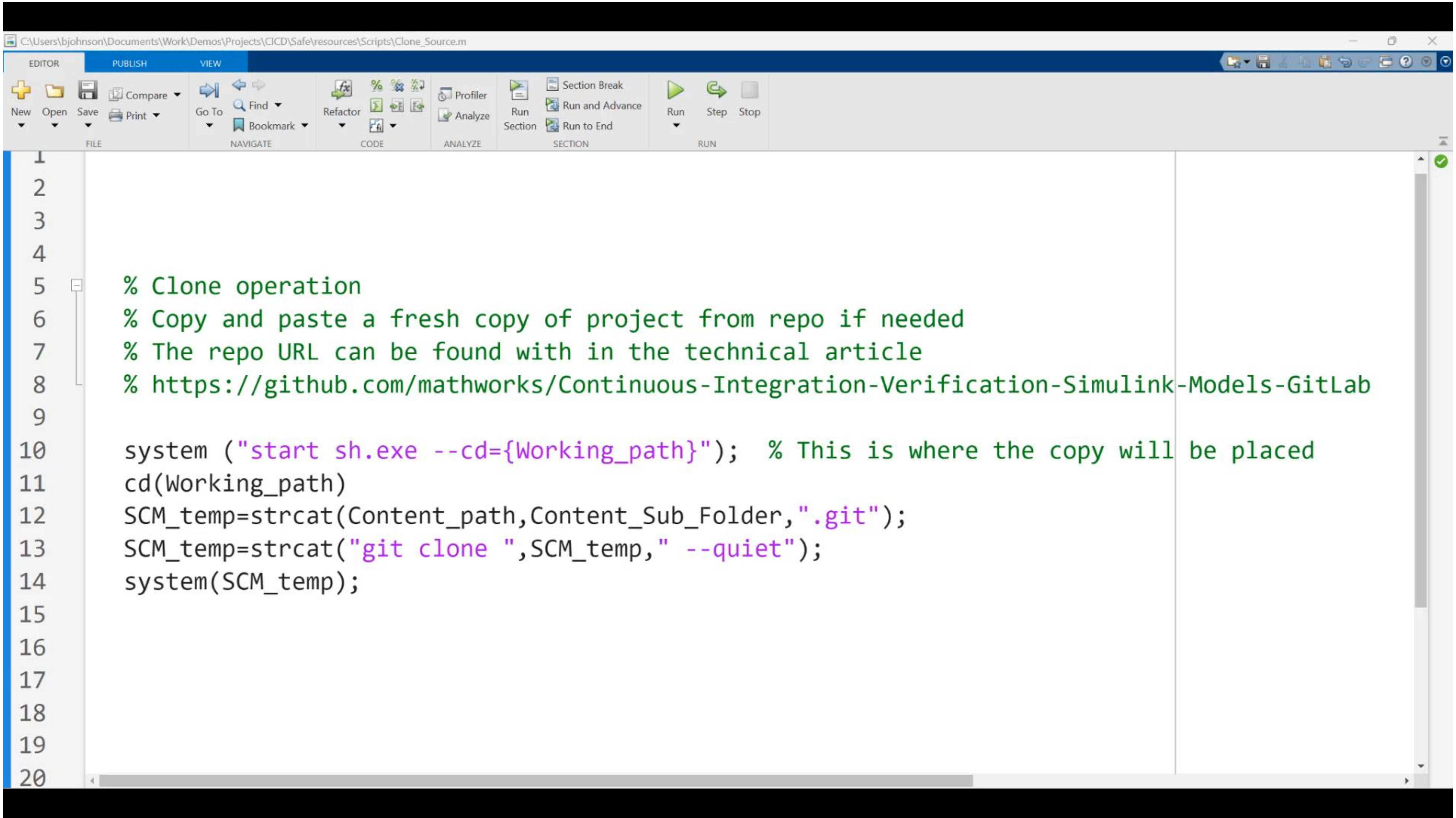
Takeaway #1: Iterate locally to innovate and prequalify

Cruise Control Case Study: Clone project and create branches



Clone from GitHub

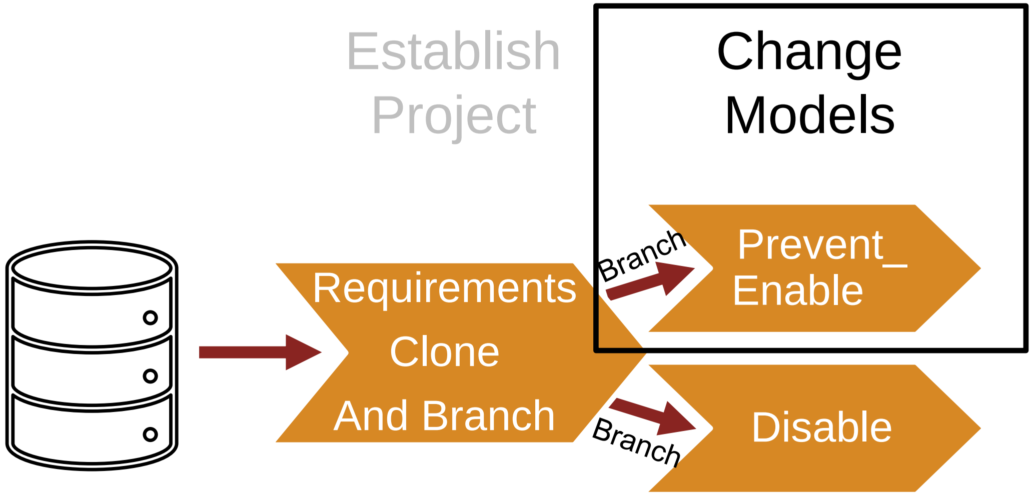
https://www.mathworks.com/help/matlab/source-control.html



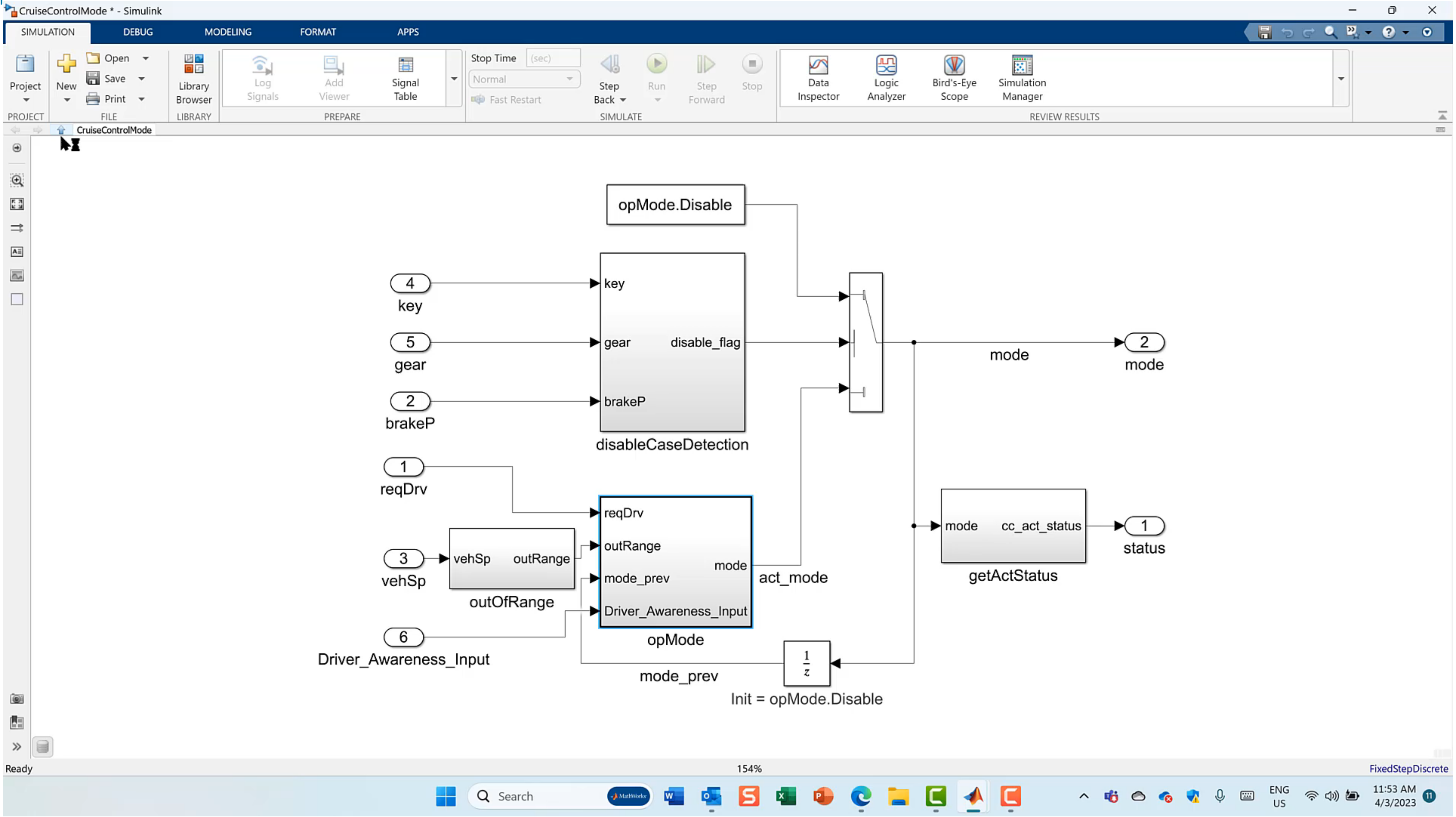
```matlab




% Clone operation
% Copy and paste a fresh copy of project from repo if needed
% The repo URL can be found with in the technical article
% https://github.com/mathworks/Continuous-Integration-Verification-Simulink-Models-GitLab

system ("start sh.exe --cd={Working_path}");  % This is where the copy will be placed
cd(Working_path)
SCM_temp=strcat(Content_path,Content_Sub_Folder,".git");
SCM_temp=strcat("git clone ",SCM_temp," --quiet");
system(SCM_temp);
```

Takeaway #1: Iterate locally to innovate and prequalify

Cruise Control Case Study: Change Models

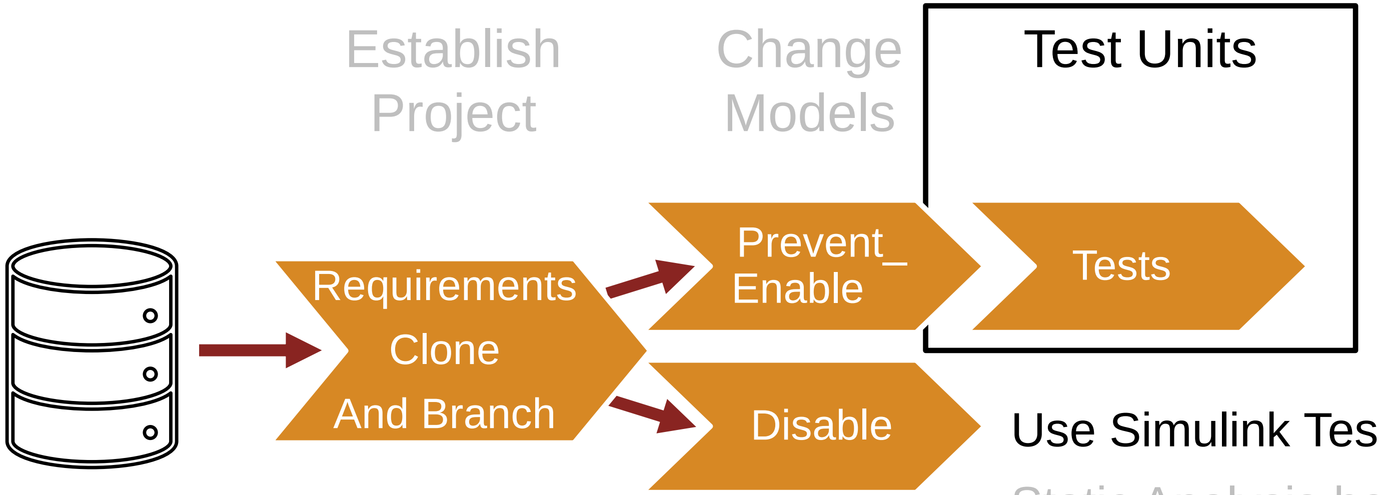


Resources: Simulink Model Management and Architecture | Highspot


CruiseControlMode * - Simulink
SIMULATION
DEBUG
MODELING
FORMAT
APPS
Project
New
Open
Save
Print
Library Browser
Log Signals
Add Viewer
Signal Table
Stop Time
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
PROJECT
FILE
LIBRARY
PREPARE
SIMULATE
REVIEW RESULTS
CruiseControlMode
opMode.Disable
4
key
5
gear
2
brakeP
key
gear
brakeP
disable_flag
disableCaseDetection
mode
2
mode
1
reqDrv
3
vehSp
vehSp
outRange
outOfRange
6
Driver_Awareness_Input
reqDrv
outRange
mode_prev
Driver_Awareness_Input
mode
opMode
act_mode
mode
cc_act_status
getActStatus
1
status
1/z
mode_prev
Init = opMode.Disable
Ready
154%
FixedStepDiscrete
Search
ENG
US
11:53 AM
4/3/2023

Takeaway #1: Iterate locally to innovate and prequalify

Cruise Control Case Study: Test Units

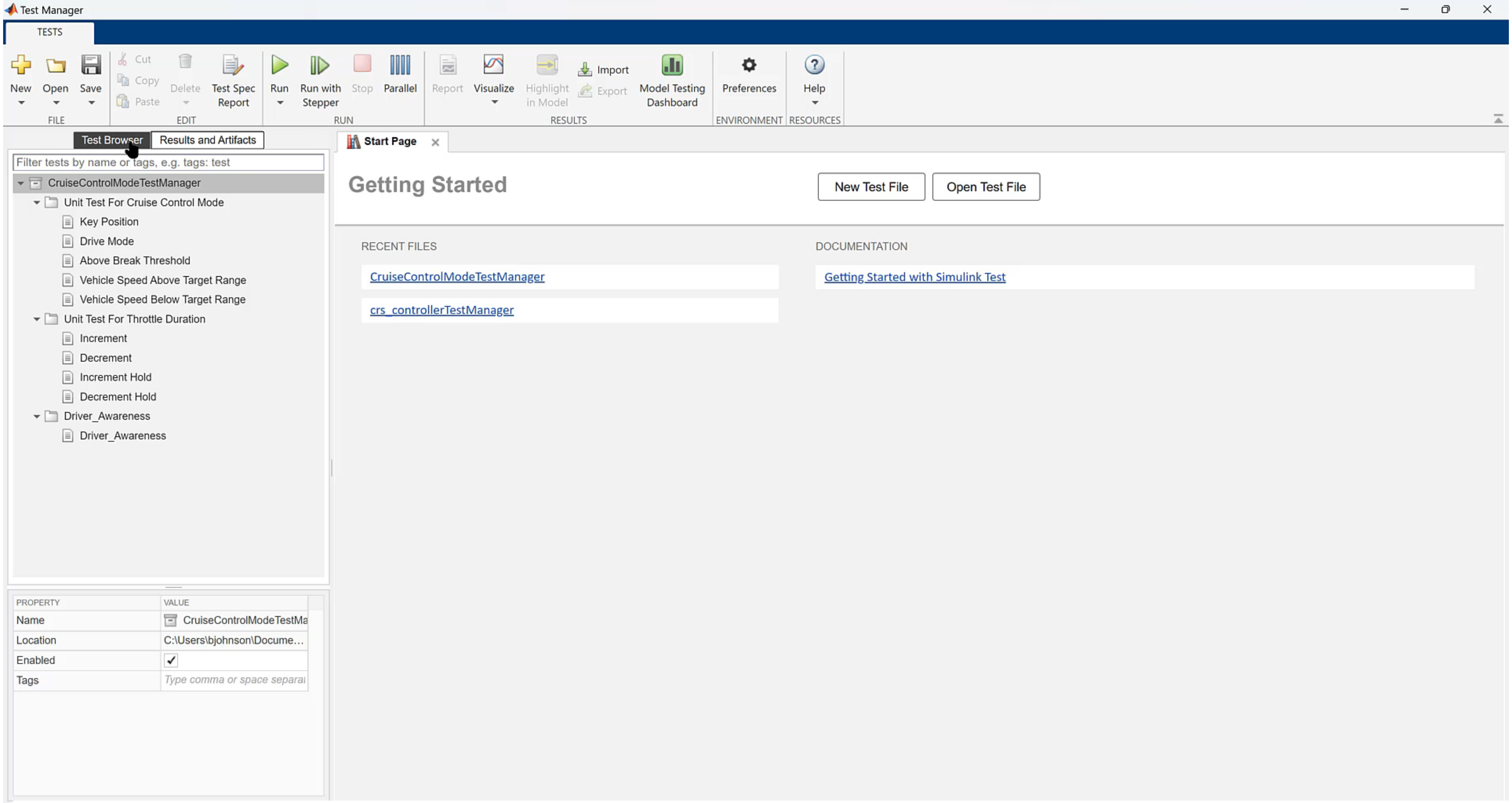


Use Simulink Test to help assure function

Static Analysis help assure structural integrity

Commit the work

Resources: Simulink Test (mathworks.com)



Filter tests by name or tags, e.g. tags: test

- CruiseControlModeTestManager
  - Unit Test For Cruise Control Mode
    - Key Position
    - Drive Mode
    - Above Break Threshold
    - Vehicle Speed Above Target Range
    - Vehicle Speed Below Target Range
  - Unit Test For Throttle Duration
    - Increment
    - Decrement
    - Increment Hold
    - Decrement Hold
  - Driver_Awareness
    - Driver_Awareness

PROPERTY	VALUE
Name	CruiseControlModeTestMa
Location	C:\Users\bjohnson\Docume…
Enabled	✓
Tags	Type comma or space separa

Getting Started

RECENT FILES

CruiseControlModeTestManager

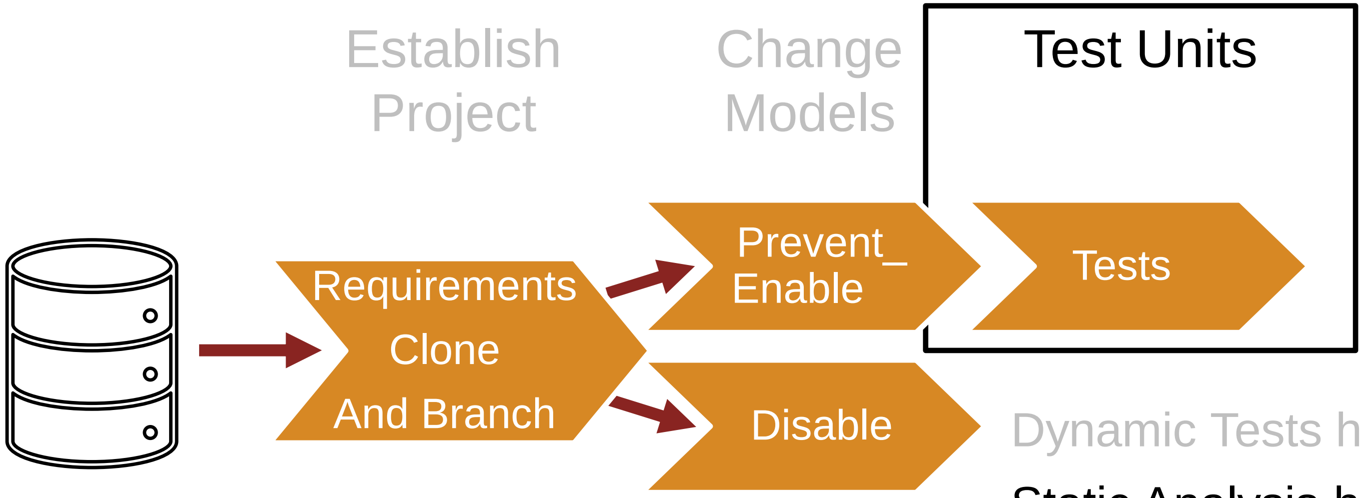
crs_controllerTestManager

DOCUMENTATION

Getting Started with Simulink Test

Takeaway #1: Iterate locally to innovate and prequalify

Cruise Control Case Study: Static Analysis

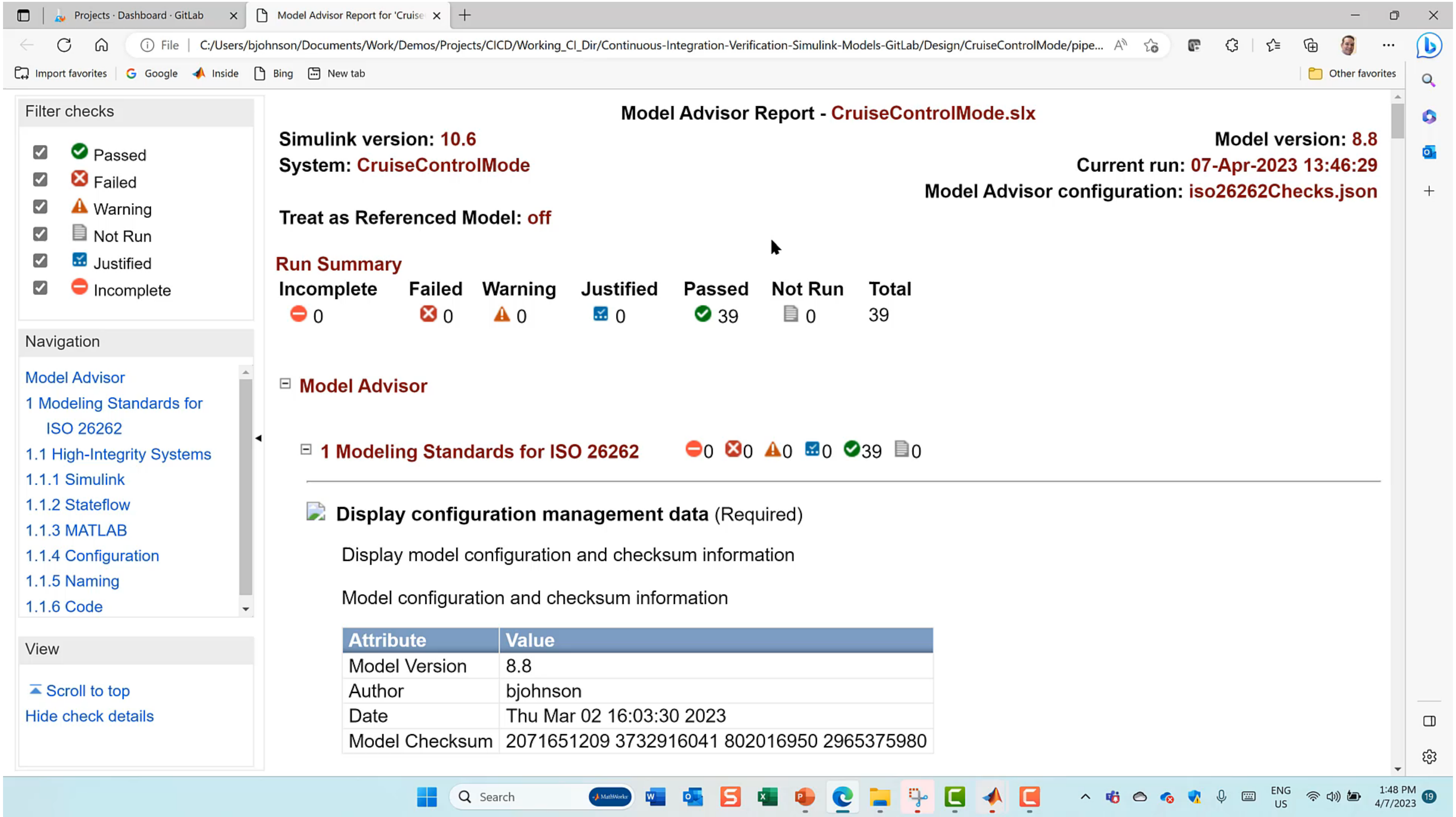


Dynamic Tests help assure function

Static Analysis help assure structural integrity

Commit the work

Model Advisor - MATLAB & Simulink (mathworks.com)


Projects · Dashboard · GitLab
Model Advisor Report for 'Cruise
File
C:/Users/bjohnson/Documents/Work/Demos/Projects/CICD/Working_CI_Dir/Continuous-Integration-Verification-Simulink-Models-GitLab/Design/CruiseControlMode/pipe...
Import favorites
Google
Inside
Bing
New tab
Other favorites
Search
ENG
US
1:48 PM
4/7/2023

Filter checks

- ☑ ✓ Passed
- ☑ ☒ Failed
- ☑ ⚠ Warning
- ☑ □ Not Run
- ☑ ☑ Justified
- ☑ ⊖ Incomplete

Navigation

- Model Advisor
- 1 Modeling Standards for ISO 26262
- 1.1 High-Integrity Systems
- 1.1.1 Simulink
- 1.1.2 Stateflow
- 1.1.3 MATLAB
- 1.1.4 Configuration
- 1.1.5 Naming
- 1.1.6 Code

View

- Scroll to top
- Hide check details

Model Advisor Report - CruiseControlMode.slx

Simulink version: 10.6

Model version: 8.8

System: CruiseControlMode

Current run: 07-Apr-2023 13:46:29

Model Advisor configuration: iso26262Checks.json

Treat as Referenced Model: off

Run Summary

Incomplete	Failed	Warning	Justified	Passed	Not Run	Total
⊖ 0	☒ 0	⚠ 0	☑ 0	✓ 39	□ 0	39

⊟ Model Advisor

⊟ 1 Modeling Standards for ISO 26262 ⊖0 ☒0 ⚠0 ☑0 ✓39 □0

Display configuration management data (Required)

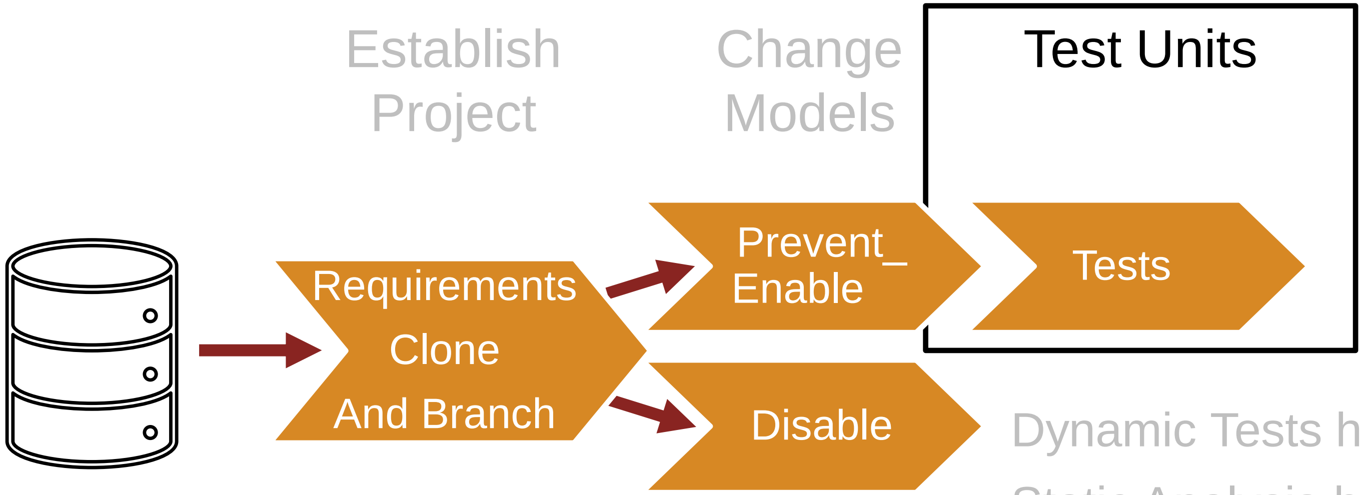
Display model configuration and checksum information

Model configuration and checksum information

Attribute	Value
Model Version	8.8
Author	bjohnson
Date	Thu Mar 02 16:03:30 2023
Model Checksum	2071651209 3732916041 802016950 2965375980

Takeaway #1: Iterate locally to innovate and prequalify

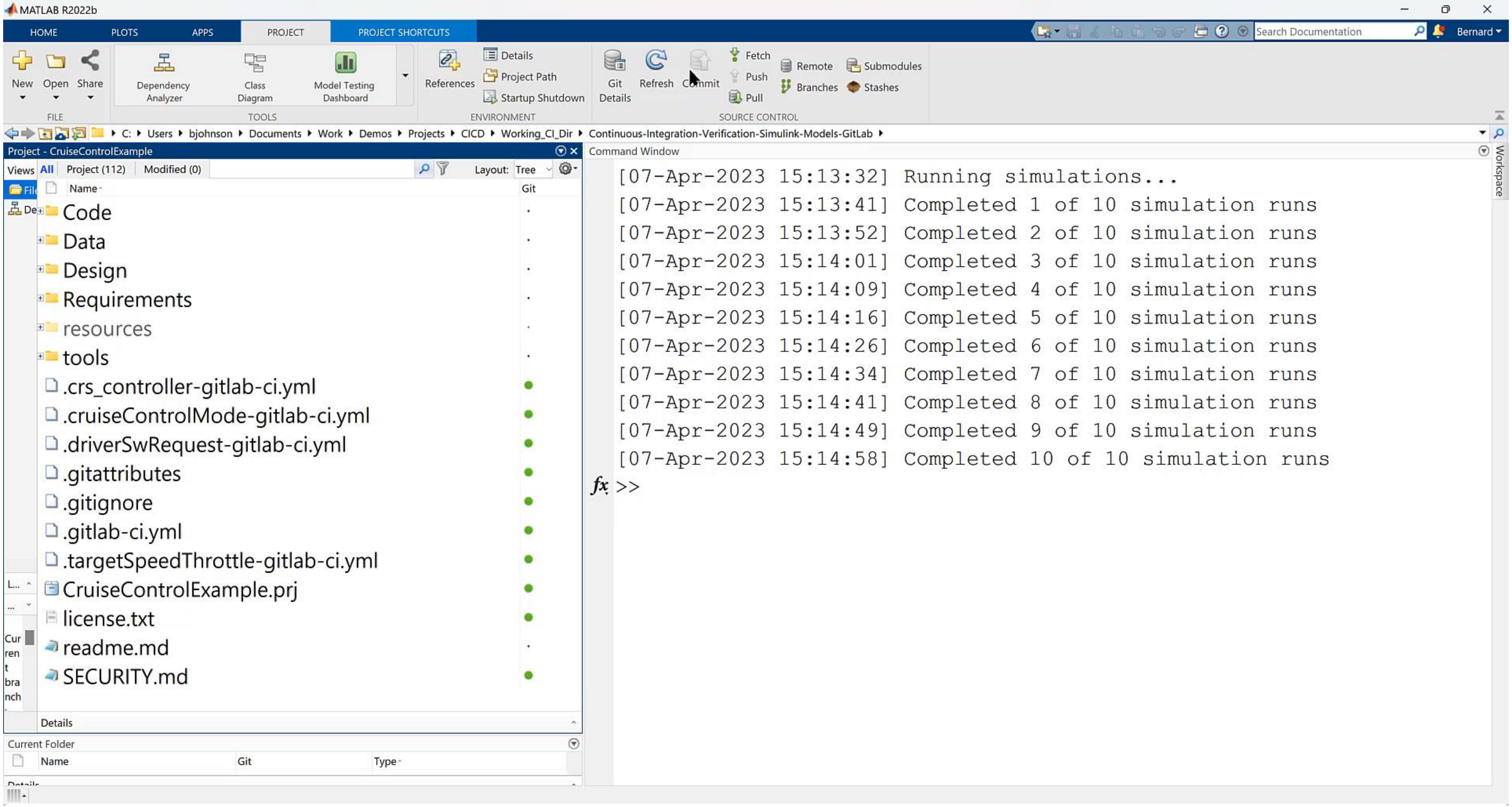
Cruise Control Case Study: Commit Work



Dynamic Tests help assure function

Static Analysis help assure structural integrity

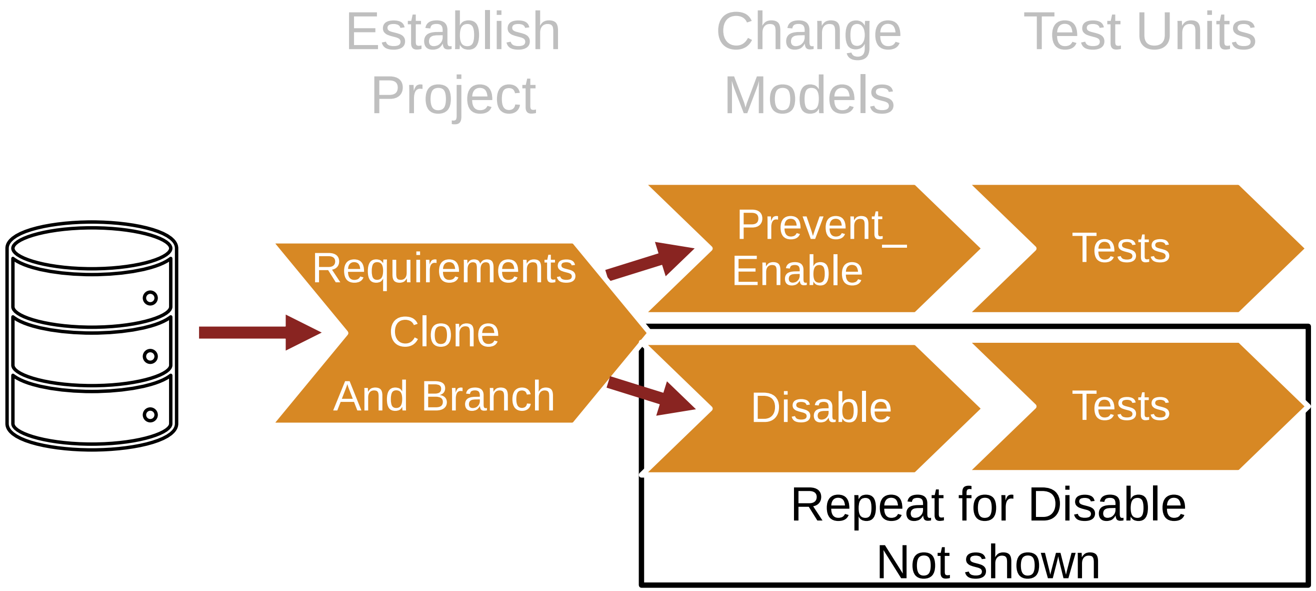
Commit the work



```
[07-Apr-2023 15:13:32] Running simulations...
[07-Apr-2023 15:13:41] Completed 1 of 10 simulation runs
[07-Apr-2023 15:13:52] Completed 2 of 10 simulation runs
[07-Apr-2023 15:14:01] Completed 3 of 10 simulation runs
[07-Apr-2023 15:14:09] Completed 4 of 10 simulation runs
[07-Apr-2023 15:14:16] Completed 5 of 10 simulation runs
[07-Apr-2023 15:14:26] Completed 6 of 10 simulation runs
[07-Apr-2023 15:14:34] Completed 7 of 10 simulation runs
[07-Apr-2023 15:14:41] Completed 8 of 10 simulation runs
[07-Apr-2023 15:14:49] Completed 9 of 10 simulation runs
[07-Apr-2023 15:14:58] Completed 10 of 10 simulation runs
fx >>
```

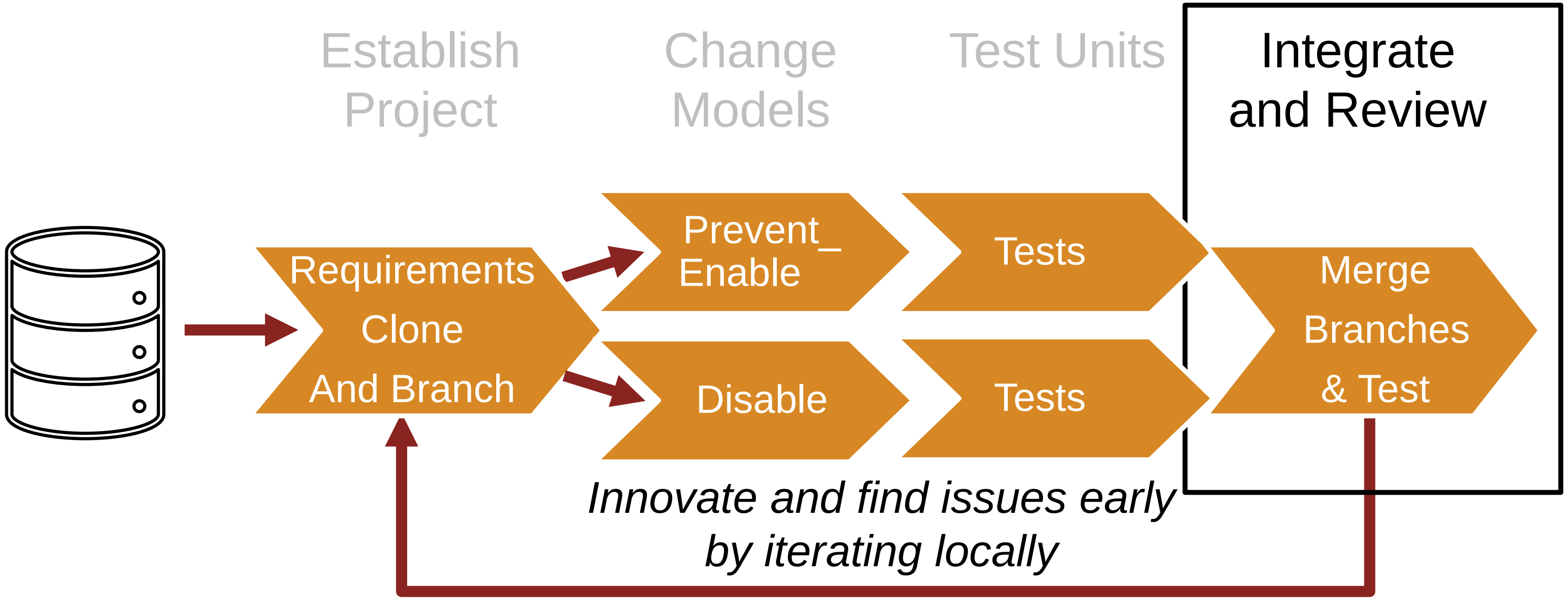
Takeaway #1: Iterate locally to innovate and prequalify

Cruise Control Case Study: Complete the Disable branch

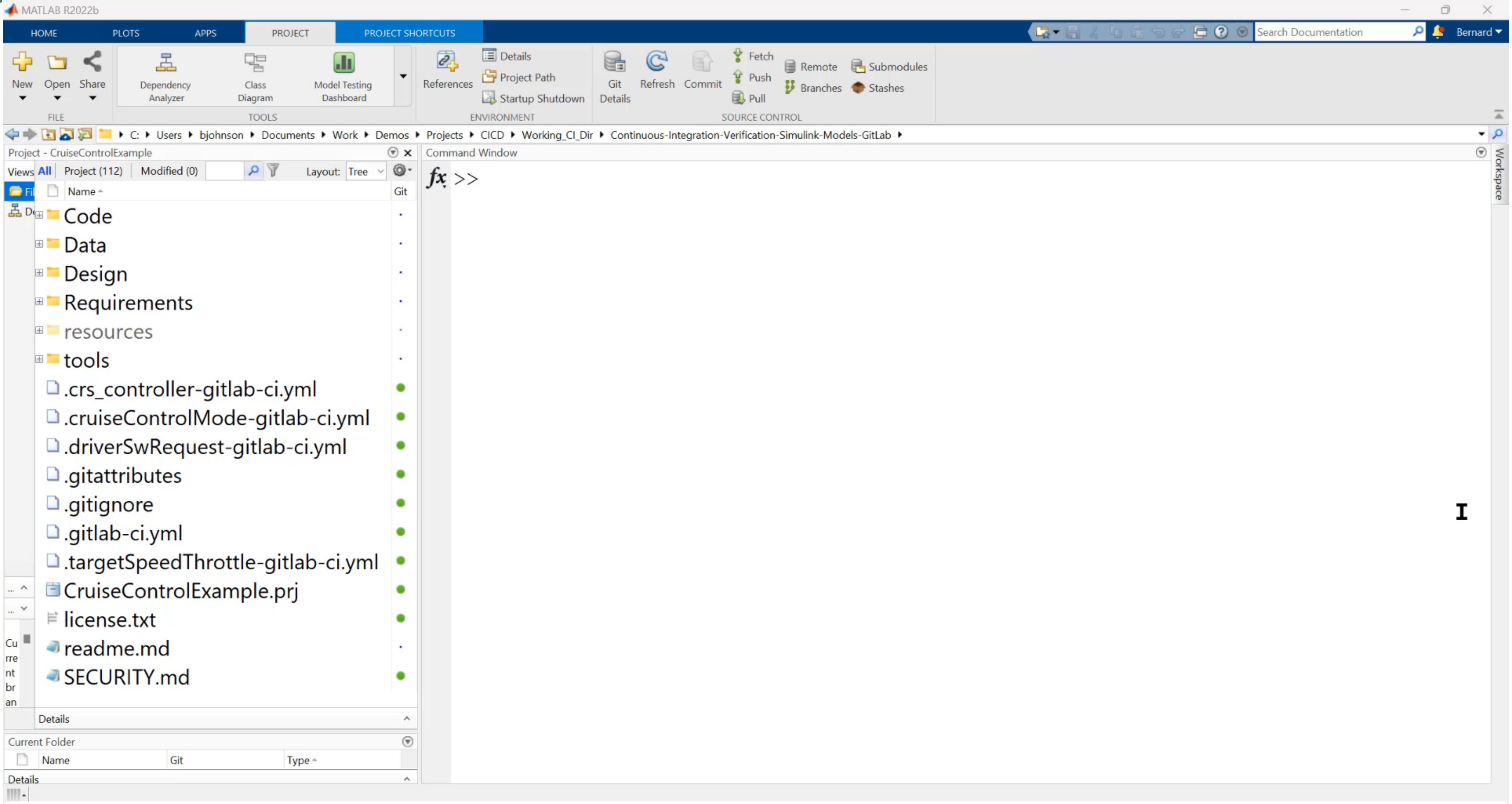


Takeaway #1: Iterate locally to innovate and prequalify

Cruise Control Case Study: Integrate and Review



Innovate and find issues early by iterating locally



C: ▸ Users ▸ bjohnson ▸ Documents ▸ Work ▸ Demos ▸ Projects ▸ CICD ▸ Working_CI_Dir ▸ Continuous-Integration-Verification-Simulink-Models-GitLab ▸

Project - CruiseControlExample

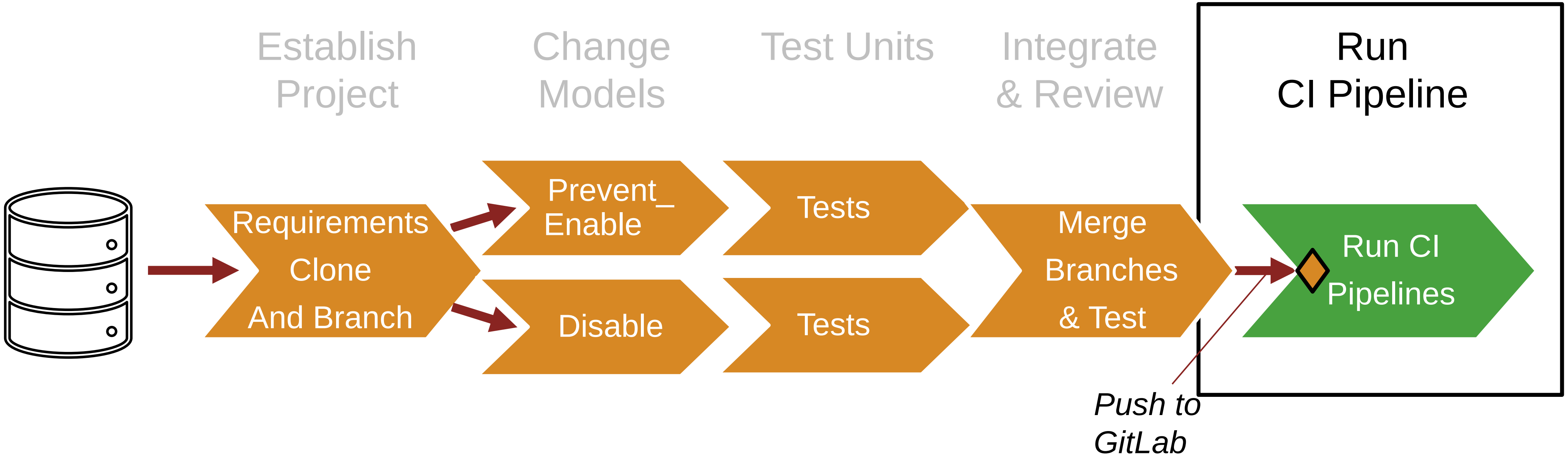
Views All | Project (112) | Modified (0) | Layout: Tree

Name	Git
Code	·
Data	·
Design	·
Requirements	·
resources	·
tools	·
.crs_controller-gitlab-ci.yml	●
.cruiseControlMode-gitlab-ci.yml	●
.driverSwRequest-gitlab-ci.yml	●
.gitattributes	●
.gitignore	●
.gitlab-ci.yml	●
.targetSpeedThrottle-gitlab-ci.yml	●
CruiseControlExample.prj	●
license.txt	●
readme.md	·
SECURITY.md	●

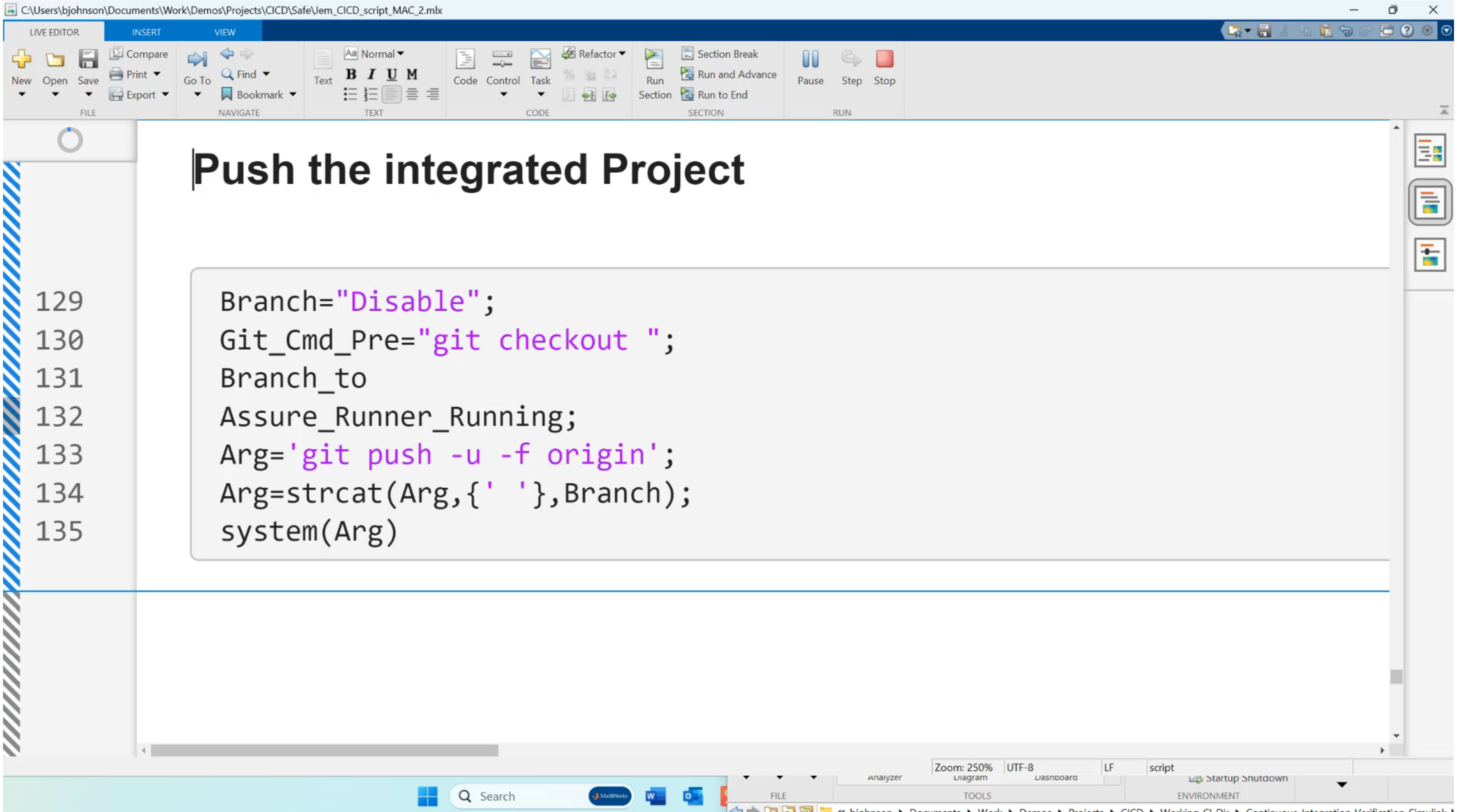
```
fx >>
```

Takeaway #2: Extend Model-Based Design Workflows into CI Platforms

Cruise Control Case Study: Run CI Pipeline



Learn More: Continuous Integration - MATLAB & Simulink (mathworks.com)

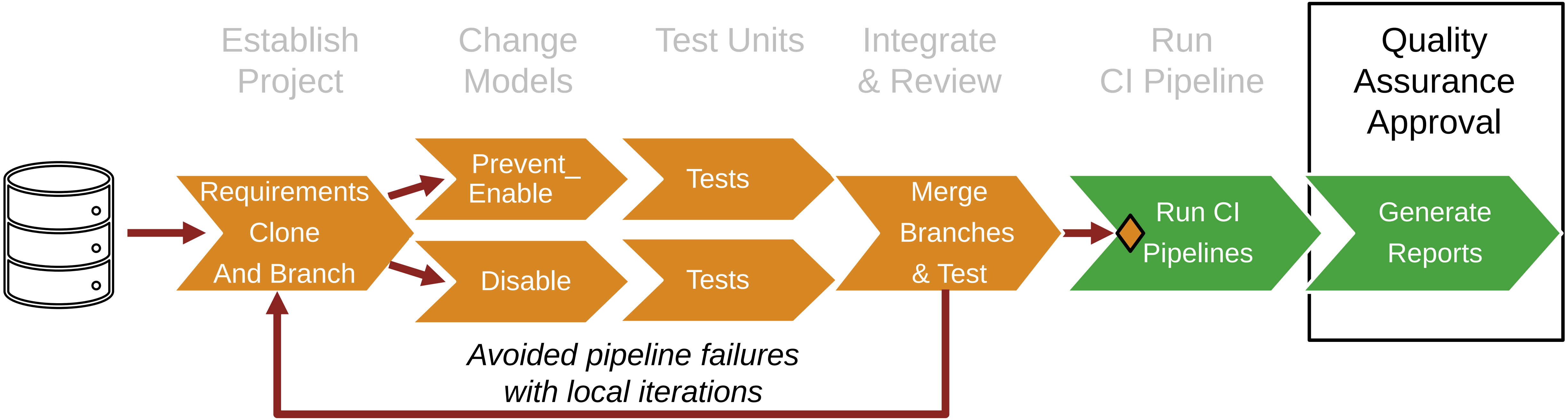


Push the integrated Project

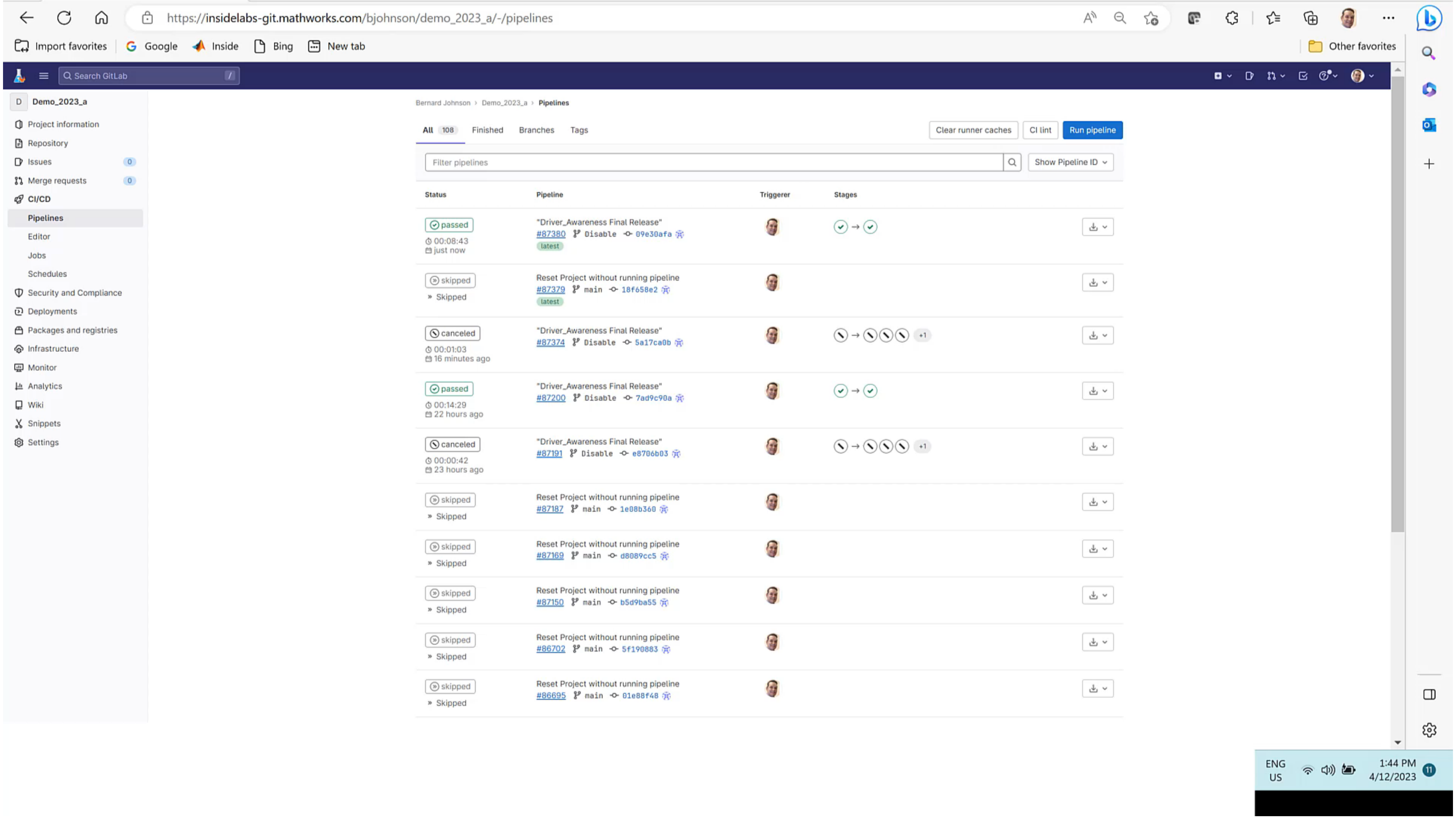
```
Branch="Disable";
Git_Cmd_Pre="git checkout ";
Branch_to
Assure_Runner_Running;
Arg='git push -u -f origin';
Arg=strcat(Arg,{' '},Branch);
system(Arg)
```

Takeaway #2: Extend Model-Based Design Workflows into CI Platforms

Cruise Control Case Study: Approve Release

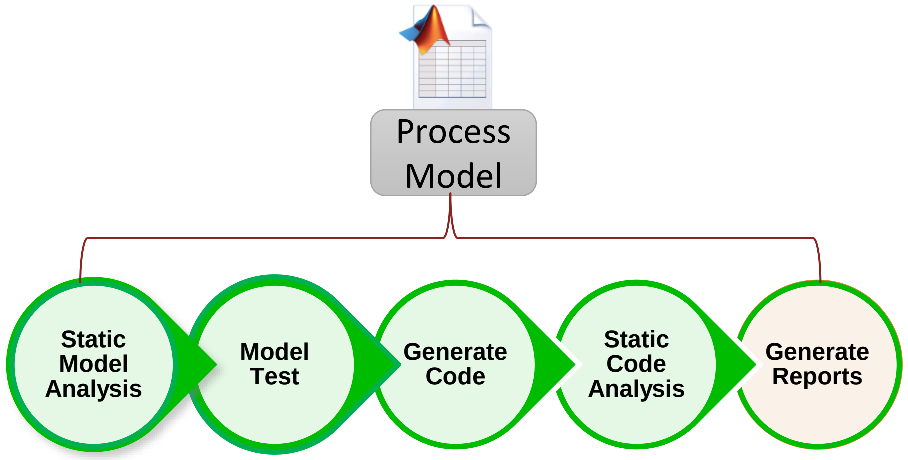


Avoided pipeline failures with local iterations

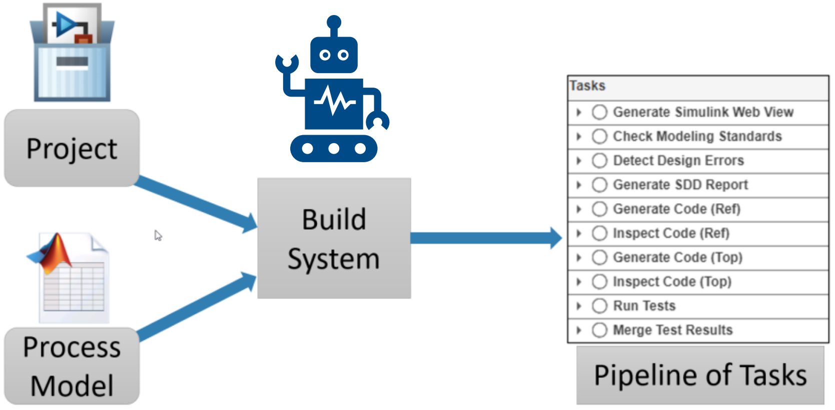


Status	Pipeline	Triggerer	Stages
passed 00:08:43 just now	"Driver_Awareness Final Release" #87380 Disable 09e30afa latest		✓ → ✓
skipped » Skipped	Reset Project without running pipeline #87379 main 18f658e2 latest		
canceled 00:01:03 16 minutes ago	"Driver_Awareness Final Release" #87374 Disable 5a17ca0b		⊘ → ⊘ ⊘ ⊘ +1
passed 00:14:29 22 hours ago	"Driver_Awareness Final Release" #87200 Disable 7ad9c90a		✓ → ✓
canceled 00:00:42 23 hours ago	"Driver_Awareness Final Release" #87191 Disable e8706b03		⊘ → ⊘ ⊘ ⊘ +1
skipped » Skipped	Reset Project without running pipeline #87187 main 1e08b360		
skipped » Skipped	Reset Project without running pipeline #87169 main d8089cc5		
skipped » Skipped	Reset Project without running pipeline #87150 main b5d9ba55		
skipped » Skipped	Reset Project without running pipeline #86702 main 5f190883		
skipped » Skipped	Reset Project without running pipeline #86695 main 01e88f48		

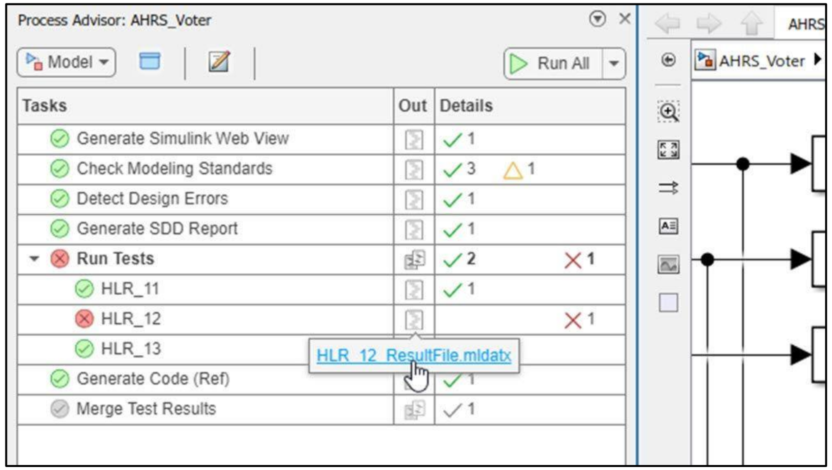
3. Simplify adoption by using the CI Automation Support Package



Prebuilt & Tailorable Model-Based Design Pipeline

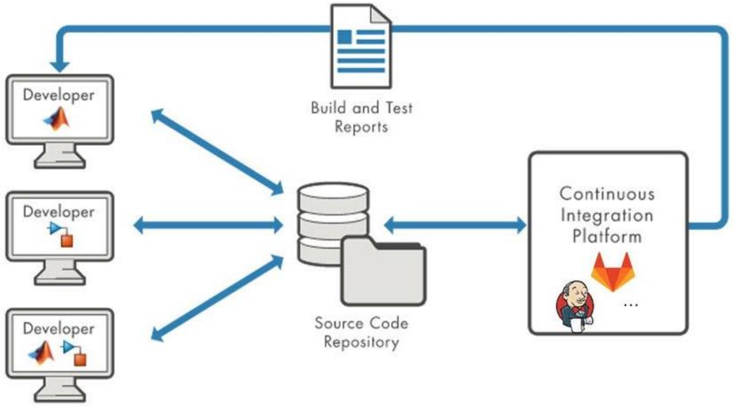


Build system to generate and optimally execute the process in your CI system



Tasks	Out	Details
Generate Simulink Web View		✓ 1
Check Modeling Standards		✓ 3 △ 1
Detect Design Errors		✓ 1
Generate SDD Report		✓ 1
Run Tests		✓ 2 ✗ 1
HLR_11		✓ 1
HLR_12		✗ 1
HLR_13		HLR_12_ResultFile.mldatx
Generate Code (Ref)		✓ 1
Merge Test Results		✓ 1

Prequalification with Process Advisor



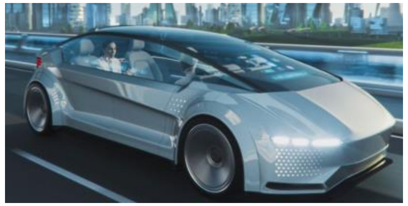
Examples to run process on common CI Systems

Learn more: [Continuous Integration for Model-Based Design]()

A few Continuous Integration success stories in Automotive

A123 SYSTEMS

A123 link: Similar case study, but uses Jenkins



HL Klemove link: Focus on Polyspace

Key Takeaways

1. Iterate locally to innovate and prequalify before submitting to CI pipeline
2. Extend Model-Based Design Workflows into CI Platforms
3. Simplify adoption by using the CI Automation Support Package

Closing

Please contact Bernard Johnson for questions or next steps.

bjohnson@mathworks.com

Thank you

Seven reasons to consider automation and pipelines

1. Architect and standardize workflows for repeatability
2. Users need less training than authors
3. Continuous improvement and learning
4. Helps Archive tool-chains
5. Flexible compute resources
6. Work in parallel while pipeline runs
7. Collaboration