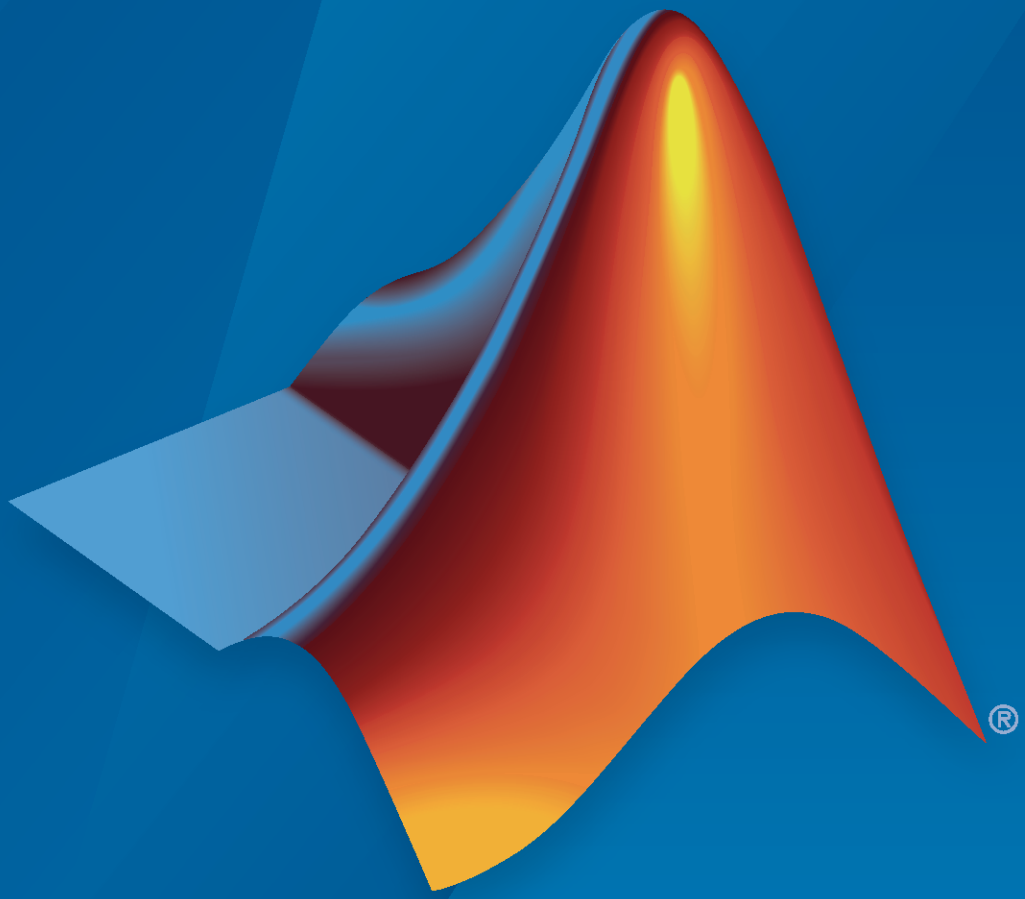
CI/CD Automation for Simulink® Check™ Support Package

User's Guide



MATLAB® & SIMULINK®

R2022a — R2023a

MathWorks®

How to Contact MathWorks

Latest news: `www.mathworks.com`

Sales and services: `www.mathworks.com/sales_and_services`

User community: `www.mathworks.com/matlabcentral`

Technical support: `www.mathworks.com/support/contact_us`

Phone: 508-647-7000

The MathWorks, Inc.
1 Apple Hill Drive
Natick, MA 01760-2098

CI/CD Automation for Simulink® Check™ User's Guide

Revision History

August 2022	PDF Only	Version 22.1.0 (R2022a)
September 2022	PDF Only	Version 22.1.1
October 2022	PDF Only	Versions 22.1.2 and 22.2.2 (R2022b)
November 2022	PDF Only	Versions 22.1.3 and 22.2.3
December 2022	PDF Only	Versions 22.1.4 and 22.2.4
February 2023	PDF Only	Versions 22.1.5 and 22.2.5
March 2023	PDF Only	Version 23.1.5 (R2023a)
April 2023	PDF Only	Versions 22.1.6, 22.2.6, and 23.1.6
June 2023	PDF Only	Versions 22.1.7, 22.2.7, and 23.1.7
July 2023	PDF Only	Versions 22.1.8, 22.2.8, and 23.1.8

Contents

1 User's Guide

2 Fundamentals

3 Run Tasks Using Process Advisor

4 Author Your Process Model

6 Integrate into CI

7 Troubleshooting and Limitations

8 Version History

User's Guide

The support package CI/CD Automation for Simulink® Check™ provides tools to help you integrate your model-based process into a Continuous Integration / Continuous Delivery (CI/CD) system.

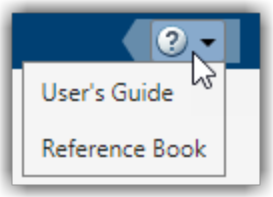
The support package provides:

- A customizable process modeling system that you can use to define your build and verification process
- A build system that can efficiently execute a pipeline in your CI system
- The Process Advisor app for deploying and automating your prequalification process
- Integration with common CI systems, including a pipeline generator to automatically create child pipeline files in CI

You can use the support package to help you set up a model-based design (MBD) pipeline, reduce build time, reduce build failures, debug build failures, and deploy a consistent build and verification process. For an overview of these features, see the chapter "Fundamentals".

This PDF is a User's Guide with general information and examples. For information on the API, artifact types, built-in tasks, and built-in queries, see the Reference Book PDF. You can access the PDFs from:

- https://www.mathworks.com/matlabcentral/fileexchange/115220-ci-cd-automation-for-simulink-check
- The question mark icon in the Process Advisor app



Where to Get Started

If you are a:

- Model developer or test engineer, you might want to start with "Run Tasks Using Process Advisor".
- Process engineer, you might want to start with "Author Your Process Model" and "Control Builds".
- DevOps engineer, you might want to start with "Integrate into CI".

Note The support package only supports:

- R2022a Update 4 and later updates
- R2022b Update 1 and later updates
- R2023a

For information on the supported versions, features, and compatibility considerations, see the "Version History" at the end of this PDF.

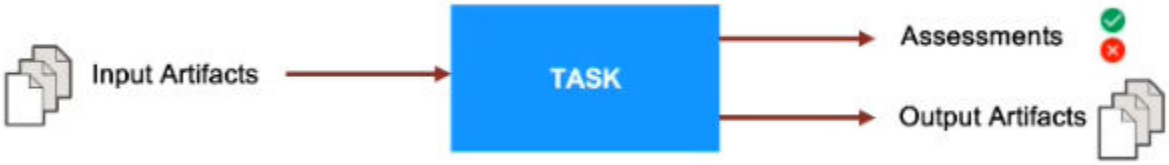
Fundamentals

MBD Pipeline

In a typical CI/CD pipeline, the CI/CD system automatically builds your source code, performs testing, packages deliverables, and deploys the packages to production. With the support package CI/CD Automation for Simulink Check, you can create a pipeline for the steps in your build and verification process, and maintain a repeatable CI/CD process for model-based design. For example, you can create an MBD pipeline that checks modeling standards, runs tests, generates code, and performs a custom task.

You can use the customizable process modeling system to define the steps in your model-based design (MBD) pipeline. You define the steps by using a process model. A *process model* is a MATLAB® script that specifies the tasks in the CI/CD process, dependencies between the tasks, and artifacts that you associate with each task.

A *task* is a single step in your process. Tasks can accept your project artifacts as inputs, perform actions, generate pass, fail, or warning assessments, and return project artifacts as outputs.



The support package contains built-in tasks for several common steps, including:

- Creating Simulink web views for your models with Simulink Report Generator™
- Checking modeling standards with the Model Advisor
- Running tests with Simulink Test™
- Detecting design errors with Simulink Design Verifier™
- Generating a System Design Description (SDD) report with Simulink Report Generator
- Generating code with Embedded Coder®
- Checking coding standards with Polyspace® Bug Finder™
- Inspecting code with Simulink Code Inspector™
- Generating a consolidated test results report and a merged coverage report with Simulink Test and Simulink Coverage™

Tip You can view the source code for the built-in tasks. After installing the support package, the built-in task source code is available in the support package folder. In the MATLAB Command Window, enter:

```
cd(fullfile(matlabshared.supportpkg.getSupportPackageRoot,...
"toolbox","padv","build_service","ml","+padv","+builtin","+task"))
```

This command changes the current working folder to the directory that contains the built-in task source code.

The support package contains a default process model for an MBD pipeline, but you can also customize the default process model to fit your development workflow goals. For example, your process model might include the built-in tasks for checking modeling standards, running tests, and generating code before performing a custom task. You can customize the process model to add or remove any tasks in the MBD pipeline. You can also reconfigure the tasks in your process model to change what action a task performs or how a task performs the action.

For more information on the process modeling system, see the chapter "Author Your Process Model". For information on the built-in tasks, see the chapter "Built-In Task Library" in the Reference Book PDF.

Build System

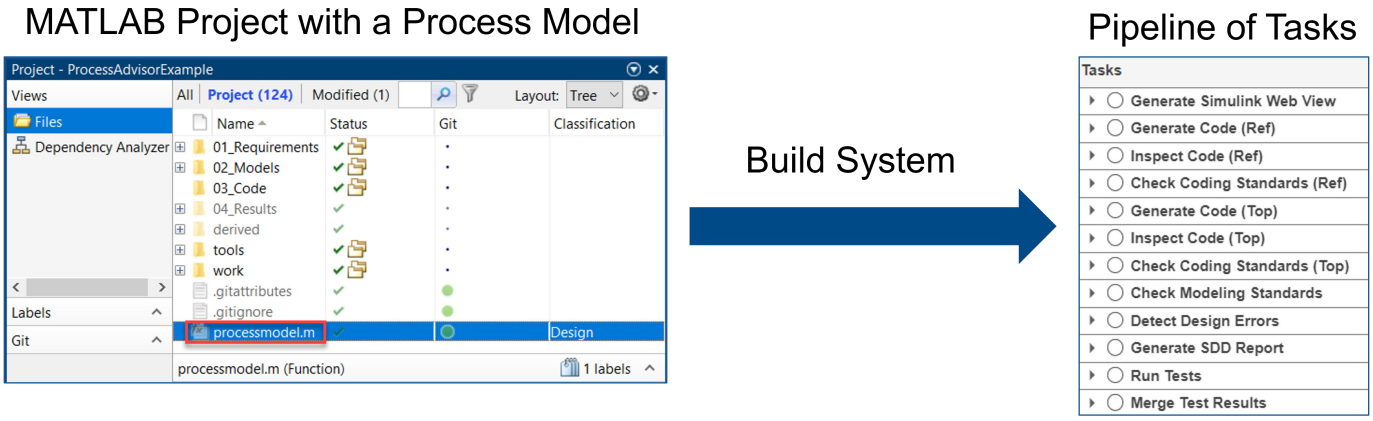
The support package CI/CD Automation for Simulink Check provides a build system that you can use to orchestrate and automate the steps in your MBD pipeline. The *build system* is software that can orchestrate tasks, efficiently execute tasks in the pipeline, and perform other actions related to the pipeline.

The build system needs:

1. A project to analyze
2. A process model in the project that defines the tasks in the pipeline

If the project does not contain a process model, the build system copies the default process model into the project and uses the default process model to define a default MBD pipeline.

When you call the build system, the build system loads the process model, analyzes the project, and orchestrates the creation of a pipeline of tasks.



To run the tasks in the pipeline, you can call the build system using one of these approaches:

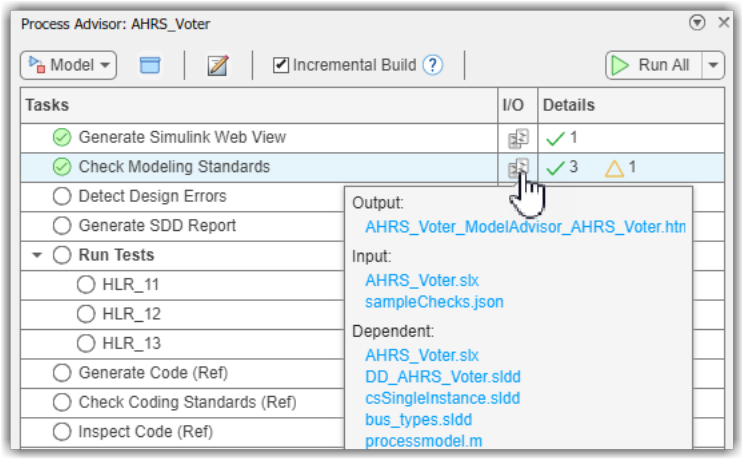
- In a CI environment by using the build system API. The build system API includes a function `runprocess` that you can use to run the tasks in a pipeline.
- Locally on your machine by using either the build system API or the Process Advisor app. Process Advisor is a user interface that can call the build system and has run buttons that you can use to run the tasks in a pipeline. If there is a failure in the CI environment, you can reproduce the issue locally by using Process Advisor on your local machine.

The build system supports incremental builds. If you change an artifact in your project, the build system can detect the change and automatically determine which of the tasks in your MBD pipeline now have outdated results. In your next build, you can instruct the build system to run only the tasks with outdated results. By identifying the tasks with outdated results, the build system can help you reduce build time by reducing the number of tasks you need to re-run after making changes to your project artifacts.

Note There are limitations to the types of changes that the support package can detect. For more information, see the "Limitations on Incremental Build" section.

Process Advisor

A prequalification process can help you prevent build and test failures from occurring in your CI/CD system. Use the Process Advisor desktop app to deploy and automate your prequalification process. You can use the app to run the tasks in your MBD pipeline and to prequalify your changes on your machine before submitting to source control. Process Advisor is a user interface that runs your tasks locally for prequalification. You can run the tasks in your MBD pipeline and to check your progress towards completing tasks in your prequalification pipeline.



If you make a change to an artifact in your project, Process Advisor can detect the change and automatically determine the impact of the change on your existing task results. For example, if you complete a task but then update your model, the Process Advisor automatically invalidates the task completion and marks the task results as outdated.

Note There are limitations to the types of changes that Process Advisor can detect. For more information, see the "Limitations on Incremental Build".

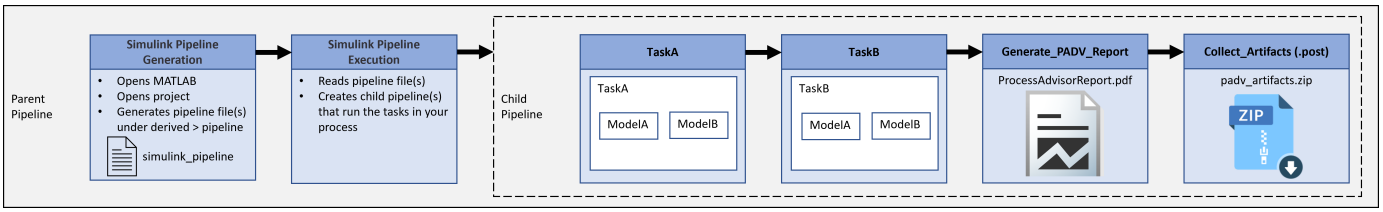
For information on Process Advisor, see "Run Tasks Using Process Advisor".

CI/CD System Integration

You can use the support package CI/CD Automation for Simulink Check to integrate your model-based design process into common CI/CD systems.

Typically, when you configure a CI pipeline, you need to manually create and update pipeline configuration files as you add, remove, and change the artifacts in your project. However, the support package provides a pipeline generator function (`padv.pipeline.generatePipeline`) and example pipeline configuration files that you can use to automatically generate the CI pipelines for you. After you do the initial setup for the pipeline generator, you no longer need to manually update your pipeline configuration files. When you trigger your pipeline, the pipeline generator uses the digital thread to analyze the files in your project and uses your process model to automatically generate any necessary pipeline configuration files for you.

For example, if your process model contains two tasks, `TaskA` and `TaskB`, the pipeline generator can automatically create a child pipeline that runs the tasks, generates a report, and collects the output artifacts from the CI jobs.



The pipeline generator supports these CI platforms:

- GitLab® — For instructions, see "Integrate into GitLab".
- Jenkins® — For instructions, see "Integrate into Jenkins".

For information on how to integrate the support package into other CI platforms, see "Integrate into Other CI Platforms".

The support package also contains an example `Dockerfile` for creating a Docker® container to run MATLAB with the support package and other MathWorks® products.

Run Tasks Using Process Advisor

This chapter describes how to use the Process Advisor app to run tasks and prequalify your changes:

Prequalify Changes Before Submitting to Source Control

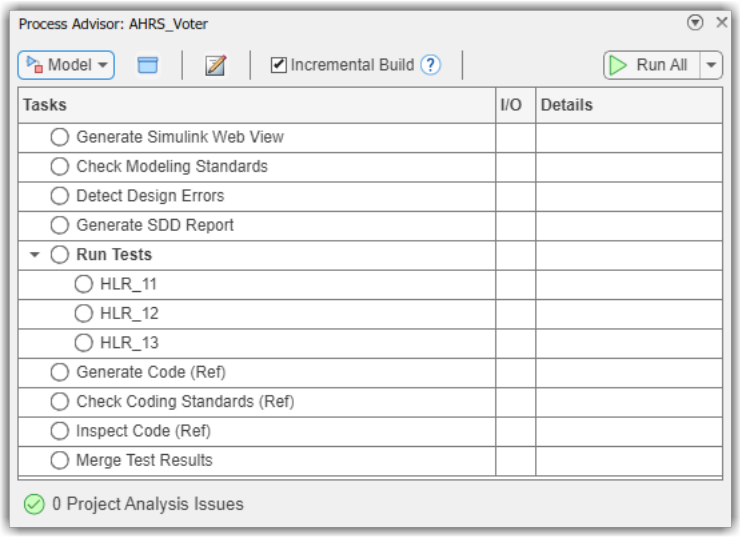
This example shows how to open the Process Advisor app, run tasks locally for prequalification, and review task results. The example uses an example process model to create an MBD pipeline with several common model-based design tasks. You can use Process Advisor to run each task in the MBD pipeline before submitting to source control.

1 Process Advisor runs on projects. For this example, open the Process Advisor example project. In the MATLAB Command Window, enter:

```
processAdvisorExampleStart
```

This command creates a copy of the Process Advisor example project and opens Process Advisor on the model `AHRS_Voter`.

Process Advisor opens in a pane to the left of the Simulink canvas. Process Advisor loads the process model, analyzes the project, and creates a pipeline of tasks. The **Tasks** column shows the pipeline of tasks associated with the current model. The tasks appears in the order that the build system will run them.



Note Each time you call `processAdvisorExampleStart`, MATLAB creates a new copy of the Process Advisor example project. The example project contains several models and an example process model file, `processmodel.m`, that specifies the tasks in the pipeline. The **Tasks** column shows the pipeline of tasks generated from the process model.

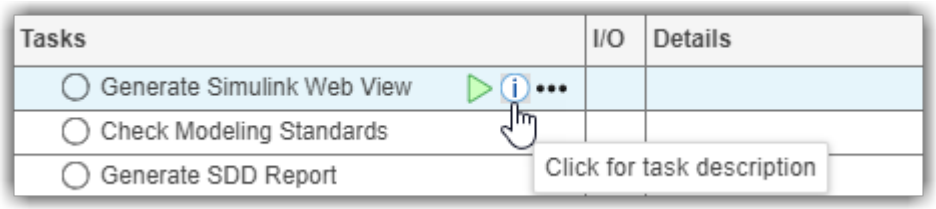
If you already have your own project, you can open Process Advisor on a model in your project:

- On the **Apps** tab for that model, click **Process Advisor**.
- Or, in the Command Window, enter:

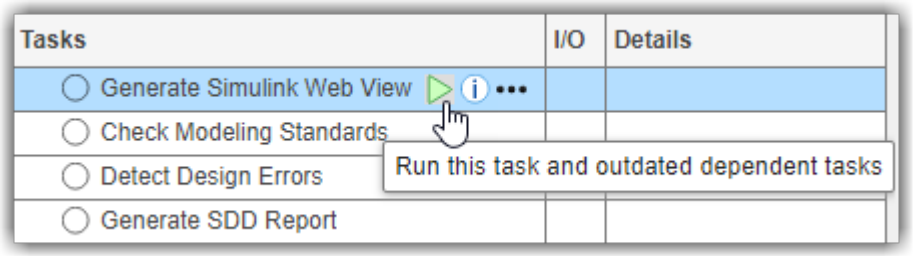
  ```
  processadvisor(modelName)
  ```

---

2 To view information about a task, point to the task in the **Tasks** column and click on the information icon. When you click on the information icon, you can view the task description.



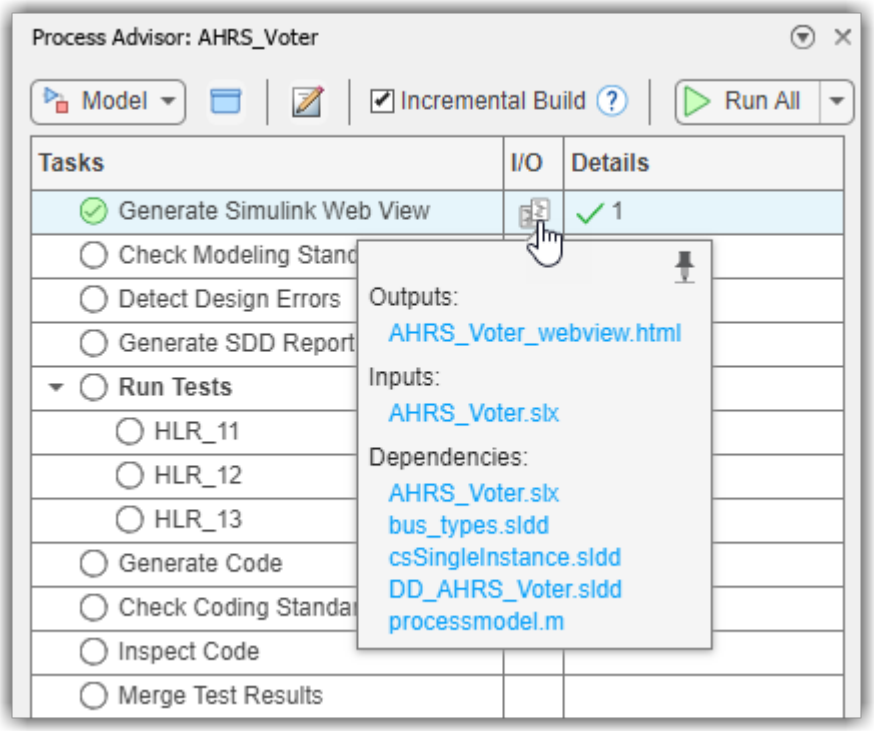
3 Point to the **Generate Simulink Web View** task and click the run button.



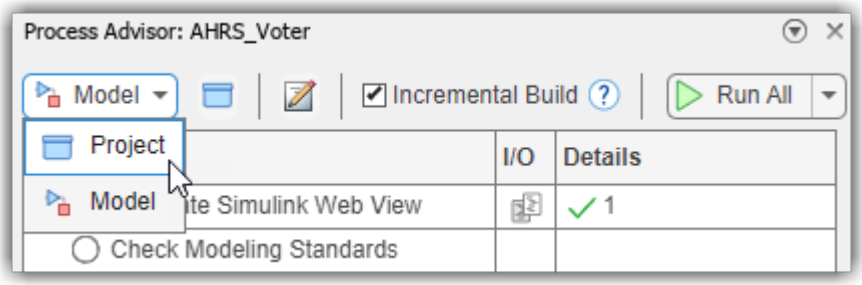
The **Generate Simulink Web View** task runs on the current model. Process Advisor logs task activity in the MATLAB Command Window.

When the task runs successfully, the status in the **Tasks** column shows a green circle with a check mark. When you point to the task status icon, you can view details about the status, including the name of the task status and how long the task took to run.

If you point to the file icon in the **I/O** column, the pop-up shows hyperlinks to the outputs from the task, in this case a HTML file, and any inputs and dependencies for the task. In the **Details** column, you can see that the task successfully generated one Simulink web view.



4 In the top-left corner of the Process Advisor pane, switch the filter from **Model** to **Project**.



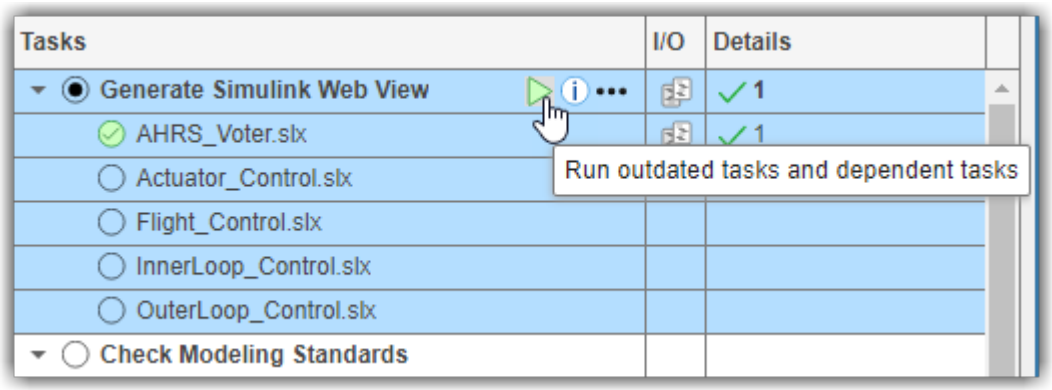
When you set the filter to **Project**, the Process Advisor pane shows the tasks associated with the project. By default, the **Generate Simulink Web View** task is configured to run once on each model in the project. The Process Advisor uses a query to find each of the models in the project and shows the names of the models as individual task iterations below the task title. The task status for **Generate Simulink Web View** shows the multiple statuses icon ◉ because the task passed on the `AHRS_Voter` model and was not run on the other models. For more information on icons, see "Icon Overview".

Note You can click on an artifact name in the **Tasks** column to open the artifact.

To open a tool associated with the task, point to the task iteration and click the ellipsis (**...**) and then **Open *`Tool Name`***. For example, when you point to the **Generate Simulink Web View** task and click the ellipsis (**...**), you have the option to **Open Web View Options**.

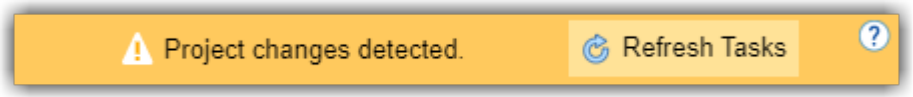
You can also open a new window that shows the tasks associated with the project by clicking on the open project window button, to the left of the **Edit process model** icon.

5 Point to **Generate Simulink Web View** and click the run button to run the task for each model in the project.



6 In the `AHRS_Voter` model, make a change and re-save the model. For this example, you can click and drag the Model Info block to a different part of the Simulink canvas and re-save the model.

Process Advisor detects the change to the model and shows a warning banner.

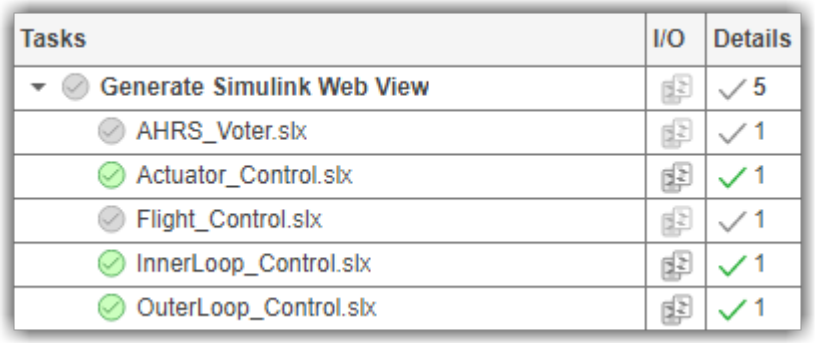


Note There are limitations to the types of changes that the Process Advisor can detect. For more information, see the "Limitations on Incremental Build" section.

Note that sometimes the warning banner might appear while you are running tasks or after you have finished running tasks, depending on when file system events reach MATLAB.

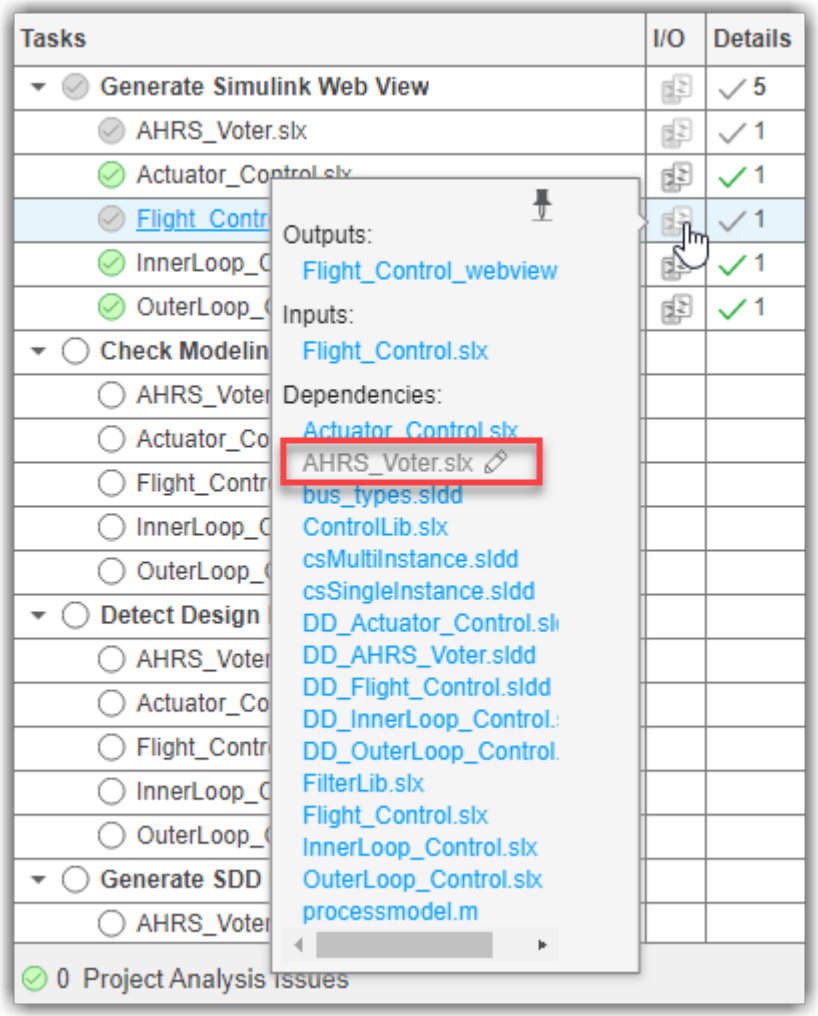
7 Click the **Refresh Tasks** button on the warning banner to refresh the information shown in Process Advisor to reflect the impact of your change on the task statuses.

Process Advisor automatically identified that the **Generate Simulink Web View** task results are outdated for both **AHRS_Voter.slx** and **Flight_Control.slx**. When a task previously passed but now has outdated results, the task status in the **Tasks** column shows the **Passed (Outdated)** icon.



The task results for **AHRS_Voter.slx** are outdated because you modified the model and directly invalidated the task results. The task results for **Flight_Control.slx** are outdated because the `AHRS_Voter` model now has outdated results and `Flight_Control` references the `AHRS_Voter`.

If you point to the file icon in the **I/O** column, the pop-up shows why the task results are stale. The outdated file icon appears next to files that changed and caused the task results to become outdated. In this example, `Flight_Control.slx` depends on the model `AHRS_Voter.slx` and `AHRS_Voter.slx` changed since the last time **Generate Simulink Web View** ran on `Flight_Control.slx`.



8 Re-run the **Generate Simulink Web View** task to get updated task results. Point to the **Generate Simulink Web View** task and click the run button ▷.

The build system automatically runs an incremental build that runs only the outdated tasks and skips any tasks that already have up-to-date results.

In the column **Results**, Process Advisor displays the number of passing, warning, or failing results:

- A green check mark ✓ indicates a passing result.
- An orange triangle △ indicates a warning result.
- A red "X" ✕ indicates a failing result.

Process Advisor aggregates the results of each task. For this example, the **Generate Simulink Web View** task successfully created five web views, so the column **Results** shows a value of **5** next to the green check mark for the task.

The log in the MATLAB Command Window shows the build results from running the task, including the number of task iterations that the build system was able to skip because the results were already up-to-date.

```
#### Build Status:              Pass
#### Number of tasks:           5
#### Number of tasks executed:  2
#### Number of tasks skipped:   3
```

9 Generate a PDF report with the current task results. Create a `padv.ProcessAdvisorReportGenerator` object and call `generateReport` on the object. In the MATLAB Command Window, enter:

```
rptObj = padv.ProcessAdvisorReportGenerator; % create a report object
generateReport(rptObj) % generate a report
```

The report generates in your current working folder. The report summarizes the task statuses, task results, and other information about the task execution. For more information, see the "Generate Build Report" section of this PDF.

Before you submit your changes to source control, click the **Run All** button to run each of the tasks in your process and confirm that each of your tasks passes. The build system automatically skips tasks that already have up-to-date results and only runs tasks that have outdated results. Process Advisor allows you to confirm that your changes do not cause issues with your existing functionality and helps you to prevent failures in CI.

Note Process Advisor creates a `derived` folder that contains information about your project and task results. Do not add the `derived` folder to your project or to your source control system. The `derived` folder contains derived results that should not be under source control.

If failures occur in CI, you can download the CI job artifacts and reproduce the issue on your local machine. For more information, see "Locally Reproduce Issues Found in CI".

For information on the Process Advisor app, see "Quick Reference for Process Advisor App".

Locally Reproduce Issues Found in CI

After you run a pipeline in your CI system, you can find issues in your artifacts that you need to fix on your local machine. You can copy results from CI jobs onto your local machine by cloning a copy of the project that you ran in CI and copying the latest job artifacts.

To copy CI results onto your machine:

1. Get the latest changes by cloning a copy of the project onto your local machine. For information, see https://www.mathworks.com/help/simulink/ug/clone-git-repository.html.
2. Close your local copy of the project.
3. In your CI system, open the job that failed and download the artifacts that the job generated.

   For example, in GitLab, you can use either the GitLab UI or API to download job artifacts: https://docs.gitlab.com/ee/ci/pipelines/job_artifacts.html#download-job-artifacts

   Job artifacts typically download as a ZIP file.
4. Extract the files from the ZIP file and copy the artifacts into your local copy of the project. The copied artifacts do not need to be added to the MATLAB path or project path.
5. Open your local copy of the project in MATLAB.
6. Open the Process Advisor app. If there is a warning banner, click **Refresh Tasks**.

After you refresh the tasks, you can:

- See the task results from the CI job in your local Process Advisor app
- Re-run tasks locally to reproduce the CI failure on your local machine
- Make changes to your project to fix the issues observed in CI
- Re-run tasks locally to confirm that you resolve any open issues before submitting to source control

Quick Reference for Process Advisor App

Process Advisor

Automate your development workflow and prequalify changes before submitting to source control

Description

Use the Process Advisor app to create, deploy, and automate a consistent prequalification process for Model-Based Design (MBD). The app includes built-in tasks for performing common MBD tasks like checking modeling standards with the Model Advisor app, running tests with Simulink Test, generating code with Embedded Coder, and inspecting code with Simulink Code Inspector. You can use the customizable process modeling system to define the steps in your process and use the app to run each of the steps. As you edit and save the artifacts in your project, the app tracks changes and automatically identifies tasks and task iterations that have outdated results. The Process Advisor app runs your tasks locally for prequalification. The tasks run on the machine that is running MATLAB and does not use an external CI system.

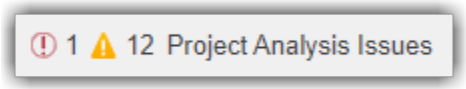
To run tasks:

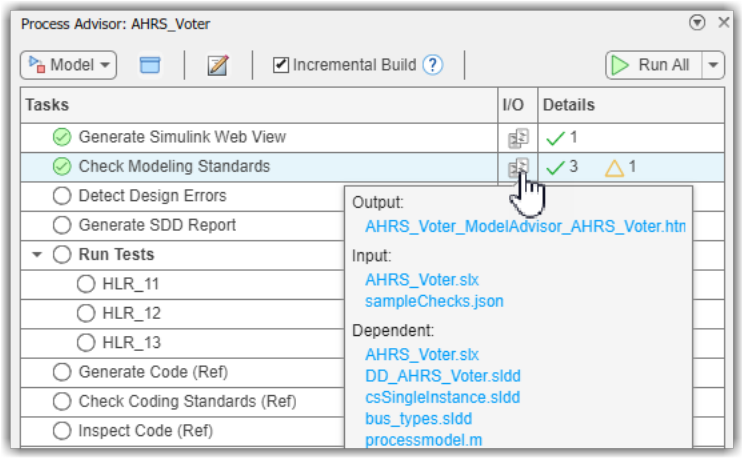
- Point to a task in the **Tasks** column and click the run button to run that task and any dependent tasks.
- Click **Run All** to run each of the tasks shown in the **Tasks** column.
- Click **Run All** > **Force Run All** to force the build system to run each task, even if the tasks already have up-to-date results.
- Click **Run All** > **Clean All** to clear the task results and delete task outputs for each of the tasks.
- Click **Run All** > **Refresh All** to manually refresh the list of tasks that appears in the **Tasks** column.

When the Process Advisor app runs tasks, a **Stop** button appears in the top-right corner. You can click the **Stop** button to stop the queued tasks from running next.

To edit the process model, click the **Edit process model** icon. If you have a P-coded process model file, you must delete the `processmodel.p` file before you can edit the process model using Process Advisor.

At the bottom of the Process Advisor app is a **Project Analysis Issues** pane. After Process Advisor analyzes the project, the **Project Analysis Issues** shows any errors or warnings that were generated during artifact analysis. For more information, see the "Troubleshooting and Limitations" section.

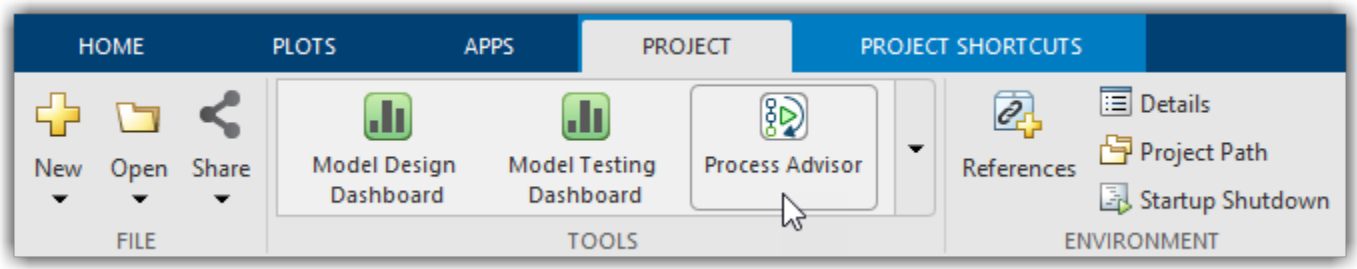




Open the Process Advisor App

- For a Simulink model:
  - On the **Apps** tab, click **Process Advisor**.
  - Or, in the Command Window, enter:

    ```
    processadvisor(modelName)
    ```
- For a project:
  - On the **Project** tab, in the **Tools** section, click **Process Advisor**.



  - Or, in the Command Window, enter:

    ```
    processAdvisorWindow
    ```

Examples

Open Process Advisor For Model

Open the **Process Advisor** app for a Simulink model in a project.

Create and open a working copy of the **Process Advisor** example project. MATLAB copies the files to an example folder so that you can edit them.

```
processAdvisorExampleStart
```

The project contains the model `OuterLoop_Control.slx`.

Open the **Process Advisor** app for the model `OuterLoop_Control.slx`.

```
processadvisor("OuterLoop_Control")
```

Open Process Advisor For Project

Open the **Process Advisor** for a project and view the pipeline of tasks.

Create and open a working copy of an example project. MATLAB copies the files to an example folder so that you can edit them.

```
proj = Simulink.createFromTemplate("code_generation_example.sltx",...
Name="New Project");
```

Open the **Process Advisor** for the project.

```
processAdvisorWindow
```

The **Tasks** column shows the pipeline of tasks generated from the process model.

Click **Edit**  to open the `processmodel.m` file that defines the process.

Programmatic Use

Note that you need to load a project before you open the **Process Advisor**.

`processadvisor(modelName)` opens the Simulink model, `modelName`, in the current project and opens a Process Advisor pane to the left of the Simulink canvas.

`processAdvisorWindow()` opens the Process Advisor app for the current project. The app opens in a standalone window.

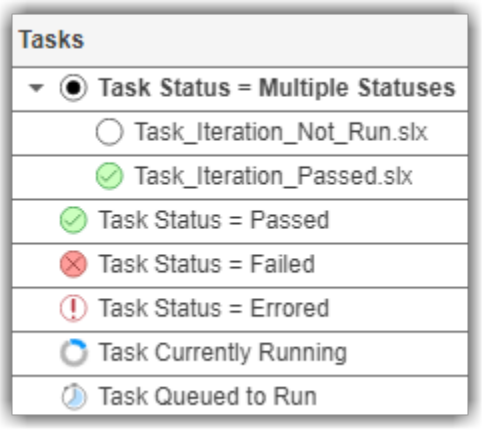
Version History

Introduced in R2022a

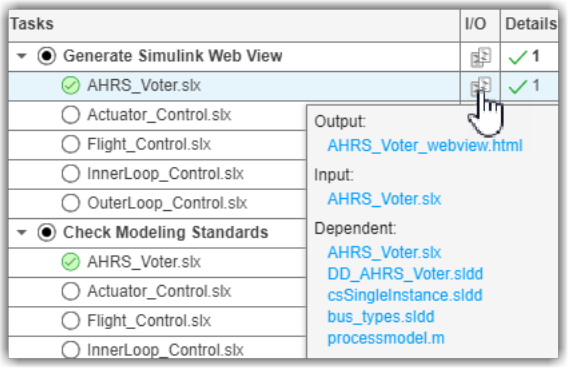
Icon Overview

The Process Advisor app uses the:

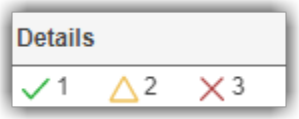
- **Tasks** column to show the statuses for the tasks and task iterations.



- **I/O** column to show the outputs from the tasks and task iterations.



- **Details** column to show detailed results for tasks and task iterations that specify result values.



Tasks Column

The status for the task or task iteration is shown on the left side of the **Tasks** column.

Statuses in the Tasks Column

Icon	Status of the Task or Task Iteration	Icon When Results Outdated	Icon When Incremental Builds Turned Off
	Not run.	Not applicable.	Uses same icon.
	Currently running.	Not applicable.	Uses same icon.
	Queued to run during the current build.	Not applicable.	Uses same icon.
	Passed.		
	Failed.		
	Generated an error.		
	Multiple statuses for different iterations of a task.		Uses same icon.

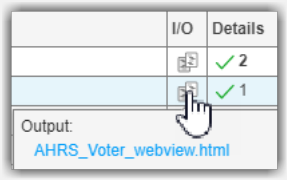
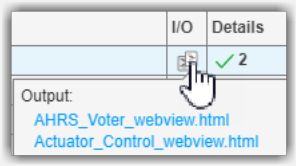
For more information on the task statuses, see the documentation for the `Status` property of the `padv.TaskResult` class in the Reference Book PDF.

Note Tasks that generated an error do not rerun automatically. To rerun an errored task, point to the task and click the run button or use `runprocess` with `RerunErroredTasks` as `true`.

I/O Column

The Process Advisor app shows the outputs from a task or task iteration when you point to the icon in the **I/O** column.

Outputs in the I/O Column

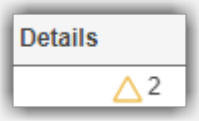
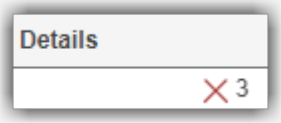
Icon	Description	Icon When Outdated
	The task or task iteration output a single artifact. 	
	The task or task iteration output multiple artifacts. 	

For more information on the outputs, see the documentation for the `OutputArtifacts` property of the `padv.TaskResult` class in the Reference Book PDF.

Details Column

Detailed results from a task or task iteration are shown in the **Details** column.

Results in the Details Column

Icon	Result Value	Result Value for the Task or Task Iteration	Icon When Outdated
	Pass.	The value to the right of the icon indicates the number of result values that passed. 	
	Warn.	The value to the right of the icon indicates the number of result values that generated a warning. Review the reports, outputs, or other results from the task. 	
	Fail.	The value to the right of the icon indicates the number of result values that failed. Review any reports, outputs, or other results from the task. 	

For more information on the detailed results, see the documentation for the `ResultValues` property of the `padv.TaskResult` class in the Reference Book PDF.

Author Your Process Model

This chapter describes how to use the customizable process modeling system to define your build and verification process:

Tip You can access API help from the MATLAB Command Window by using the `help` function.

For example, this code returns help information for the class `padv.Task`:

```
help padv.Task
```

The Reference Book PDF also includes documentation for the API and built-ins.

About the Process Model

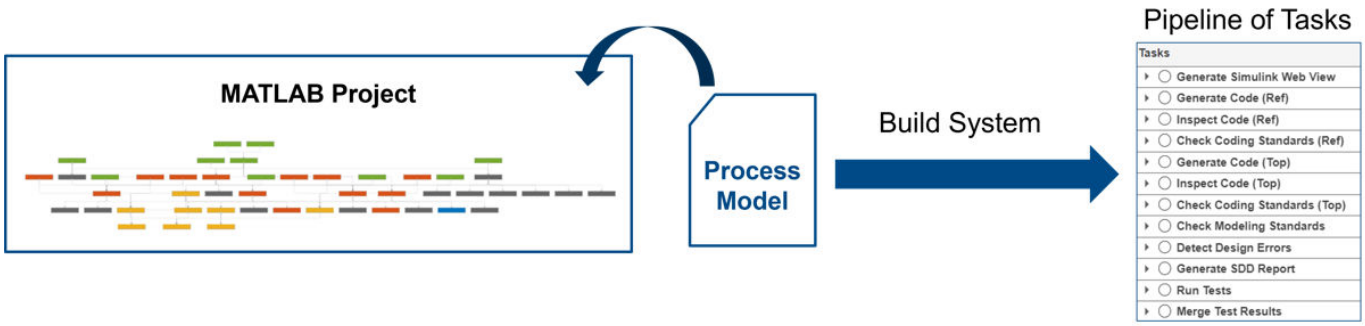
The support package has a customizable process modeling system that you can use to define your process. The support package also has a build system and front-end (Process Advisor app) for managing, deploying, and using your process. You can run the build system and Process Advisor locally on your desktop, and you can run the same build system in your CI environment.

The support package includes a default process model that can create an MBD pipeline. The default process model can create an MBD pipeline that contains several common model-based design tasks. You can modify the default `processmodel.m` file to fit your development process goals or you can create a new process model from an empty template. For more information, see "Modify Default Process Model to Fit Your Process".

Requirements

The Process Advisor app requires you to have:

- Your files in a project.
- A process model file (`processmodel.p` or `processmodel.m`) on the MATLAB path. If possible, place your process model file in the project root folder so changes to the process model file are tracked. If your project does not have a process model and you open the Process Advisor app, the Process Advisor automatically creates a default process model for you at the root of the project.



You define your pipeline of tasks in the process model. The *process model* is a file that specifies the tasks in the process, queries that determine which artifacts to use for each task, artifacts associated with each task, and dependencies between the tasks.

Your file serves as the process model if it meets the following criteria:

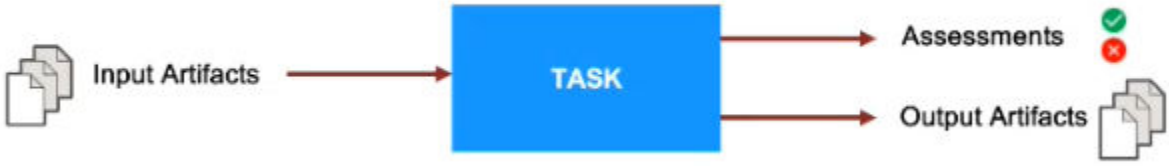
- The filename is `processmodel.p` or `processmodel.m`. If you have both a P-code file and a `.m` file, the P-code file takes precedence over the corresponding `.m` file for execution, even after modifications to the `.m` file.
- The file is in the project root folder.

You do not need to manually run the process model. The process model only defines the tasks that you want to include in your pipeline. When you run tasks by using the Process Advisor app or the build system API, the build system automatically loads the process model to create your pipeline of tasks.

Tasks and Queries

The process modeling system allows you to manage your process by using:

- Tasks — Individual steps in your process. Tasks can accept your project artifacts as inputs, perform actions, generate pass, fail, or warning assessments, and return project artifacts as outputs. Your process is a collection of steps that you want to perform on a project. There are built-in tasks for common tasks like running Model Advisor checks, generating code, and running tests, but you can also reconfigure the built-in tasks or create new custom tasks. For more information on the built-ins, see the "Built-In Task Library" in the Reference PDF. For information on custom tasks, see "Create Custom Task".



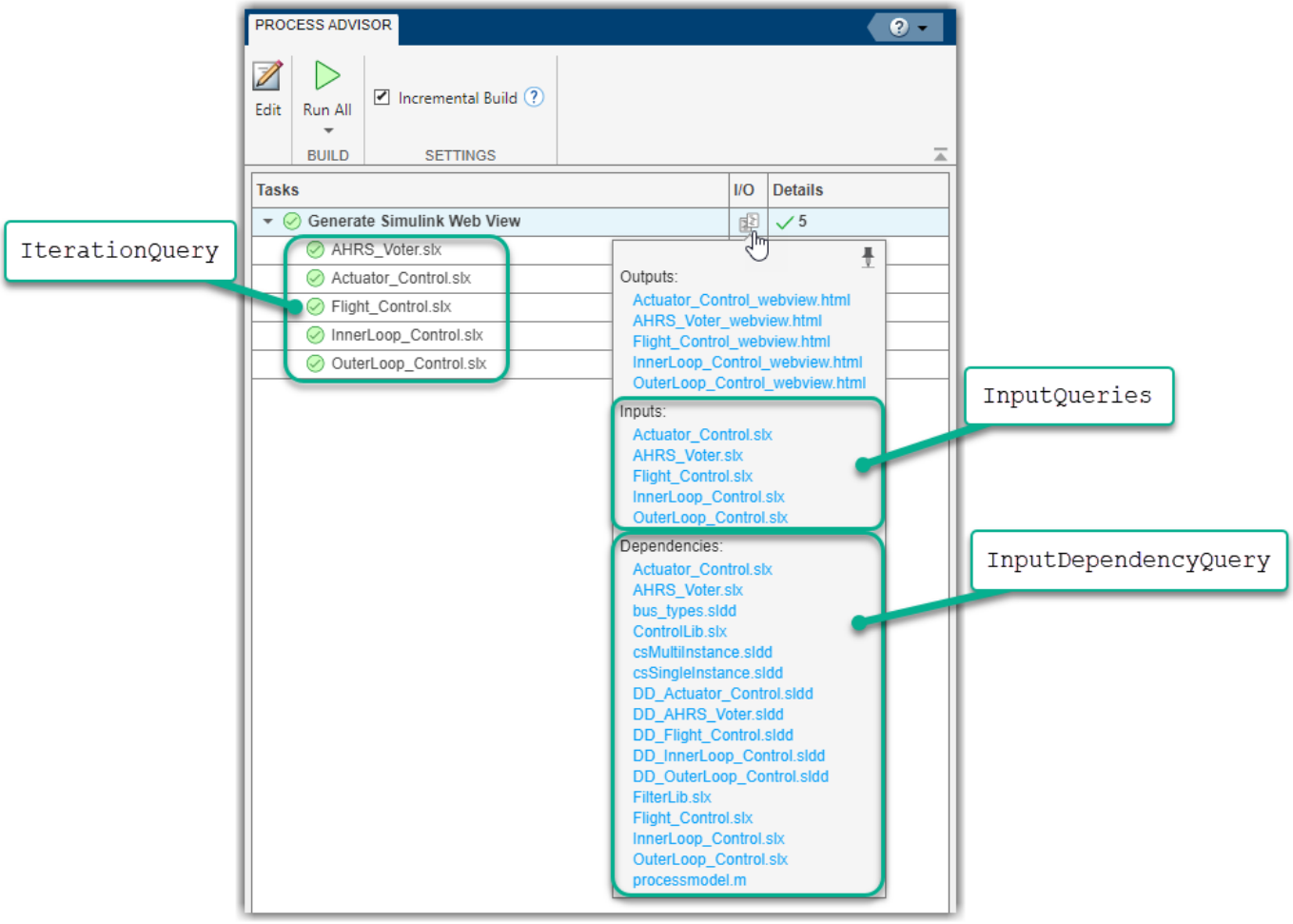
- Queries — Find artifacts in your project automatically, without needing to manually update a static list of files. You can use queries to find artifacts based on the artifact type, project label, file path, and other properties. There are built-in queries for finding artifacts based on specific search criteria, finding top models, and finding the artifact that a task performs an action on, but you can also create your own custom queries. For more information, see "Change How Often Tasks Run", "Add Inputs to Tasks", and "Create Custom Query".

When you add a task to your process model, you can use queries to specify:

- How often the task runs (defined by the `IterationQuery`)
- Additional inputs to the task (defined by the `InputQueries`)

For each task in the process, the build system runs the `IterationQuery` to determine which artifacts to run the task for. Most built-in tasks use the iteration query `IterationQuery = "padv.builtin.query.FindModels"` to run the task once for each model in the project. The build system then creates a task iteration, runs any additional queries the task needs, runs the task, and saves the task results. The task iteration is the pairing of the task to a specific artifact, for example running the **Generate Simulink Web View** task for the model `AHRS_Voter.slx`. The task iterations appear below the task title in the **Tasks** column in Process Advisor. If the iteration query does not return any results, the task no longer appears in Process Advisor.

For each task iteration, the build system runs the `InputQueries` to find the inputs for that specific task iteration. For each input, the build system runs the `InputDependencyQuery` to find any additional dependencies that can affect whether task results are up-to-date. The task inputs appear under **Inputs** and the additional dependencies appear under **Depenendencies** in the **I/O** column in Process Advisor.


PROCESS ADVISOR
Edit
Run All
BUILD
Incremental Build
SETTINGS
Tasks
I/O
Details
Generate Simulink Web View
5
AHRS_Voter.slx
Actuator_Control.slx
Flight_Control.slx
InnerLoop_Control.slx
OuterLoop_Control.slx
Outputs:
Actuator_Control_webview.html
AHRS_Voter_webview.html
Flight_Control_webview.html
InnerLoop_Control_webview.html
OuterLoop_Control_webview.html
Inputs:
Actuator_Control.slx
AHRS_Voter.slx
Flight_Control.slx
InnerLoop_Control.slx
OuterLoop_Control.slx
Dependencies:
Actuator_Control.slx
AHRS_Voter.slx
bus_types.sldd
ControlLib.slx
csMultiInstance.sldd
csSingleInstance.sldd
DD_Actuator_Control.sldd
DD_AHRS_Voter.sldd
DD_Flight_Control.sldd
DD_InnerLoop_Control.sldd
DD_OuterLoop_Control.sldd
FilterLib.slx
Flight_Control.slx
InnerLoop_Control.slx
OuterLoop_Control.slx
processmodel.m
IterationQuery
InputQueries
InputDependencyQuery

Modify Default Process Model to Fit Your Process

When your team has a standard process for local prequalification and CI builds, you can efficiently enforce guidelines and make collaboration easier. This example shows how to reconfigure the default process model to create a consistent, repeatable process that you can deploy to your team. In this example, you take the default process model and modify the tasks and queries to fit your requirements.

Create Process for Project

1. Open a project. You can use your own project, or, to use an example project, enter:

   ```
   processAdvisorExampleStart
   ```

2. Open Process Advisor on the project. In the **Project** tab, click **Process Advisor** or enter:

   ```
   processAdvisorWindow
   ```

   If your project does not have a process model, Process Advisor automatically creates a process model file, `processmodel.m`, at the root of the project. The `processmodel.m` file serves as the definition for your process. You do not need to manually run the `processmodel.m` file. Process Advisor automatically reads the process model and uses the file to determine which tasks to run, how the tasks perform their actions, and in which order the tasks need to run. The tasks defined in the process model appear in the **Tasks** column in Process Advisor and appear in the order that they run.

Note Alternatively, you can programmatically create a new process model by using the `createprocess` function. For example:

```
createprocess(Template="default",Overwrite=true)
```

Inspect Process

Inspect the process model. In the Process Advisor window, click the **Edit** button  .

Process Advisor opens the process model at the root of the project. The default process model contains built-in tasks for several common tasks like checking modeling standards with Model Advisor, running tests with Simulink Test, and generating code with Embedded Coder. But you can customize the process model to reconfigure the built-in tasks, add custom tasks, or remove tasks.

The default process model has four main sections. In the following diagram, the letters A, B, C, and D indicate the location of the sections in the default process model.

```
function processmodel(pm)
    % Defines the project's processmodel

    arguments
        pm padv.ProcessModel
    end

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    %% Include/Exclude Tasks in processmodel
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    includeModelStandardsTask = true;
    includeDesignErrorDetectionTask = false;
    includeSDDTask = true;
    includeSimulinkWebViewTask = true;
    includeTestsPerTestCaseTask = true;
    includeMergeTestResultsTask = true;
    includeGenerateCodeTask = true;
    includeAnalyzeModelCode = true && exist('polyspaceroot','file');
    includeCodeInspection = false;


    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    %% Define Variables
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    % Set default root directory for task results
    pm.DefaultOutputDirectory = fullfile('$PROJECTROOT$', 'PA_Results');
    defaultResultPath = fullfile( ...
        '$DEFAULTOUTPUTDIR$','$ITERATIONARTIFACT$');

    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
    %% Register Tasks
    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

    %% Checking model standards on a model
    if includeModelStandardsTask
        maTask = pm.addTask(padv.builtin.task.RunModelStandards());
        maTask.ReportPath = fullfile( ...
            defaultResultPath,'model_standards_results');
    end

    %% Run Design Error Detection (DED) on a model
    if includeDesignErrorDetectionTask
        dedTask = pm.addTask(padv.builtin.task.DetectDesignErrors()); %#ok<*UNRCH>
        dedTask.ReportFilePath = fullfile( ...
            defaultResultPath, 'design_error_detections','$ITERATIONARTIFACT$_DED');
    end
```

```
100
101     %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
102     %% Set Task relationships
103     %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
104
105     %% Set Task Dependencies
106     if includeGenerateCodeTask && includeCodeInspection
107         slciTask.dependsOn(codegenTask);
108     end
109     if includeGenerateCodeTask && includeAnalyzeModelCode
110         psTask.dependsOn(codegenTask);
111     end
112     if includeTestsPerTestCaseTask && includeMergeTestResultsTask
113         mergeTestTask.dependsOn(milTask, "WhenStatus",{'Pass','Fail'});
114     end
115
116     %% Set Task Run-Order
117     if includeModelStandardsTask && includeSimulinkWebViewTask
118         maTask.runsAfter(slwebTask);
119     end
120     if includeDesignErrorDetectionTask && includeModelStandardsTask
121         dedTask.runsAfter(maTask); %#ok<*NODEF>
122     end
123     if includeSDDTask && includeModelStandardsTask
124         sddTask.runsAfter(maTask);
125     end
126     if includeTestsPerTestCaseTask && includeModelStandardsTask
127         milTask.runsAfter(maTask);
128     end
129     % Set the code generation task to always run after Model Standards,
130     % System Design Description and Test tasks
131     if includeGenerateCodeTask && includeModelStandardsTask
132         codegenTask.runsAfter(maTask);
133     end
134     if includeGenerateCodeTask && includeSDDTask
135         codegenTask.runsAfter(sddTask);
136     end
137     if includeGenerateCodeTask && includeTestsPerTestCaseTask
138         codegenTask.runsAfter(milTask);
139     end
140     % Both the Polyspace Bug Finder (PSBF) and the Simulink Code Inspector
141     % (SLCI) tasks depend on the code generation tasks. SLCI task is set to
142     % run after the PSBF task without establishing an execution dependency
143     % by using 'runsAfter'.
144     if includeGenerateCodeTask && includeAnalyzeModelCode ...
145             && includeCodeInspection
146         slciTask.runsAfter(psTask);
147     end
148
```

C

D

Section A — Add or Remove Built-In Tasks

This section of the process model defines which built-in tasks are added to the process:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Include/Exclude Tasks in processmodel
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

includeModelStandardsTask = true;
includeDesignErrorDetectionTask = false;
includeSDDTask = true;
includeSimulinkWebViewTask = true;
includeTestsPerTestCaseTask = true;
includeMergeTestResultsTask = true;
includeGenerateCodeTask = true;
includeAnalyzeModelCode = true && exist('polyspaceroot','file');
includeCodeInspection = false;
```

You can update this section to add or remove built-in tasks from your process by setting the variable associated with a task to `true` or `false`.

For example, to add the design error detection task to your process, you can change line 13 in your `processmodel.m` file to specify:

```
includeDesignErrorDetectionTask = true;
```

The following table maps the variables in the process model to the associated built-in task title that appears in Process Advisor.

Variable	Task Title in Process Advisor
`includeModelStandardsTask`	**Check Modeling Standards**
`includeDesignErrorDetectionTask`	**Detect Design Errors**
`includeSDDTask`	**Generate SDD Report**
`includeSimulinkWebViewTask`	**Generate Simulink Web View**
`includeTestsPerTestCaseTask`	**Run Tests**
`includeMergeTestResultsTask`	**Merge Test Results**
`includeGenerateCodeTask`	**Generate Code**
`includeAnalyzeModelCode`	**Check Coding Standards**
`includeCodeInspection`	**Inspect Code**

In addition to the built-in tasks, you can also add custom tasks to your process model. For information on how to create and use custom tasks, see "Create Custom Task".

Section B — Change Behavior of Built-In Tasks

This section of the process model changes the values of built-in task properties to change how the tasks perform their actions:

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Register Tasks
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%% Checking model standards on a model
if includeModelStandardsTask
    maTask = pm.addTask(padv.builtin.task.RunModelStandards());
    maTask.ReportPath = fullfile( ...
        defaultResultPath,'model_standards_results');
end

...
```

For example, the built-in task `padv.builtin.task.RunModelStandards` has a property `ReportPath` that specifies where the task saves the output Model Advisor report. The default process model specifies that, for this process, the task should save the Model Advisor report in a subfolder named `model_standards_results`.

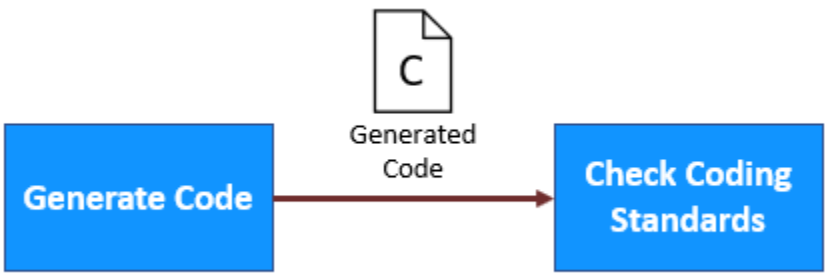
For more information on how to use the properties of built-in tasks to change their behavior, see "Change Task Behavior".

Section C — Specify Dependencies Between Tasks

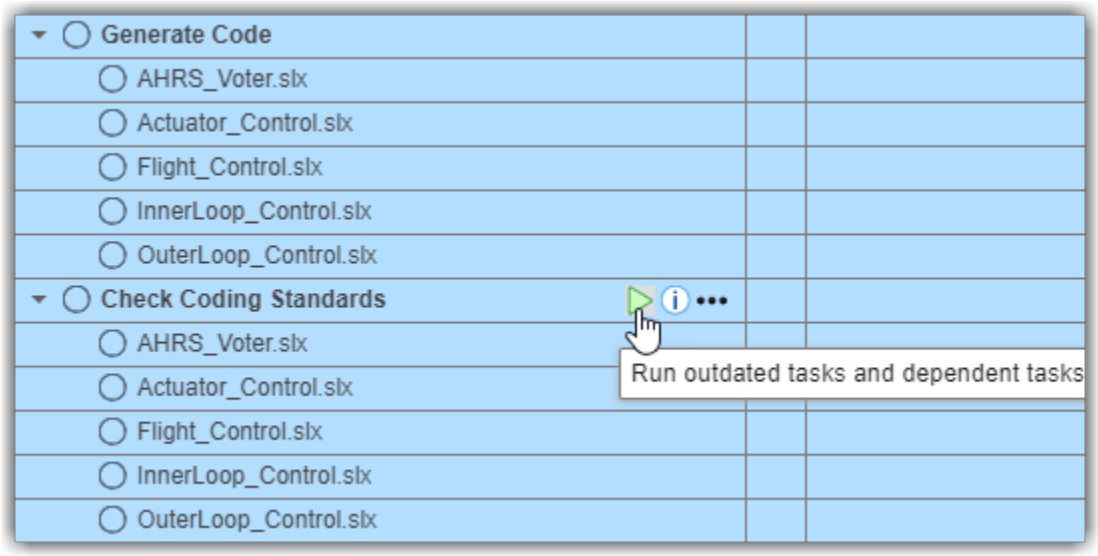
This section of the process model uses the `dependsOn` function to specify which tasks depend on other tasks in order to run successfully:

```
%% Set Task Dependencies
if includeGenerateCodeTask && includeCodeInspection
    slciTask.dependsOn(codegenTask);
end
if includeGenerateCodeTask && includeAnalyzeModelCode
    psTask.dependsOn(codegenTask);
end
if includeTestsPerTestCaseTask && includeMergeTestResultsTask
    mergeTestTask.dependsOn(milTask,"WhenStatus",{'Pass','Fail'});
end
```

For example, you need to generate code before you can use Polyspace to analyze the code. So the default process model specifies that the Polyspace task (`psTask`) depends on the code generation task (`codegenTask`).



If you open Process Advisor and point to the Polyspace task, Process Advisor highlights the dependency between the tasks. If you try to run the Polyspace task, the build system automatically runs the code generation task first.



For more information on task dependencies, see "Specify Dependencies Between Tasks".

Section D — Specify Preferred Task Execution Order

This section of the process model uses the `runsAfter` function to specify a preferred execution order for specific tasks:

```
%% Set Task Run-Order
if includeModelStandardsTask && includeSimulinkWebViewTask
    maTask.runsAfter(slwebTask);
end
if includeDesignErrorDetectionTask && includeModelStandardsTask
    dedTask.runsAfter(maTask);
end
if includeSDDTask && includeModelStandardsTask
    sddTask.runsAfter(maTask);

...
```

These tasks do not need to run in this order to run successfully, but the `runsAfter` function specifies that, if possible, the build system should try to run the tasks in this order.

For example, the default process model specifies that, if possible, the modeling standards task (`maTask`) should run after the Simulink web view task (`slwebTask`). The modeling standards task does not depend on any information from the Simulink web view task in order to run, but that is the preferred execution order for the tasks in this particular process.

For more information on task ordering, see "Specify Preferred Task Order".

Change Task Behavior

You can change the behavior of a built-in task by overriding the values of built-in task properties in the process model.

For example, the built-in task `padv.builtin.task.RunModelStandards` has several properties, like `CheckIDList`, `DisplayResults`, and `ExtensiveAnalysis`.

```
padv.builtin.task.RunModelStandards

ans =

  RunModelStandards with properties:

                     CheckIDList: <missing>
                  DisplayResults: "Summary"
               ExtensiveAnalysis: "on"
                           Force: "on"
                    ParallelMode: "off"
                    ReportFormat: "html"
                    ...
```

The task uses these properties to specify input arguments for the function `ModelAdvisor.run`. The property `CheckIDList` allows you to specify a list of Model Advisor checks that you want the task to run.

By default, the `padv.builtin.task.RunModelStandards` task runs a subset of high-integrity systems checks. But if you specify a new value for the `CheckIDList` property in the process model, the task will run those Model Advisor checks instead:

```
%% Checking model standards on a model
if includeModelStandardsTask
    maTask = pm.addTask(padv.builtin.task.RunModelStandards());
    maTask.ReportPath = fullfile( ...
        defaultResultPath,'model_standards_results');

    % Specify which Model Advisor checks to run
    maTask.CheckIDList = {'mathworks.jmaab.db_0032',...
        'mathworks.jmaab.jc_0281'};

end
```

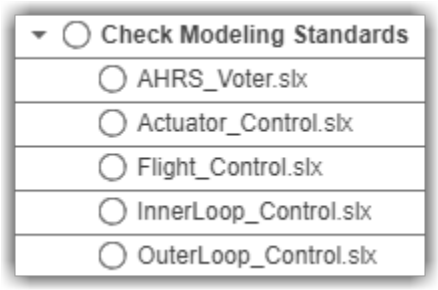
Note This example code shows how to specify a list of Model Advisor checks for the task to run. If you want to specify a Model Advisor configuration file instead, you need to provide the configuration file as an input to the task. For information, see "Add Inputs to Tasks".

For information on the built-in task properties, see the "Built-In Task Library" in the Reference Book PDF or open the source code for the built-in task. For example:

```
open padv.builtin.task.RunModelStandards
```

Change How Often Tasks Run

Most built-in tasks run once for each model in the project. For example, in the Process Advisor example project (`processAdvisorExampleStart`), the task **Check Modeling Standards** runs once for each of these models in the project and the model names appear below the task title in Process Advisor.



However, you can change the `IterationQuery` for a task to specify a different set of artifacts for the task. You must specify the value of `IterationQuery` as either a `padv.Query` object or the name of a `padv.Query`. For each task in the process, the build system runs the iteration query to determine which artifacts to run the task for. By default, the built-in tasks consider the artifacts returned by the iteration query as inputs to the task. Therefore the built-in tasks are able to run on each of the artifacts returned by the iteration query. The support package contains several built-in queries that you can use.

The most commonly used built-in queries are:

- `padv.builtin.query.FindModels` — Find models in the project
- `padv.builtin.query.FindTestCasesForModel` — Find test cases associated with a specific model in the project
- `padv.builtin.query.FindArtifacts` — Finds artifacts in the project that meet the criteria specified in the input arguments

Additionally, some built-in queries have optional arguments that you can use to filter certain artifacts out of the query results.

For information on the built-in queries, see the "Built-In Query Library" in the Reference Book PDF.

Tip You can also access help for the built-in queries from the MATLAB Command Window. For example, this code returns help information for the built-in query `padv.builtin.query.FindArtifacts`:

```
help padv.builtin.query.FindArtifacts
```

Only Run for Specific Models

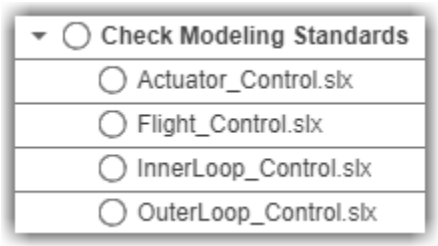
By default, the **Check Modeling Standards** task uses the built-in query `padv.builtin.query.FindModels` as the `IterationQuery`.

But suppose that you only want to run the **Check Modeling Standards** task for models that have `Control` in their file path. In the process model, you can change the `IterationQuery` for the task to:

1. Use the built-in query `padv.builtin.query.FindModels` to find the models in the project
2. Specify the `IncludePath` argument of the query to filter out any models that do not have `Control` in the file path

```
%% Checking model standards on a model
if includeModelStandardsTask
    maTask = pm.addTask(padv.builtin.task.RunModelStandards());
    maTask.ReportPath = fullfile( ...
        defaultResultPath,'model_standards_results');

    % Specify which set of artifacts to run for
    maTask.IterationQuery = ...
        padv.builtin.query.FindModels(IncludePath = 'Control')

end
```

In Process Advisor, the model `AHRS_Voter.slx` no longer appears under the task because `AHRS_Voter.slx` does not include `Control` in the path.



Only Run for Specific Test Cases

By default, the **Run Tests** task in the default process model uses the built-in query `padv.builtin.query.FindTestCasesForModel` as the `IterationQuery`. This means that the task runs once for each test case associated with models in the project.

But suppose that you only want to run the task for tests that use a specific project label. In the process model, you can change the `IterationQuery` for the task to:

1. Use the built-in query `padv.builtin.query.FindTestCasesForModel` to find the models in the project
2. Specify the `IncludeLabel` argument of the query to only include test cases that use a specific project label. In this example, the project label is `ModelTest` and the project label category is `TestType`.

```
%% Running tests on test case to test case basis
if includeTestsPerTestCaseTask
    milTask = pm.addTask(padv.builtin.task.RunTestsPerTestCase());
    % Configure the tests per testcase task
    milTask.OutputDirectory = fullfile( ...
        '$PROJECTROOT$','PA_Results','test_results');
```

```
        % Specify which set of artifacts to run for
        milTask.IterationQuery = ...
            padv.builtin.query.FindTestCasesForModel(IncludeLabel = {'TestType','ModelTest'});

    end
```

For more information on the built-in queries, see "Built-In Query Library" in the Reference Book PDF. If you need to perform a query that is not already covered by a built-in query, see "Create Custom Query".

Add Inputs to Tasks

By default, the built-in tasks automatically consider the artifacts returned by the `IterationQuery` as input artifacts to the task. But if you want to provide additional inputs to a task, you can add inputs to a task by using the `addInputQueries` function. The `addInputQueries` function adds input queries to the `InputQueries` property of the task. When you run a task, the build system runs the input queries of the task to find the input artifacts that the task can run on.

Use File as Input to Task

For example, by default, the **Check Modeling Standards** task runs a subset of high-integrity checks. But suppose that you want the task to run the Model Advisor checks specified by the Model Advisor configuration file `sampleChecks.json` instead. In the process model, you can use the `addInputQueries` function to specify an input query that finds the Model Advisor configuration file. You can use the built-in query `padv.builtin.query.FindFileWithAddress` as an input query to find the Model Advisor configuration file:

- The first argument, `'ma_config_file'`, specifies that the file is a Model Advisor configuration file.
- The second argument specifies the path to the Model Advisor configuration file.

```
%% Checking model standards on a model
if includeModelStandardsTask
    maTask = pm.addTask(padv.builtin.task.RunModelStandards());
    maTask.ReportPath = fullfile( ...
        defaultResultPath,'model_standards_results');

    % Specify which Model Advisor configuration file to run
    maTask.addInputQueries(padv.builtin.query.FindFileWithAddress( ...
        'ma_config_file', fullfile('tools','sampleChecks.json')));

end
```

Note If you specify both a list of check IDs (`CheckIDList`) and a Model Advisor configuration file for the **Check Modeling Standards** task, the task runs Model Advisor using the Model Advisor configuration file and ignores the list of check IDs.

Use Task Outputs as Task Inputs

Suppose that you want to pass the output of one task as the input to another task. You can use the built-in query `padv.builtin.query.GetOutputsOfDependentTask` to find the outputs of the predecessor task and specify that query as an input query for the task.

For example, the default process model specifies that the **Merge Test Results** task depends on the **Run Tests** task:

```
if includeTestsPerTestCaseTask && includeMergeTestResultsTask
    mergeTestTask.dependsOn(milTask, "WhenStatus",{'Pass','Fail'});
end
```

If you open the source code for the **Merge Test Results** task, you can see that the task uses the built-in query `padv.builtin.query.GetOutputsOfDependentTask` as an input query.

```
open padv.builtin.task.MergeTestResults

...
options.InputQueries = padv.builtin.query.GetOutputsOfDependentTask(...
    'padv.builtin.task.RunTestsPerTestCase');
options.InputDependencyQuery = padv.builtin.query.GetDependentArtifacts;
...
```

When you run the **Merge Test Results** task, the build system runs this input query, which passes the outputs of the **Run Tests** task as inputs to the **Merge Test Results** task.

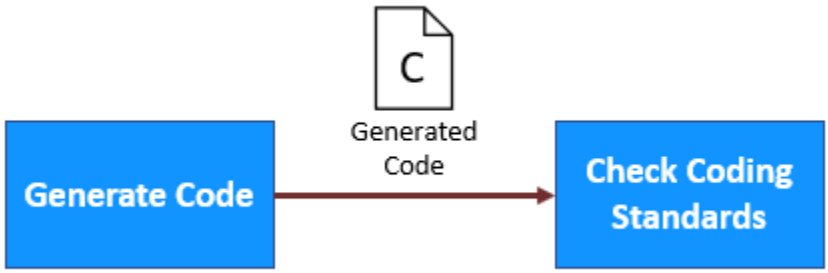
Task Relationships

When you author your process model, you might want to specify dependencies between tasks or specify a preferred task execution order. You can do this by adding a relationship between the tasks.

You can specify the relationship between two tasks as either a:

- `dependsOn` relationship — If a task should not run without another task running first, the task depends on the other task.

  For example, the **Check Coding Standards** task depends on the **Generate Code** task. Without the generated code, the **Check Coding Standards** task cannot run successfully.



- `runsAfter` relationship — If a task does not depend on another task, but you want the task to run after that other task, the task should run after the other task.

  For example, the default process model specifies that the **Check Modeling Standards** task should run after the **Generate Simulink Web View** task. The **Check Modeling Standards** task can run successfully without the **Generate Simulink Web View** task. But the default process model specifies that, if possible, the build system should generate the web view before checking modeling standards.

For information on the `dependsOn` relationship, see "Specify Dependencies Between Tasks". For information on the `runsAfter` relationship, see "Specify Preferred Task Order".

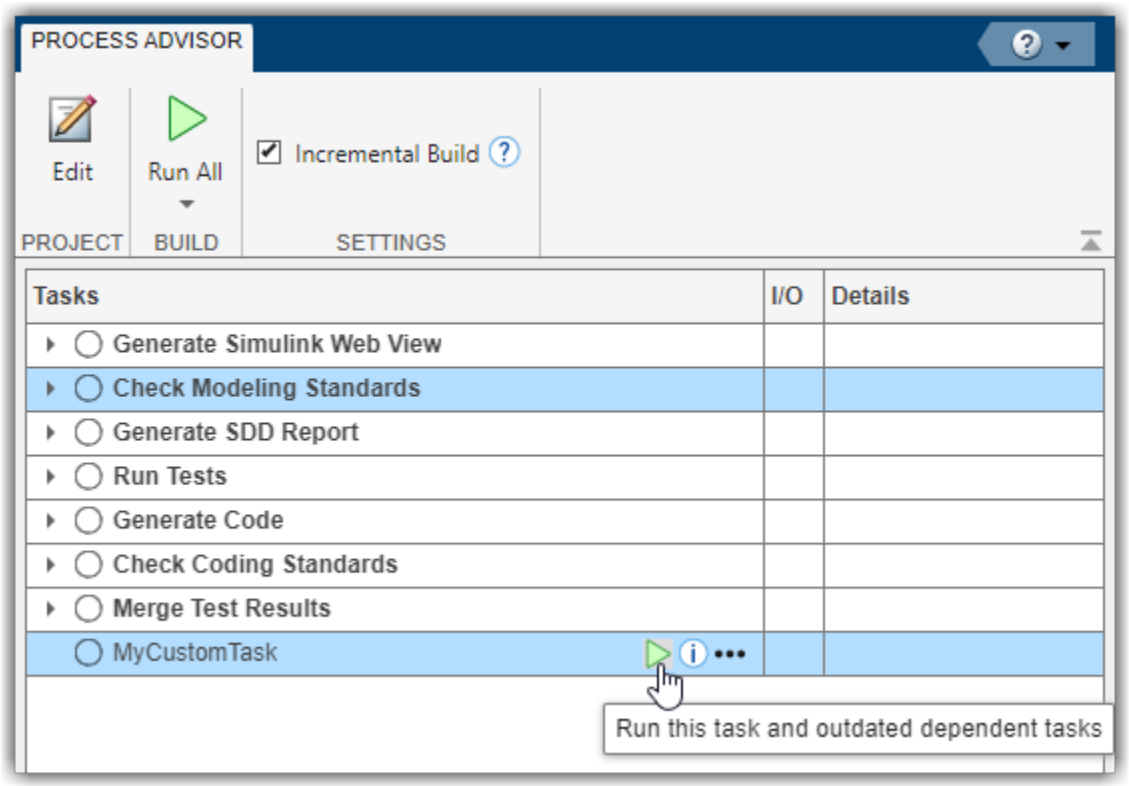
Specify Dependencies Between Tasks

You can use the `dependsOn` function in your process model to specify that a task depends on another task running first.

For example, to specify that a custom task, `MyCustomTask`, depends on the task **Check Modeling Standards**, use the `dependsOn` function on the task objects in your `processmodel.m` file:

```
% dependsOn(task,dependency)
dependsOn(taskObject,maTask);
```

If you open Process Advisor and point to a task that depends on another task, Process Advisor highlights the dependency.



If you try to run `MyCustomTask`, the build system will automatically run **Check Modeling Standards** first. By default, `MyCustomTask` will not run until **Check Modeling Standards** runs completely and returns a task status.

Note If you want to force a task to run independently, without dependent tasks running first, you can use the `Isolation` argument of `runprocess`:

```
runprocess(Task = taskIterationID, Isolation = true)
```

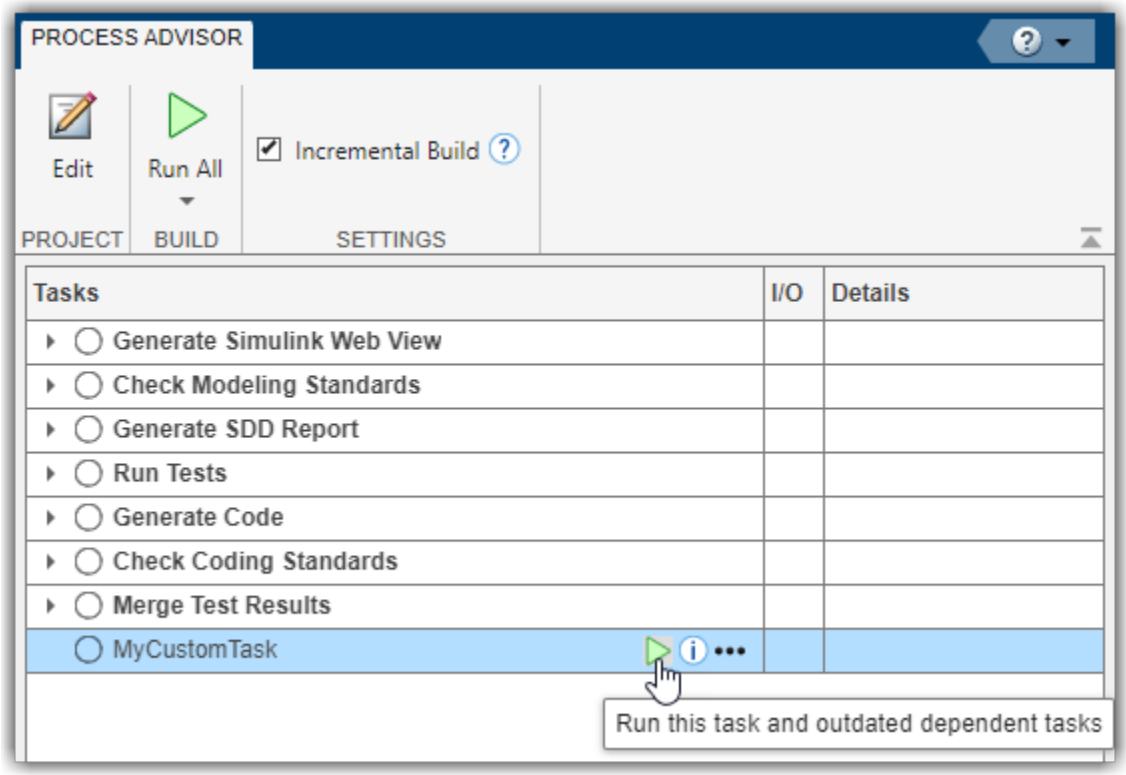
Specify Preferred Task Order

If a task does not depend on another task, but should run after that task, you can use the `runsAfter` function in your process model to specify your preferred task execution order. The build system will try to run the tasks in the order that you specify.

For example, to specify that a custom task, `MyCustomTask` (`taskObject`), should run after the **Generate Simulink Web view** task (`slwebTask`), you would add this code to the `processmodel.m` file:

```
% runsAfter(task,predecessors)
runsAfter(taskObject,slwebTask);
```

In Process Advisor, the tasks appears in the order that the build system will run them.



If a task **must always run** before another task, use `dependsOn` instead to make sure that both tasks always run together in sequence.

Note If you define multiple relationships between the same tasks, the build system only uses the most recent relationship and ignores previous relationships. For example, suppose you have a process model that contains:

```
runsAfter(taskA, taskB)
runsAfter(taskB, taskA) % build system only uses this relationship
```

This code defines a circular relationship between `taskA` and `taskB` because the code specifies both that `taskA` should run after `taskB` and that `taskB` should run after `taskA`.

By default, the build system ignores the first `runsAfter` command and only uses the second `runAfter` command.

If you want circular relationships to generate an error, specify the name-value argument `StrictOrdering` as `true`.

For example:

```
runsAfter(taskObject,slwebTask,...
    StrictOrdering = true); % error if this creates a circular relationship
```

Note By default, the build system only runs the predecessor tasks on artifacts that the task and the predecessor tasks have in common. If you need all task iterations of the predecessor tasks to run, specify `IterationArtifactMatching` as `false`.

For example:

```
runsAfter(taskObject,slwebTask,...
    IterationArtifactMatching = false); % run predecessor task on all its artifacts
```

Create Custom Task

The support package contains several built-in tasks that you can reconfigure and use to perform steps in your process. But if you need to perform a step that is not already covered by a built-in task, you can create your own custom task to use in your process model. You can define a custom task by using a MATLAB class.

Choose Superclass for Custom Task

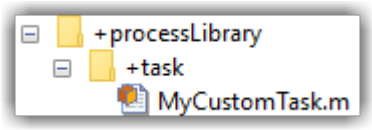
There are two ways to define custom tasks:

- Inherit from a built-in task — Use this approach if there is a built-in task that is similar to the custom task that you want to create. When you inherit from a built-in task, like `padv.builtin.task.RunModelStandards`, your custom task inherits the functionality of that task, but then you can override the properties and methods of the class to fit your needs.
- Inherit from `padv.Task` — Use this approach if your custom task needs to perform a step that is not similar to a built-in task. `padv.Task` is the base class of the built-in tasks, so you must completely define the inputs, functionality, and outputs of the task.

Define and Use Custom Task in Process

1 Create a new MATLAB class in your project.

Tip Package folders can help you organize the class definition files for your custom tasks. In the root of your project, create a folder `+processLibrary` with a subfolder `+task` and save your class in that folder.



---

2 Use one of these approaches to define your custom task:

- If you are inheriting from a built-in task, you can replace the contents of your class file with this example code:

```
classdef MyCustomTask < padv.builtin.task.RunModelStandards
    % task definition goes here
    methods
        function obj = MyCustomTask(options)
            arguments
                options.Name = "MyCustomTask";
                options.Title = "My Custom Task";
            end
            obj@padv.builtin.task.RunModelStandards(Name = options.Name);
            obj.Title = options.Title;
        end
    end
end
```

This code uses the built-in task `padv.builtin.task.RunModelStandards`, but you can change those lines of code to use any built-in task.

- If you are inheriting from `padv.Task`, you can replace the contents of your class file with this example code:

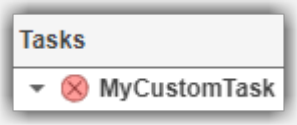
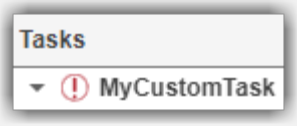
```
classdef MyCustomTask < padv.Task
    methods
        function obj = MyCustomTask(options)
            arguments
                % unique identifier for task
                options.Name = "MyCustomTask";
                % artifacts the task iterates over
                options.IterationQuery = "padv.builtin.query.FindModels";
                % input artifacts for the task
                options.InputQueries = "padv.builtin.query.GetIterationArtifact";
                % where the task outputs artifacts
                options.OutputDirectory = fullfile(...
                    '$DEFAULTOUTPUTDIR$','my_custom_task_results');
            end

            % Calling constructor of superclass padv.Task
            obj@padv.Task(options.Name,...
                IterationQuery=options.IterationQuery,...
                InputQueries=options.InputQueries);
            obj.OutputDirectory = options.OutputDirectory;
        end

        function taskResult = run(obj,input)
            % "input" is a cell array of input artifacts
            % length(input) = number of input queries

            % class definition goes here

            % specify results from task using padv.TaskResult
            taskResult = padv.TaskResult;
            taskResult.Status = padv.TaskStatus.Pass;
            % taskResult.Status = padv.TaskStatus.Fail;
            % taskResult.Status = padv.TaskStatus.Error;
        end
    end
end
```

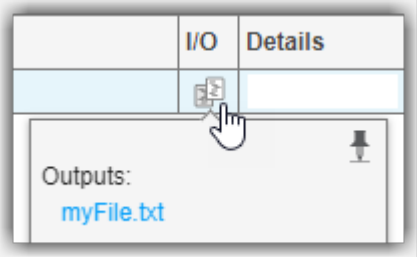
When you inherit from `padv.Task`, you must specify a `Name` (unique task identifier) and a `run` method (action that the task performs). Other class arguments are optional, but can help define the inputs and other properties of the task. Common class arguments that you might want to specify include:

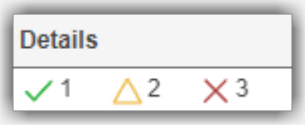
Argument	Description
`Name`	Unique identifier for task

Argument	Description
`IterationQuery` (optional)	Which artifacts the task iterates over. For example, to have the task run one time for each model in the project, specify `IterationQuery` as the built-in query `"padv.builtin.query.FindModels"`. By default, custom tasks run once on the project. If you only want the task to run once for your project, do not specify an `IterationQuery`.
`InputQueries` (optional)	Inputs to the task. For example, to have the task run on each artifact that the task iterates over, specify the built-in query `"padv.builtin.query.GetIterationArtifact"`. The query `padv.builtin.query.GetIterationArtifact` returns the current artifact that the task is iterating over.
`OutputDirectory` (optional)	Directory where the task outputs artifacts. **Note** If you want to generate CI pipeline with `padv.pipeline.generatePipeline`, you must specify an `OutputDirectory` for your custom task. The `OutputDirectory` argument specifies the directory where the outputs from the task are stored.

The `run` method must return a `padv.TaskResult` object. Process Advisor and the build system use the `padv.TaskResult` object to assess the status of your custom task. The task result properties `Status`, `OutputPaths`, and `ResultValues` correspond to the **Tasks**, **I/O**, and **Details** columns in Process Advisor:

Example Code	Appearance in Process Advisor
`taskResult.Status = padv.TaskStatus.Pass`	
`taskResult.Status = padv.TaskStatus.Fail`	
`taskResult.Status = padv.TaskStatus.Error`	

Example Code	Appearance in Process Advisor
`taskResult.OutputPaths=string(...` `fullfile("PA_Results","myFile.txt"));`	

`taskResult.ResultValues.Pass = 1;`
`taskResult.ResultValues.Warn = 2;`
`taskResult.ResultValues.Fail = 3;`
	

The example custom task calls the constructor of the superclass `padv.Task`. For information on superclass constructors, see https://www.mathworks.com/help/matlab/matlab_oop/subclass-constructors.html.

3 Add your custom task to your process model by using the `addTask` function. For example:

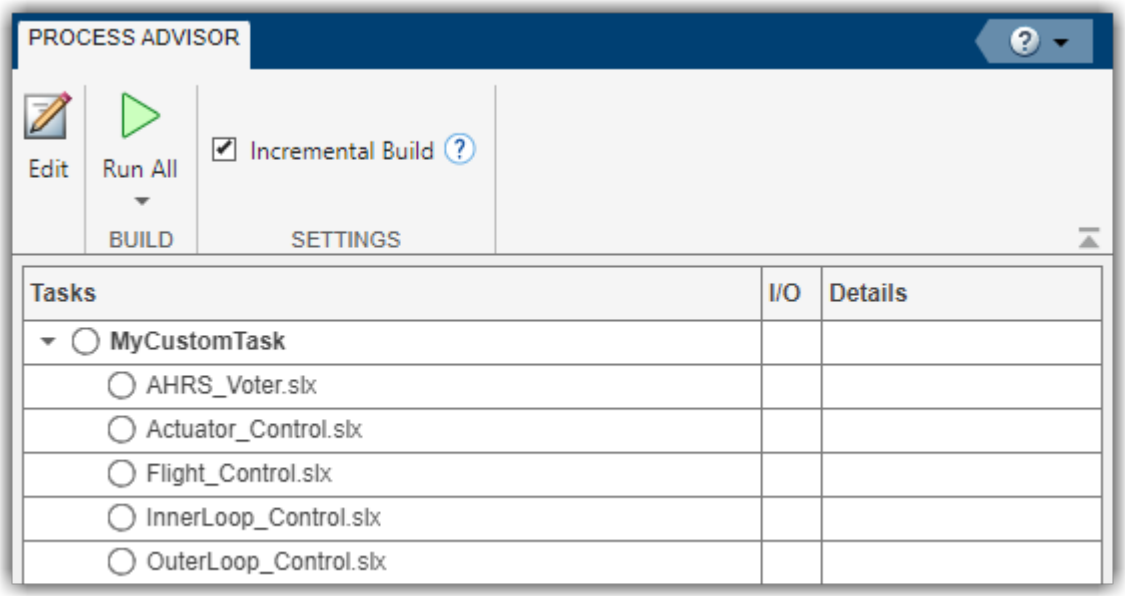
```
function processmodel(pm)
    % Defines the project's processmodel

    arguments
        pm padv.ProcessModel
    end

    addTask(pm,processLibrary.task.MyCustomTask);

end
```

This example assumes that you saved your class file in the `+task` subfolder inside the `+processLibrary` folder.

4 You can confirm that your custom task is in the process by opening Process Advisor. In the MATLAB Command Window, enter:

```
processAdvisorWindow
```

The custom task, `MyCustomTask`, is in the **Tasks** column.



5 Run the task to confirm that the custom task runs and returns the expected status and results.

Example Custom Tasks

Perform Post-Processing on Task Results

You can use custom tasks to perform pre-processing or post-processing actions. For example, suppose you want to run Model Advisor and if any checks generate a failure or a warning, you want the task to fail. There are no built-in tasks that perform this exact functionality by default, but the built-in task `padv.builtin.task.RunModelStandards` runs Model Advisor and the task fails if any of the checks generate a failure.

You can use a custom task to create your own version of `padv.builtin.task.RunModelStandards` that overrides the results from the task to specify that if any Model Advisor check returns a warning, the task should also fail.

This example shows a custom task that inherits from the built-in task `padv.builtin.task.RunModelStandards`, overrides the input queries to use the file `sampleChecks.json` as the Model Advisor configuration file, and extends the `run` method of the built-in task to fail the task if Model Advisor returns any warnings.

```
classdef MyRunModelStandards < padv.builtin.task.RunModelStandards
    % RunModelStandards, but use my Model Advisor configuration file
    % and fail the task if there are any warnings from Model Advisor checks

    methods
        function obj = MyRunModelStandards(options)

            arguments
                options.Name = "MyRunModelStandards";
                options.Title = "My Check Modeling Standards";
            end

            obj@padv.builtin.task.RunModelStandards(Name = options.Name);
```

```
            obj.Title = options.Title;
            % specify current model (iteration artifact) and
            % Model Advisor configuration file as inputs to the task
            obj.addInputQueries([padv.builtin.query.GetIterationArtifact,...
                padv.builtin.query.FindFileWithAddress('ma_config_file',...
                fullfile('tools','sampleChecks.json'))]);

        end

        function taskResult = run(obj,input)

            % use RunModelStandards to run Model Advisor
            taskResult = run@padv.builtin.task.RunModelStandards(obj,input);
            % If any checks for a model fail, then the status will be
            % set to fail.

            % But you can extend the built-in task to specify that
            % if any checks for a model generate a warning, then the
            % task status will also be set to fail.
            if taskResult.ResultValues.Warn > 0
                taskResult.Status=padv.TaskStatus.Fail;
            end

        end

    end

end
```

Note In this example, the `run` method of the custom task extends the `run` method of the built-in task by calling it from within the custom task `run` method. But you can also reimplement the `run` method for a custom task to implement your own version of the `run` method. For more information and common class designs, see:

https://www.mathworks.com/help/matlab/matlab_oop/modifying-superclass-methods-and-properties.html

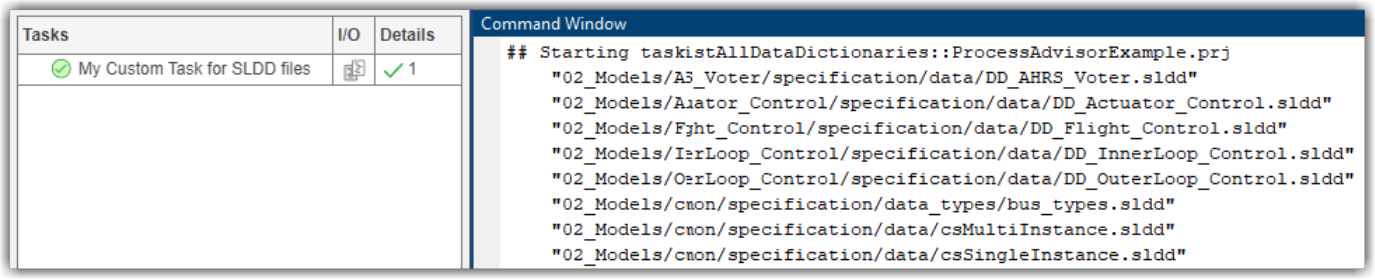
Run Custom Task for Project

Suppose that you want to return a list of the data dictionaries in your project. There are no built-in tasks that perform this functionality, so you can create a custom task that inherits directly from the base class `padv.Task` and use the arguments to specify the behavior of the custom task.

```
classdef ListAllDataDictionaries < padv.Task

    methods
        function obj = ListAllDataDictionaries(options)

            arguments
                options.InputQueries = padv.builtin.query.FindArtifacts(...
                    ArtifactType="sl_data_dictionary_file");
                options.Name = "ListAllDataDictionaries";
            end
                inputQueries = options.InputQueries;
                obj@padv.Task(options.Name, ...
```

```
                    Title = "My Custom Task for SLDD files", ...
                    InputQueries = inputQueries, ...
                    DescriptionText = "My Custom Task for SLDD files", ...
                    Licenses={});
        end

        function taskResult = run(~, input)
            % Print names of SLDDs
            disp([input{1}.Address]')
            taskResult = padv.TaskResult;
            taskResult.Status = padv.TaskStatus.Pass;
            taskResult.ResultValues.Pass = 1;
        end
    end
end
```

In the custom task, you can find the data dictionaries in the project by using the query `padv.builtin.query.FindArtifacts` and specifying the query as one of the `InputQueries` for the task. In the `run` function, you can specify the action that the task performs and specify the task results, in a format that Process Advisor can recognize, by using a `padv.TaskResult` object. The `input` is a cell array of input artifacts that the build system automatically creates based on the `InputQueries` that you specify. In this example, the first cell in `input` is an array of `padv.Artifact` objects that represent the data dictionaries in the project. The `disp` function can display the addresses of the data dictionaries in the MATLAB Command Window. When you specify the task result `Status`, that sets the task status in the **Tasks** column in Process Advisor. `ResultValues.Pass` sets the number of passing results in the **Details** column in Process Advisor.



Create Custom Query

To find artifacts in your project, you can use the built-in queries that ship with the support package or you can create your own custom queries. Use the built-in queries whenever possible. If your use case requires custom queries, use the following steps to create a custom query. Note that to reconfigure the functionality of a built-in task, your custom queries can inherit from a built-in query.

After you create a custom query, you can use that query as an input query for a task to modify or filter the task inputs.

Choose Superclass for Custom Query

There are two ways to define custom queries:

- Inherit from a built-in query — Use this approach if there is a built-in query that is similar to the custom query that you want to create. When you inherit from a built-in query, like `padv.builtin.query.FindArtifacts`, your custom query inherits the functionality of that query, but then you can override the properties and methods of the class to fit your needs.
- Inherit from `padv.Query` — Use this approach if your custom query needs to find artifacts in a way that is not similar to a built-in query. `padv.Query` is the base class of the built-in queries, so you must completely define the functionality of the query.

Define and Use Custom Query in Process

1. Create a new MATLAB class in your project.

   Tip Package folders can help you organize the class definition files for your custom queries. In the root of your project, create a folder `+processLibrary` with a subfolder `+query` and save your class in that folder.

2. Use one of these approaches to define your custom query:

   - If you are inheriting from a built-in query, you can replace the contents of your class file with this example code:

     ```
     classdef MyCustomQuery < padv.builtin.query.FindArtifacts
         % query definition goes here
         % by default, this query finds all artifacts in the project
     end
     ```

     This example query inherits from the built-in query `padv.builtin.query.FindArtifacts`, but you can change that line of code to inherit from any built-in query. Use the properties of the query to specify which sets of artifacts you want the query to return. For examples, see the next section, "Example Custom Queries".

   - If you are inheriting from `padv.Query`, you can replace the contents of your class file with this example code:

     ```
     classdef MyCustomQuery < padv.Query

         methods
             function obj = MyCustomQuery(NameValueArgs)
                 obj@padv.Query("MyCustomQuery");
             end
     ```

```
            function artifacts = run(obj,~)
                artifacts = padv.Artifact.empty;
                    % Core functionality of the query goes here
                % artifacts = padv.Artifact(artifactType,...
                    % padv.util.ArtifactAddress(fullfile(fileparts);

            end
        end
    end
```

A query must have:

- a unique name, specified using the `Name` property
- a `run` function that returns either a `padv.Artifact` object or array of `padv.Artifact` objects. For more information, see "padv.Artifact" in the Reference Book PDF.

3 You can use your custom query in your process model. For example, you can control which artifacts a task iterates over by using your custom query as the iteration query for a task:

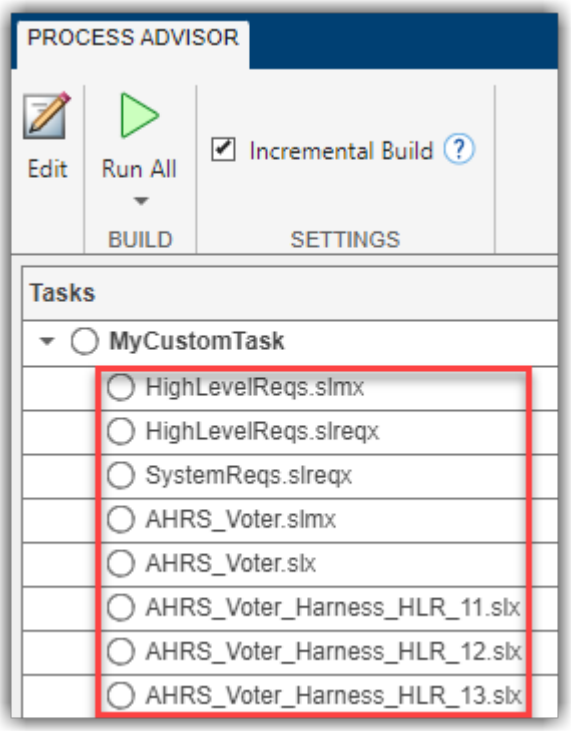
```
function processmodel(pm)
    % Defines the project's processmodel

    arguments
        pm padv.ProcessModel
    end

    t = addTask(pm,"MyCustomTask",...
        IterationQuery = processLibrary.query.MyCustomQuery);

end
```

This example assumes that you saved your class file in the `+query` folder inside the `+processLibrary` folder.

4 You can confirm which artifacts your task iterates over by opening Process Advisor. In the MATLAB Command Window, enter:

```
processAdvisorWindow
```

The artifacts that the task iterates over appear under the task name in the **Tasks** column.



Example Custom Queries

Run Task on Data Dictionaries in Project

Suppose you want to find each of the data dictionaries in your project. There are no built-in queries that perform this functionality by default, but there is a built-in query `padv.builtin.query.FindArtifacts` that can find artifacts that meet certain search criteria. Effectively you can create your own version of the built-in query, but specialized to only find data dictionaries. You can create a class-based, custom query that inherits from `padv.builtin.query.FindArtifacts` and specifies the `ArtifactType` argument as a Simulink data dictionary.

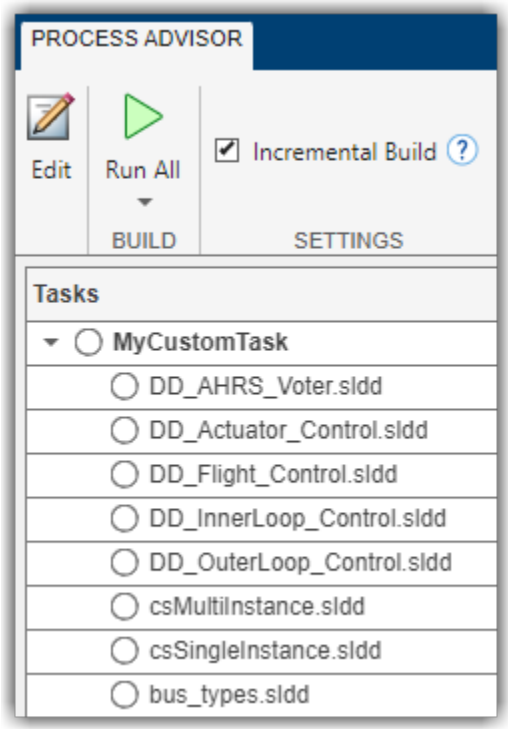
```
classdef FindSLDDs<padv.builtin.query.FindArtifacts
%FindSLDDs This query is like FindArtifacts, but only returns data dictionaries.

    methods
        function obj = FindSLDDs(NameValueArgs)
            arguments
                NameValueArgs.ArtifactType string = "sl_data_dictionary_file";
            end

            obj.Name = "FindSLDDs";
            obj.ArtifactType = NameValueArgs.ArtifactType;

        end
    end
end
```

The example class `FindSLDDs` inherits its properties and run function from the built-in query `padv.builtin.query.FindArtifacts`, but specifies a unique `Name` and `ArtifactType`. The

`ArtifactType` is specified as `sl_data_dictionary_file` because that is the artifact type associated with Simulink data dictionary files. For a list of the valid artifact types, see the "Artifact Types" chapter in the Reference Book PDF.

You can have a task run once for each data dictionary in your project by using the custom query as the iteration query for the task.

```
function processmodel(pm)
    % Defines the project's processmodel

    arguments
        pm padv.ProcessModel
    end

    t = addTask(pm,"MyCustomTask",...
        IterationQuery = processLibrary.query.FindSLDDs);

end
```



Test Tasks and Queries

If you are trying to debug or test a task or query, it can be helpful to run the task or query directly from the MATLAB Command Window. To test a task, you can find the ID for a specific task iteration and use the `runprocess` function to run that task iteration. To test a query, you can create an instance of the query and use the `run` function to get the artifacts that the query returned.

This example shows how to test a built-in query and then use the artifacts that the query returns to test a built-in task.

1 Open a project. For this example, you can open the Process Advisor example project.

```
processAdvisorExampleStart
```

2 Suppose that you want to test the query `padv.builtin.query.FindModels`. You can create an instance of this query. In the MATLAB Command Window, enter:

```
q = padv.builtin.query.FindModels;
```

3 To see which artifacts the query returns, run the query.

```
artifacts = run(q)
```

```
artifacts =

  1×5 Artifact array with properties:

    Type
    Parent
    ArtifactAddress
```

In this example, the query returns the five models in the example project.

Tip If you open the `ArtifactAddress` property, you can see the names of each of the models returned by the `padv.builtin.query.FindModels` query.

```
artifacts.ArtifactAddress
```

---

4 To filter the artifacts returned by the query, you can modify the behavior of the query using the name-value arguments. For example, to exclude artifacts that contain `Control` in the file path, you would specify:

```
q = padv.builtin.query.FindModels(ExcludePath = "Control");
```

5 Re-run the query to see the updated query results.

```
artifacts = run(q)
```

```
artifacts =

  Artifact with properties:

                Type: "sl_model_file"
              Parent: [0×0 padv.Artifact]
     ArtifactAddress: [1×1 padv.util.ArtifactAddress]
```

For this example, the query returns a single Simulink model, `AHRS_Voter.slx`, since `AHRS_Voter.slx` is the only model that does not contain `Control` in its file path.

```
artifacts.ArtifactAddress

ans =

ArtifactAddress

          FileAddress: "02_Models/AHRS_Voter/specification/AHRS_Voter.slx"
        OwningProject: "ProcessAdvisorExample"
    IsSubFileArtifact: 0
```

6. Suppose that you want to test the task `padv.builtin.task.GenerateSimulinkWebView`. You can create an instance of this query. In the MATLAB Command Window, enter:

```
t = padv.builtin.task.GenerateSimulinkWebView;
```

7. Then suppose that you want to test that task on the `AHRS_Voter` model returned in `artifacts`. You can use the function `createProcessTaskID` to generate the ID for the task iteration.

```
id = createProcessTaskID(t,artifacts(1))
```

Note The `createProcessTaskID` function expects you to specify a task and a single artifact. Make sure the task exists in the process model and the artifact exists in the project. Otherwise, `runprocess` cannot run for that task iteration.

---

8. Run the task iteration by using the `runprocess` function.

```
runprocess(Task = id)
```

Tip You can use the name-value arguments of `runprocess` to specify how the task iteration runs. For example, `Force = true` forces the task iteration to run, even if the results are already up-to-date and `Isolation = true` has the task iteration run without running any of its dependencies.

```
runprocess(Task = id, Force = true, Isolation = true)
```

For more information, see "runprocess" in the Reference Book PDF or, in the MATLAB Command Window, enter:

```
help runprocess
```

Example Process Models

Add One Built-In Task and One Custom Task

```
function processmodel(pm)
    arguments
        pm padv.ProcessModel
    end

     % Adding a built-in task
     task1 = addTask(pm,padv.builtin.task.RunModelStandards);

     % Adding a custom task
     task2 = addTask(pm,"Custom Task",Action=@CustomAction);

     % Specify that the custom task should run after the built-in task
     runsAfter(task2,task1);

end

 function results = CustomAction(~)
     disp("Hello, world")
     results = padv.TaskResult;
 end
```

Specify a Task Execution Order

```
function processmodel(pm)
    arguments
        pm padv.ProcessModel
    end

     %% ADD CUSTOM TASKS TO THE PROCESS MODEL
     task1 = addTask(pm,"Task 1");
     task2 = addTask(pm,"Task 2");
     task3 = addTask(pm,"Task 3");
     task4 = addTask(pm,"Task 4");
     task5 = addTask(pm,"Task 5");

     %% SPECIFY THE TASK EXECUTION ORDER
     % task2 must run after task1
         runsAfter(task2,task1,StrictOrdering=true);
     % task3 should run after task2
     % but task3 can run independently
         runsAfter(task3,task2);
     % task4 should run after task3
     % but task4 can run independently
         runsAfter(task4,task3);
     % task5 must run after task4
         runsAfter(task5,task4,StrictOrdering=true);

end
```

Include Multiple Instances of a Task

If you include duplicates of a task, the Process Advisor will return an error:`Invalid definition in 'processmodel.m' file. Unable to add task because a task named` *`taskName`* `already exists.`

To include multiple instances of the same type of task, you need to specify different values of `Name` for each of the tasks. For built-in tasks, you need to override the `Name` when you create the task iteration.

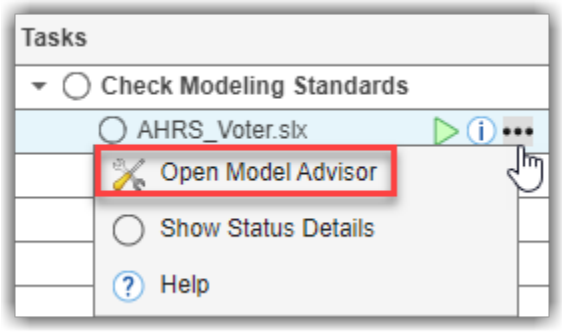
For example, suppose you want to add two versions of the built-in task `padv.builtin.task.RunTestsPerTestCase`. When you create an instance of the task by using `padv.builtin.task.RunTestsPerTestCase`, you need to specify a different value for the `Name`.

```
function processmodel(pm)
    arguments
        pm padv.ProcessModel
    end
    taskA_v1 = addTask(pm,...
        padv.builtin.task.RunTestsPerTestCase(Name="Something else"),...
        Title="Task A - Version 1");
    taskA_v2 = addTask(pm, padv.builtin.task.RunTestsPerTestCase,...
        Title="Task A - Version 2");
end
```

You can then specify different values for the `IterationQuery` so that the tasks operate on different sets of artifacts. For an example, see the documentation for the built-in query `padv.builtin.query.FindTestCasesForModel` in the Reference Book PDF.

Specify Which Tool to Launch for a Custom Task

When you point to a task in the Process Advisor app, you can click the ellipsis (**...**) to see more options. For built-in tasks, you have the option to launch a tool associated with the task. For example, the built-in task **Check Modeling Standards** allows you to directly open Model Advisor for the model that the task iteration runs on.



For custom tasks, you can specify the property `LaunchToolAction` to associate a tool with the options menu for the task.

For example, suppose you have a custom task that runs on each model in the project and you want the task to launch the Dependency Analyzer for the model. For `LaunchToolAction`, specify the handle to a function that launches the tool.

```
function processmodel(pm)
    % Defines the project's processmodel

    arguments
        pm padv.ProcessModel
    end

    customTask = addTask(pm,"MyCustomTask",...
        IterationQuery = padv.builtin.query.FindModels,...
        InputQueries = padv.builtin.query.GetIterationArtifact,...
        LaunchToolAction=@myLaunchToolAction);

end

function result = myLaunchToolAction(obj, artifact)

     result = struct('ToolLaunched', false);

     % identify model name
     [~,modelName,~] = fileparts(artifact.Address);

     % open Dependency Analyzer for model
     depview(modelName)

     result.ToolLaunched = true;

end
```

The function that launches the tool has two inputs, `obj` and `artifact`, and must return a `result` structure with the status of the tool launch action, `ToolLaunched`.

Note Although you can launch other tools from the Process Advisor app, make sure you use the Process Advisor app or build system to run your tasks and to collect task results. The app and build system might not detect changes to settings, files, or task results from actions that you perform in other tools.

Control Builds

This chapter describes how to run builds and customize build execution:

Run Tasks in MBD Pipeline Using Build System

You can run tasks programmatically by using the `runprocess` function.

- To run each of the tasks associated with the current project, enter:

  ```
  runprocess()
  ```

- To run a specific set of tasks, specify a list of tasks by using the `Tasks` argument. For example, you can specify the relative path to a model, use the `generateProcessTasks` function to list the tasks, and then specify the `Tasks` argument.

  ```
  % specify the relative path to the model AHRS_Voter
  model = padv.Artifact("sl_model_file",...
  padv.util.ArtifactAddress(...
  fullfile("02_Models","AHRS_Voter","specification","AHRS_Voter.slx")));

  % find the tasks associated with the model AHRS_Voter
  ahrsVoterTasks = generateProcessTasks(FilterArtifact=model)

  % run only the ahrsVoterTasks
  runprocess(Tasks=ahrsVoterTasks)
  ```

  For more information, see the documentation in the Reference Book PDF.

Incremental Builds

By default, the build system and the Process Advisor app perform incremental builds. Incremental builds can help you reduce the number of task iterations that you need to re-run by identifying and running only the task iterations with outdated results. If the task iteration results are up-to-date, the build system and the Process Advisor app skip the task iteration.

How to Disable Incremental Builds

If you want to force the build system and the Process Advisor app to re-run task iterations, you can disable incremental builds for the project. When you disable incremental builds, the build system and the **Process Advisor** app do not identify any results as up-to-date or outdated, and effectively force run task iterations in the project. In the **Process Advisor** app, in the **Tasks** column, the statuses for tasks and task appear in black because the app is no longer identifying up-to-date or outdated results. The statuses only indicate whether the task or task iteration passed, failed, generated an error, or did not run.

You can disable incremental builds by using one of the following approaches:

- In the Process Advisor app, in the toolstrip, clear the check box for the **Incremental Build** option.
- Create a `padv.Preferences` object and specify the property `IncrementalBuild` as `false`. For example:

  ```
  PREF = padv.Preferences;
  PREF.IncrementalBuild = false;
  ```

  Note that `padv.Preferences` do not persist if you restart your MATLAB session or if you run `clear classes`. To create preferences that the **Process Advisor** app and build system will use each time they run on your project, create a project startup script that specifies the properties for `padv.Preferences`.

Build System API Overview

Run Tasks in Pipeline

You can run tasks programmatically by using the `runprocess` function.

- To run each of the tasks associated with the current project, enter:

  ```
  runprocess()
  ```

- To run a specific set of tasks, specify a list of tasks by using the `Tasks` argument. For example, you can specify the relative path to a model, use the `generateProcessTasks` function to list the tasks, and then specify the `Tasks` argument.

  ```
  % specify the relative path to the model AHRS_Voter
  model = padv.Artifact("sl_model_file",...
  padv.util.ArtifactAddress(...
  fullfile("02_Models","AHRS_Voter","specification","AHRS_Voter.slx")));

  % find the tasks associated with the model AHRS_Voter
  ahrsVoterTasks = generateProcessTasks(FilterArtifact=model)

  % run only the ahrsVoterTasks
  runprocess(Tasks=ahrsVoterTasks)
  ```

View Available Tasks in Pipeline

- Use the `generateProcessTasks` function to return a list of the available tasks in the current process model.

  ```
  generateProcessTasks
  ```

- List a set of specific tasks by using the `FilterArtifact` argument. For example, you can specify the relative path to a model and list the associated tasks.

  ```
  % specify the relative path to the model AHRS_Voter
  model = padv.Artifact("sl_model_file",...
  padv.util.ArtifactAddress(...
  fullfile("02_Models","AHRS_Voter","specification","AHRS_Voter.slx")));

  % find the tasks associated with the model AHRS_Voter
  ahrsVoterTasks = generateProcessTasks(FilterArtifact=model)
  ```

Generate Build Report

You can generate a report that summarizes the build results for the tasks that you run in your pipeline.

The report includes a:

- Summary of task statuses
- Summary of task results
- Details about the task configuration and execution

For example, if you run the tasks in the default MBD pipeline, the report provides an overview of the:

- Model Advisor analysis, including the number of passing, warning, and failing checks
- Test results, organized by iteration
- Generated code files
- Coding standards checks

Generate Report After Running Process

To automatically generate a report after you run your process, specify the `GenerateReport` argument of the `runprocess` function as `true`:

```
runprocess(GenerateReport = true)
```

By default, the report generates as a PDF file in the current working directory. You can use the `ReportFormat` and `ReportPath` arguments to specify a different report format and a different report name or full file path:

```
runprocess(GenerateReport = true,...
ReportFormat = "html-file",...
ReportPath = fullfile(pwd,"folderName","reportName"))
```

Generate Report from Recent Task Results

After you run the tasks in your pipeline, you can also generate a report using the most recent task results.

After you run a task, create a `padv.ProcessAdvisorReportGenerator` report object.

```
rptObj = padv.ProcessAdvisorReportGenerator;
```

Run `generateReport` on the report object to generate a build report in the current directory.

```
generateReport(rptObj)
```

By default, the report generator generates a PDF. To generate an HTML report, specify the `Format` of the `ProcessAdvisorReportGenerator` object as `html-file`.

```
htmlReport=padv.ProcessAdvisorReportGenerator(Format="html-file");
generateReport(htmlReport);
```

Best Practices for Effective Builds

The following are best practices for an effective build schedule:

- For builds that you perform on a daily or more frequent basis, use incremental builds. Incremental builds are faster and more efficient, but incremental builds skip tasks that the build system considers up to date.

  By default, the function `runprocess` performs an incremental build:

  ```
  runprocess()
  ```

  If you use a pull request workflow, incremental builds are helpful for efficiently prequalifying changes before merging with the main repository.
- Outside of the normal build schedule, you should run a full (non-incremental) build at least one time per week and anytime you are qualifying software for a release. When you run a full build, the build system force runs each of the tasks in the pipeline. The full build makes sure that each task in the pipeline executes and that the output artifacts reflect the latest changes.

  To run a full build, use the function `runprocess` with the argument `Force` specified as `True`:

  ```
  runprocess(Force=true)
  ```

  The `Force` argument forces tasks in the pipeline to execute, even if the tasks already have up to date results.

For more information, see "Incremental Builds" section in this PDF and the documentation for the `runprocess` function in the Reference Book PDF.

Integrate into CI

This chapter describes how to integrate MathWorks tools into a CI system using the support package CI/CD Automation for Simulink Check:

Prerequisites

Before integrating with a CI system:

1. Check that the CI system can run MATLAB. For information on the supported platforms, see https://www.mathworks.com/help/matlab/matlab_prog/continuous-integration-with-matlab-on-ci-platforms.html.

   Note License Considerations for CI: If you plan to perform CI on many hosts or on the cloud, contact MathWorks (continuous-integration@mathworks.com) for help. Transformational products such as MathWorks coder and compiler products might require client access licenses (CAL).

2. Install the support package CI/CD Automation for Simulink Check on the MATLAB instance or instances that run in your CI system. For information on how to use the support package with Docker, see "Create Docker Container for Support Package".

For related information on how CI/CD can apply to model-based design, see https://www.mathworks.com/company/newsletters/articles/continuous-integration-for-verification-of-simulink-models.html.

How Pipeline Generation Works

A *pipeline* is a collection of automated procedures and tools that execute in a specific order to enable a streamlined software delivery process. CI systems allow you to define and configure a pipeline by using a pipeline file.

- In GitLab, you can configure your pipeline by using a `.yml` file that you store in your project. The `.yml` file can configure different parts of your CI/CD jobs including the stages of the job, the tag for your GitLab Runner, the script that the Runner executes, and artifacts you want to attach to a successful job. The support package contains an example pipeline configuration file, `.gitlab-ci.yml`, that you can use in your project.
- In Jenkins, you can configure your pipeline by using a Jenkinsfile that you store in your project. The Jenkinsfile can configure different parts of your CI/CD jobs including the stages of the job, the label for the Jenkins agent that executes the pipeline, the script that the agent executes, and artifacts you want to attach to a successful job. The support package contains an example pipeline configuration file, `Jenkins`, that you can use in your project.

Typically, when you configure a CI pipeline, you need to manually create and update pipeline configuration files as you add, remove, and change the artifacts in your project. However, the example pipeline configuration files use a pipeline generator function (`padv.pipeline.generatePipeline`) that can automatically generate the updated pipeline configuration files for you. After you do the initial setup for the pipeline generator, you no longer need to manually update your pipeline configuration files. When you trigger your pipeline, the pipeline generator uses the digital thread to analyze the files in your project and uses your process model to automatically generate any necessary pipeline configuration files for you.

The pipeline generator supports these CI platforms:

- GitLab
- Jenkins

Initial Setup

The major steps to set up the pipeline generator are:

1. Connect your MATLAB project to either a GitLab or Jenkins project.
2. Add the example pipeline configuration file to your project.
3. Edit the example pipeline configuration file to specify any credentials or other information needed to run jobs in your CI system.
4. Optionally, you can edit the example pipeline configuration file to change how the pipeline generator creates and executes pipelines in CI.
5. Push the changes to your source control system. By default, GitLab projects use `.gitlab-ci.yml` as the pipeline configuration file and Jenkins projects use `Jenkinsfile` as the pipeline configuration file.

For instructions, see either:

- "Integrate into GitLab"
- "Integrate into Jenkins"

Automatically Generated Pipelines

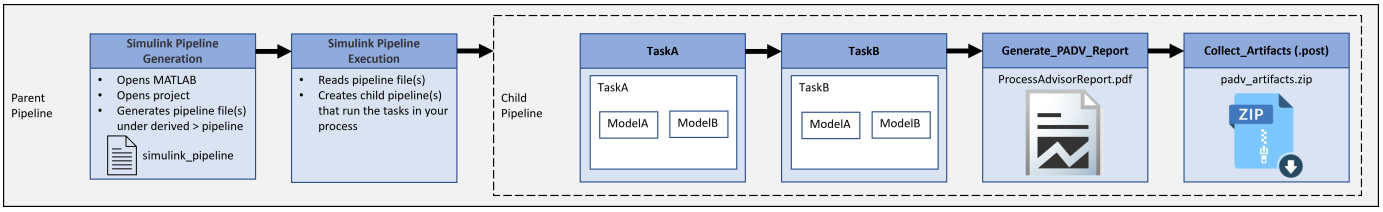
After you perform the initial setup and trigger your pipeline, the pipeline generator generates a parent pipeline and a child pipeline.

The parent pipeline contains two stages:

- **Simulink Pipeline Generation** — This stage analyzes your project and process model to automatically generate the necessary pipeline configuration files to run your process in CI. The main, generated pipeline configuration file is called `simulink_pipeline.yml` in GitLab or `simulink_pipeline` in Jenkins. If you want to view any of the generated pipeline configuration files, the pipeline generator stores the files under the `derived > pipeline` folder in the project.
- **Simulink Pipeline Execution** — This stage creates and executes a child pipeline that runs the tasks in your process, generates a build report, and collects the job artifacts.

By default, the child pipeline contains:

- One stage for each task in your process model.
- One stage that generates a build report, `ProcessAdvisorReport.pdf`.
- One stage that collects the job artifacts and compresses the artifacts into a zip file, `padv_artifacts.zip`.



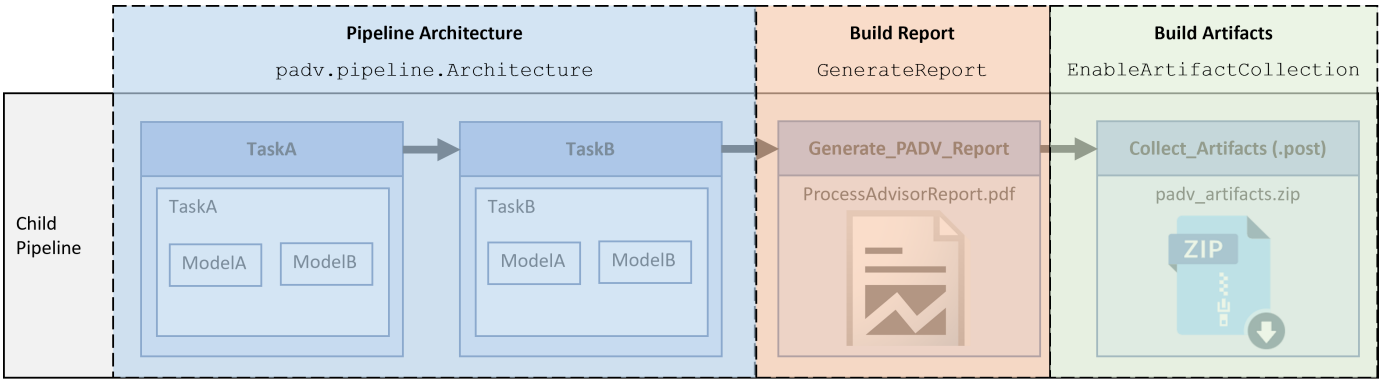
Optional Pipeline Customization

You can run the pipeline generator using the default settings or you can edit the example pipeline configuration file to customize how the pipeline generator creates and executes pipelines in CI.

The call to the pipeline generator function (`padv.pipeline.generatePipeline`) is in the example pipeline configuration file. The function `padv.pipeline.generatePipeline` requires you to specify a CI options object as an input. For GitLab, the CI options object is `padv.pipeline.GitLabOptions`. For Jenkins, the CI options object is `padv.pipeline.JenkinsOptions`.

The CI options object allows you to specify several properties of the generated CI pipeline, including:

- the pipeline architecture
- whether the pipeline generates a build report
- if and when the pipeline collects artifacts from the build



Pipeline Architecture

The pipeline architecture defines the number of stages and the grouping of tasks in the child pipeline. You can specify the pipeline architecture by using a `padv.pipeline.Architecture` object.

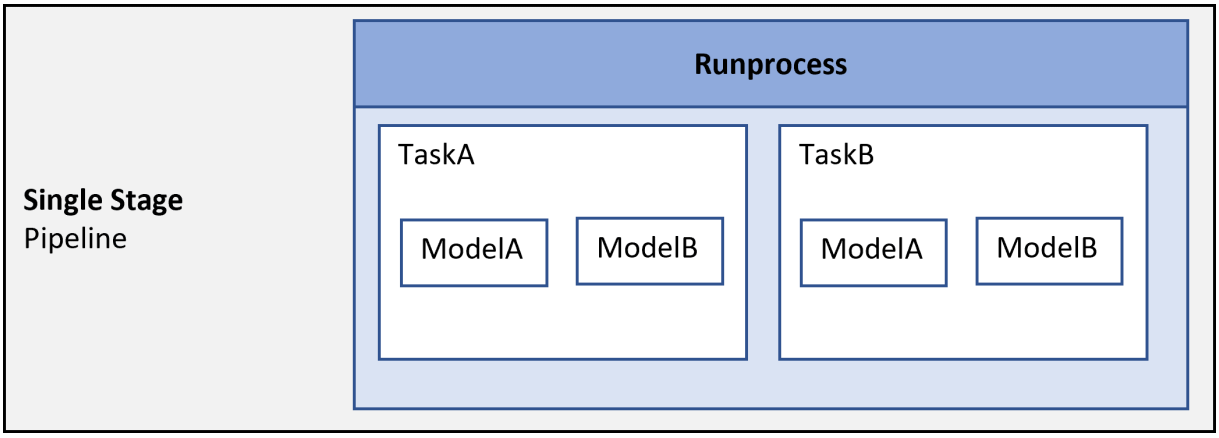
By default, the example pipeline configuration files specify the pipeline architecture as `SerialStagesGroupPerTask`, which creates one stage for each task in the process model. For example, one stage for `TaskA` and one stage for `TaskB`.

Single Stage

If you want your pipeline to run all tasks in a single pipeline stage, you can specify the pipeline architecture as `padv.pipeline.Architecture.SingleStage`. For example, in a GitLab pipeline configuration file, you would edit the file to use:

```
padv.pipeline.GitLabOptions(
PipelineArchitecture = padv.pipeline.Architecture.SingleStage)
```

The generated child pipeline would contain a single stage, **Runprocess**, that runs all the tasks in your process model. For example, if you had two tasks, `TaskA` and `TaskB`, that ran on two models, `ModelA` and `ModelB`, the **Runprocess** stage would sequentially run each of the tasks.

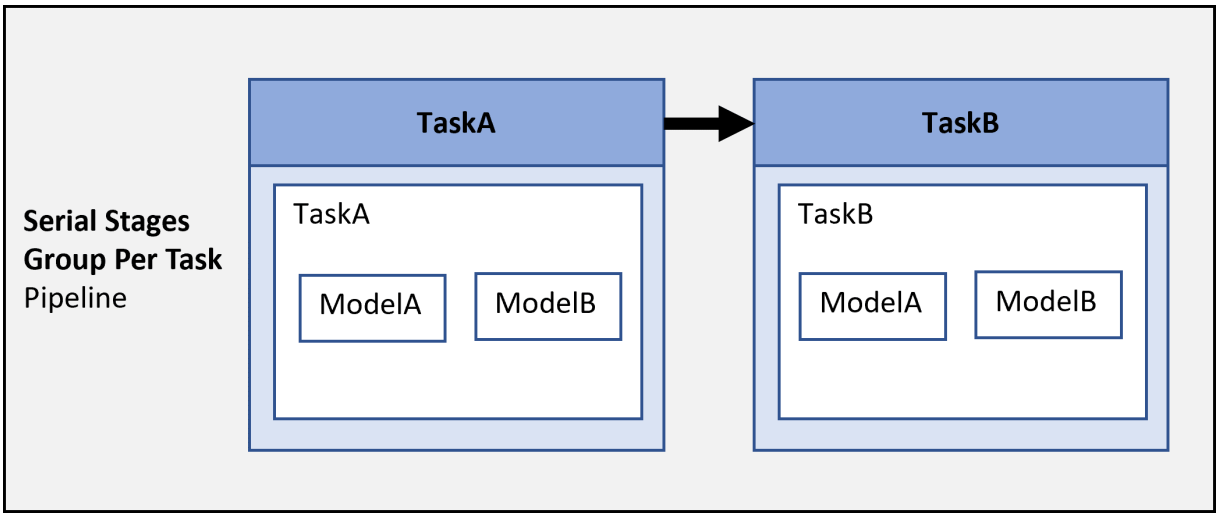


Serial Stages (Grouped Per Task)

If you want your pipeline to have separate stages for each type of task, you can specify the pipeline architecture as `padv.pipeline.Architecture.SerialStagesGroupPerTask`. For example, in a GitLab pipeline configuration file, you would edit the file to use:

```
padv.pipeline.GitLabOptions(
PipelineArchitecture = padv.pipeline.Architecture.SerialStagesGroupPerTask)
```

The generated child pipeline would contain one stage for each task in your process model. For example, if you had two tasks, `TaskA` and `TaskB`, that ran on two models, `ModelA` and `ModelB`, the generated pipeline would sequentially run two stages: **TaskA** and **TaskB**.

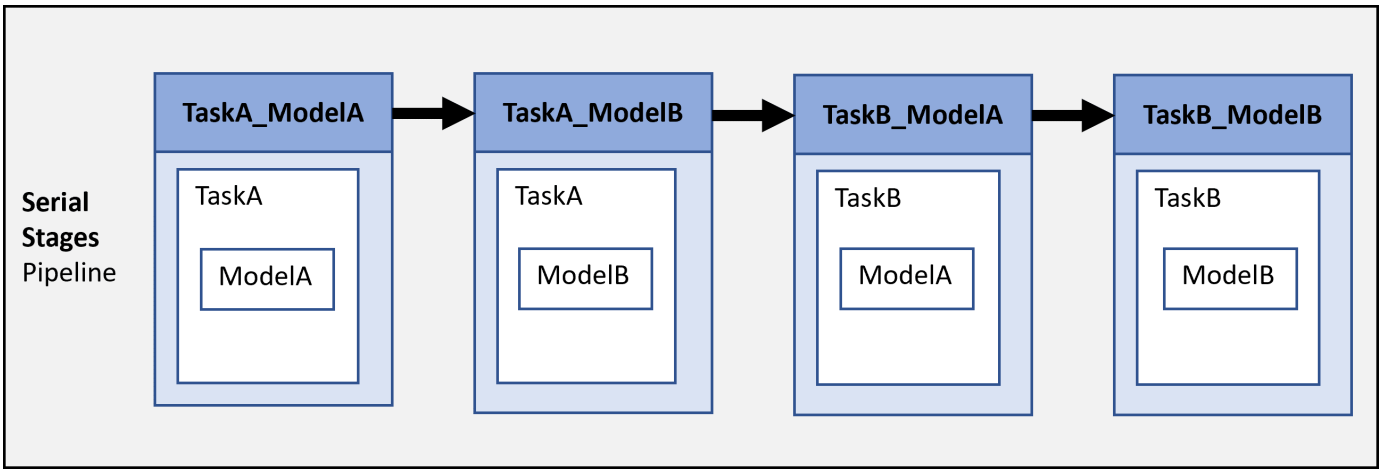


Serial Stages

If you want your pipeline to have separate stages for each task iteration, you can specify the pipeline architecture as `padv.pipeline.Architecture.SingleStage`. For example, in a GitLab pipeline configuration file, you would edit the file to use:

```
padv.pipeline.GitLabOptions(
PipelineArchitecture = padv.pipeline.Architecture.SerialStages)
```

The generated child pipeline would contain a stage for each combination of tasks and artifacts specified by the process model. For example, if you had two tasks, `TaskA` and `TaskB`, that ran on two models, `ModelA` and `ModelB`, the generated pipeline would sequentially run the stages **TaskA_ModelA**, **TaskA_ModelB**, **TaskB_ModelA**, and **TaskB_ModelB**.



Build Report

By default, the pipeline generator creates a stage, **Generate_PADV_Report**, that generates a build report for your pipeline. The build report is a PDF file `ProcessAdvisorReport.pdf`.

If you do not want to generate a report, you can specify the `GenerateReport` argument as `false`. For example, in a GitLab pipeline configuration file:

```
padv.pipeline.GitLabOptions(GenerateReport = false)
```

Build Artifacts

By default, the pipeline generator creates a stage, **Collect_Artifacts**, that collects and compresses the build artifacts from your pipeline. The ZIP file attached to the **Collect_Artifacts** stage is called `padv_artifacts.zip`. You can download these artifacts to locally reproduce issues seen in CI. For more information, see "Locally Reproduce Issues Found in CI".

You can specify if and when you want the pipeline to collect artifacts by specifying the argument `EnableArtifactCollection`:

- `"never"`, `0`, or `false` — Never collect artifacts
- `"on_success"` — Only collect artifacts when the pipeline succeeds
- `"on_failure"` — Only collect artifacts when the pipeline fails
- `"always"`, `1`, or `true` — Always collect artifacts

For example, in a GitLab pipeline configuration file:

```
padv.pipeline.GitLabOptions(EnableArtifactCollection="on_failure")
```

For more information, see the instructions in the next sections or see `padv.pipeline.GitLabOptions` and `padv.pipeline.JenkinsOptions` in the Reference Book PDF.

Integrate into GitLab

A *pipeline* is a collection of automated procedures and tools that execute in a specific order to enable a streamlined software delivery process. CI systems allow you to define and configure a pipeline by using a pipeline file. In GitLab, you can configure your pipeline by using a `.yml` file that you store in your project. The `.yml` file can configure different parts of your CI/CD jobs including the stages of the job, the tag for your GitLab Runner, the script that the Runner executes, and artifacts you want to attach to a successful job.

The support package CI/CD Automation for Simulink Check comes with an example `.yml` file, `.gitlab-ci.yml`, that you can add to your project to automatically run pipelines in GitLab. The example `.gitlab-ci.yml` file uses the pipeline generator to generate and execute pipelines for you so that you do not need to manually update any pipeline files when you change the tasks and artifacts in your project.

Integrate Using Default Options

1. Configure your project to use local Git™ source control. In MATLAB, on the **Project** tab, click **Use Source Control**. In the Source control Information dialog box, click **Add Project to Source Control**. In the Add to Source Control dialog box, in the **Source control tool** list, select `Git` and then click **Convert**.

2. In GitLab, set up a remote GitLab repository by creating a new blank project. For information, see the GitLab documentation: https://docs.gitlab.com/ee/

3. Install, register, and start a GitLab Runner. For information, see the GitLab documentation: https://docs.gitlab.com/runner/install/index.html

4. In MATLAB, on the **Project** tab, click **Remote** and specify the URL for the remote origin in GitLab where your repository is hosted. For more information, see https://www.mathworks.com/help/simulink/ug/add-a-project-to-source-control.html.

5. Open the example project that contains the example `.gitlab-ci.yml` file. In the MATLAB Command Window, enter:

   ```
   processAdvisorGitLabExampleStart
   ```

   This command creates a copy of the example project and opens the example `.gitlab-ci.yml` file from the root of the project. The project also contains an example `Dockerfile` that you can use to run MATLAB, the support package, and other MathWorks products using a Docker container. For information, see "Create Docker Container for Support Package".

6. Copy the example `.gitlab-ci.yml` file into your project and then add the file to your project.

   Note The example `.gitlab-ci.yml` file is generic and can work with any project.

7. Open and inspect the `.gitlab-ci.yml` file in your project.

   The file `.gitlab-ci.yml` defines a parent pipeline. The parent pipeline uses the pipeline generator, `padv.pipeline.generatePipeline`, to automatically generate and execute a child pipeline for your project. The options for the child pipeline are specified by the object

`padv.pipeline.GitLabOptions`. For more information about parent-child pipelines, see https://docs.gitlab.com/ee/ci/pipelines/downstream_pipelines.html.

8 In your `.gitlab-ci.yml` file, replace `padv_demo_ci` with the CI/CD tag associated with your GitLab Runner.

For example, if your Runner is associated with the tag `high_memory`, change the `tags` field to:

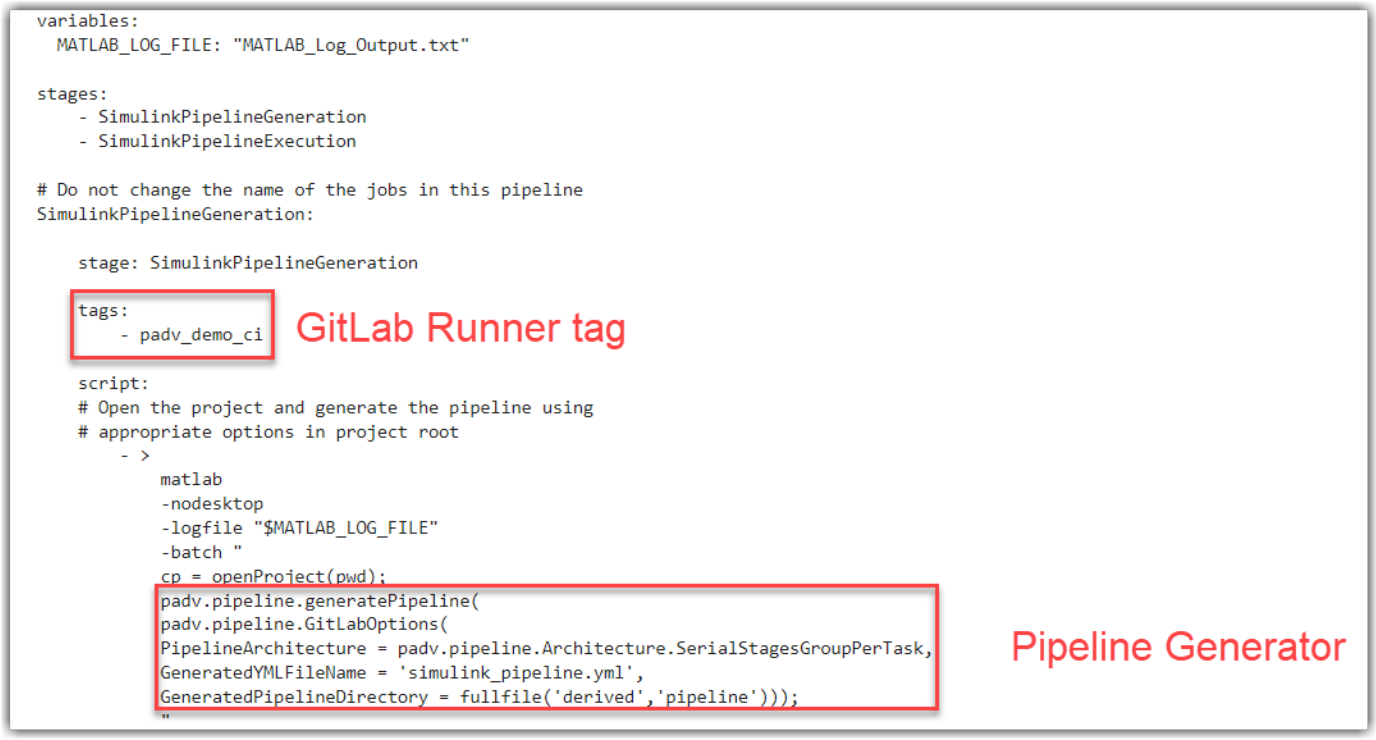
```
tags:
    - high_memory
```

9 Modify the object `padv.pipeline.GitLabOptions` to specify the CI/CD tag associated with your GitLab Runner. `.gitlab-ci.yml` passes the tag to the child pipeline.

For example, if your Runner is associated with the tag `high_memory`, you would specify:

```
padv.pipeline.generatePipeline(
padv.pipeline.GitLabOptions(
Tags='high_memory',
PipelineArchitecture = padv.pipeline.Architecture.SerialStagesGroupPerTask,
GeneratedYMLFileName = 'simulink_pipeline.yml',
GeneratedPipelineDirectory = fullfile('derived','pipeline')));
```

Now your `.gitlab-ci.yml` file will have your GitLab Runner tag specified in the `tags` field and in your `padv.pipeline.GitLabOptions` in the call to the pipeline generator function `padv.pipeline.generatePipeline`.



10 Push the changes to your GitLab repository.

By default, a GitLab project automatically considers any file named `.gitlab-ci.yml` as the CI/CD configuration file for the repository. Your GitLab Runner can now automatically generate and execute a custom pipeline for your project each time that you submit changes.

Note You do not need to update the `.gitlab-ci.yml` file if you make changes to your projects or process model. The pipeline generator generates the child pipeline using the latest project and process model. You only need to update the `.gitlab-ci.yml` file if you want to change how the pipeline generator organizes and executes the pipeline.

In GitLab, your pipeline will contain two upstream jobs:

- **SimulinkPipelineGeneration** — Generates a child pipeline file.
- **SimulinkPipelineExecution** — Executes the child pipeline file. By default, the child pipeline contains these downstream jobs:
  - One job for each task defined in the process model file
  - One job, `Generate_PADV_Report`, that generates a Process Advisor build report
  - One job, `Collect_Artifacts`, that collects build artifacts

The pipeline generator automatically generates JUnit-style XML reports for each task. When you open the **SimulinkPipelineExecution** job in GitLab, the **Tests** tab shows a summary of the task results. For information on how JUnit information appear in GitLab, see the GitLab documentation: https://docs.gitlab.com/ee/ci/testing/unit_test_reports.html#view-unit-test-reports-on-gitlab. If you do not want to generate JUnit reports, specify the `GenerateJUnitForProcess` property in `padv.pipeline.GitLabOptions` as `false`.

If you want to change how the downstream jobs get organized and executed, you can modify the properties of the `padv.pipeline.GitLabOptions`. For example, you can modify the `PipelineArchitecture` property to change the number of stages and the grouping of tasks in each stage of the child pipeline. For more information, see "Customize Child Pipeline" or enter this code in the MATLAB Command Window:

```
help padv.pipeline.GitLabOptions
```

Customize Child Pipeline

You can use the properties of `padv.pipeline.GitLabOptions` to control which GitLab Runner tags to associate with the child pipeline, the number of stages and the grouping of tasks in the child pipeline (defined by the pipeline architecture), how tasks execute, MATLAB startup options in CI, and artifact collection for CI jobs.

For example, in your `.gitlab-ci.yml` file you can change the `script` field to specify different values for the `Tags`, `RerunFailedTasks`, and `PipelineArchitecture` properties in `padv.pipeline.GitLabOptions`:

```
script:
# Open the project and generate the pipeline using
# appropriate options in project root
    - >
        matlab
        -nodesktop
        -logfile "$MATLAB_LOG_FILE"
```

```
-batch "
cp = openProject(pwd);
padv.pipeline.generatePipeline(
padv.pipeline.GitLabOptions(
Tags='high_memory',
RerunFailedTasks = true,
PipelineArchitecture = padv.pipeline.Architecture.SerialStages,
GeneratedYMLFileName = 'simulink_pipeline.yml',
GeneratedPipelineDirectory = fullfile('derived','pipeline')));
"
```

This code specifies that the pipeline should be associated with the GitLab Runner tag `high_memory`, should try to rerun failed tasks, and should use a serial stage pipeline architecture that creates a job for each task iteration (for example, one job for running **Check Modeling Standards** on `ModelA` and one job for running **Check Modeling Standards** on `ModelB`). For more information about the available pipeline architectures, see the next section "Customize Pipeline Architecture".

To see a list of the available properties in the MATLAB Command Window, enter:

```
help padv.pipeline.GitLabOptions
```

Customize Pipeline Architecture

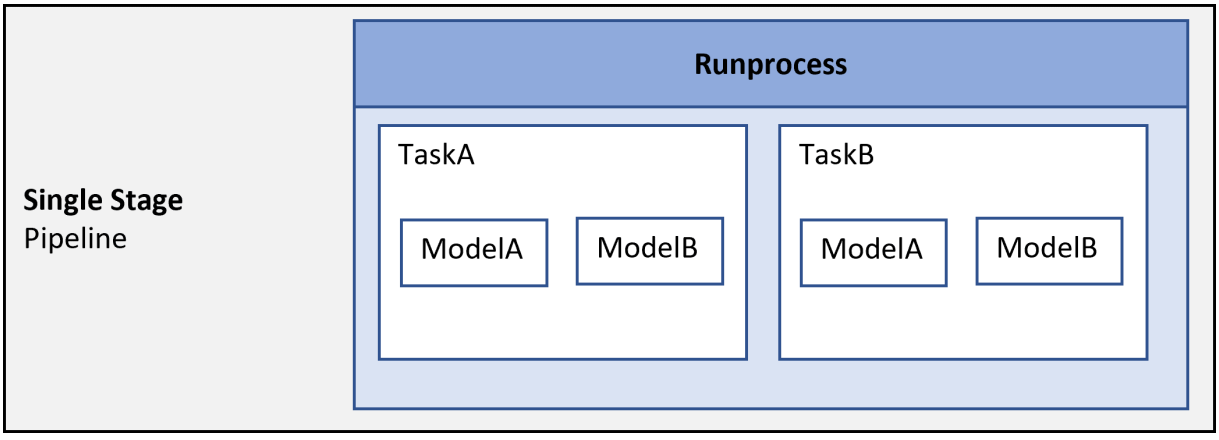
After you run a pipeline, GitLab shows the overall status of the pipeline and the status of each stage in the pipeline. For example, the **Stages** column can show a pipeline mini graph that shows the first stage passed, the second stage failed, and the third stage was skipped.

If you want to group the information that appears in your pipeline results, you can specify a pipeline architecture that defines more stages. If a pipeline has more stages, you can more easily identify where any failures occurred, but the pipeline execution might not be as efficient.

If you specify the pipeline architecture as:

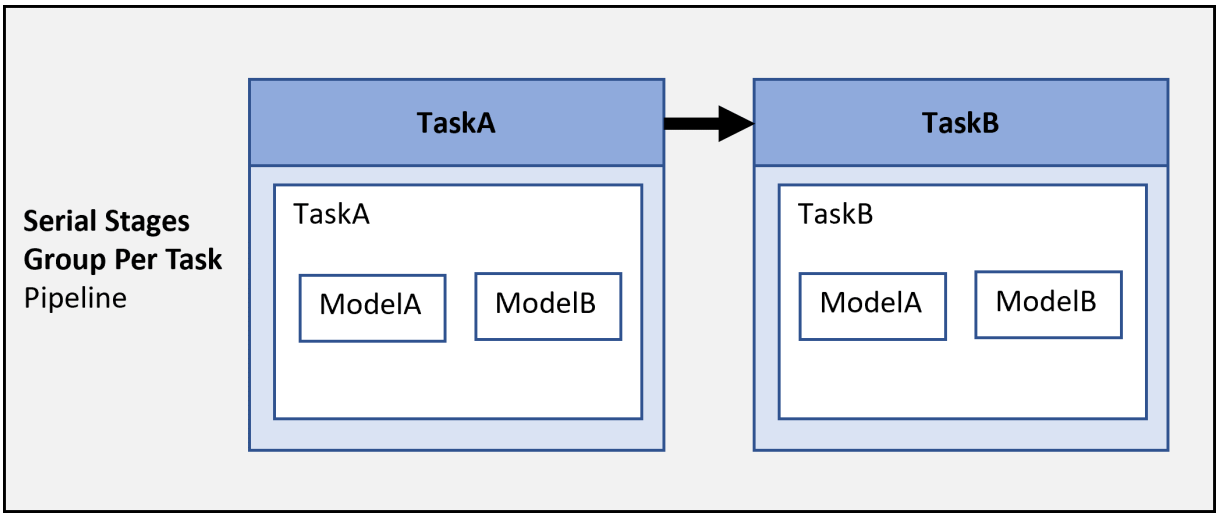
- `padv.pipeline.Architecture.SingleStage` — The generated pipeline contains a single stage, **Runprocess**, that runs all tasks.

  ```
  padv.pipeline.GitLabOptions(
  PipelineArchitecture = padv.pipeline.Architecture.SingleStage)
  ```



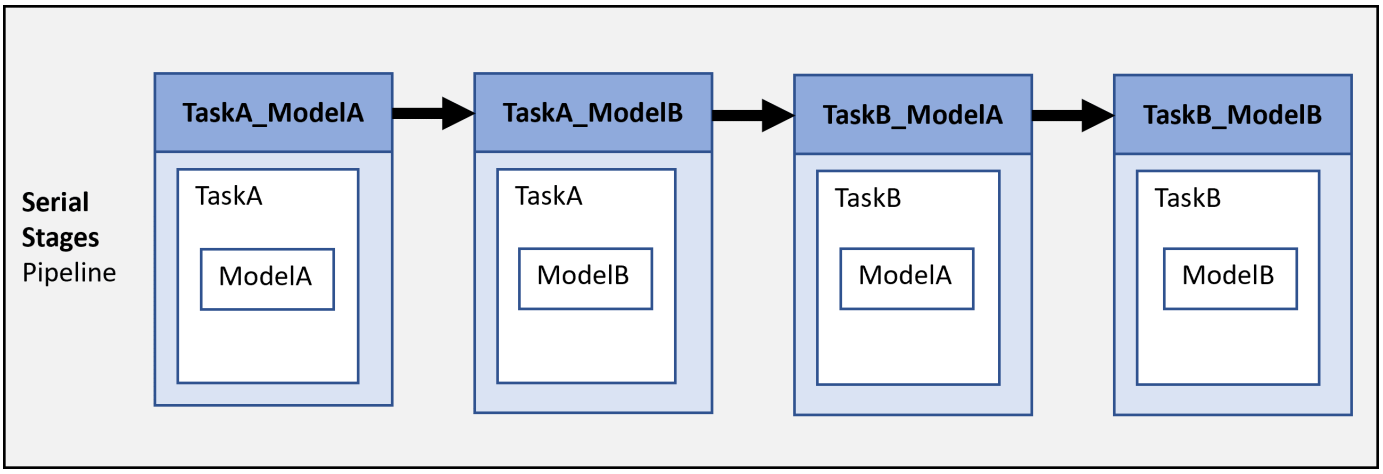
- `padv.pipeline.Architecture.SerialStagesGroupPerTask` — The generated pipeline contains one stage for each type of task.

```
padv.pipeline.GitLabOptions(
PipelineArchitecture = padv.pipeline.Architecture.SerialStagesGroupPerTask)
```



- `padv.pipeline.Architecture.SerialStages` — The generated pipeline contains one stage for each task iteration.

```
padv.pipeline.GitLabOptions(
PipelineArchitecture = padv.pipeline.Architecture.SerialStages)
```



Comparison of Pipeline Architectures

The following table compares the different pipeline architectures.

Type	Pipeline Architecture Value	Benefits	Limitations
Serial	`SingleStage`	One stage for all tasks. Efficient execution since the CI system only launches MATLAB and the project one time.	Difficult to identify where a failure occurred. If the pipeline fails, you must investigate the logs, build report, or other output files to identify which specified task or task iteration failed.
	`SerialStagesGroupPerTask`	One stage for each task. The stages run in series, not in parallel. If the pipeline fails, you can see which task failed, directly in the pipeline results.	Less efficient execution because the CI system has to close and reopen MATLAB and the project one time for each stage
	`SerialStages`	One stage for each task iteration. The stages run in series, not in parallel. If the pipeline fails, you can see which task iteration failed, directly in the pipeline results.	Inefficient execution because the CI system has to close and reopen MATLAB and the project one time for each stage

Integrate into Jenkins

A *pipeline* is a collection of automated procedures and tools that execute in a specific order to enable a streamlined software delivery process. CI systems allow you to define and configure a pipeline by using a pipeline file. In Jenkins, you can configure your pipeline by using a Jenkinsfile that you store in your project. The Jenkinsfile can configure different parts of your CI/CD jobs including the stages of the job, the label for the Jenkins agent that executes the pipeline, the script that the agent executes, and artifacts you want to attach to a successful job.

The support package CI/CD Automation for Simulink Check comes with an example Jenkinsfile, `Jenkinsfile`, that you can add to your project to run pipelines in Jenkins. When you use the example Jenkinsfile, the file generates and loads pipelines for you so that you do not need to manually update any pipeline files when you change the tasks and artifacts in your project.

Integrate Using Default Options

Note This section assumes that Jenkins and your project are connected to your source control system. For an example of how to use GitLab for version control and Jenkins for continuous integration, see the Appendix in https://www.mathworks.com/company/newsletters/articles/continuous-integration-for-verification-of-simulink-models.html.

1. Connect your project to Jenkins by installing the following plugins on your Jenkins controller:
   - MATLAB Plugin for Jenkins. The plugin allows you to use the `runMATLABCommand` command to run MATLAB in freestyle and multi-configuration (matrix) Jenkins projects. For information, see the plugin on Jenkins Plugin Index: https://plugins.jenkins.io/matlab/
   - Jenkins Core Plugin, which allows pipelines to archive artifacts using the `archiveArtifacts` step. For information, see the Jenkins documentation: https://www.jenkins.io/doc/pipeline/steps/core/#archiveartifacts-archive-the-artifacts
   - JUnit Plugin, which allows Jenkins to show test failures and trends directly in the user interface. For information, see https://plugins.jenkins.io/junit/.
2. Open the example project that contains the example `Jenkinsfile`. In the MATLAB Command Window, enter:

   ```
   processAdvisorJenkinsExampleStart
   ```

   This command creates a copy of the example project and opens the example `Jenkinsfile` from the root of the project. The project also contains an example `Dockerfile` that you can use to run MATLAB, the support package, and other MathWorks products using a Docker container. For information, see "Create Docker Container for Support Package".
3. Copy the example `Jenkinsfile` file into the root of your project and then add the file to your project in source control.

   Note The example `Jenkinsfile` file is generic and can work with any project.
4. Open and inspect the `Jenkinsfile` file in your project.

The file `Jenkinsfile` defines a parent pipeline. The parent pipeline uses the pipeline generator, `padv.pipeline.generatePipeline`, to automatically generate and execute an internal pipeline for your project. The options for the internal pipeline are specified by the object `padv.pipeline.JenkinsOptions`.

5 In your `Jenkinsfile`, update the file to use the:

- Git `branch`, `credentialsId`, and `url` for your repository. For example:

```
git branch: 'testBranch',
  credentialsId: 'jenkins-common-creds',
            url: 'git://example.com/my-project.git'
```

- Path to the bin directory for your MATLAB installation. For example:
  - `env.PATH = "C:\\Program Files\\MATLAB\\R2022b\\bin;${env.PATH}" // Windows`
    `// env.PATH = "/usr/local/MATLAB/R2022b/bin:${env.PATH}"        // Linux`
    `// env.PATH = "/Applications/MATLAB_R2022b.app/bin:${env.PATH}" // macOS`
  - `withEnv(["PATH=C:\\Program Files\\MATLAB\\R2022b\\bin;${env.PATH}"]) { // Windows`
    `// withEnv(["PATH=/usr/local/MATLAB/R2022b/bin:${env.PATH}"]) {        // Linux`
    `// withEnv(["PATH=/Applications/MATLAB_R2022b.app/bin:${env.PATH}"]) { // macOS`

Now your `Jenkinsfile` file contains the Git repository information and path to the MATLAB installation for your CI setup.

```
//Scripted Pipeline
node {

        stage('Git Clone'){
            git branch: '#### Enter your branch ####',
            credentialsId: '#### Enter your credentials, if any ####',
            url: '#### Enter your repository URL ####'
        }


        // Requires MATLAB plugin
        stage('Pipeline Generation'){

            env.PATH = "C:\\Program Files\\MATLAB\\R2022a\\bin;${env.PATH}"

            /* Open the project and generate the pipeline using
            appropriate options */

            runMATLABCommand '''cp = openProject(pwd);
            padv.pipeline.generatePipeline(...
            padv.pipeline.JenkinsOptions(...
            PipelineArchitecture = padv.pipeline.Architecture.SerialStagesGroupPerTask,...
            GeneratedJenkinsFileName = "simulink_pipeline",...
            GeneratedPipelineDirectory = fullfile("derived","pipeline")));'''
        }


        // pass necessary environment variables to generated pipeline
        withEnv(["PATH=C:\\Program Files\\MATLAB\\R2022a\\bin;${env.PATH}"]) {

            def rootDir = pwd()

            /* This file is generated automatically by
            padv.pipeline.generatePipeline with a default name
            of simulink_pipeline. Update this field if the
            name or location of the generated pipeline file is changed */

            load "${rootDir}/derived/pipeline/simulink_pipeline"
        }
}
```

Git Repository Information

Environment Path

Pipeline Generator

Environment Path
(for generated pipeline)

6 Push the changes to your project in source control. If your Jenkins project is not automatically triggered by pushing changes to source control, manually trigger your Jenkins pipeline.

By default, a Jenkins project automatically considers the file `Jenkinsfile` at the root of the source control repository as the CI/CD configuration file for the build. Your Jenkins agent can now automatically generate and execute a custom, internal pipeline for your project each time a Jenkins build triggers.

Note You do not need to update the `Jenkinsfile` file if you make changes to your projects or process model. The pipeline generator generates the internal pipeline using the latest project and process model. You only need to update the `Jenkinsfile` file if you want to change how the pipeline generator organizes and executes the pipeline.

In Jenkins, your pipeline will contain two upstream jobs:

- **Git_Clone** — Loads your Git repository information.
- **Pipeline Generation** — Automatically generates and loads a downstream Jenkinsfile that defines a Jenkins pipeline for your process. By default, the downstream pipeline contains:
  - One job for each task defined in the process model file

- One job, `Generate_PADV_Report`, that generates a Process Advisor build report
- One job, `Collect_Artifacts`, that collects build artifacts

The pipeline generator automatically generates JUnit-style XML reports for each task. Jenkins can use the JUnit reports to show test failures and trends directly in the user interface. For information on how Jenkins displays JUnit information, see the Jenkins documentation: https://plugins.jenkins.io/junit/. If you do not want to generate JUnit reports, specify the `GenerateJUnitForProcess` property in `padv.pipeline.JenkinsOptions` as `false`.

If you want to change how the downstream jobs get organized and executed, you can modify the properties of the `padv.pipeline.JenkinsOptions`. For example, you can modify the `PipelineArchitecture` property to change the number of stages and the grouping of tasks in each stage of the downstream pipeline.

For more information, see "Customize Downstream Pipeline" or enter this code in the MATLAB Command Window:

```
help padv.pipeline.JenkinsOptions
```

Customize Downstream Pipeline

You can use the properties of `padv.pipeline.JenkinsOptions` to control which Jenkins agent to associate with the downstream pipeline, the number of stages and the grouping of tasks in the downstream pipeline (defined by the pipeline architecture), how tasks execute, and artifact collection for CI jobs.

For example, in your `Jenkinsfile` file you can change the `Pipeline Generator` stage to specify different values for the `AgentLabel`, `RerunFailedTasks`, and `PipelineArchitecture` properties in `padv.pipeline.JenkinsOptions`:

```
        // Requires MATLAB plugin
        stage('Pipeline Generation'){

            env.PATH = "C:\\Program Files\\MATLAB\\R2022b\\bin;${env.PATH}" // Windows
            // env.PATH = "/usr/local/MATLAB/R2022b/bin:${env.PATH}"        // Linux
            // env.PATH = "/Applications/MATLAB_R2022b.app/bin:${env.PATH}" // macOS

            /* Open the project and generate the pipeline using
            appropriate options */

            runMATLABCommand '''cp = openProject(pwd);
            padv.pipeline.generatePipeline(...
            padv.pipeline.JenkinsOptions(...
            AgentLabel="high_memory",...
            RerunFailedTasks = true,...
            PipelineArchitecture = padv.pipeline.Architecture.SerialStages,...
            GeneratedJenkinsFileName = "simulink_pipeline",...
            GeneratedPipelineDirectory = fullfile('derived','pipeline')));'''
        }
```

This code specifies that the pipeline should be associated with the Jenkins agent labeled `high_memory`, should try to rerun failed tasks, and should use a serial stage pipeline architecture that creates a job for each task iteration (for example, one job for running **Check Modeling Standards** on `ModelA` and one job for running **Check Modeling Standards** on `ModelB`). For more

information about the available pipeline architectures, see the next section "Customize Pipeline Architecture".

To see a list of the available properties in the MATLAB Command Window, enter:

```
help padv.pipeline.JenkinsOptions
```

Customize Pipeline Architecture

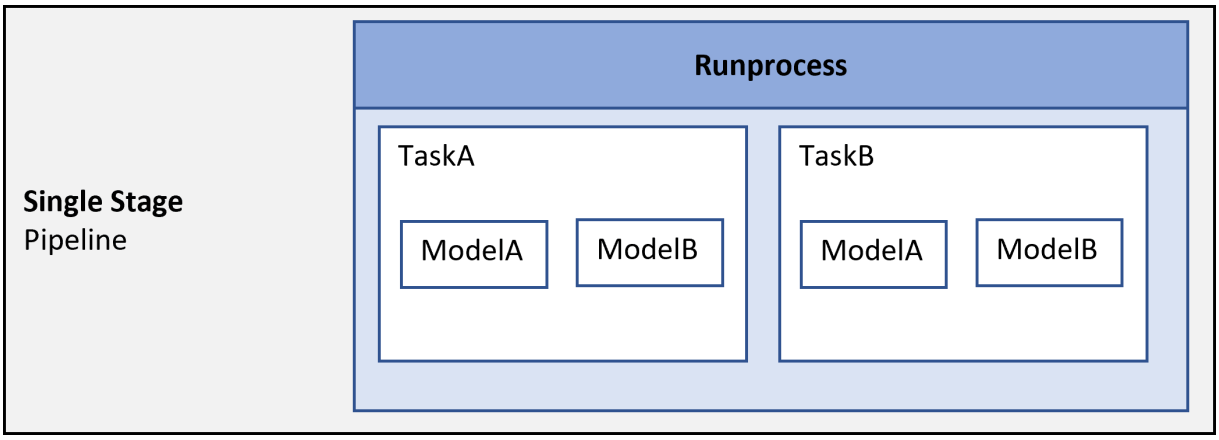
After you run a pipeline, the **Stage View** in Jenkins shows the status of each stage in the build.

To change the stages that appear in the **Stage View** for your automatically generated pipeline, you can specify a different pipeline architecture in the call to the pipeline generator. The pipeline architecture defines the number of stages in your pipeline and the grouping of tasks in each stage. If a pipeline has more stages, you can more easily identify where any failures occurred, but the pipeline execution might not be as efficient.

If you specify the pipeline architecture as:

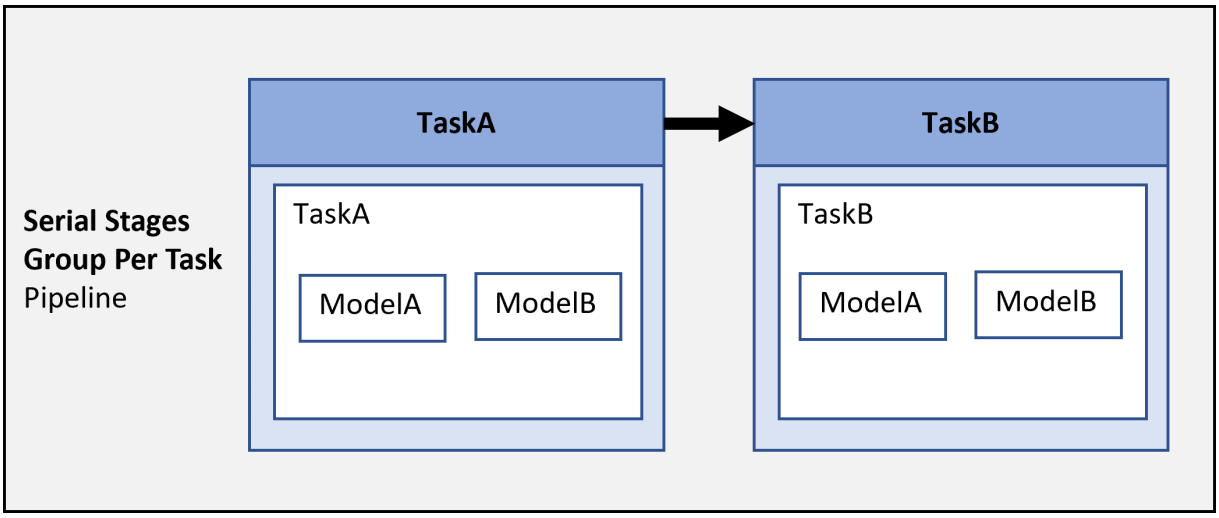
- `padv.pipeline.Architecture.SingleStage` — The generated pipeline contains a single stage, **Runprocess**, that runs all tasks.

  ```
  padv.pipeline.JenkinsOptions(...
  PipelineArchitecture = padv.pipeline.Architecture.SingleStage)
  ```



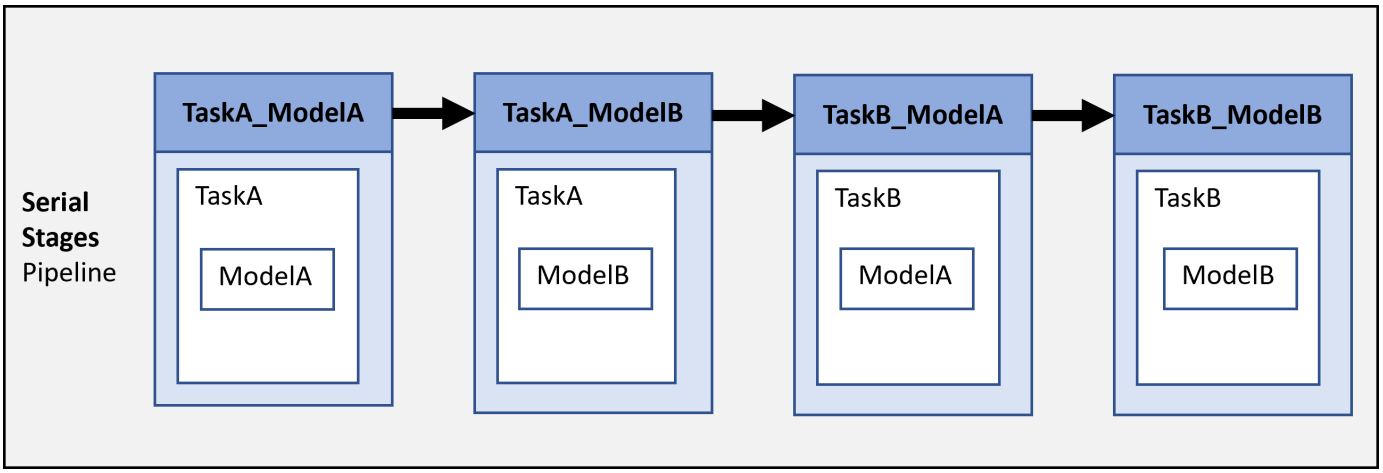
- `padv.pipeline.Architecture.SerialStagesGroupPerTask` — The generated pipeline contains one stage for each type of task.

  ```
  padv.pipeline.JenkinsOptions(...
  PipelineArchitecture = padv.pipeline.Architecture.SerialStagesGroupPerTask)
  ```



- `padv.pipeline.Architecture.SerialStages` — The generated pipeline contains one stage for each task iteration.

```
padv.pipeline.JenkinsOptions(...
PipelineArchitecture = padv.pipeline.Architecture.SerialStages)
```



Comparison of Pipeline Architectures

The following table compares the different pipeline architectures.

Type	Pipeline Architecture Value	Benefits	Limitations
Serial	`SingleStage`	One stage for all tasks. Efficient execution since the CI system only launches MATLAB and the project one time.	Difficult to identify where a failure occurred. If the pipeline fails, you must investigate the logs, build report, or other output files to identify which specified task or task iteration failed.
	`SerialStagesGroupPerTask`	One stage for each task. The stages run in series, not in parallel. If the pipeline fails, you can see which task failed, directly in the **Stage View**.	Less efficient execution because the CI system has to close and reopen MATLAB and the project one time for each stage
	`SerialStages`	One stage for each task iteration. The stages run in series, not in parallel. If the pipeline fails, you can see which task iteration failed, directly in the **Stage View**.	Inefficient execution because the CI system has to close and reopen MATLAB and the project one time for each stage

Integrate into Other CI Platforms

You can use any of the MATLAB-supported CI platforms to run your automated pipeline of tasks. For information on the supported platforms, see https://www.mathworks.com/help/matlab/matlab_prog/continuous-integration-with-matlab-on-ci-platforms.html.

To perform continuous integration, you can use the `runprocess` function to either:

- Run all the tasks in the pipeline

  ```
  runprocess()
  ```

- Run specific tasks by using task IDs

  ```
  % specify the relative path to the model AHRS_Voter
  model = padv.Artifact("sl_model_file",...
  padv.util.ArtifactAddress(...
  fullfile("02_Models","AHRS_Voter","specification","AHRS_Voter.slx")));

  % find the tasks associated with the model AHRS_Voter
  ahrsVoterTasks = generateProcessTasks(FilterArtifact=model)

  % run only the ahrsVoterTasks
  runprocess(Tasks=ahrsVoterTasks)
  ```

Use the `matlab` command with the `-batch` option in your CI system. You can use `matlab -batch` to run MATLAB code, including the `runprocess` function, noninteractively. For example, `matlab -batch "runprocess"` starts MATLAB noninteractively and runs each of the tasks in the pipeline defined by the process model file (`processmodel.p` or `processmodel.m`) in the project. MATLAB terminates automatically with the exit code `0` if the specified code executes successfully without error. Otherwise, MATLAB terminates with a nonzero exit code.

Create Docker Container for Support Package

A container is an isolated unit of software that contains everything required to run a specific application. You can use a container to run in a cloud environment.

Follow these steps to create a Docker image that includes MATLAB, other MathWorks products, and the CI/CD Automation for Simulink Check support package.

Note The MATLAB Docker image is a Linux® executable, but can run on any host operating system that Docker supports. For general information about MATLAB container images, see https://github.com/mathworks-ref-arch/matlab-dockerfile.

1. Open the Add-On Explorer. In MATLAB, go to the **Home** tab and, in the **Environment** section, click the **Add-Ons** icon.
2. In the Add-On Explorer, use the search bar to search for "CI/CD Automation for Simulink Check" and then select the support package from the list.

   In the top-right corner of the page are the available install actions.
3. Download the offline installer by selecting **Install** > **Download Only**.

   By default, the offline installer files download inside a subfolder in the `SupportPackages` folder. For example, on Windows®: `C:\Users\<UserName>\Downloads\MathWorks\SupportPackages\<Release>`

Note If you already have a local install of the support package, you might need to uninstall the support package to see the **Download Only** install action.

4. Create a zip file of the offline installer files that you downloaded in the previous step. Open a Linux shell from the download folder, and run:

   ```
   tar -czvf cicd-offline-install.tar.gz <name of download folder>
   ```
5. In MATLAB, find the location of the example `Dockerfile` on your machine by entering:

   ```
   fullfile(matlabshared.supportpkg.getSupportPackageRoot,...
   "toolbox","padv","demos")
   ```

   The `Dockerfile` (no file extension) is in the `demos` folder.

6. Copy the `Dockerfile` from that location and place the file inside the folder that contains your `cicd-offline-install.tar.gz` file.

7. Open the `Dockerfile` and follow the instructions in the comments of the file. You need to update the file to specify your:

   - MATLAB version (`MATLAB_VERSION`)
   - MathWorks products (`PRODUCTS`) that you want your Docker container to use
   - Network license (`LICENSE_SERVER`) or license file (LIC)

   Note For other license types, leave `LICENSE_SERVER` unset and contact MathWorks (continuous-integration@mathworks.com) for help.

   Your folder should now contain your updated `Dockerfile`, the zip file for the offline installer, and your license file (if applicable).

8. Use the `docker build` command to create an image using the `Dockerfile`, zip file, and license file (if applicable).

   For example, to build an image named `matlabcicd`:

   ```
   docker build -t matlabcicd .
   ```

   For information, see the Docker documentation: https://docs.docker.com/engine/reference/commandline/build/

9. Use the `docker run` command to create a container from the generated image.

   For information, see the Docker documentation: https://docs.docker.com/engine/reference/commandline/run/

   The new container appears in your Docker hub.

Troubleshooting and Limitations

Troubleshooting Missing Tasks or Artifacts

When you use CI/CD Automation for Simulink Check, the support package creates a digital thread to capture the attributes and unique identifiers of the artifacts in your project. The digital thread is a set of metadata information about the artifacts in a project, the artifact structure, and the traceability relationships between artifacts. The Process Advisor app and build system monitor and analyze the digital thread to identify artifacts, detect changes to project files, generate task iterations, and identify outdated task results. The digital thread is cached in a database stored in `derived > artifacts.dmr` in the project.

See the next sections for troubleshooting steps and limitations.

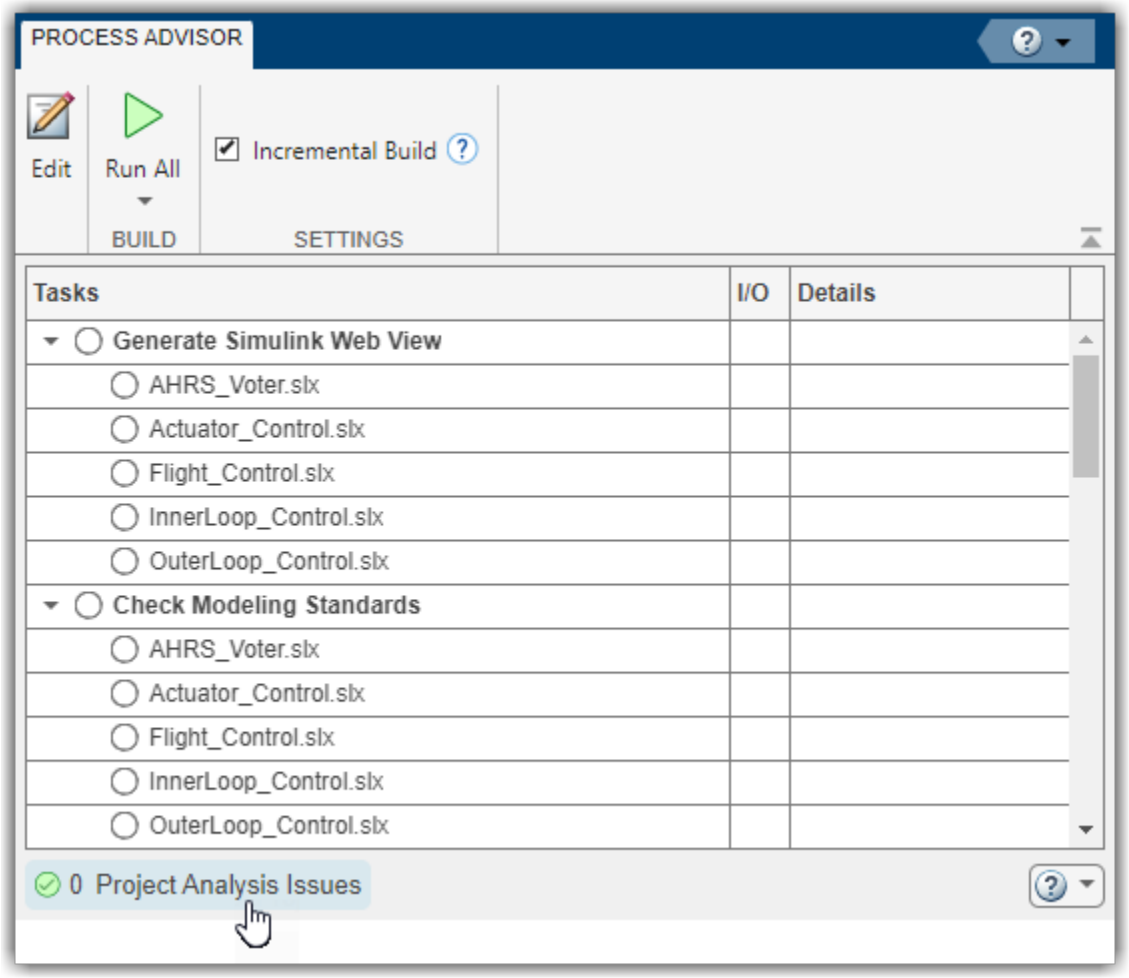
Artifact Issues

Before you begin troubleshooting Process Advisor or the build system:

- Check that artifacts are saved in the project.
- If you are using R2022a or R2022b, check that artifacts are not in a referenced project. Project references are supported starting in R2023a.
- Artifacts are on the MATLAB search path before you open the Process Advisor app.
- You used the Process Advisor app or build system to run your tasks and to collect task results.
- Artifacts are not saved to a prohibited output folder. Prohibited output folders include the simulation cache, project resources folder, and `.SimulinkProject`.
- You have a compiler configured. You should use the same compiler that you use in the target development environment. If you only have the MinGW® compiler installed on your system, the `mex` command automatically chooses MinGW.
- Make sure your tests are testing a model or an atomic subsystem, Stateflow® chart, MATLAB function, or subsystem reference.

Project Analysis Issues

At the bottom of the Process Advisor app is a **Project Analysis Issues** pane. After Process Advisor analyzes the project, the **Project Analysis Issues** shows any errors or warnings that were generated during artifact analysis.



1 Investigate project analysis issues in the project by clicking on **Project Analysis Issues**.

- An error indicates that Process Advisor might not have been able to properly analyze artifacts, trace artifact, or identify outdated results, so the information shown by Process Advisor might be incomplete.
- A warning indicates that Process Advisor does not support that specific artifact, modeling construct, or relationship.

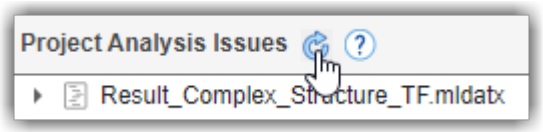
2 Fix the issues listed in the **Project Analysis Issues** pane to make sure the app can fully analyze the project, generate the expected task iterations, and detect outdated results.

If there are issues with an artifact, check that the artifact does not use the following unsupported modeling constructs:

Affected Artifact	Unsupported Construct
Library	Library forwarding table
	Self-modifiable masks
Model	Saved in release R2012a or earlier

Affected Artifact	Unsupported Construct
	Model loading callbacks
	Model shadowing
Test case	MATLAB-based Simulink test
Test file	Test-file level callbacks
Test suite	Test-suite level callbacks

3 Click the refresh button in the pane to refresh the list of project analysis issues.



Note To test libraries with Process Advisor, specify function interfaces for each of your library blocks and use the library-based code generation workflow. For more information, see https://www.mathworks.com/help/ecoder/ug/library-based-code-generation-for-subsystems-shared-across-models.html.

Make sure you only use the library blocks in the model context that you verified. When you test the model, you can use coverage filters to exclude the library blocks that you already tested.

Limitations on Incremental Build

There are changes that incremental build does not detect. Tasks depending on those changes will remain up-to-date and will not execute with **Run All**. If incremental build does not detect changes to a file that a task depends on, the file is an *untracked dependency*.

The table in this section lists the known untracked dependencies.

- The **Artifact** column lists the artifacts with known untracked dependencies.
- The **Untracked Dependency** column lists the files that incremental build does not detect changes to. Changes to these files do not cause tasks associated with the artifact to become outdated.

For example, if you have a model that uses a referenced global workspace variable and you make a change to the variable, the task results associated with the model will not become outdated. The table shows:

- **Artifact**: Model
- **Untracked Dependency**: Referenced global workspace variable

Artifact	Untracked Dependency
Model	Model callbacks
	Referenced global workspace variables*
	Global enumeration definitions*
	Externally-saved model workspace variables (if auto-initialized)
	Data or functions referenced in masks or callbacks inside the model
	Known dependencies specified in the model reference rebuild options of a configuration set
	Simulation inputs and simulation outputs specified in model configuration sets
	Signal Editor scenarios
	C code referenced in C Caller blocks
	Code inside SIL (software-in-the-loop) blocks
	Files associated with S-Functions
	Code replacement libraries
	Custom code
	System Composer™ profiles or stereotypes
Test case	MATLAB code in: • Pre-load, post-load, clean-up, and assessment callbacks • Custom criteria
	External configurations
	MATLAB test files

*If possible, use a Simulink Data Dictionary file instead. The digital thread tracks changes to data dictionaries.

Note If you do not want the build system or the Process Advisor app to run incremental builds, you can disable incremental builds for a project. For more information, see the section "How to Disable Incremental Builds".

You can also force up-to-date tasks to execute by using one of these approaches:

- In the Process Advisor app, either point to a task and click the run button or click **Run All** > **Force Run All**.
- For the `runprocess` function, specify `Force` as `true`.

Note The build system and Process Advisor app are able to track the following test case dependencies:

- Baseline files in `.mat`, `.xlsm`, `.xlsb`, `.xlsx`, `.xls`, and `.mldatx` format.
- Input files in `.mat`, `.xlsm`, `.xlsb`, `.xlsx`, and `.xls` format.
- Parameter override files in `.mat`, `.xlsm`, `.xlsb`, `.xlsx`, `.xls`, and `.m` format.

Other Limitations

There are known limitations in the Process Advisor app and build system:

- Process Advisor only shows results for tasks that you ran using Process Advisor and the build system.
- If a top model and at least one referenced model have unsaved changes, the Process Advisor is unable to save the top model and generates the error:`The following files were not able to be saved: <Path to top model>`
- If a test harness is saved inside a model file, the Process Advisor and build system return an incorrect warning that the internal test harness is not on the MATLAB search path. Ignore the warning, and, if possible, convert your internal test harnesses to external test harnesses so that the support package can differentiate between changes to the test harness and changes to the main model.
- When you add the built-in tasks `padv.builtin.task.AnalyzeModelCode` and `padv.builtin.task.AnalyzeModelCode` to your process model, you must add code that checks if Polyspace Bug Finder is installed and setup. Otherwise, you get an error message: `Unrecognized function or variable 'polyspaceroot'.`

  Use this code:

  ```
  if exist('polyspaceroot','file') % if Polyspace installed and set up
      psTaskObj = addTask(pm, padv.builtin.task.AnalyzeModelCode);
  end
  ```
- Before you use the pipeline generator, make sure that all of the products used by your pipeline are licensed and installed. If a product is not licensed or installed, the pipeline generator returns an error message: `Error using + Not enough input arguments. Error in padv.pipeline.internal.gitlab.PipelineGenerator/createGitlabYMLContent (line 166) gitlabPipelineFullPath = obj.GitlabOptions.PipelineDirRelPath + '###' + gitlabPipeline.Name;`.

Resolve Path Issues

If an artifact is not on the MATLAB search path, add the artifact to your project, then close and re-open the project. When you re-open the project, the MATLAB search path reflects the updated search path.

Note In R2022a and R2022b, if a test harness is saved inside a model file, the Process Advisor and build system return an incorrect warning that the internal test harness is not on the MATLAB search path. Ignore the warning, and, if possible, convert your internal test harnesses to external test harnesses so that the support package can differentiate between changes to the test harness and changes to the main model.

To convert a test harness, open Simulink Test for the main model and, on the **Tests** tab, click **Manage Test Harnesses** > **Convert to External Harnesses**. Click **Yes** to convert the affected test harnesses.

Version History

July 2023

Supports:

- R2023a
- R2022b Update 1 (and later updates)
- R2022a Update 4 (and later updates)

Fixes

- Removed unsupported call to `padv.utils.isMACacheUpdated` in the built-in task `padv.builtin.task.RunModelStandards` (**Check Modeling Standards**).

Features:

- The built-in tasks `padv.builtin.task.RunTestsPerModel` and `padv.builtin.task.RunTestsPerTestCase` support test cases that run test iterations in fast restart.
- The built-in task `padv.builtin.task.MergeTestResults` has a new property `LoadSimulationSignalData`. If you specify `LoadSimulationSignalData` as `true`, the task loads simulation signal data when loading the test results.

June 2023

Supports:

- R2023a
- R2022b Update 1 (and later updates)
- R2022a Update 4 (and later updates)

Features:

- **Artifacts**
  - There are new utility functions for working with artifacts. For information, enter:

    ```
    help padv.util
    ```
  - You can use the utility functions when working with artifacts and artifact addresses. For example, you can use `padv.util.ArtifactAddress` to specify the address of a `padv.Artifact`:

    ```
    model = padv.Artifact("sl_model_file",...
    padv.util.ArtifactAddress(...
    fullfile("02_Models","AHRS_Voter","specification","AHRS_Voter.slx")));
    ```
- **Build System**
  - You can automatically generate a build report after running tasks with `runprocess`:

    ```
    runprocess(GenerateReport = true)
    ```

    For information on how to specify a different report name and format, see "Generate Build Report".
  - Process Advisor and the build system support a P-coded process model file `processmodel.p`. If you have both a P-code file and a `.m` file, the P-code file takes precedence over the corresponding `.m` file for execution, even after modifications to the `.m` file.
- **Built-In Tasks and Queries**
  - You can use the `Tags` argument of the built-in query `padv.builtin.query.FindTestCasesForModel` to find test cases that use specific tags.
  - The built-in tasks `padv.builtin.task.RunTestsPerModel` and `padv.builtin.task.RunTestsPerTestCase` now use the MATLAB test runner, `matlab.unittest.TestRunner`, to run tests and generate JUnit-style XML reports in CI.
- **Pipeline Generation**
  - The pipeline generator now allows you to specify if and when you want to collect artifacts for your pipeline. In `padv.pipeline.GitLabOptions` or `padv.pipeline.JenkinsOptions`, you can specify the property `EnableArtifactCollection` as:
    - `"never"`, `0`, or `false` — Never collect artifacts
    - `"on_success"` — Only collect artifacts when the job succeeds
    - `"on_failure"` — Only collect artifacts when the job fails
    - `"always"`, `1`, or `true` — Always collect artifacts

(continues on next page)

- The pipeline generator now allows you to control whether a pipeline stops or continues running after a stage fails. In `padv.pipeline.GitLabOptions` or `padv.pipeline.JenkinsOptions`, you can specify the property `StopOnStageFailure` as either `true` or `false`. By default, the pipeline does not stop if a stage in the pipeline fails.
- The pipeline generator automatically generates a Process Advisor build report before collecting build artifacts. The report generates in a new job, `Generate_PADV_Report`. For more information, see "How Pipeline Generation Works".

Compatibility Considerations

- **Artifacts**
  - `padv.Artifact` no longer returns the properties `Address`, `UUID`, `Label`, and `StorageAddress`. `padv.Artifact` now returns an `ArtifactAddress` property instead:

    ```
    a =

      Artifact with properties:

                  Type: "artifact_type"
                Parent: [0×0 padv.Artifact]
       ArtifactAddress: [1×1 padv.util.ArtifactAddress]
    ```

    For information, see "padv.util.ArtifactAddress" in the Reference Book PDF.
- **Queries**
  - The `Name` property for `padv.Query` objects is now immutable. You cannot change the value of the `Name` property after the query object is created. If you want to set a property value for a `padv.Query` object, set the value by using the name-value arguments in the constructor.
- **Built-In Tasks and Queries**
  - The `CovReportPath` property was removed from the built-in task `padv.builtin.task.MergeTestResults`. The coverage and test reports automatically generate into the folder location specified by `ReportPath`.
  - The `Tags` property was removed from the built-in task `padv.builtin.task.RunTestsPerTestCase`. Use `Tags` argument of query `padv.builtin.query.FindTestCasesForModel` to find test cases with specific test tags instead:

    ```
    addTask(pm,padv.builtin.task.RunTestsPerTestCase,...
    IterationQuery = padv.builtin.query.FindTestCasesForModel(Tags="FeatureA"));
    ```
  - The `Tags` property will be removed from the built-in task `padv.builtin.task.RunTestsPerModel` in a future release. Use the `Tags` argument of query `padv.builtin.query.FindTestCasesForModel` instead.
  - The `GenerateJUnitForTask` property was removed from `padv.Task`. `padv.Task` now uses the properties `CISupportOutputsForTask` and `CISupportOutputsByTask` to control whether tasks generate CI aware result files, like JUnit-style XML reports.
  - The built-in tasks `padv.builtin.task.RunTestsPerModel` and `padv.builtin.task.RunTestsPerTestCase` no longer support test cases that run test iterations in fast restart.
- **Pipeline Generation**

- The property `ArtifactsWhen` will be removed from `padv.pipeline.GitLabOptions` in a future release. Use the property `EnableArtifactCollection` to specify when artifacts are collected instead.

  (continues on next page)

- The property `SaveArtifactsOnSuccess` will be removed from `padv.pipeline.JenkinsOptions` in a future release. Use the property `EnableArtifactCollection` to specify when artifacts are collected instead.

April 2023

Supports:

- R2023a
- R2022b Update 1 (and later updates)
- R2022a Update 4 (and later updates)

Features:

- The pipeline generator automatically generates JUnit-style XML reports for tasks. The JUnit reports allow you to see a summary of task results directly in the GitLab or Jenkins user interface. For information, see "Integrate into GitLab" or "Integrate into Jenkins".
- The support package contains an example `Dockerfile` for creating a Docker container to run MATLAB with the support package and other MathWorks products. For more information, see "Create Docker Container for Support Package".
- `padv.ProcessModel` has a property `DefaultOutputDirectory` which controls the `$DEFAULTOUTPUTDIR$` token in the example `processmodel.m` file. By default, Process Advisor outputs files inside a `PA_Results` folder in the project root. For more information, see the Reference Book PDF.
- You can filter the artifacts returned by built-in queries like `padv.builtin.query.FindCodeFolderForModel` by using the properties `IncludeLabel`, `ExcludeLabel`, `IncludePath`, and `ExcludePath`.

  ```
  q = padv.builtin.query.FindRequirements(...
  ExcludePath = "HighLevel");
  run(q)
  ```

- The task `padv.builtin.task.MergeTestResults` now supports inputs that supply multiple test results and supports dependencies on multiple predecessor tasks.

Compatibility Considerations

- Previously, several built-in tasks ran on either reference models **(Ref)** or top models **(Top)**. These tasks have been combined into a single task that can automatically run on both reference models and top models:

Previous Built-In Task Name	Current Built-In Task Name
`padv.builtin.task.AnalyzeRefModelCode`	`padv.builtin.task.AnalyzeModelCode`
`padv.builtin.task.AnalyzeTopModelCode`	
`padv.builtin.task.GenerateCodeAsRefModel`	`padv.builtin.task.GenerateCode`
`padv.builtin.task.GenerateCodeAsTopModel`	
`padv.builtin.task.RunCodeInspectionAsRefModel`	`padv.builtin.task.RunCodeInspection`
`padv.builtin.task.RunCodeInspectionAsTopModel`	

(continues on next page)

Update your code to use the current built-in task names or instances.

```
% Using current built-in task instances
psTask = pm.addTask(padv.builtin.task.AnalyzeModelCode());
codegenTask = pm.addTask(padv.builtin.task.GenerateCode());
slciTask = pm.addTask(padv.builtin.task.RunCodeInspection());
```

If you want the task to only run on either reference models or top models, you can use the properties of the task (`TreatAsRefModel` or `IsTopModel`) to override the default behavior. For example:

```
% To override the default behavior

psRefTask = pm.addTask(padv.builtin.task.AnalyzeModelCode(...
    "TreatAsRefModel", true,...
    IterationQuery = padv.builtin.query.FindRefModels));

codegenRefMdlTask = pm.addTask(padv.builtin.task.GenerateCode(...
    "TreatAsRefModel", true,...
    IterationQuery = padv.builtin.query.FindRefModels));

slciRefTask = pm.addTask(padv.builtin.task.RunCodeInspection(...
    "IsTopModel", false,...
    IterationQuery = padv.builtin.query.FindRefModels));
```

If your process model uses multiple instances of a task, like `padv.builtin.task.RunCodeInspection`, make sure to specify a unique `Name` for each instance of the task.

```
% Provide unique names

slciTopTask = pm.addTask(padv.builtin.task.RunCodeInspection(...
    "Name", "inspectCodeTop",...
    "Title", "Inspect Code (Top)",...
    "IsTopModel", true,...
    IterationQuery = padv.builtin.query.FindTopModels));

slciRefTask = pm.addTask(padv.builtin.task.RunCodeInspection(...
    "Name", "inspectCodeRef",...
    "Title", "Inspect Code (Ref)",...
    "IsTopModel", false,...
    IterationQuery = padv.builtin.query.FindRefModels));
```

- The options structures, `RunOptions` and `ReportOptions`, for built-in tasks will be removed in a future release. The options structures have been replaced by properties of the built-in tasks. To reconfigure a built-in task, use the properties of the task instead.

  For example:

Previously	Now
`maTask.RunOptions.ReportPath`	`maTask.ReportPath`

  You can open the source code for a built-in task to see a mapping of the options structure to the task properties. For example:

  ```
  open padv.builtin.task.RunModelStandards
  ```

The `getLegacyOptions` function shows the mapping. For example:

```
function options = getLegacyOptions()
options = [ ...
    "RunOptions.CheckIDList", "CheckIDList" ...
    "RunOptions.DisplayResults", "DisplayResults"...
    "RunOptions.Force", "Force" ...
    "RunOptions.ParallelMode", "ParallelMode" ...
    "RunOptions.TempDir", "TempDir" ...
    "RunOptions.ShowExclusions", "ShowExclusions" ...
    "RunOptions.ExtensiveAnalysis", "ExtensiveAnalysis" ...
    "RunOptions.ReportName", "ReportName" ...
    "RunOptions.ReportFormat", "ReportFormat" ...
    "RunOptions.ReportPath", "ReportPath" ...
    ];
end
```

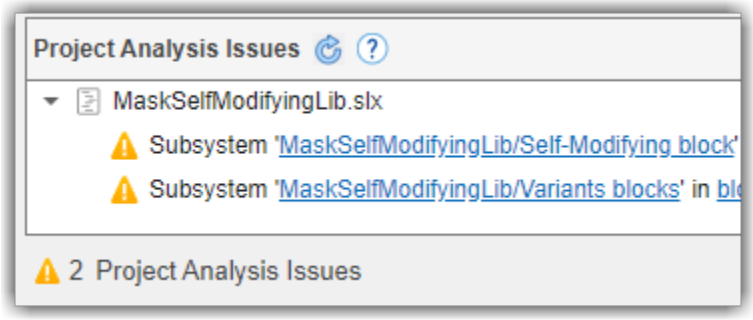
March 2023

Supports:

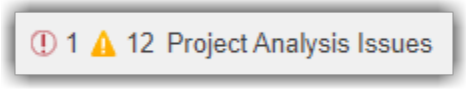
- R2023a
- R2022b Update 1 (and later updates)
- R2022a Update 4 (and later updates)

Features:

- The support package now supports R2023a.
- Starting in R2023a:
  - The support package can analyze artifacts in referenced projects.
  - The **Project Analysis Issues** pane returns warnings for artifacts in the project.



The number of errors and warnings in the project are summarized at the bottom of the Process Advisor app.



For more information, see "Quick Reference for Process Advisor App".

February 2023

Supports:

- R2022b Update 1 (and later updates)
- R2022a Update 4 (and later updates)

Features:

- Automatically generate a pipeline file for a Jenkins pipeline by using the function `padv.pipeline.generatePipeline`. For more information, see the section "Integrate into Jenkins".

- The CI options for pipeline generation have two new properties:
  - `AddBatchStartupOption` — Specify whether to open MATLAB using the `-batch` startup option
  - `GeneratedPipelineDirectory` — Specify where the generated pipeline file generates
- `padv.Task` has new properties:
  - `AlwaysRun` — If you specify `AlwaysRun` as `true`, the task will always run, even if the task results are already up to date.
  - `LaunchToolText` — Specify a tooltip for a custom launch action for a task.
  - `OutputDirectory` — Location for standard outputs that the task produces
  - `CacheDirectory` — Location for any additional cache files that the task generates

- The built-in query `padv.builtin.query.FindArtifacts` accepts a cell array of multiple artifact types for the `ArgumentType` argument. For example, to find the Simulink models and MATLAB M files in a project:

```
q = padv.builtin.query.FindArtifacts(...
ArtifactType={"sl_model_file","m_file"});
run(q)
```

Fixes:

- In the standalone Process Advisor window, Linux users can point to a task and click the ellipses (**...**) without having to use the arrows on the keyboard to interact with the options in the menu.

Compatibility Considerations

- The `ArtifactsPath` property was removed from `padv.pipeline.GitLabOptions` and `padv.pipeline.JenkinsOptions`. If you previously specified the `ArtifactsPath` property, update your code to no longer specify `ArtifactsPath`. The pipeline generator uses the `OutputDirectory` property of the task to automatically identify which artifacts to collect.

December 2022

Supports:

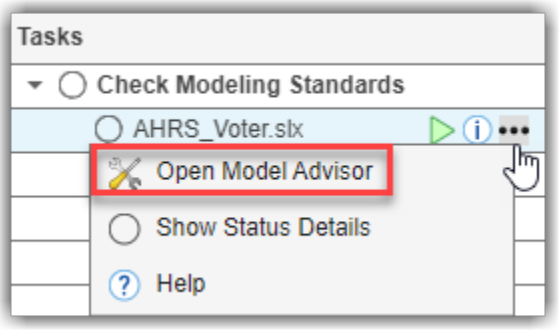
- R2022b Update 1 (and later updates)
- R2022a Update 4 (and later updates)

Features:

- Automatically generate a pipeline configuration file for a GitLab pipeline by using the new function `padv.pipeline.generatePipeline`. For more information, see the section "Integrate into GitLab" or enter:

  ```
  help padv.pipeline.generatePipeline
  ```

- Open the tool associated with a task by pointing to the task in the Process Advisor app and clicking the ellipsis (**...**) and then **Open *`Tool Name`***.



- Automatically view detailed statuses, inputs, outputs, and dependencies for tasks and task results shown in the Process Advisor app.
- The built-in task **Design Error Detection** now outputs the Simulink Design Verifier data file as an output in the **I/O** column.
- Find artifacts in your project that meet specific search criteria by using the new built-in query `padv.builtin.query.FindArtifacts`.

  For information, enter:

  ```
  help padv.builtin.query.FindArtifacts
  ```

- Find requirement sets in your project and requirement links to models by using the new built-in queries `padv.builtin.query.FindRequirements` and `padv.builtin.query.FindRequirementsForModel`, respectively.

November 2022

Supports:

- R2022b Update 1 (and later updates)
- R2022a Update 4 (and later updates)

Features:

- You can now open artifacts, in their associated tool, directly from the Process Advisor app. In the **Tasks** column, point to the name of an artifact and click the hyperlink.
- If there is a new version of the support package available, the Process Advisor app shows an update icon in the bottom-right corner.
- The built-in task for generating a Simulink Web view now includes additional options like the ability to include user notes and export models in subfolders. To view the source code for the task, enter this code in the MATLAB Command Window:

  ```
  open padv.builtin.task.GenerateSimulinkWebView
  ```

Fixes:

- The Process Advisor app respects requests to cancel artifact analysis.
- The task `padv.builtin.task.AnalyzeModelCode` returns an error if Polyspace Bug Finder is either not installed or not linked to the current MATLAB installation.

October 2022

Supports:

- R2022b Update 1 (and later updates)
- R2022a Update 4 (and later updates)

Features:

- The support package now supports R2022b for Update 1 and later updates.
- Turn off incremental builds for a project by clearing the **Incremental Build** check box in the Process Advisor app. For more information, see the section "How to Disable Incremental Builds".
- The build system and **Process Advisor** app take advantage of `runsAfter` relationships when determining the task execution order for tasks associated with the project.

September 2022

Supports:

- R2022a Update 4 (and later updates)

Features:

- You can create a new example project instance that includes an example YAML file for configuring GitLab pipelines:

  ```
  processAdvisorGitLabExampleStart
  ```

  The example YAML file, `.gitlab-ci.yml`, is in the project root.
- You can create a new example project instance that includes an example Jenkinsfile for configuring Jenkins pipelines:

  ```
  processAdvisorJenkinsExampleStart
  ```

  The example Jenkinsfile, `Jenkinsfile`, is in the project root.
- Test harnesses are now tracked as dependencies for test cases.
- Externally-saved input or output baselines (including `.mat` and Excel) are now tracked as dependencies for test cases.

Fixes:

- If you are using the project window and there is an error, the error dialog is able to open the artifact listed in the hyperlink.

August 2022

Initial release.

Supports:

- R2022a Update 4 (and later updates)