

Instructions & Documentation

JaamSim Sequential Sampling
and Batch Sampling Entities

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1 Inputs and Outputs

1.1 Sequential Sampler

1.1.1 Inputs

Key Inputs Graphics		
Keyword	Default	Value
AttributeDefinitionList	<i>None</i>	
CustomOutputList	<i>None</i>	
UnitList	DimensionlessUnit	
DataList	<i>None</i>	
HalfWidths	<i>None</i>	
ConfidencePercent	95.0	

Figure 1.1: Inputs for a Sequential Sampler entity

UnitList

The UnitList is to input the type of units for the inputs to make sure they correspond. This is in order to prevent, for example, a TimeUnit being compared to a CostUnit. The input units are to be separated by spaces and the only acceptable unit types are the unit types that are already available in JaamSim.

If only one unit type is present, then all of the units are assumed to be of the same type. The default input is DimensionlessUnit.

DataList

The DataList input is the list of outputs or expressions that will have their final values at the ends of runs saved so that confidence intervals can be calculated. The format is that each is enclosed by curly brackets, i.e. '{' and '}', within the brackets is the expression or output, surrounded by single quotes if there are spaces or brackets in the expression. The unit types of the expressions must match up to the inputs in UnitList.

HalfWidths

This stores the expressions for the values of the Half Width intervals, such that, when the calculated half width intervals are below the input values, the entity outputs true. The values in this input must be enclosed by curly brackets similar to the DataList input.

ConfidencePercent

This is the list of percentages for which to calculate the confidence intervals. The valid range is from 0.01 to 99.99. The number of inputs must be either one or the same as the number of units and data inputs. If only one input is present then all half width intervals will be calculated for that percentage.

1.1.2 Outputs

CompletedRuns

The number of runs for which the sequential sampler has collected values.

Means

The array of the means of the values collected from the completed runs.

HalfWidthIntervals

The array of the half widths of the confidence intervals, calculated from the values collected over the completed runs.

AllWithinUserRange

This outputs TRUE when all the half width lengths are less than the value inputs in half widths.

WidthCheckList

This is an array of boolean values that are true if the value of the half width length is less than the value of the input. These are the individual results and not the collected as in AllWithinUserRange. This can be used to pause the simulation using the width check of selected outputs.

1.2 Batch Statistics

1.2.1 Inputs

Key Inputs Graphics		
Keyword	Default	Value
AttributeDefinitionList	<i>None</i>	
CustomOutputList	<i>None</i>	
DefaultEntity	<i>None</i>	
NextComponent	<i>None</i>	<i>Required Input</i>
UnitType	<i>None</i>	<i>Required Input</i>
SampleValue	<i>None</i>	<i>Required Input</i>
InputType	TALLY_MEAN	<i>Required Input</i>
NumberIntervals	20	
ShortestInterval	0.25 h	
MinNumberSamples	16	
PercentConfidence	95.0	

Figure 1.2: Inputs for a Batch Statistics entity

The unlisted inputs in this section are the same as those for the Statistics entity as this class is derived from the Statistics Entity.

InputType

This input is a drop down box that allows the user to select either “TALLY_MEAN” or “TIME_MEAN” as the type of mean being recorded. The tally mean is for the batching over the number of entities that have passed through the BatchStatistics and the time mean is for the time average of the SampleValue with the batches being the time interval.

MaxNumberIntervals

This is the input for the maximum number of intervals for which a half width interval can be calculated before they are rebatched into intervals with twice the width. This must be even as rebatching involves averaging successive pairs of intervals.

ShortestInterval

This is relevant only for a time mean; it is the time width of the starting interval from which the batches are constituted.

MinNumberSamplesInterval

This is relevant only for a tally mean; it is the starting number of samples that constitute an interval.

PercentConfidence

This percentage for which to calculate the confidence interval. The input number must be between 0.01 and 99.99.

1.2.2 Outputs

The unlisted outputs are the same as those of the Statistics entity.

CurrentIntervalAverage

The average of the value in the current interval.

NumberOfIntervals

The number of completed intervals.

IntervalTimeWidth

The length of time that each interval mean is calculated over if the input type is TIME_MEAN.

IntervalSamplesWidth

The number of samples that the interval means are calculated over if the input type is TALLY_MEAN.

AllIntervalMeans

The means of the previous intervals, not including the value in the current interval.

PreviousIntervalsMean

The mean of the previous intervals' means, not including the value in the current interval.

HalfWidthInterval

The half width length for the previously completed intervals. If the means are not independent, then the output is positive infinity.

SamplesIndpendent

Outputs true if the sample means in the intervals satisfy the conditions in the test from Fishman 78 [1].

1.3 Batch Recorder

1.3.1 Inputs

Key Inputs		
Graphics		
Keyword	Default	Value
AttributeDefinitionList	<i>None</i>	
CustomOutputList	<i>None</i>	
SmallestInterval	0.25 h	
NumberIntervals	20	
InputType	ACCUMULATED	
UnitType	<i>None</i>	<i>Required Input</i>
SampleValue	<i>None</i>	<i>Required Input</i>
PercentConfidence	95.0	

Figure 1.3: Inputs for a Batch Recorder entity

SmallestInterval

This is the time width of the starting interval from which the batches are constituted.

MaxNumberIntervals

This is the input for the maximum number of intervals for which a half width interval can be calculated before they are rebatched into intervals with twice the width. This must be even as rebatching involves averaging successive pairs of intervals.

InputType

A drop down box input to allow for different types of sample value and modifies how the batch values are collected. There are three types of input: “ACCUMULATED”, “TIME_MEAN” and “TRANSIENT”. Accumulated values increase with time such as the total number of entities to pass through a linked entity. Time mean is when the sample value is a time mean over the entire time interval from the initialisation time onwards. Finally, the transient values are read from a raw output of an entity such as queue length or a boolean variable such as if the server is processing an entity. This value is designed for discrete values not continuous values.

UnitType

The unit type of the sample value.

SampleValue

The sample output or expression to be recorded for the batches. If there are spaces in the expression, it must be enclosed by single quotation marks. The unit type in the UnitType input must correspond to the type of unit of the sample.

PercentConfidence

This percentage for which to calculate the confidence interval. The input number must be between 0.01 and 99.99.

1.3.2 Outputs

CurrentMean

The average of the value in the current interval.

NumberIntervals

The number of completed intervals.

IntervalWidth

The length of time that an interval covers.

ValuesInIntervals

The means of the previous intervals, not including the value in the current interval.

PreviousIntervalsMean

The mean of the previous intervals' means, not including the value in the current interval.

HalfWidthInterval

The half width length for the previously completed intervals. If the means are not independent, then the output is positive infinity.

SamplesIndependent

Outputs true if the sample means in the intervals satisfy the conditions in the test from Fishman 78 [1].

2 Examples—How to Use

This section details how to add the components to a Jaamsim model and how they are used, with an example model. This guide assumes that the reader has some prior knowledge of how to use JaamSim.

Upon opening JaamSim, ensure that the RunObjects folder appears in the Model Builder—figure 2.1—otherwise you have opened the incorrect version.

The example model for all of the tutorials is the ExtendedHealthClinic. Make sure the contents of the zip folder have been extracted to a directory of your choice.

The icons and display images used for the entities may change in future versions of JaamSim.

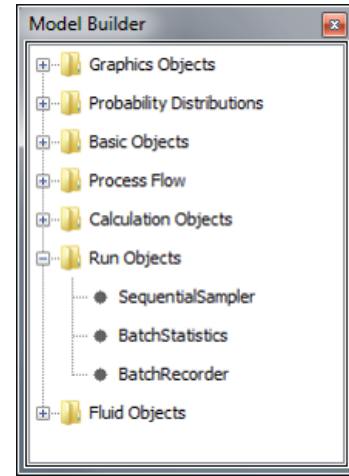


Figure 2.1: Model Builder with Run Objects Folder

2.1 Sequential Sampler

Open the ExtendedHealthClinic config file from JaamSim. In the Model Builder, expand the RunObjects folder and drag a SequentialSampler entity into the view window. Then position and scale it how you want. In the Object Selector, rename it to Sampler.

The entity operates similarly to the Run Output List for the simulation entity at the top of the object selector. First, you have to input the list of units, the units are the category, not the name unit itself, e.g. TimeUnit and MassUnit versus seconds and tonnes. The units have to correspond to the unit types from the samples input. In this example, the sample inputs for the Sequential Sampler are listed in table 1 below. The four inputs are to demonstrate the operation of the entity.

Table 1: Example inputs for sequential sampler

Input	Value
UnitList	TimeUnit TimeUnit DimensionlessUnit DimensionlessUnit
DataList	{ [TimeInSys].SampleAverage } { [TimeInSys].SampleMaximum } { '[Doctor].Utilisation + [Doctor2Appointment].Utilisation + [Doctor2Walkup].Utilisation' } { '[WalkupQueue].QueueLengthMaximum + [AppointmentQueue].QueueLengthMaximum' }
HalfWidths	{ 1.0 min } { 5.0 min } { 0.1 } { 0.5 }
Confidence-Percent	95 90 95 95

After the sequential sampler's inputs have been entered, select the Simulation entity at the top of the Object Selector to display its inputs. Then, in the PauseCondition input add the following expression: **[Sampler].AllWithinUserRange**

Leave the ExitAtPauseCondition blank because it defaults to FALSE. If the value is set to TRUE, it will cause the simulation to run through all of the remaining runs which would take unnecessary time.

Save and then start the model. The model should run for a bit and then pause after 98 iterations. After it has become paused, the half widths should be: 0.9395, 4.997, 0.007220, and 0.4936; all rounded to 4 significant figures. The full list of outputs of the SequentialSampler are shown in figure 2.2 below.

SequentialSampler	
CompletedRuns	98
Means	{46.070758186180164, 135.64102095493197, 1.3416791403040977, 10.571428571428571}
HalfWidthIntervals	{0.9394640289681246, 4.997496062449427, 0.007220432793053388, 0.4936165374603272}
IsPause	true
WidthCheckList	{ true, true, true, true }

Figure 2.2: Outputs from the Sequential Sampler Example

2.2 Batch Statistics

The entity in this example is very similar to the Statistics entity from the ProcessFlow folder in that the first six inputs are the same as those for a Statistics Entity. Open the ExtendedHealthClinic config file from JaamSim then, from the RunObjects folder in the Model Builder, drag the BatchStatistics entity into the view window. Rename the new object to “BatchTimeInSys”. Move it to the right side of the screen near to the top row of statistics objects. Afterwards, change the NextComponent Input of “WaitingTreat” to be “BatchTimeInSys” and then of this to be “PatientWalkupSink”, thus placing the new object in the model.

Copy the UnitType and SampleValue inputs of the “TimeInSys” entity into “BatchTimeInSys”. For the InputType, choose “TALLY_MEAN” and then input 32 in MinNumSamplesInterval. All the inputs are shown in table 2 below.

Table 2: Example inputs for Batch Statistics

Input	Value
NextComponent	PatientWalkupSink
UnitType	TimeUnit
SampleValue	'this.obj.StateTimes([[Arrive]]) + this.obj.StateTimes([[WaitTriage]]) + this.obj.StateTimes([[Triage]]) + this.obj.StateTimes([[WaitTest]]) + this.obj.StateTimes([[Test]]) + this.obj.StateTimes([[WaitTreat]]) + this.obj.StateTimes([[Treat]]) + this.obj.StateTimes([[Leave]])'
InputType	TALLY_MEAN
MinNumber-SamplesInterval	32

Before running, in the Simulation Input editor, change the RunDuration input to 16800 h—multiply it by a factor of 100. Then in the Multiple Runs tab, change the EndingRunNumber to 4-1. Save and then start the model. After it has finished running, the entity should have processed 405 505 entities, the NumberOfIntervals should be 24 and the HalfWidthInterval should be 0.4613 min (27.68 s). The outputs are shown in figure 2.3a.

If you want the simulation to stop once the HalfWidthInterval is less than a desired value, then in the Simulation entity at the top of the ObjectSelector window, add the expression '[BatchTimeInSys].HalfWidthInterval < 1 [min]' to the PauseCondition input and input TRUE into ExitAtPauseCondition.

After resetting, saving and running the model, it will have completed running in a much shorter span of time. The number of entities processed is now only 22 528 and the HalfWidthInterval is 0.9609 min (57.65 s). The outputs are shown in figure 2.3b.

Output Viewer - BatchTimeInSys	
Output	Value
LinkedComponent	
obj	null
NumberAdded	405505
NumberProcessed	405505
NumberInProgress	0
ProcessingRate	0.000670478 /s
ReleaseTime	1.00814e+07 min
Statistics	
SampleMinimum	12.3455 min
SampleMaximum	271.288 min
SampleAverage	46.9530 min
SampleStandardDeviation	24.4008 min
StandardDeviationOfTh...	0.0383182 min
TimeAverage	40.2244 min
TimeStandardDeviation	19.9496 min
BatchStatistics	
CurrentIntervalAverage	48.6979 min
NumberOfIntervals	24
AllIntervalMeans	{46.40033554677734, 47.78436...
PreviousIntervalsMean	46.8985 min
HalfWidthInterval	0.461308 min
SamplesIndependent	true

(a) Outputs from run with no half width length limit

Output Viewer - BatchTimeInSys	
Output	Value
LinkedComponent	
obj	null
NumberAdded	22528
NumberProcessed	22528
NumberInProgress	0
ProcessingRate	0.000669242 /s
ReleaseTime	562472 min
Statistics	
SampleMinimum	12.6316 min
SampleMaximum	206.797 min
SampleAverage	46.9701 min
SampleStandardDeviation	23.7771 min
StandardDeviationOfTh...	0.158419 min
TimeAverage	40.2389 min
TimeStandardDeviation	19.6506 min
BatchStatistics	
CurrentIntervalAverage	0.00000 min
NumberOfIntervals	22
AllIntervalMeans	{48.059176587532555, 44.8064...
PreviousIntervalsMean	46.9701 min
HalfWidthInterval	0.960869 min
SamplesIndependent	true

(b) Outputs from run with a 1 minute half width length limit

Figure 2.3: Outputs from Batch Statistics Examples

2.3 Batch Recorder

The BatchRecorder is similar to the BatchStatistics in that it separates the collection of data into intervals but it differs in that it can only do time intervals and is not connected in the model flow; it watches a components outputs to collect data.

Open the ExtendedHealthClinic config file from JaamSim. Then, from the Run-Objects folder in the Model Builder, drag the BatchRecorder entity into the view window. Scale and position it to your liking.

Rename the new entity to “WalkupQLength”. Set SmallestInterval to 30 min, NumberIntervals to 30 and change the input type to TRANSIENT. For this example the UnitType will be DimensionlessUnit and the SampleValue will be set to [WalkupQueue].QueueLength (no inverted commas necessary). The outputs are shown in table 3 below.

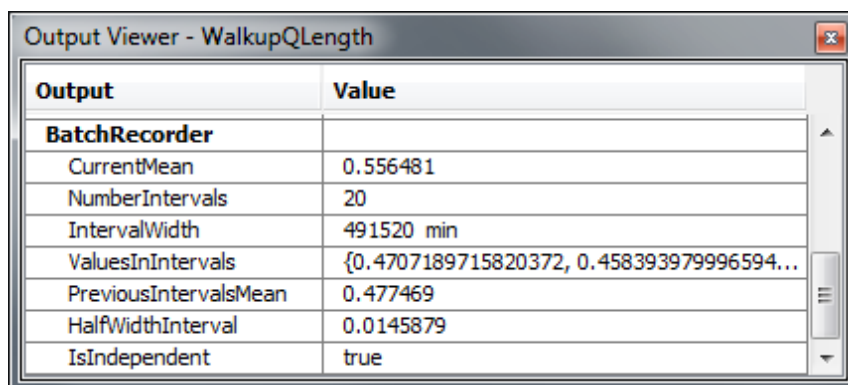
Table 3: Example Inputs for the First Batch Recorder

Input	Value
SmallestInterval	30 min
MaxNumberIntervals	30
InputType	TRANSIENT
UnitType	DimensionlessUnit
SampleValue	[WalkupQueue].QueueLength

Before running, in the Simulation Input editor, change the RunDuration input to 16800 h—multiply it by a factor of 100. Then in the Multiple Runs tab, change the EndingRunNumber to 4-1. Also make sure that the PauseCondition is empty. Then save and start the model.

After it has finished, the output HalfWidthInterval should be 0.01459 and NumberIntervals should be 20. The outputs are shown in figure 2.4 below. To stop the simulation running once the half width interval is less than a desired value, add an expression similar to the following to PauseCondition in Simulation:

'[WalkupQLength].HalfWidthInterval < 0.02'



Output	Value
BatchRecorder	
CurrentMean	0.556481
NumberIntervals	20
IntervalWidth	491520 min
ValuesInIntervals	{0.4707189715820372, 0.458393979996594...}
PreviousIntervalsMean	0.477469
HalfWidthInterval	0.0145879
IsIndependent	true

Figure 2.4: Outputs from the First BatchRecorder Example

The next example uses the same JaamSim model file. At the top of the JaamSim window, select Units in the tool bar and in RateUnit select “/h”. Next, drag a new BatchRecorder into the view and position and scale it to your preference; rename it “OutputRate”. As inputs, set InputType to TIME_MEAN, UnitType to RateUnit and SampleValue:

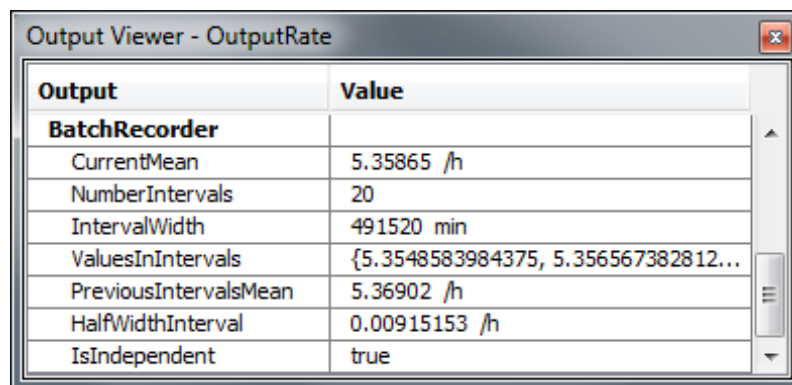
' [TreatToLeave].ProcessingRate + [TreatToLeave2].ProcessingRate '

All the inputs are shown in table 4.

Table 4: Example Inputs for the Second Batch Recorder Example

Input	Value
InputType	TIME_MEAN
UnitType	RateUnit
SampleValue	' [TreatToLeave].ProcessingRate + [TreatToLeave2].ProcessingRate '

Save the model and make sure that there is no PauseCondition in Simulation in Object Selector. Start the simulation running. Once the simulation has finished, the following outputs should be in the Output Viewer for OutputRate. NumberIntervals should be 20 and HalfWidthInterval should be 0.009152 /h. All of the outputs are shown in figure 2.5 below.



Output	Value
BatchRecorder	
CurrentMean	5.35865 /h
NumberIntervals	20
IntervalWidth	491520 min
ValuesInIntervals	{5.3548583984375, 5.356567382812...}
PreviousIntervalsMean	5.36902 /h
HalfWidthInterval	0.00915153 /h
IsIndependent	true

Figure 2.5: Outputs from the Second BatchRecorder Example

References

- [1] G. S. Fishman, “Grouping observations in digital simulation”, *Management Science*, vol. 24, no. 5, pp. 510–521, 1978. DOI: 10.1287/mnsc.24.5.510. eprint: <https://doi.org/10.1287/mnsc.24.5.510>. [Online]. Available: <https://doi.org/10.1287/mnsc.24.5.510>.