TMT-SE How to Add an ne w Observation Workflow

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How to Add a New Observatory Level Workflow to the TMT Model

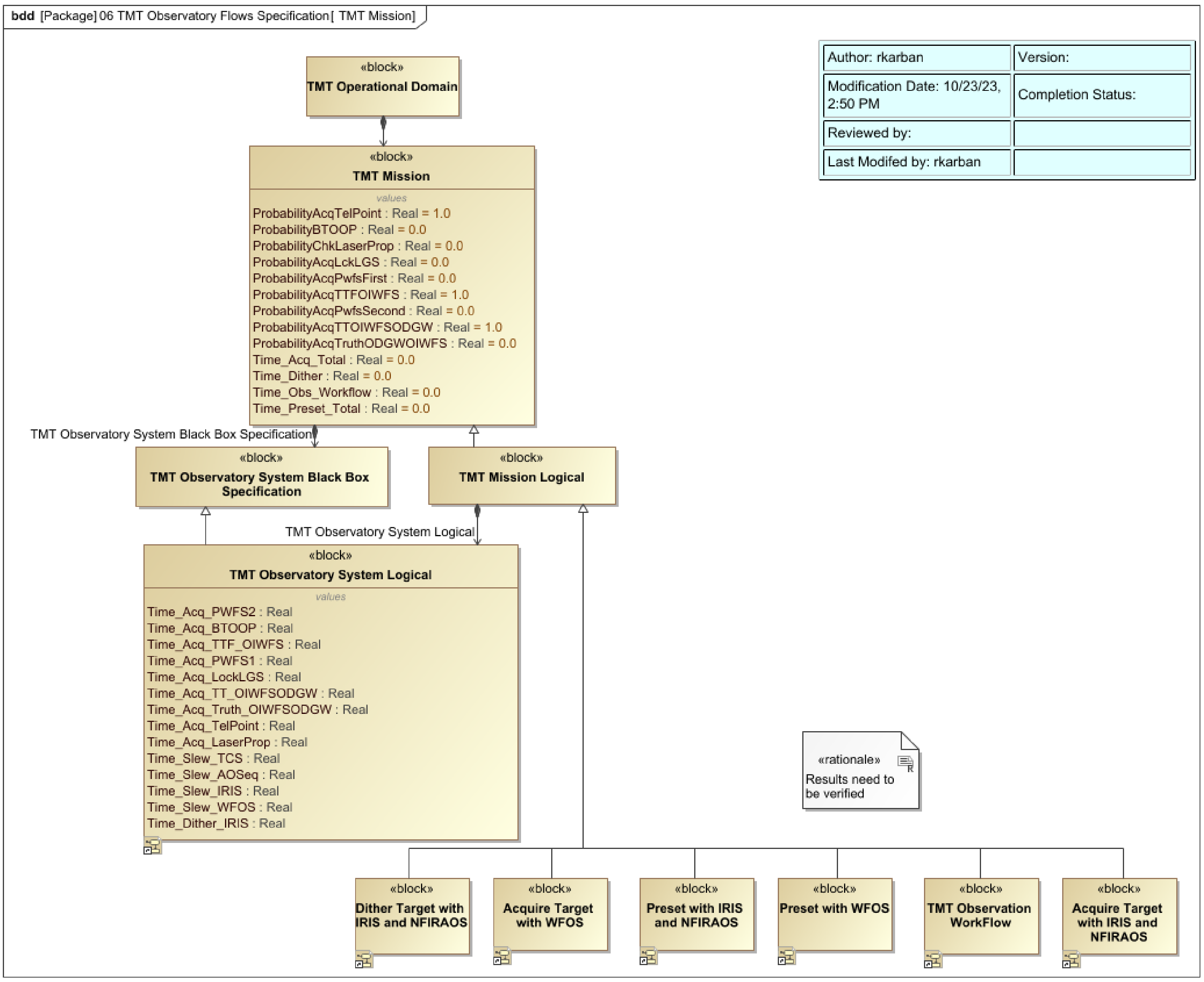
1 Introduction

TMT model entails several workflows to describe different scenarios. The following sections describe the steps for adding a new workflow to the TMT model by utilizing the same pattern

2 Create New Workflow Activities

Within the model, each workflow consists of activity and state machine diagrams to describe the behavior and operational modes. Existing workflows are illustrated in the figure below which are specializations of the "TMT Mission Logical" block. This block inherits the properties of the "TMT Mission" block which describes different probabilities utilized for the probabilistic nature of the model.

TMT Mission


bdd [Package] 06 TMT Observatory Flows Specification [TMT Mission]
«block»
TMT Operational Domain
«block»
TMT Mission
values
ProbabilityAcqTelPoint : Real = 1.0
ProbabilityBTOOP : Real = 0.0
ProbabilityChkLaserProp : Real = 0.0
ProbabilityAcqLckLGS : Real = 0.0
ProbabilityAcqPwfsFirst : Real = 0.0
ProbabilityAcqTTFOIWFS : Real = 1.0
ProbabilityAcqPwfsSecond : Real = 0.0
ProbabilityAcqTTOIWFSODGW : Real = 1.0
ProbabilityAcqTruthODGWOIWFS : Real = 0.0
Time_Acq_Total : Real = 0.0
Time_Dither : Real = 0.0
Time_Obs_Workflow : Real = 0.0
Time_Preset_Total : Real = 0.0
TMT Observatory System Black Box Specification
«block»
TMT Observatory System Black Box Specification
«block»
TMT Mission Logical
TMT Observatory System Logical
«block»
TMT Observatory System Logical
values
Time_Acq_PWFS2 : Real
Time_Acq_BTOOP : Real
Time_Acq_TTF_OIWFS : Real
Time_Acq_PWFS1 : Real
Time_Acq_LockLGS : Real
Time_Acq_TT_OIWFSODGW : Real
Time_Acq_Truth_OIWFSODGW : Real
Time_Acq_TelPoint : Real
Time_Acq_LaserProp : Real
Time_Slew_TCS : Real
Time_Slew_AOSeq : Real
Time_Slew_IRIS : Real
Time_Slew_WFOS : Real
Time_Dither_IRIS : Real
«rationale»
Results need to be verified
«block»
Dither Target with IRIS and NFIRAOS
«block»
Acquire Target with WFOS
«block»
Preset with IRIS and NFIRAOS
«block»
Preset with WFOS
«block»
TMT Observation WorkFlow
«block»
Acquire Target with IRIS and NFIRAOS

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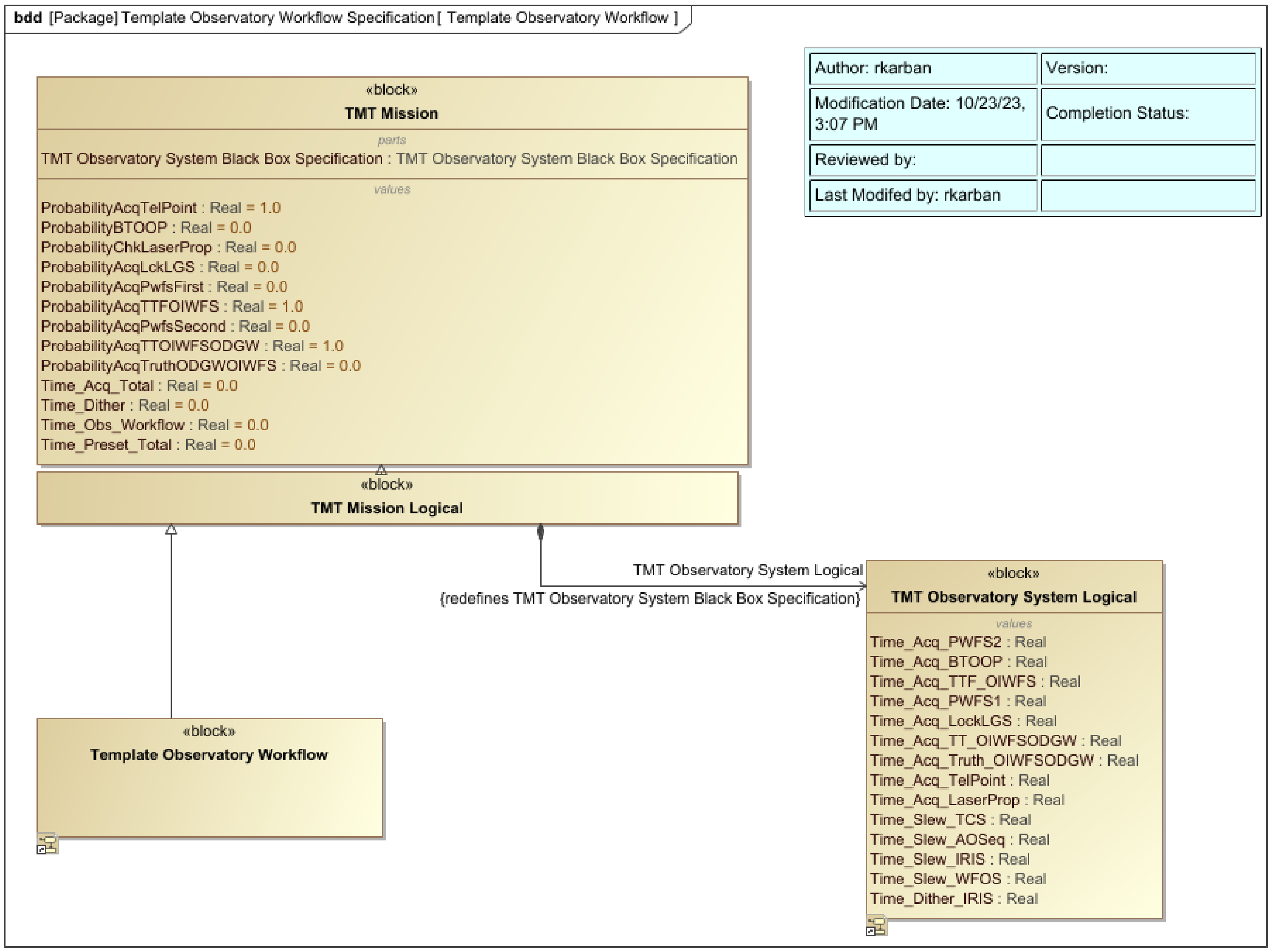
Similarly to existing workflows, template workflow is created for users as a reference when creating new workflows. In order to create a new workflow, copy the template workflow in the model and make necessary adjustments (bottom-up approach), or leverage it as a reference for adding a new workflow from scratch (top-down approach).

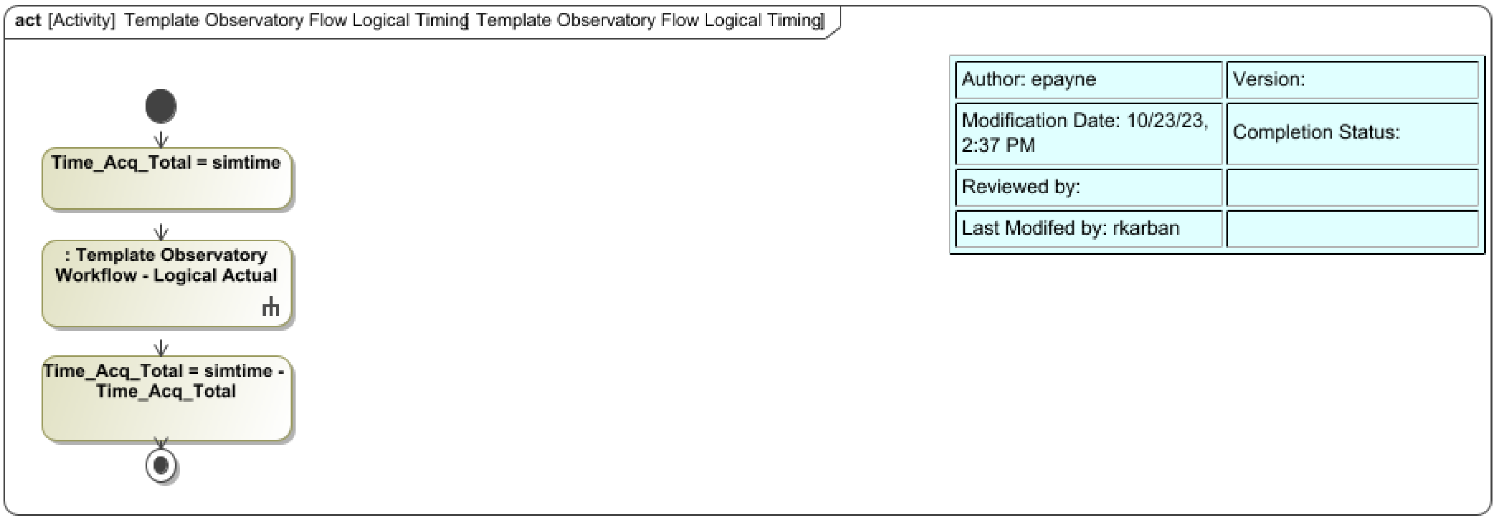
Template Observatory Workflow


bdd [Package] Template Observatory Workflow Specification [Template Observatory Workflow]
Author: rkarban
Version:
Modification Date: 10/23/23, 3:07 PM
Completion Status:
Reviewed by:
Last Modifed by: rkarban
«block»
TMT Mission
parts
TMT Observatory System Black Box Specification : TMT Observatory System Black Box Specification
values
ProbabilityAcqTelPoint : Real = 1.0
ProbabilityBTOOP : Real = 0.0
ProbabilityChkLaserProp : Real = 0.0
ProbabilityAcqLckLGS : Real = 0.0
ProbabilityAcqPwfsFirst : Real = 0.0
ProbabilityAcqTTFOIWFS : Real = 1.0
ProbabilityAcqPwfsSecond : Real = 0.0
ProbabilityAcqTTOIWFSODGW : Real = 1.0
ProbabilityAcqTruthODGWOIWFS : Real = 0.0
Time_Acq_Total : Real = 0.0
Time_Dither : Real = 0.0
Time_Obs_Workflow : Real = 0.0
Time_Preset_Total : Real = 0.0
«block»
TMT Mission Logical
TMT Observatory System Logical
{redefines TMT Observatory System Black Box Specification}
«block»
TMT Observatory System Logical
values
Time_Acq_PWFS2 : Real
Time_Acq_BTOOP : Real
Time_Acq_TTF_OIWFS : Real
Time_Acq_PWFS1 : Real
Time_Acq_LockLGS : Real
Time_Acq_TT_OIWFSODGW : Real
Time_Acq_Truth_OIWFSODGW : Real
Time_Acq_TelPoint : Real
Time_Acq_LaserProp : Real
Time_Slew_TCS : Real
Time_Slew_AOSeq : Real
Time_Slew_IRIS : Real
Time_Slew_WFOS : Real
Time_Dither_IRIS : Real
«block»
Template Observatory Workflow

2.1 Create Workflow Specification

Under the *TMT::01 TMT PO::System Model::TMT Observatory::01 TMT Observatory Operational Domain::03 Mission::06 TMT Observatory Flows Specification* package and *TMT Mission* block, either create a new block called [*Workflow Name] or* a copy-paste the reference *TMT Observatory Workflow* block and re-name it for the new workflow*.* Keep in mind, copying and pasting may require adjustments to for the relationships.
Within the *[Workflow Name]* block, create an activity (and corresponding activity diagram) or adjust the copied reference activity to reflect the new workflow, and name the activity/diagram [*Workflow Name. - Logical]*. As can be seen, the name of the template workflow is [*Template Observatory Workflow]* and the name of the activity/diagram representing this flow is [*Template Observatory Flow Logical Timing*].

Template Observatory Flow Logical Timing


act [Activity] Template Observatory Flow Logical Timing[Template Observatory Flow Logical Timing]
Time_Acq_Total = simtime
: Template Observatory Workflow - Logical Actual
Time_Acq_Total = simtime - Time_Acq_Total

Author: epayne	Version:
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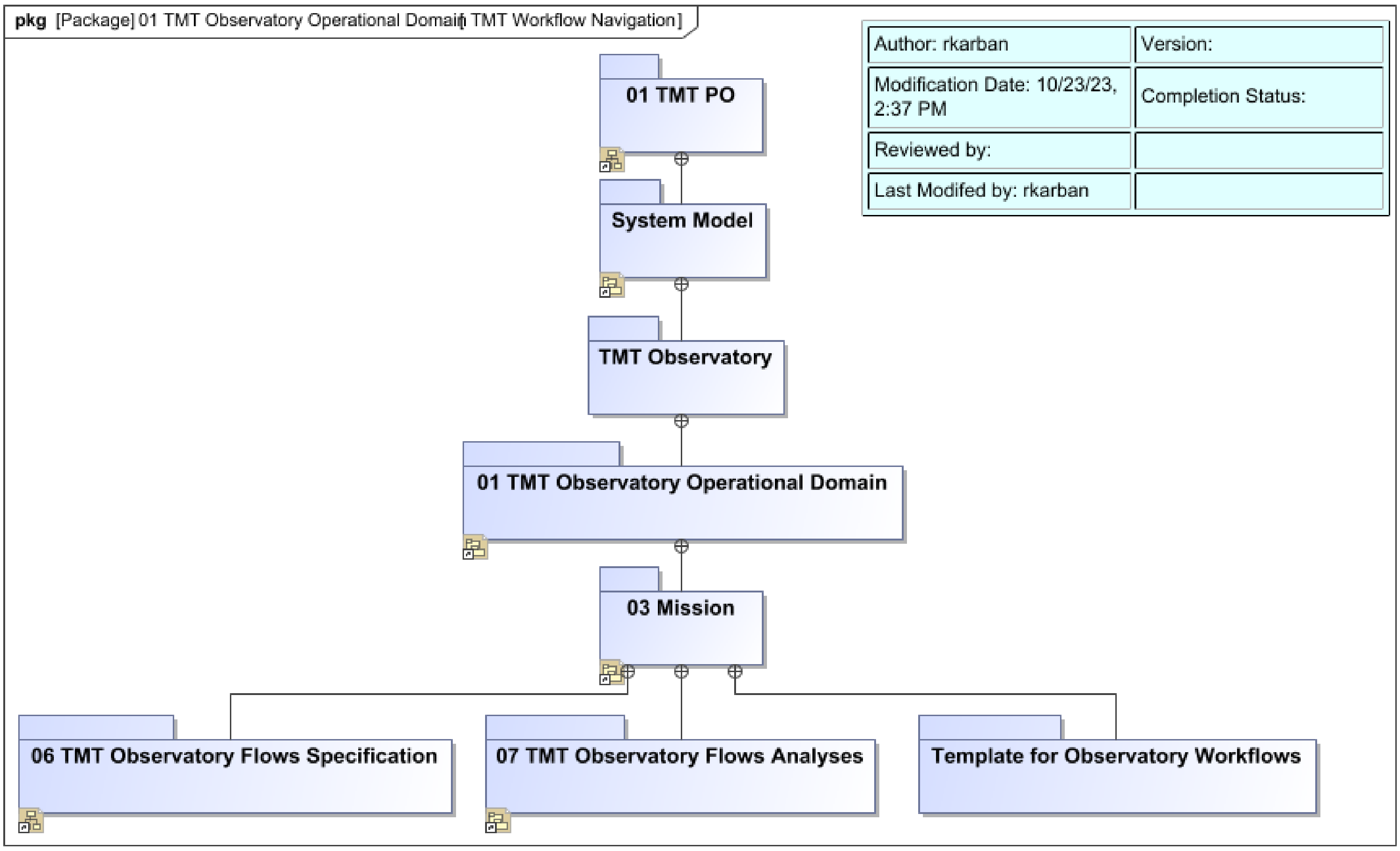
The *Logical* activity that is created will capture the actual steps/tasks of the new workflow. Create an initial node and an opaque action to specify timing variables. In this action type, total time the new workflow *[Total Time]* will calculated, which is the *TotalAcquisitionTime* in the example below. Initiate and set this time equal to *simtime* by using the equality expression with the preferred language (Javascript Rhino).
In order to describe the activities performed in the workflow, there is a need to create another activity called [*Workflow Name - Logical Actual]. Logical Actual* activity will be owned by the aforementioned *Logical* activity with a corresponding activity diagram.
Connect the *Logical Actual* activity to the opaque action by a control flow. Then, create the last opaque action which will set *[Total Time]* to the *simtime* subtracted by the *[Total Time]*. Then, add the activity final node as depicted in the figure below for the [*Acquire Target with IRIS and NFIRAOS - Logical activity*].

TMT Workflow Navigation

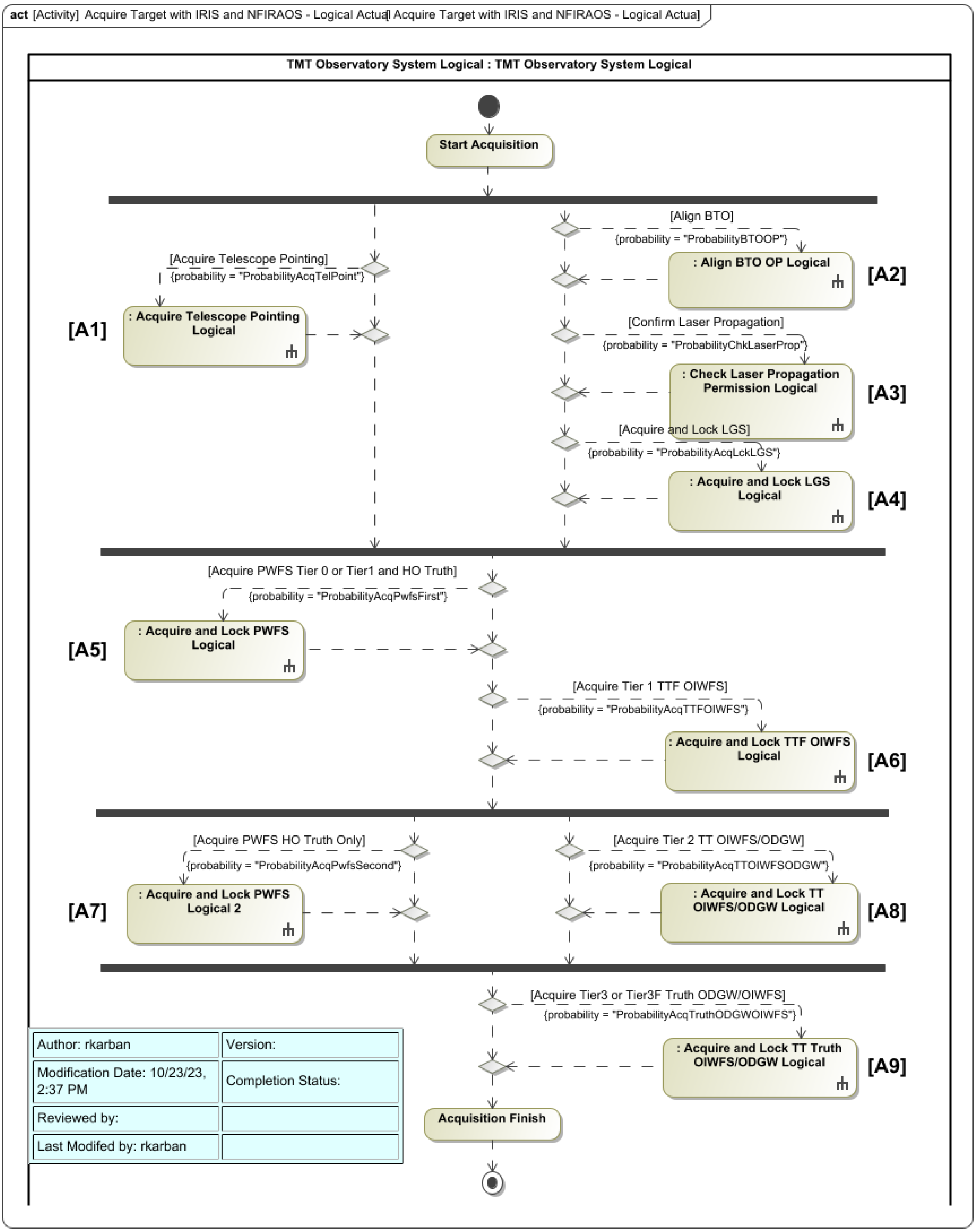

pkg [Package] 01 TMT Observatory Operational Domain [TMT Workflow Navigation]
Author: rkarban
Version:
Modification Date: 10/23/23, 2:37 PM
Completion Status:
Reviewed by:
Last Modifed by: rkarban
01 TMT PO
System Model
TMT Observatory
01 TMT Observatory Operational Domain
03 Mission
06 TMT Observatory Flows Specification
07 TMT Observatory Flows Analyses
Template for Observatory Workflows

The *Logical* activity that is created will capture the actual steps/tasks of the new workflow. Create an initial node and an opaque action to specify timing variables. In this action type, total time the new workflow *[Total Time]* will calculated, which is the *TotalAcquisitionTime* in the example below. Initiate and set this time equal to *simtime* by using the equality expression with the preferred language (Javascript Rhino).
In order to describe the activities performed in the workflow, there is a need to create another activity called [*Workflow Name - Logical Actual]. Logical Actual* activity will be owned by the aforementioned *Logical* activity with a corresponding activity diagram.
Connect the *Logical Actual* activity to the opaque action by a control flow. Then, create the last opaque action which will set *[Total Time]* to the *simtime* subtracted by the *[Total Time]*. Then, add the activity final node as depicted in the figure below for the [*Acquire Target with IRIS and NFIRAOS - Logical activity*].

2.2 Decompose Workflow Steps

The specified workflow needs to be broken down further into sub-steps within the *Logical Actual* activity. Within this activity, capture what sub-steps the workflow step/activity decomposes into. As a reference, the *Template Observatory Workflow - Logical Actual* describes the decomposed workflow activities which is shown below.

Acquire Target with IRIS and NFIRAOS - Logical Actual



act [Activity] Acquire Target with IRIS and NFIRAOS - Logical Actual[Acquire Target with IRIS and NFIRAOS - Logical Actual]
TMT Observatory System Logical : TMT Observatory System Logical
Start Acquisition
[Acquire Telescope Pointing]
{probability = "ProbabilityAcqTelPoint"}
[A1]
: Acquire Telescope Pointing Logical
[Align BTO]
{probability = "ProbabilityBTOOP"}
: Align BTO OP Logical
[A2]
[Confirm Laser Propagation]
{probability = "ProbabilityChkLaserProp"}
: Check Laser Propagation Permission Logical
[A3]
[Acquire and Lock LGS]
{probability = "ProbabilityAcqLckLGS"}
: Acquire and Lock LGS Logical
[A4]
[Acquire PWFS Tier 0 or Tier1 and HO Truth]
{probability = "ProbabilityAcqPwfsFirst"}
[A5]
: Acquire and Lock PWFS Logical
[Acquire Tier 1 TTF OIWFS]
{probability = "ProbabilityAcqTTFOIWFS"}
: Acquire and Lock TTF OIWFS Logical
[A6]
[Acquire PWFS HO Truth Only]
{probability = "ProbabilityAcqPwfsSecond"}
[A7]
: Acquire and Lock PWFS Logical 2
[Acquire Tier 2 TT OIWFS/ODGW]
{probability = "ProbabilityAcqTTOIWFSODGW"}
: Acquire and Lock TT OIWFS/ODGW Logical
[A8]
[Acquire Tier3 or Tier3F Truth ODGW/OIWFS]
{probability = "ProbabilityAcqTruthODGWOIWFS"}
: Acquire and Lock TT Truth OIWFS/ODGW Logical
[A9]
Acquisition Finish

Author: rkarban	Version:
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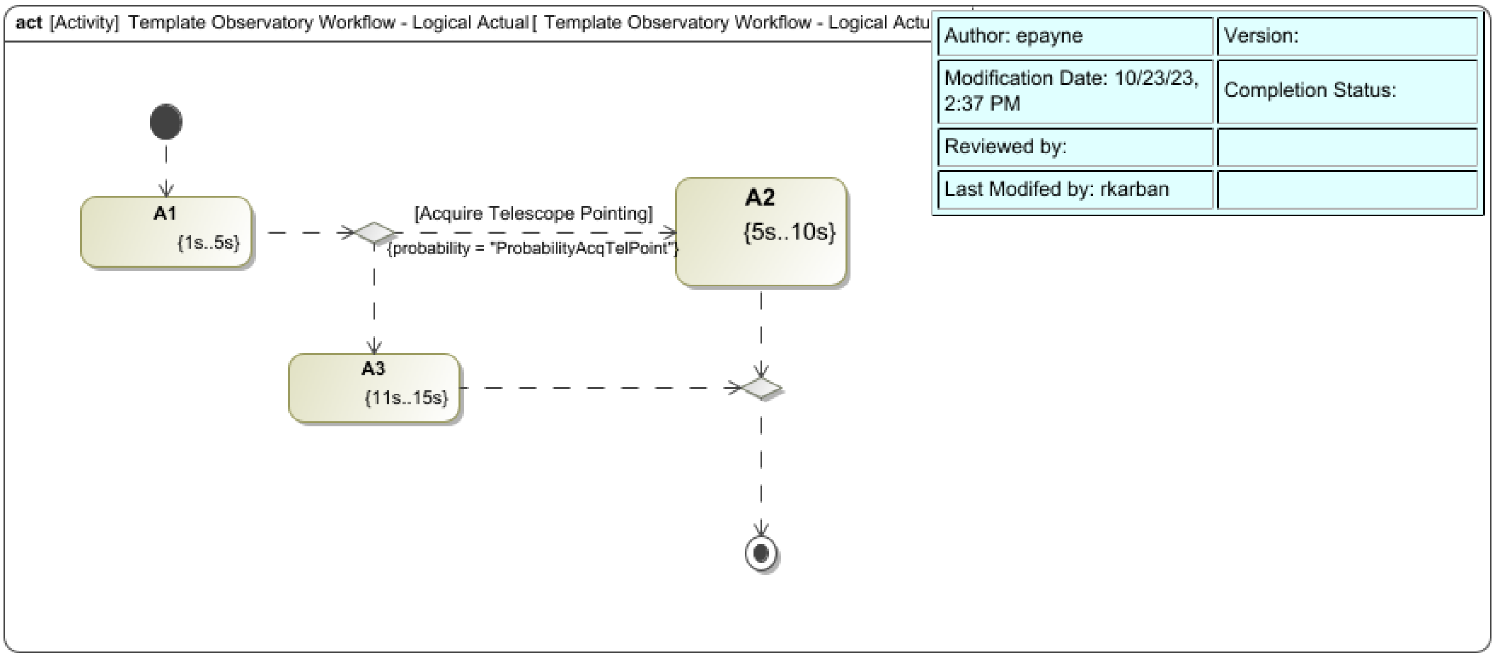
An existing workflow in the model is captured below to provide another example of the workflow activity decomposition. *Acquire Target with IRIS and NFIRAOS - Logical owns* the *Acquire Target with IRIS and NFIRAOS - Logical Actual* activity which decomposes the workflow into the steps shown in the figure below.

Template Observatory Workflow - Logical Actual


act [Activity] Template Observatory Workflow - Logical Actual [Template Observatory Workflow - Logical Actu
A1
{1s..5s}
[Acquire Telescope Pointing]
{probability = "ProbabilityAcqTelPoint"}
A2
{5s..10s}
A3
{11s..15s}

Author: epayne	Version:
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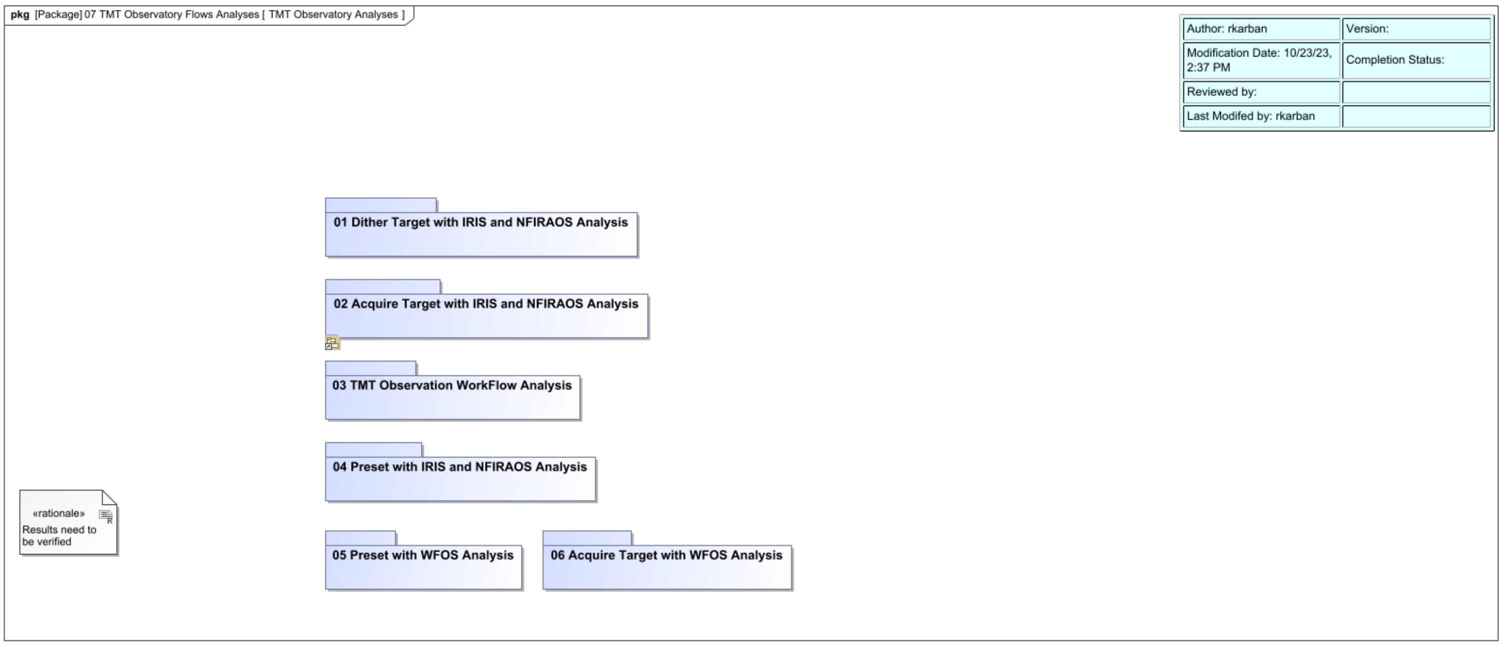
Last Modifed by: rkarban	

Note that if the new workflow requires that certain actions/activities be allocated to certain part properties, utilize swimlanes and have *Allocation Mode* set to *Usage* as demonstrated in the figure above.

3 Create Workflow Analyses

After the workflow is specified, the corresponding analyses need to be defined under the TMT::01 TMT PO::System Model::TMT Observatory::01 TMT Observatory Operational Domain::03 Mission::07 TMT Observatory Flows Analyses package. Current workflow analysis packages are shown in the figure below.

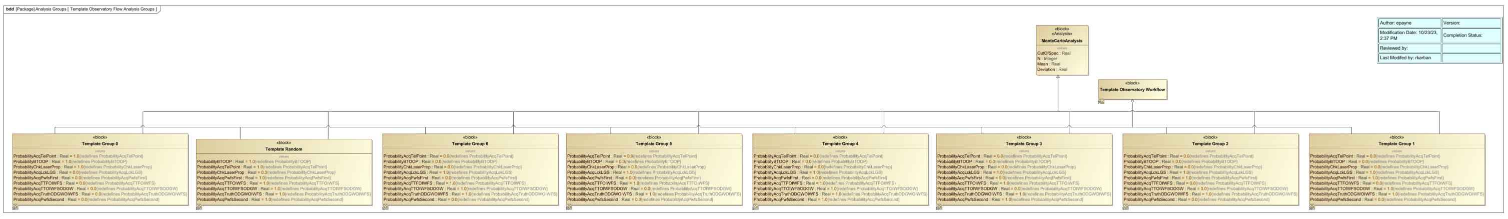
TMT Observatory Analyses


pkg [Package] 07 TMT Observatory Flows Analyses [TMT Observatory Analyses]
01 Dither Target with IRIS and NFIRAOS Analysis
02 Acquire Target with IRIS and NFIRAOS Analysis
03 TMT Observation WorkFlow Analysis
04 Preset with IRIS and NFIRAOS Analysis
05 Preset with WFOS Analysis
06 Acquire Target with WFOS Analysis
«rationale»
Results need to be verified

Author: rkarban	Version:
Modification Date: 10/23/23, 2:37 PM	Completion Status:
Reviewed by:	
Last Modifed by: rkarban	

After the analysis package is created with appropriate numbering prefix in the name, three other packages need to be defined to specify the *Analysis Groups*, *Simulation Configurations*, and *Results*. The purpose for creating these packages with a certain hierarchy is to organize the model in a meaningful and consistent way. *Analysis Groups* package will contain groups of plausible scenarios for the workflow whereas the packages *Simulation Configurations* and *Results* will facilitate the organization of simulation configurations and the results of the analyses for each group of scenarios.

Template Observatory Flow Analysis Groups



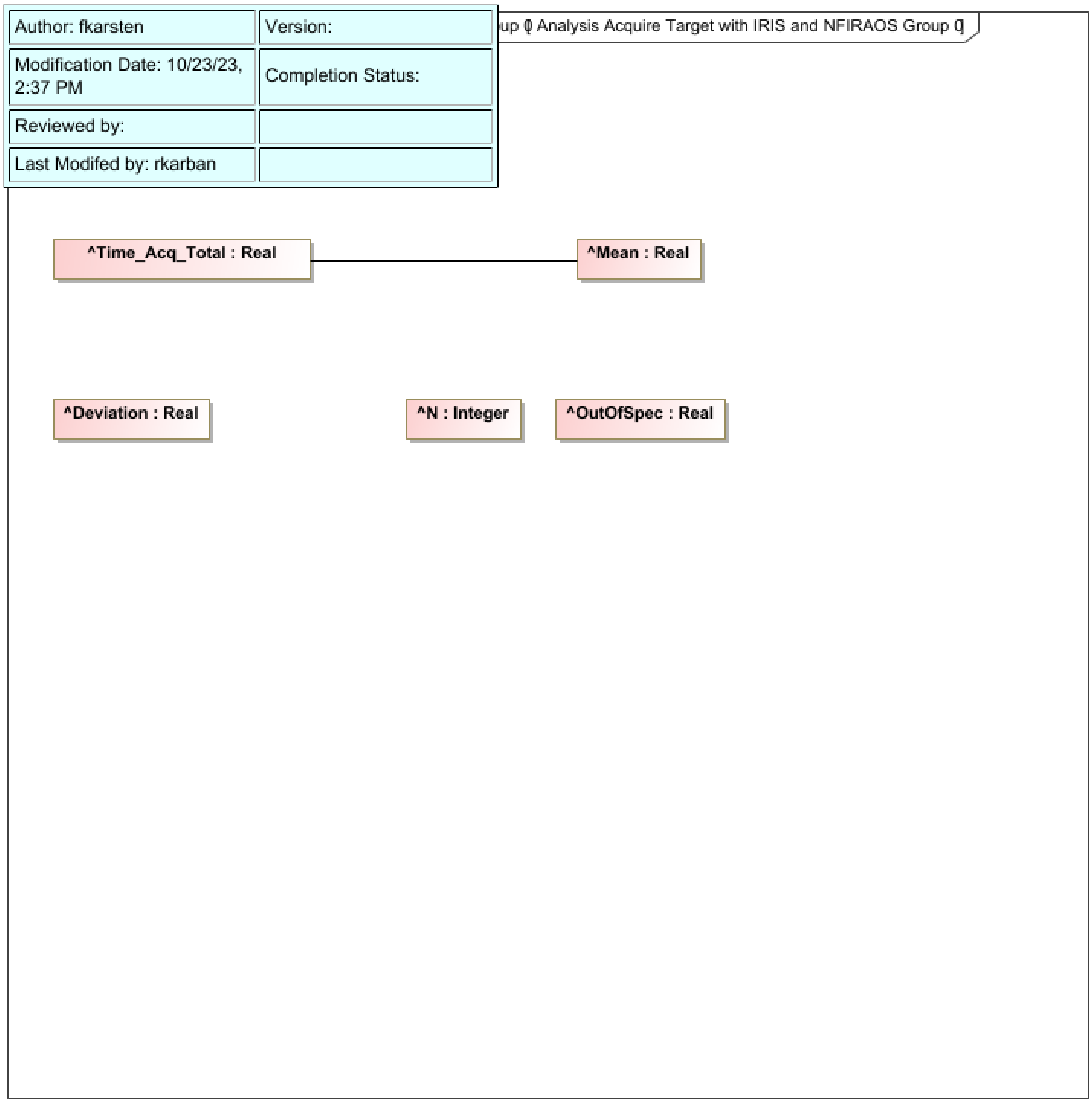
To capture different scenarios, each workflow are specialized into six different groups of plausible scenarios by using a block to represent each group. Begin by creating a block-definition diagram (bdd) under the *Analysis Groups* package and name the diagram *Analysis Groups of [Workflow Name]*. Create six new blocks, each called *Analysis [Workflow Name] Group [n]* where n is 1-6. Generalize these 6 blocks to the *workflow* block itself which is described in [*Create Workflow Specification]*. For example, we would draw a generalization relationship from *Template Group 1* to Template *Observatory Workflow*. At this point, the bdd should look like the one in figure given below. Note that each group redefines the inherited properties to reflect a different scenario of probabilities.

In order to enable **Monte Carlo Simulation**, another generalization relationship needs to be established at this stage from the workflow groups to the *MonteCarloAnalysis* block. This block can be found under MD Customization for SysML::analysis patterns. MonteCarloAnalysis block contains the following properties.

- OutOfSpec: % of samples violating any of the attached constraints/requirements
- N: statistical value, the number of observations/ data points from a Monte-Carlo simulation
- Mean: statistical value, an average of observations/ data points from a Monte-Carlo simulation
- Deviation: statistical value, a standard deviation of observations/ data points from a Monte-Carlo simulation

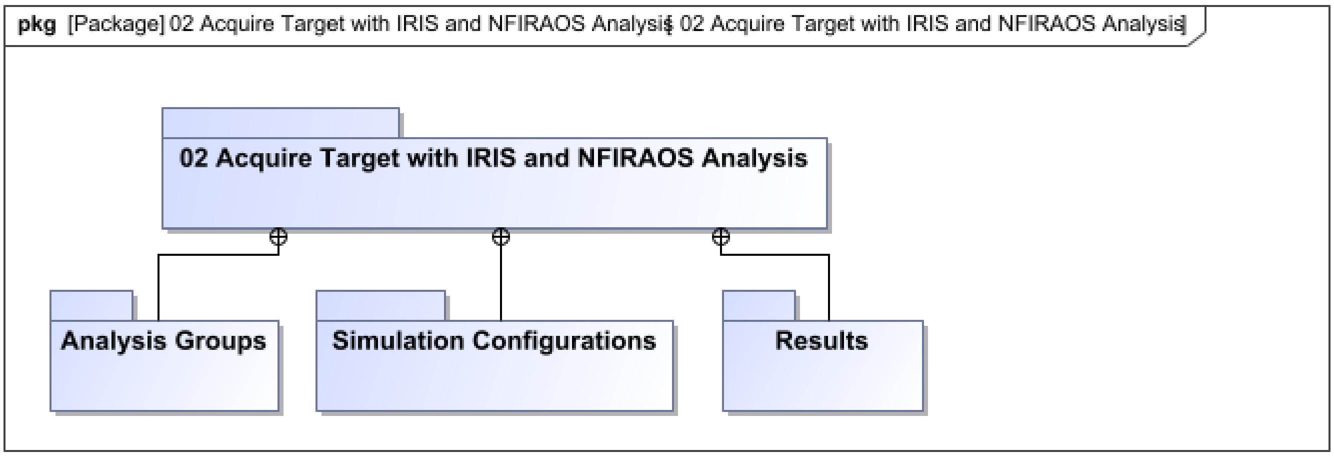
These properties will then need to be associated with related the value properties using *binding connectors* as shown in the figure below with a Parametric Diagram.
For more information about the Monte Carlo simulation and the timing variables, please refer to the OpenSE Cookbook.

Analysis Acquire Target with IRIS and NFIRAOS Group 0



Author: fkarsten	Version:
Modification Date: 10/23/23, 2:37 PM	Completion Status:
Reviewed by:	
Last Modifed by: rkarban	

02 Acquire Target with IRIS and NFIRAOS Analysis

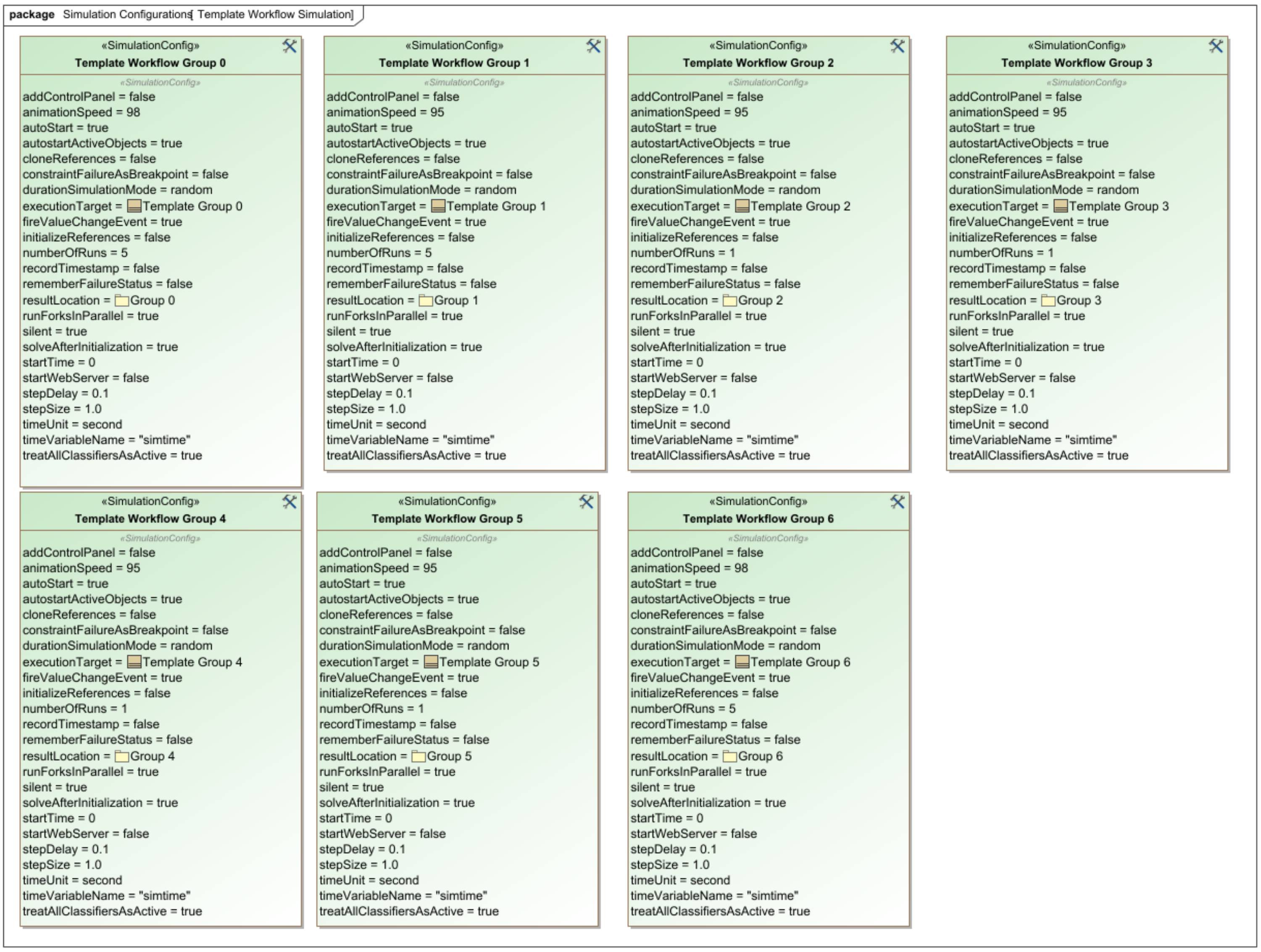

pkg [Package] 02 Acquire Target with IRIS and NFIRAOS Analysis[02 Acquire Target with IRIS and NFIRAOS Analysis]
02 Acquire Target with IRIS and NFIRAOS Analysis
Analysis Groups
Simulation Configurations
Results

4 Run Simulations

4.1 Simulation Configurations

To run a Monte Carlo Simulation within the analysis, Simulation Configuration model element will need to be configured. Within the configuration, set the executionTarget attribute to the relevant analysis group context, and indicate the results location. The number of runs and other specifications can also be adjusted according to the analysis needs. The figure below demonstrates the reference Template Workflow simulation configurations for each workflow group, located under the *Simulation Configurations* package.

Template Workflow Simulation


package Simulation Configurations[Template Workflow Simulation]

```
«SimulationConfig»
Template Workflow Group 0
«SimulationConfig»
addControlPanel = false
animationSpeed = 98
autoStart = true
autostartActiveObjects = true
cloneReferences = false
constraintFailureAsBreakpoint = false
durationSimulationMode = random
executionTarget = Template Group 0
fireValueChangeEvent = true
initializeReferences = false
numberOfRuns = 5
recordTimestamp = false
rememberFailureStatus = false
resultLocation = Group 0
runForksInParallel = true
silent = true
solveAfterInitialization = true
startTime = 0
startWebServer = false
stepDelay = 0.1
stepSize = 1.0
timeUnit = second
timeVariableName = "simtime"
treatAllClassifiersAsActive = true
```

```
«SimulationConfig»
Template Workflow Group 1
«SimulationConfig»
addControlPanel = false
animationSpeed = 95
autoStart = true
autostartActiveObjects = true
cloneReferences = false
constraintFailureAsBreakpoint = false
durationSimulationMode = random
executionTarget = Template Group 1
fireValueChangeEvent = true
initializeReferences = false
numberOfRuns = 5
recordTimestamp = false
rememberFailureStatus = false
resultLocation = Group 1
runForksInParallel = true
silent = true
solveAfterInitialization = true
startTime = 0
startWebServer = false
stepDelay = 0.1
stepSize = 1.0
timeUnit = second
timeVariableName = "simtime"
treatAllClassifiersAsActive = true
```

```
«SimulationConfig»
Template Workflow Group 2
«SimulationConfig»
addControlPanel = false
animationSpeed = 95
autoStart = true
autostartActiveObjects = true
cloneReferences = false
constraintFailureAsBreakpoint = false
durationSimulationMode = random
executionTarget = Template Group 2
fireValueChangeEvent = true
initializeReferences = false
numberOfRuns = 1
recordTimestamp = false
rememberFailureStatus = false
resultLocation = Group 2
runForksInParallel = true
silent = true
solveAfterInitialization = true
startTime = 0
startWebServer = false
stepDelay = 0.1
stepSize = 1.0
timeUnit = second
timeVariableName = "simtime"
treatAllClassifiersAsActive = true
```

```
«SimulationConfig»
Template Workflow Group 3
«SimulationConfig»
addControlPanel = false
animationSpeed = 95
autoStart = true
autostartActiveObjects = true
cloneReferences = false
constraintFailureAsBreakpoint = false
durationSimulationMode = random
executionTarget = Template Group 3
fireValueChangeEvent = true
initializeReferences = false
numberOfRuns = 1
recordTimestamp = false
rememberFailureStatus = false
resultLocation = Group 3
runForksInParallel = true
silent = true
solveAfterInitialization = true
startTime = 0
startWebServer = false
stepDelay = 0.1
stepSize = 1.0
timeUnit = second
timeVariableName = "simtime"
treatAllClassifiersAsActive = true
```

```
«SimulationConfig»
Template Workflow Group 4
«SimulationConfig»
addControlPanel = false
animationSpeed = 95
autoStart = true
autostartActiveObjects = true
cloneReferences = false
constraintFailureAsBreakpoint = false
durationSimulationMode = random
executionTarget = Template Group 4
fireValueChangeEvent = true
initializeReferences = false
numberOfRuns = 1
recordTimestamp = false
rememberFailureStatus = false
resultLocation = Group 4
runForksInParallel = true
silent = true
solveAfterInitialization = true
startTime = 0
startWebServer = false
stepDelay = 0.1
stepSize = 1.0
timeUnit = second
timeVariableName = "simtime"
treatAllClassifiersAsActive = true
```

```
«SimulationConfig»
Template Workflow Group 5
«SimulationConfig»
addControlPanel = false
animationSpeed = 95
autoStart = true
autostartActiveObjects = true
cloneReferences = false
constraintFailureAsBreakpoint = false
durationSimulationMode = random
executionTarget = Template Group 5
fireValueChangeEvent = true
initializeReferences = false
numberOfRuns = 1
recordTimestamp = false
rememberFailureStatus = false
resultLocation = Group 5
runForksInParallel = true
silent = true
solveAfterInitialization = true
startTime = 0
startWebServer = false
stepDelay = 0.1
stepSize = 1.0
timeUnit = second
timeVariableName = "simtime"
treatAllClassifiersAsActive = true
```

```
«SimulationConfig»
Template Workflow Group 6
«SimulationConfig»
addControlPanel = false
animationSpeed = 98
autoStart = true
autostartActiveObjects = true
cloneReferences = false
constraintFailureAsBreakpoint = false
durationSimulationMode = random
executionTarget = Template Group 6
fireValueChangeEvent = true
initializeReferences = false
numberOfRuns = 5
recordTimestamp = false
rememberFailureStatus = false
resultLocation = Group 6
runForksInParallel = true
silent = true
solveAfterInitialization = true
startTime = 0
startWebServer = false
stepDelay = 0.1
stepSize = 1.0
timeUnit = second
timeVariableName = "simtime"
treatAllClassifiersAsActive = true
```

Execution of the simulation configuration of the each workflow group will provide the time results statistics of the specified number of runs.

4.2 Capture Results

In order to capture results in an organized way, create a result package for each work group with the name *Group [n]* to collect the resulting instances within. Create an instance table under the same package to organize different runs in a table format as shown in the figure below.

Acquisition Time with IRIS and NFIRAOS Group 0

#	Name	N	Mean	Deviation
1	analysis Acquire T arget with IRIS and NFIRAO S Group 0 at 2022.08.24 11.4 4	5	84	4.3012

#	Name	N	Mean	Deviation
2	analysis Acquire Target with IRIS and NFIRAO S Group 0 at 2022.08.24 11.48	5	105.8	39.2518
3	analysis Acquire Target with IRIS and NFIRAO S Group 0 at 2022.08.24 11.50	17	97.5294	23.3456
4	analysis Acquire Target with IRIS and NFIRAO S Group 0 at 2022.08.24 11.52	10	119.3	34.4514
5	analysis Acquire Target with IRIS and NFIRAO S Group 0 at 2022.08.24 11.58	27	92.6589	27.6309
6	analysis Acquire Target with IRIS and NFIRAO S Group 0 at 2022.08.24 12.01	10	80.228	29.4986
7	analysis Acquire Target with IRIS and NFIRAO S A7 70% at 2023.06.22 10.51	1000	17.0116	11.0156
8	analysis Acquire Target with IRIS and NFIRAO S A6 70% at 2023.06.22 11.28	1000	53.1498	42.0567
9	analysis Acquire Target with IRIS and NFIRAO S A6 90% at 2023.06.22 11.50	1000	21.4619	18.3594
10	analysis Acquire Target with IRIS and NFIRAO S A6 50% at 2023.06.22 12.38	1000	100.1168	59.1976

#	Name	N	Mean	Deviation
11	analysis Acquire Target with IRIS and NFIRAO S A7 90% at 2023.06.22 13.20	1000	14.2849	8.5576
12	analysis Acquire Target with IRIS and NFIRAO S A7 50% at 2023.06.22 13.33	1000	21.3034	14.5
13	analysis Acquire Target with IRIS and NFIRAO S A7 00% at 2023.06.22 13.55	1000	13.2596	8.2766