Manufacturing System Analysis Experiment

Machine Learning Application in Manufacturing System

1. Experiment Overview

- Title

Machine Learning Application in Manufacturing System

- Objective
  - Understand the effects of the part quality on manufacturing productivity
  - Verify that improving the part quality increase the TH using ARENA simulation
  - Understand the advantages of using machine learning and data analytics in manufacturing system

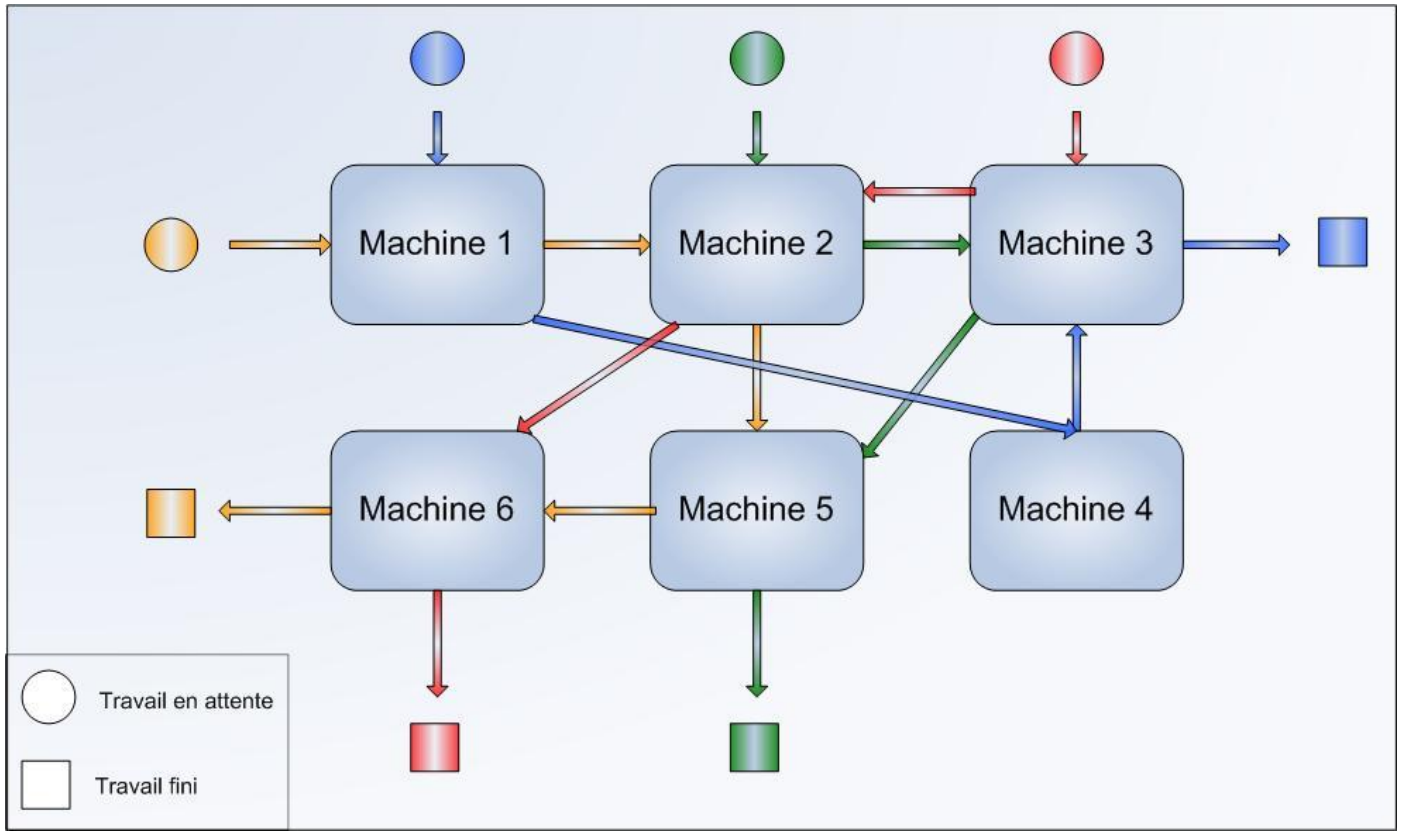
2. Theoretical Background

- Overall Equipment Effectiveness (OEE)
  - OEE is the standard measurement of manufacturing productivity (**OEE = availability x performance x quality**)
  - **Availability** takes into account all events (unplanned and planned stops) that stop planned production
  - **Performance** takes into account anything that causes manufacturing process to run at less than the maximum possible speed (slow cycles and small stops)
  - **Quality** takes into account manufactured parts that do not meet quality standards (defects)

  ➢ **Improving any one of those three can increase the throughput**

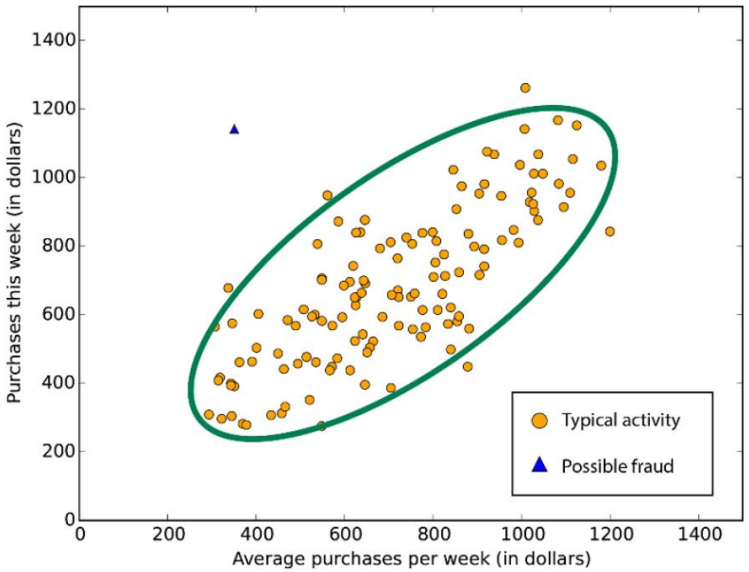
2. Theoretical Background

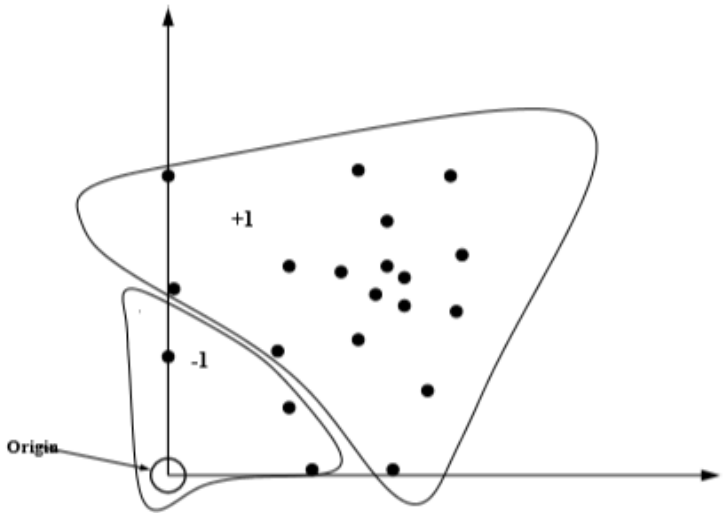
- Job shop



2. Theoretical Background

- Support Vector Machine
  - Anomaly detection (also outlier detection): the identification of rare items, events or observations which raise suspicions by differing significantly from the majority of the data
  - One-class support vector machine can be used for anomaly detection





3. Experiment Design

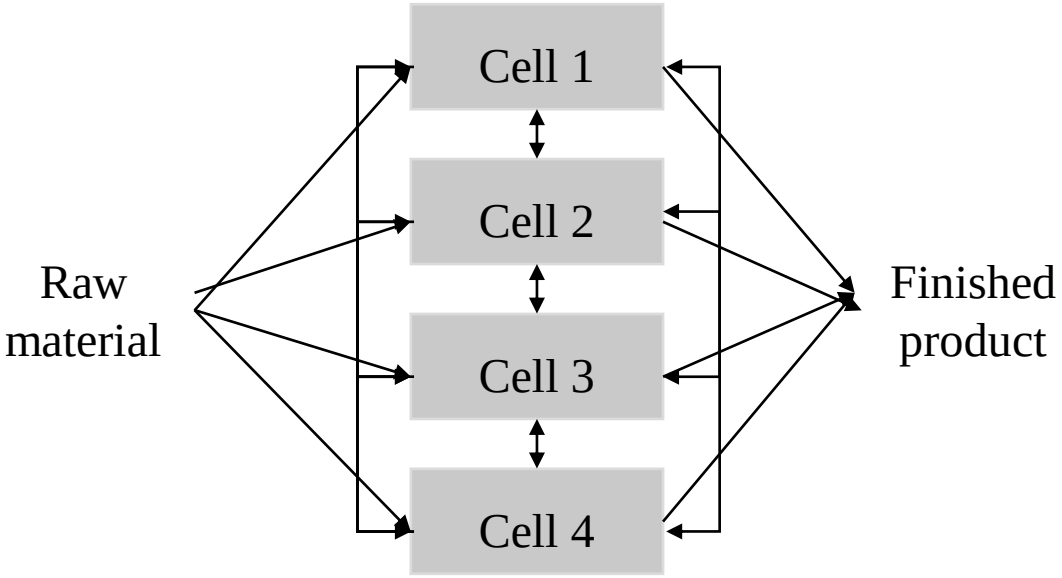
Yonsei Steel Co. has a job shop manufacturing process consists of four cells producing four different parts. Each part has different processing sequence and different processing time. Processing sequence and processing time at each process for each part is shown in the table below.

Part	Processing Sequence (Processing time)			
1	2 (3)	1 (2)	4 (3)	3 (2)
2	4 (4)	2 (2)	3 (4)	1 (3)
3	1 (2)	3 (4)	4 (3)	2 (2)
4	3 (3)	2 (3)	1 (3)	4 (4)

Company is trying to improve the OEE of the job shop process by improving the part quality. Sensors installed to each machine can collect the sound data and process can identify the defect parts more effectively using the machine learning algorithm (SVM) based on the data collected. Observe the TH of the job shop process when part quality improves.

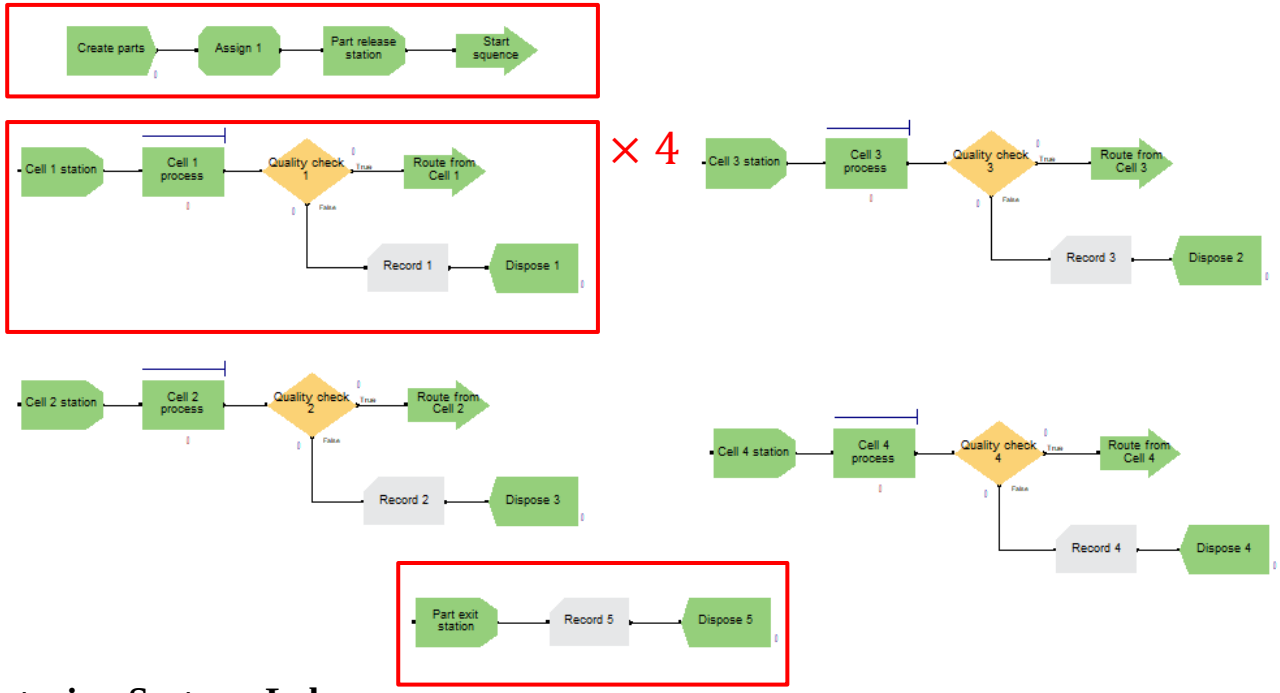
4. Experiment Procedure

- **Step 1-1. Simulation summary**
  - One M/C for each process with different process sequence and different process time
  - Simulation runs for 100 minutes of warm-up time (for system stabilization), actual experiment 1000 minutes, total of 1100 minutes



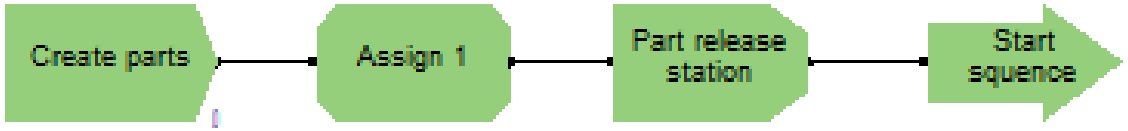
4. Experiment Procedure

- **Step 1-2. Creating the model**
  - Basic simulation model is as the picture shown below
  - Modules used: 1 Create, 1 Assign, 4 Process, 4 Decide, 5 Record, 6 Station, 5 Route, 5 Dispose



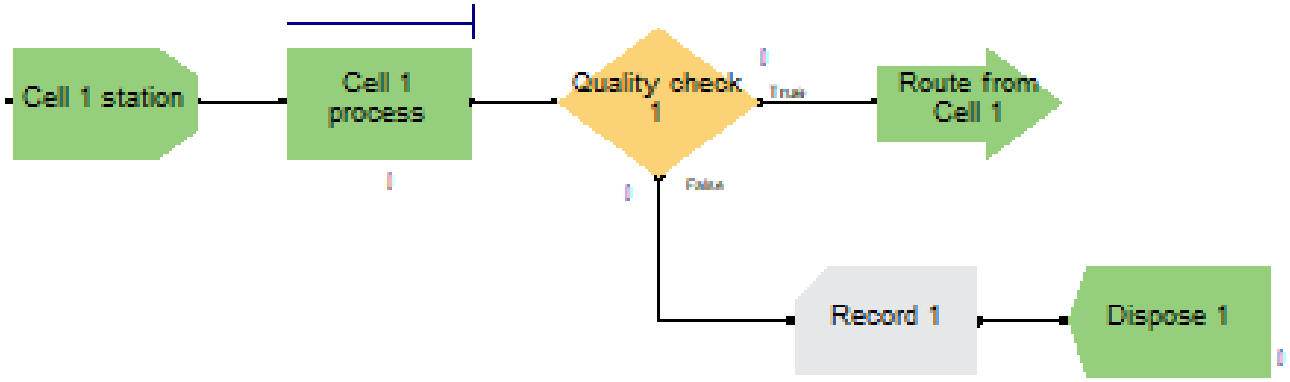
4. Experiment Procedure

- **Step 1-2. Creating the model**
  - Basic simulation model is as the picture shown below
  - Modules used: 1 Create, 1 Assign, 1 Station, 1 Route



4. Experiment Procedure

- **Step 1-2. Creating the model**
  - Basic simulation model is as the picture shown below
  - Modules used: 1 Station, 1 Process, 1 Decide, 1 Route, 1 Record, 1 Dispose(× 4)

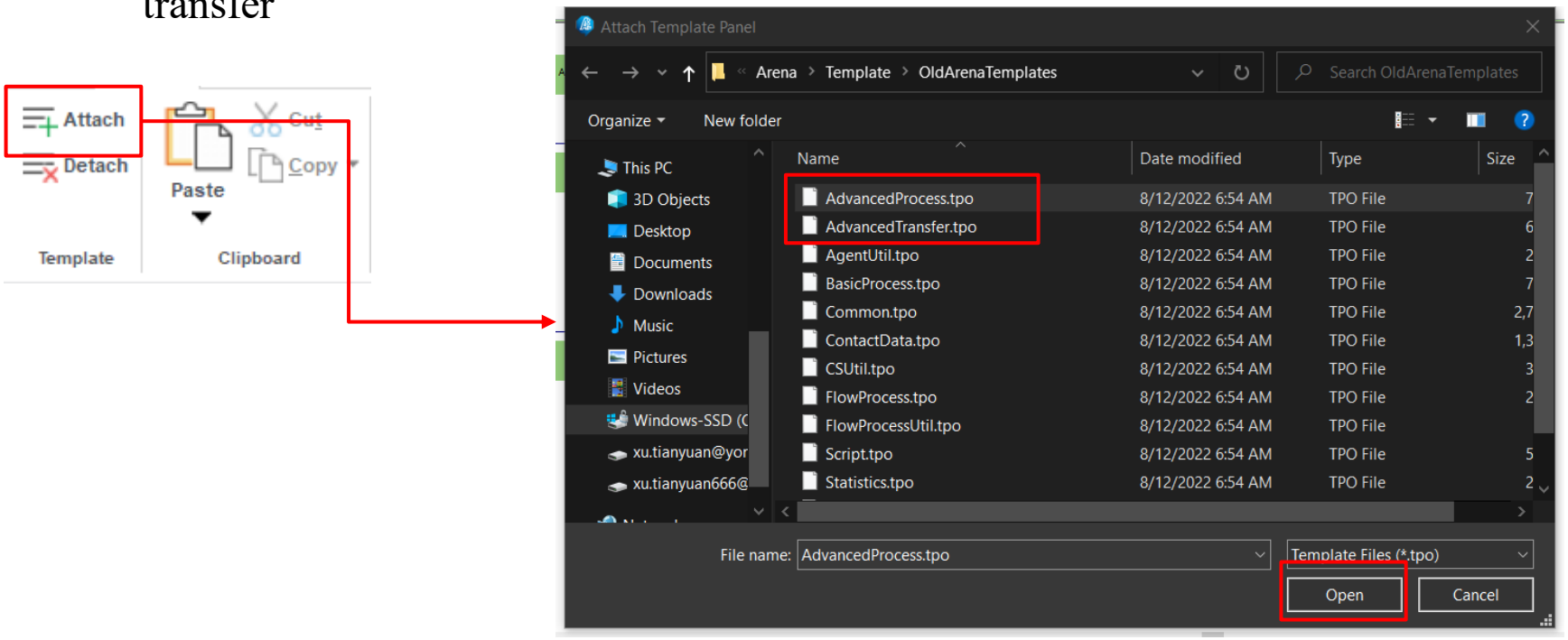


4. Experiment Procedure

- **Step 1-2. Creating the model**
  - Basic simulation model is as the picture shown below
  - Modules used: 1 Station, 1 Process, 1 Decide, 1 Route, 1 Record, 1 Dispose

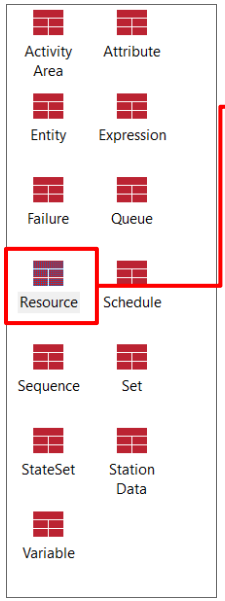
4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - File → Template Panel → Attach, open 'Advanced process' and 'Advanced transfer'



4. Experiment Procedure

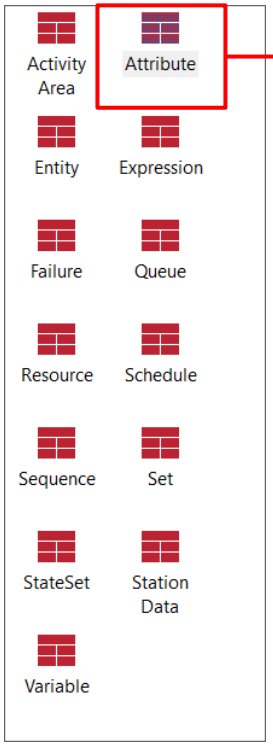
- **Step 1-2. Creating the model (cont.)**
  - Add resources (M/C) and set the number of resources



	Name	Type	Capacity	Busy / Hour	Idle / Hour	Per Use	StateSet Name	Failures
1	Cell 1 machine	Fixed Capacity	1	0.0	0.0	0.0		0 rows
2	Cell 2 machine	Fixed Capacity	1	0.0	0.0	0.0		0 rows
3	Cell 3 machine	Fixed Capacity	1	0.0	0.0	0.0		0 rows
4	Cell 4 machine	Fixed Capacity	1	0.0	0.0	0.0		0 rows

4. Experiment Procedure

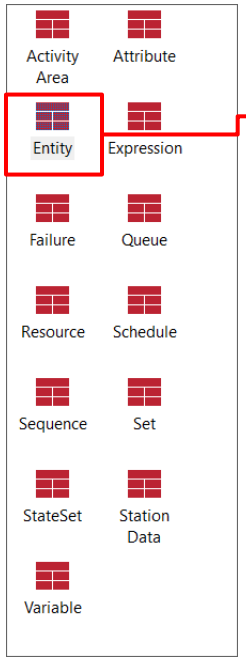
- **Step 1-2. Creating the model (cont.)**
  - Create attributes for process time and part index



	Name	Rows	Columns	Data Type	Initial Values	Comment
1	Process time			Real	0 rows	
2	Part index			Real	0 rows	

4. Experiment Procedure

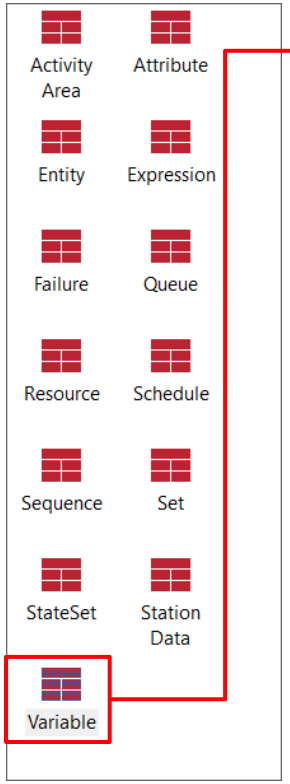
- **Step 1-2. Creating the model (cont.)**
  - Create entities for 4 parts



	Entity Type	Initial Picture	Holding Cost / Hour	Initial VA Cost	Initial NVA Cost	Initial Waiting Cost	Initial Tran Cost	Initial Other Cost
1	Part 1	Picture.Report	0.0	0.0	0.0	0.0	0.0	0.0
2	Part 2	Picture.Report	0.0	0.0	0.0	0.0	0.0	0.0
3	Part 3	Picture.Report	0.0	0.0	0.0	0.0	0.0	0.0
4	Part 4	Picture.Report	0.0	0.0	0.0	0.0	0.0	0.0
5	Entity	Picture.Report	0.0	0.0	0.0	0.0	0.0	0.0

4. Experiment Procedure

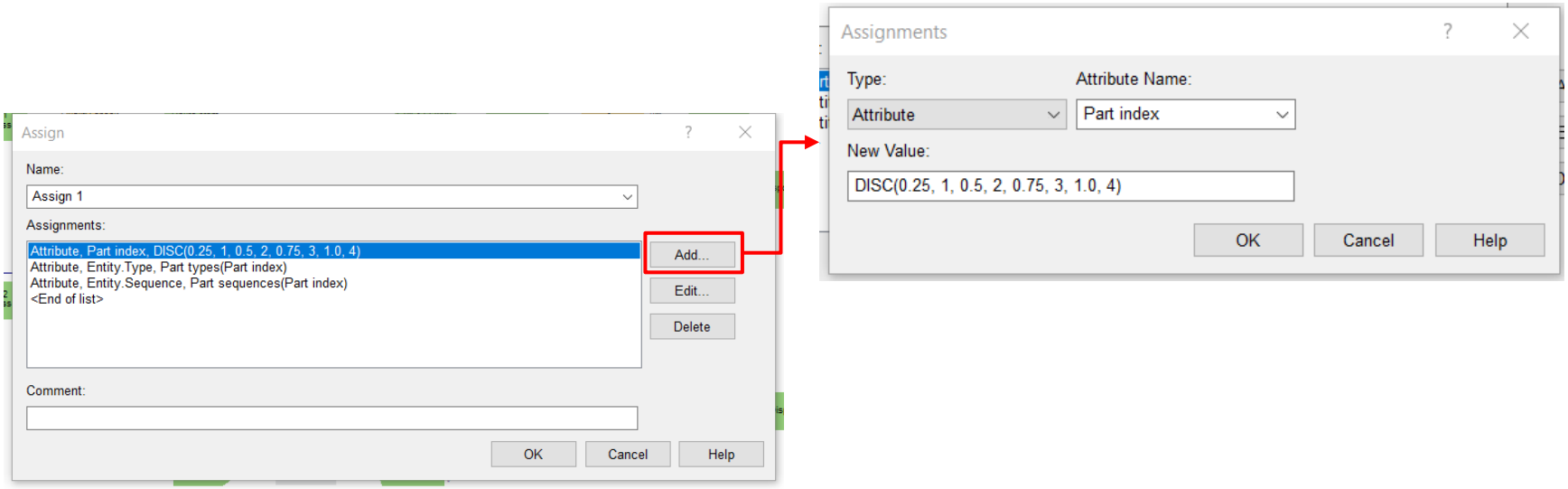
- **Step 1-2. Creating the model (cont.)**
  - Create a variable for part quality percentage



	Name	Rows	Columns	Data Type	Clear Option	File Name	Initial Values	Report Statistics	Comment
1 ▶	Quality			Real	System		1 rows	☐	

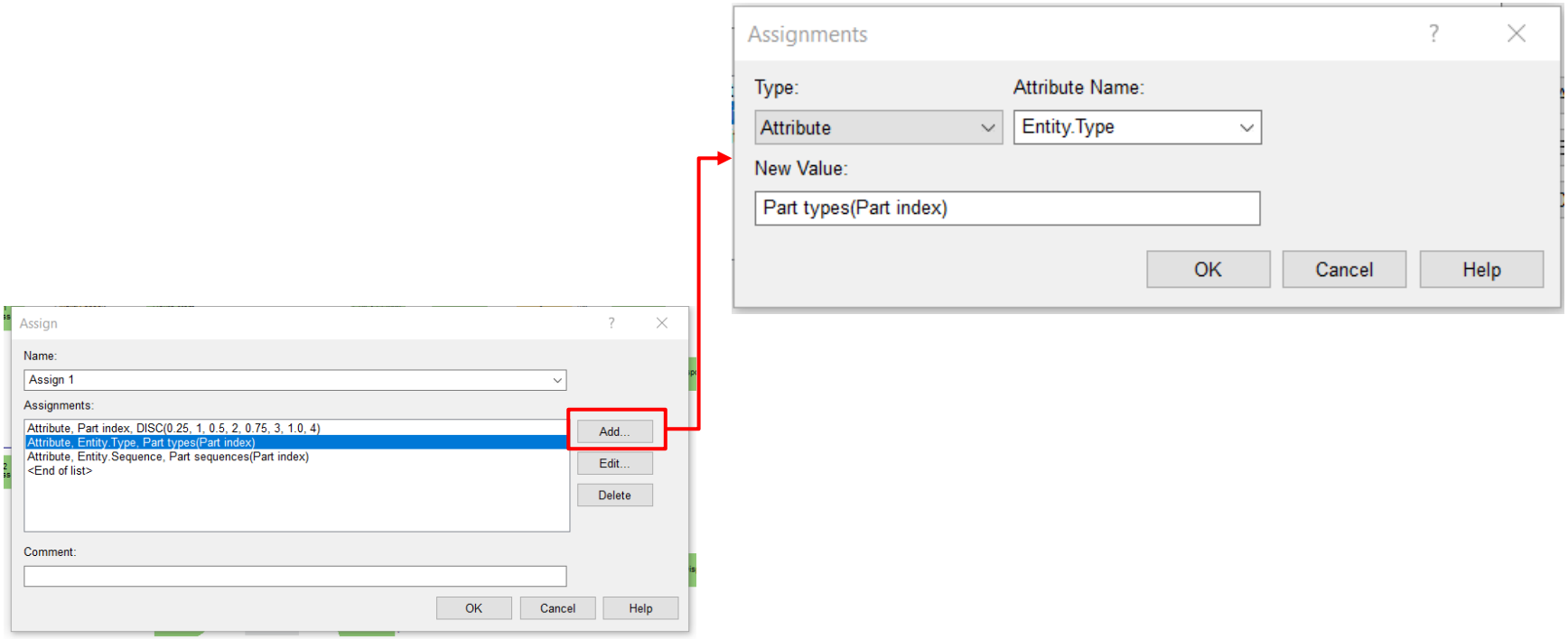
4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Use the Assign module to assign part type and part process sequence
  - Assign part index number to a entity with 0.25 probability of being a part 1~4 (DISC: discrete)



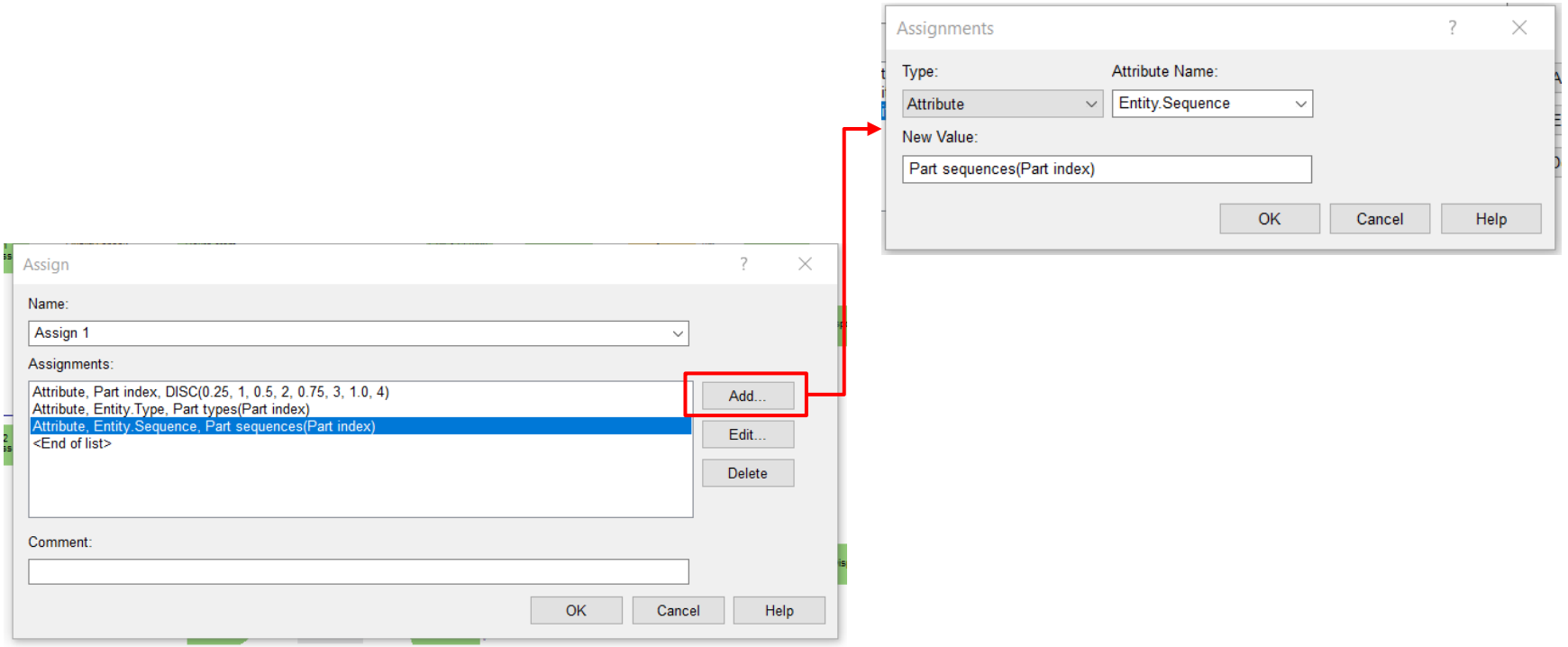
4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Assign part index to each entity type



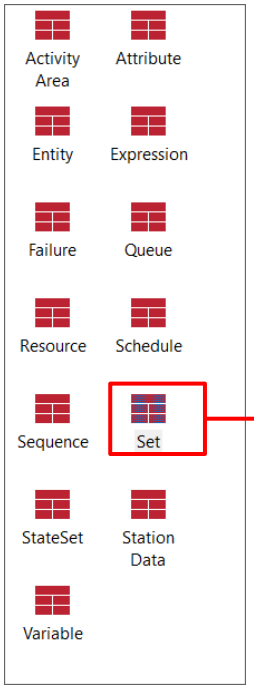
4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Assign part index to each entity sequence



4. Experiment Procedure

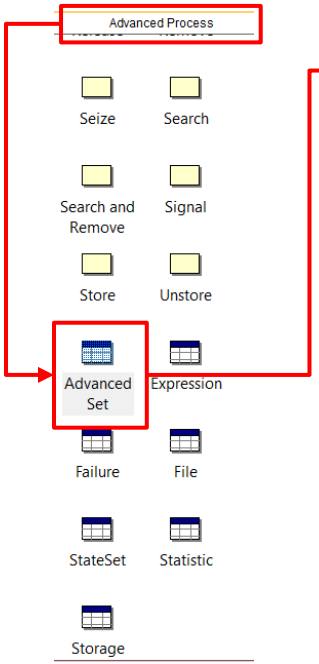
- **Step 1-2. Creating the model (cont.)**
  - Create a set for part types
  - Set name and name used in assign module must be same



	Name	Type	Member Definition Method	Members	Comment
1	Part types	Entity Type	Manual List	4 rows	

4. Experiment Procedure

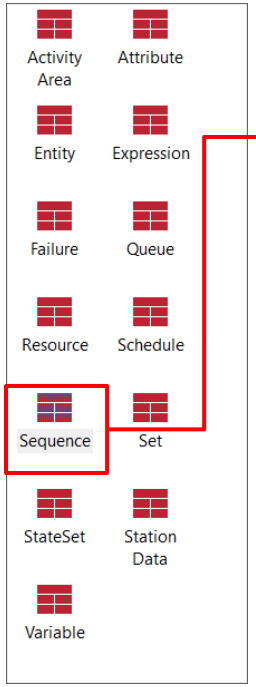
- **Step 1-2. Creating the model (cont.)**
  - Create a set for part process sequences (Advanced Process → Advanced Set)
  - Set name and name used in assign module must be same



	Name	Set Type	Member Definition Method	Members
1	Part sequences	Other	Manual List	4 rows

4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Input part process sequences (table given in experiment design)



Sequence - Advanced Transfer

	Name	Steps
1	Part 1 process plan	5 rows
2	Part 2 process plan	5 rows
3	Part 3 process plan	5 rows
4	Part 4 process plan	5 rows

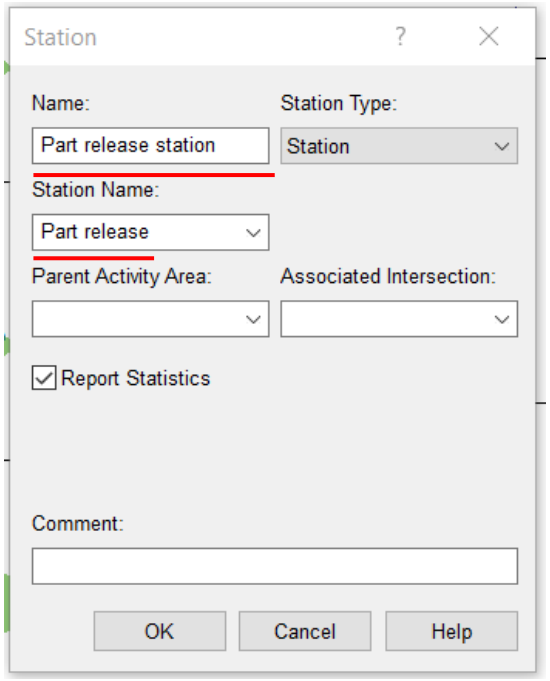
	Station Name	Step Name	Next Step	Assignments
1	Cell 2	Part 1 Step 1		1 rows
2	Cell 1	Part 1 Step 2		1 rows
3	Cell 4	Part 1 Step 3		1 rows
4	Cell 3	Part 1 Step 4		1 rows
5	Part exit	Part 1 Step 5		0 rows

	Assignment Type	Attribute Name	Value
1	Attribute	Process time	3

Part	Processing Sequence (Processing time)			
1	2 (3)	1 (2)	4 (3)	3 (2)
2	4 (4)	2 (2)	3 (4)	1 (3)
3	1 (2)	3 (4)	4 (3)	2 (2)
4	3 (3)	2 (3)	1 (3)	4 (4)

4. Experiment Procedure

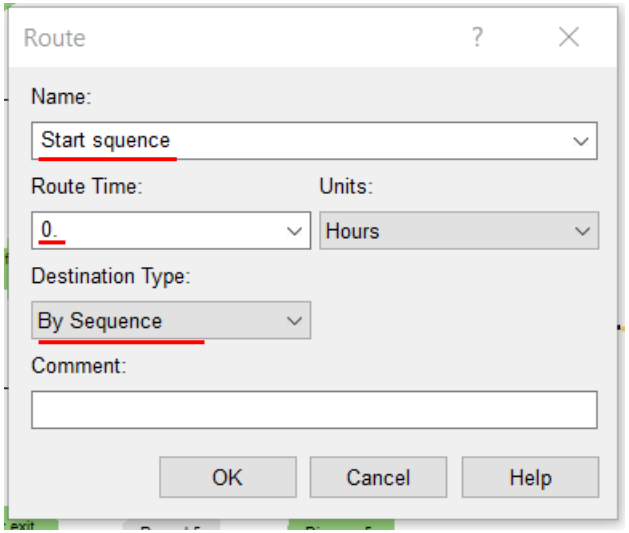
- **Step 1-2. Creating the model (cont.)**
  - Set station modules
  - Station name must be same with names in sequence



	Name	Station Type	Station Name	Parent Activity Area
1	Cell 1 station	Station	Cell 1	
2	Part release station	Station	Part release	
3	Cell 3 station	Station	Cell 3	
4	Cell 2 station	Station	Cell 2	
5	Cell 4 station	Station	Cell 4	
6	Part exit station	Station	Part exit	

4. Experiment Procedure

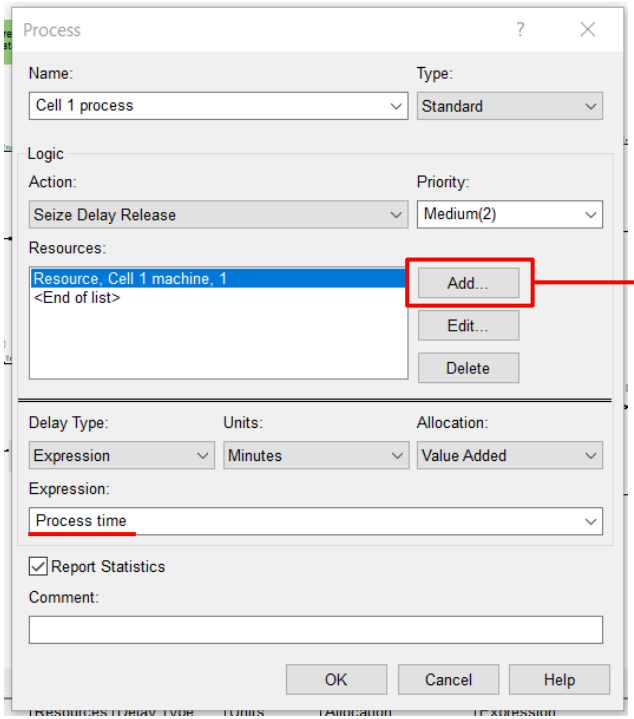
- **Step 1-2. Creating the model (cont.)**
  - Set route module
  - Destination type as by sequence
  - We do not consider the moving time

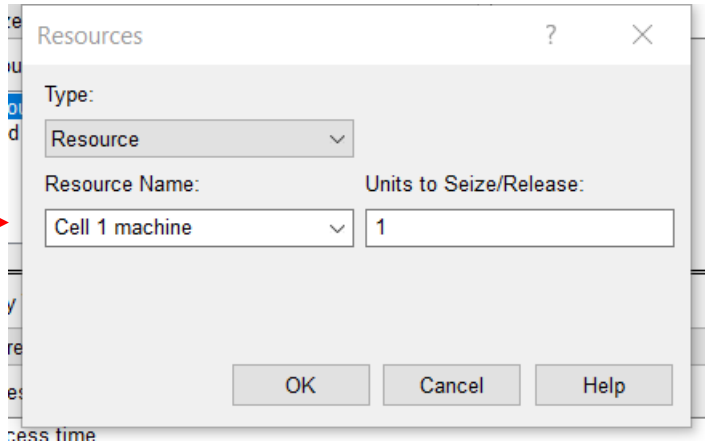


	Name	Route Time	Units	Destination Type	Comment
1	Route from Cell 1	0.	Hours	By Sequence	
2	Route from Cell 3	0.	Hours	By Sequence	
3	Route from Cell 2	0.	Hours	By Sequence	
4	Route from Cell 4	0.	Hours	By Sequence	
5	Start squence	0.	Hours	By Sequence	

4. Experiment Procedure

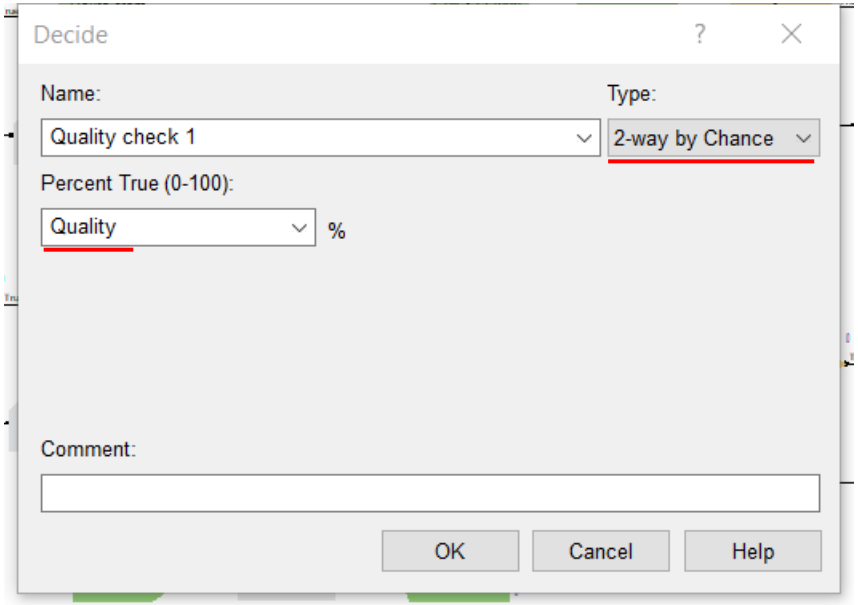
- **Step 1-2. Creating the model (cont.)**
  - Use Add button to assign resources
  - Set the delay type as expression and use the attribute for process time





4. Experiment Procedure

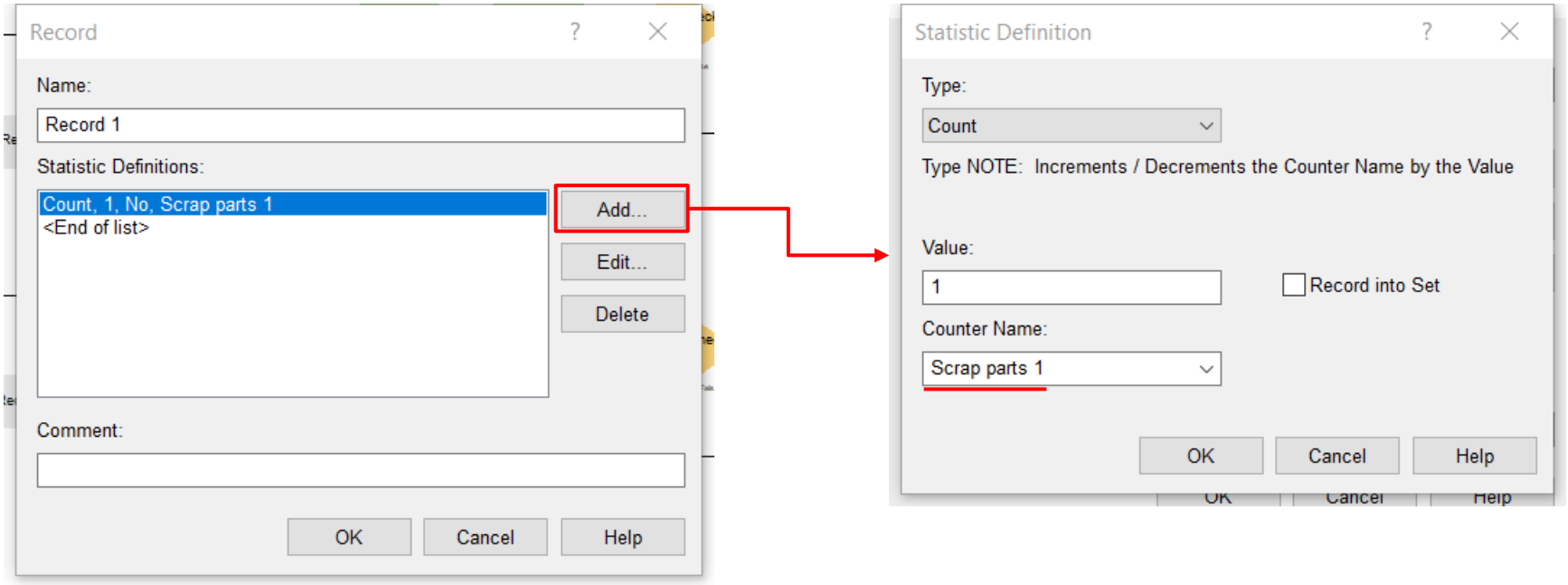
- **Step 1-2. Creating the model (cont.)**
  - Set the part quality percentage with a variable already set (Quality)



	Name	Type	Percent True	Comment
1	Quality check 1	2-way by Chance	Quality	
2	Quality check 3	2-way by Chance	Quality	
3	Quality check 2	2-way by Chance	Quality	
4	Quality check 4	2-way by Chance	Quality	

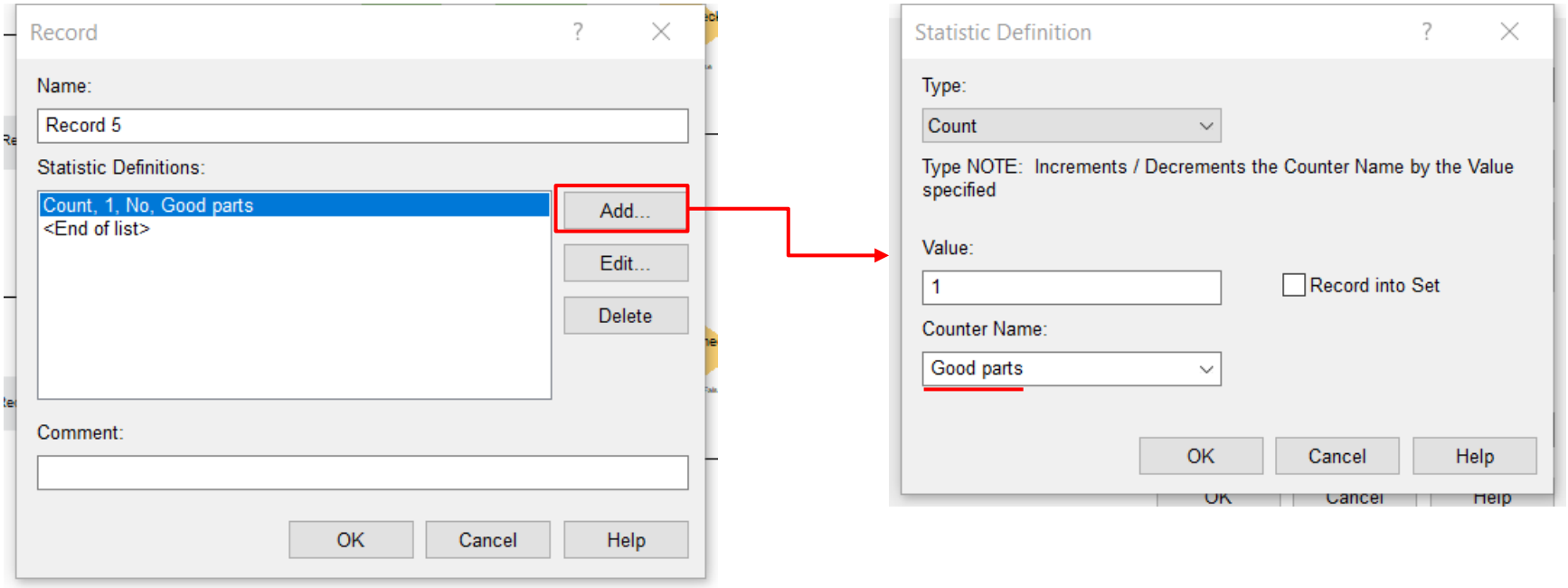
4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Set the record module to record the number of throughputs and scrap parts



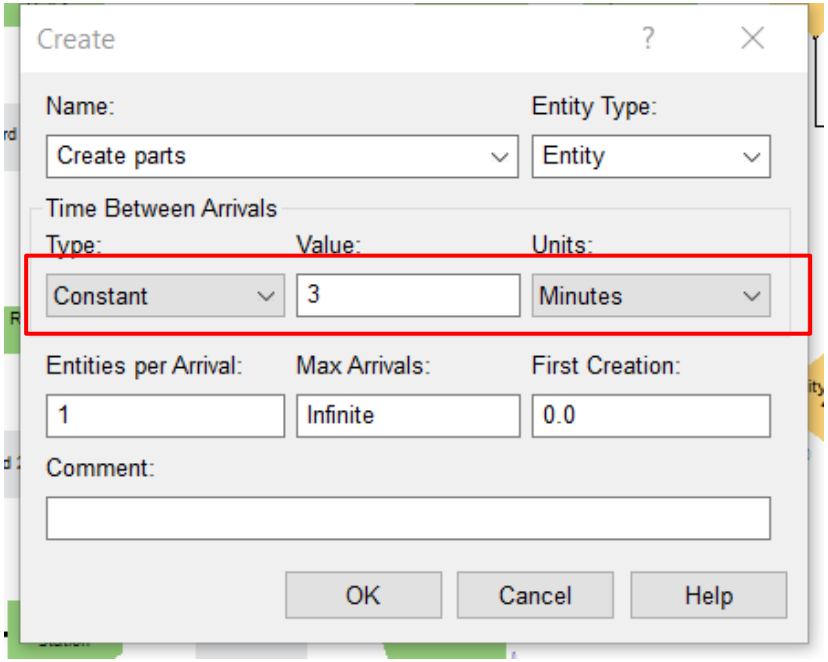
4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Set the record module to record the number of throughputs and scrap parts



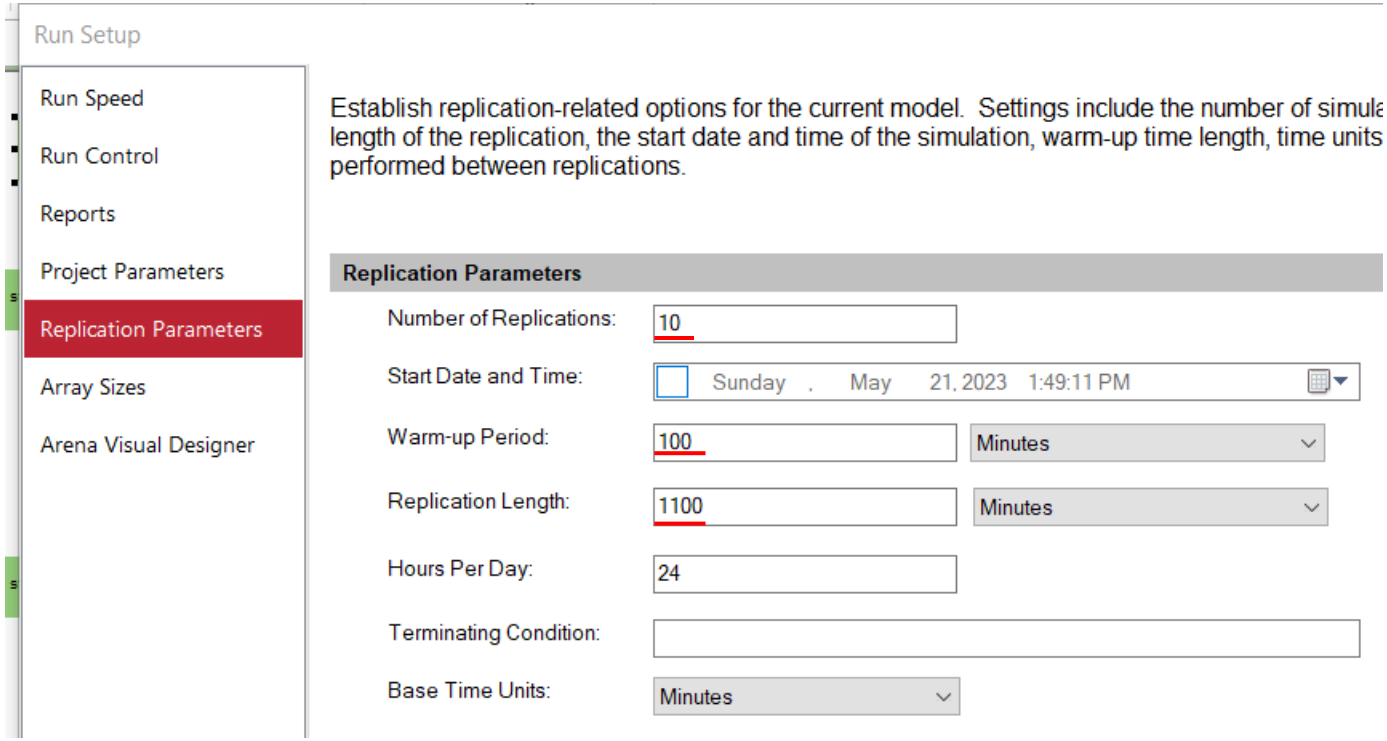
4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Create raw material entities
  - Time between Arrivals = 3 minutes



4. Experiment Procedure

- **Step 1-2. Creating the model (cont.)**
  - Warm-up period = 100 minutes, Replication length = 1100 minutes



4. Experiment Procedure

- **Step 2. Observe throughput of the system**

- **Step 3. Discussion & conclusion**

Q & A