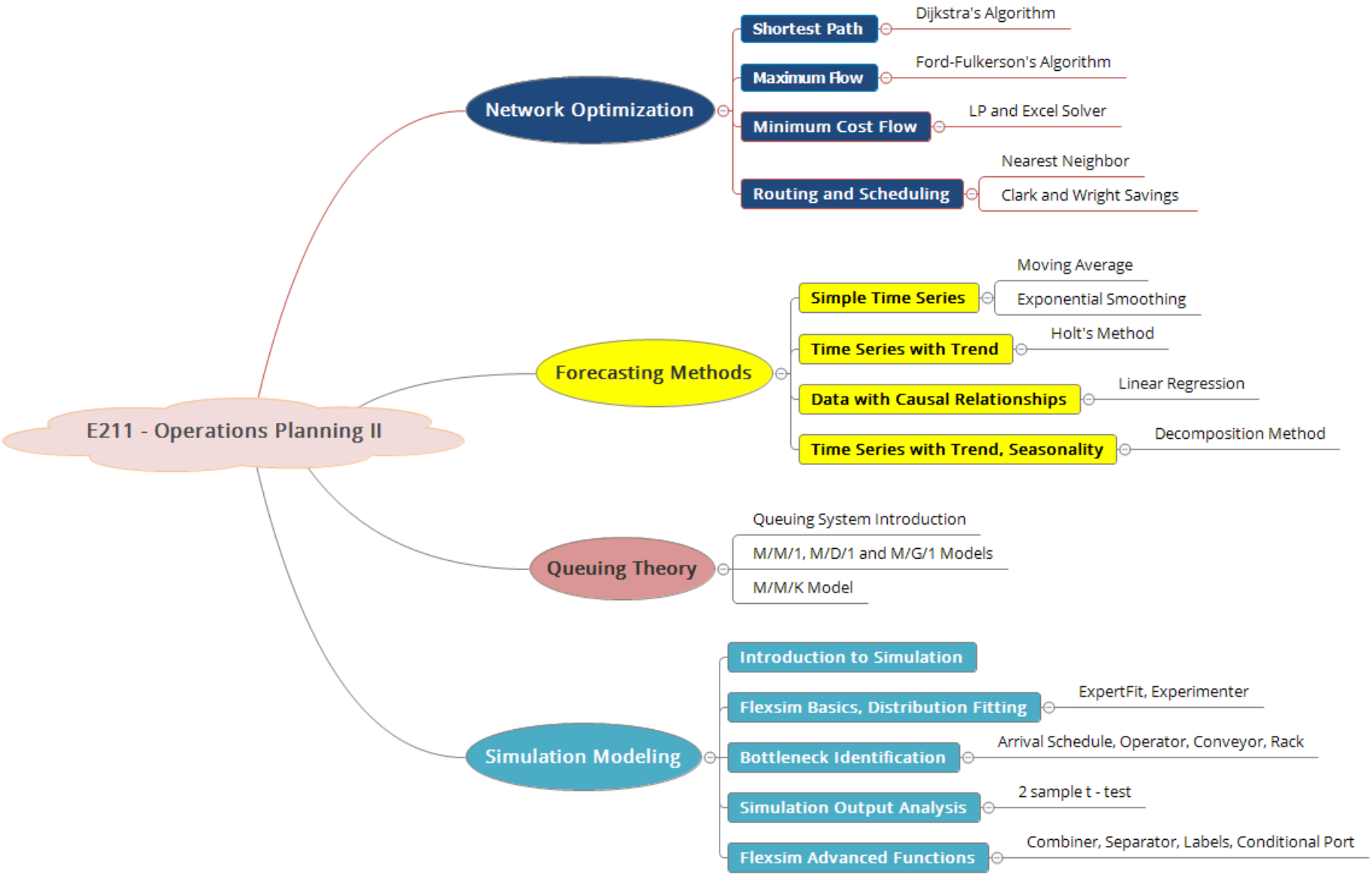
Problem 13
Bottling Process Improvement

E211 – Operations Planning II

SCHOOL OF ENGINEERING

Module Coverage: E211 Topic Tree



Problem Statement

- Nature's Boost is a manufacturer and distributor of organic vegetable and fruit juice blends.

- Due to increasing sales of their products, the company is planning to ramp up production.

- After improving the warehouse outbound efficiency, the operations manager turns his attention to the bottling section of the manufacturing process. He identifies the following issues:

  - Manual unpacking and packing processes are too time-consuming
  - Many bottles are discarded due to failing QC check. This increases production cost

Process Description

Current Bottling Process

Team Discussion

To build the simulation model of the bottling process, discuss:

- Data required to build the model
- What performance measures to use

Data Requirement and Performance Measures

Data needed for the simulation:

- Products arrival schedule
- Process time distribution for unpacking, quality check, rework and packing processes
- Set up time distribution for unpacking, quality check, rework and packing processes
- Percent of products that pass or fail the quality check
- Resources and their properties: operators, conveyors, etc.

Performance measures:

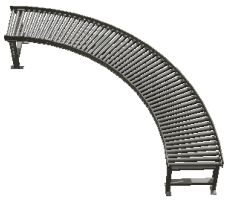
- Average Cycle Time
- Total Output and Reclaim

Initial Model

- Load the flexsim file
- Connect the objects according to the process flow (for now just perform the connection without adjusting object properties)
- Run the simulation and make sure the items flow correctly

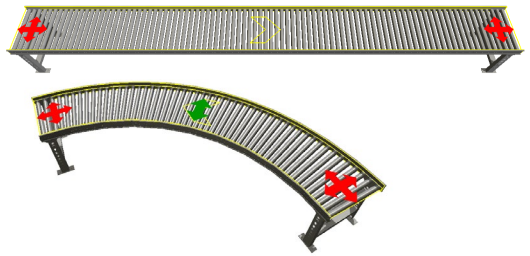
Simulation Techniques - Conveyor

- Used to convey flowitems from one location in the model to another location.
- Time to convey depends on the conveyor's length divided by its speed.
- Can be accumulating or non-accumulating. Accumulating = roller conveyor. Non-accumulating = belt conveyor (all parts on the conveyor will stop when a part reaches the end of the conveyor and is blocked)

Name and Icon	Description	Appearance
Straight Conveyor	The **Straight Conveyor** can simulate conveyor belts or roller conveyors. As its name suggests, this conveyor has a straight shape.	
Curved Conveyor	The **Curved Conveyor** is another object that can simulate conveyor belts or roller conveyors. Unlike the **Straight Conveyor**, this conveyor has a curved shape with varying radius settings.	

Simulation Techniques - Conveyor

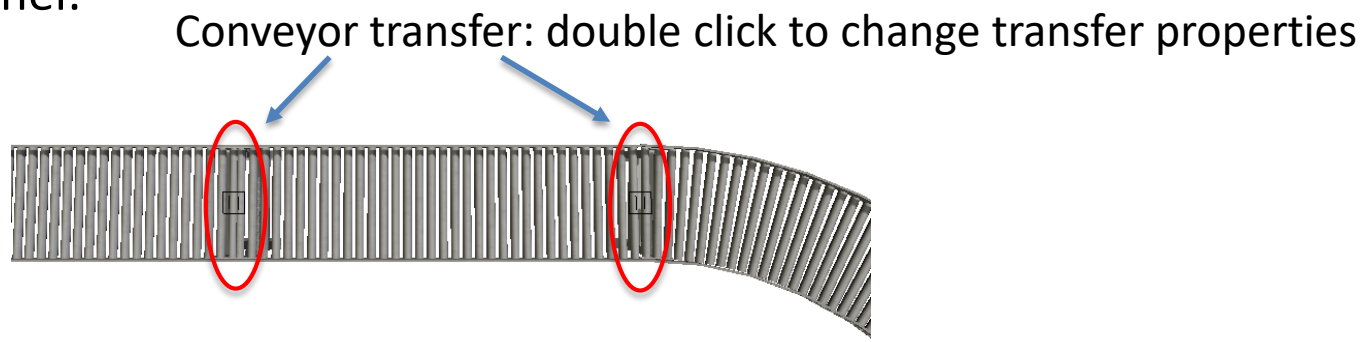
- The **Straight** and **Curved Conveyor** objects have a default size if you click and drag them into the model.
- You can set the initial lengths by clicking either the Straight Conveyor or the Curved Conveyor object under the Library. Your mouse pointer will change to a plus sign with either a Straight Conveyor icon or a Curved Conveyor icon next to it. 
- Find the position in your simulation model where you want to place the tail of the conveyor. Click on that position and start moving the mouse pointer.
- Reposition the mouse pointer until the conveyor head is at the approximate length, angle, and radius you want it to be relative to the tail. Click the mouse again to finish building the conveyor.
- You can also edit the length of an existing conveyor by clicking on the conveyor and dragging its cross arrows



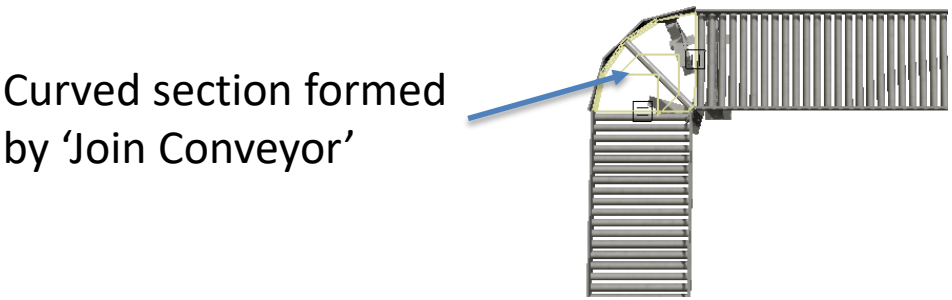
Simulation Techniques - Conveyor

To connect two conveyors together:

- Click on one conveyor and drag it close to the edge of the other conveyor. When the edges of the two conveyors get close enough, they will snap together.

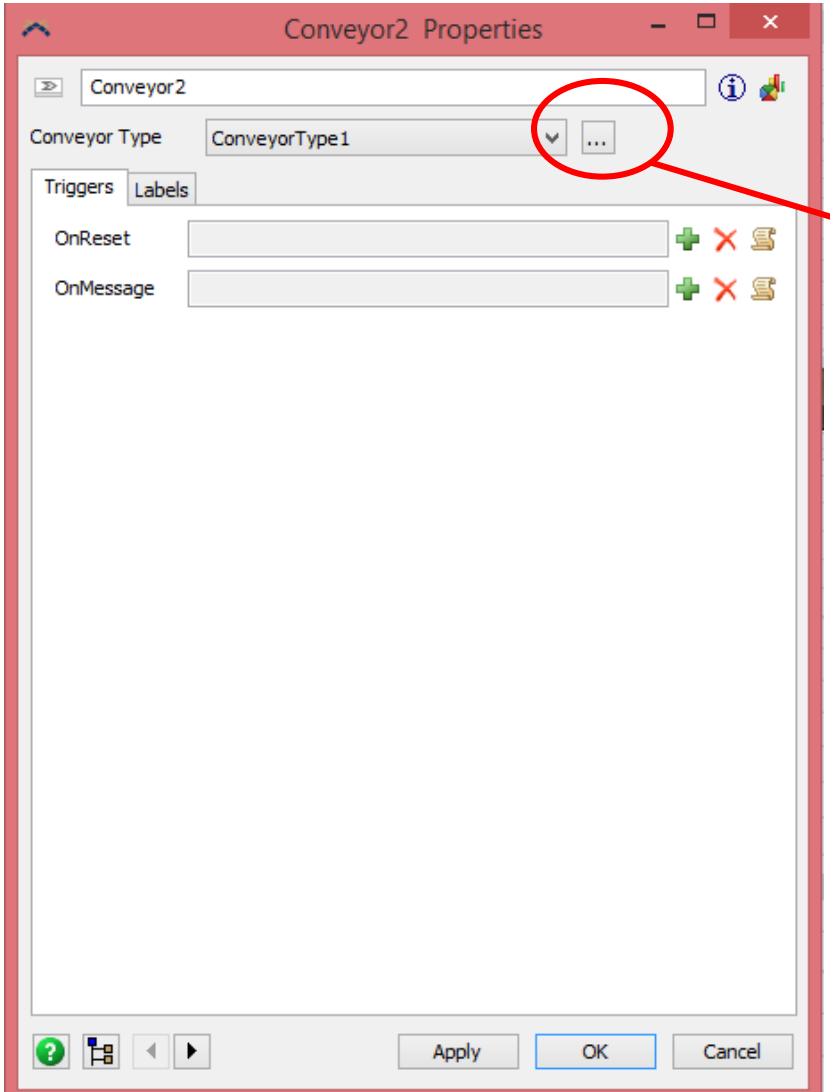


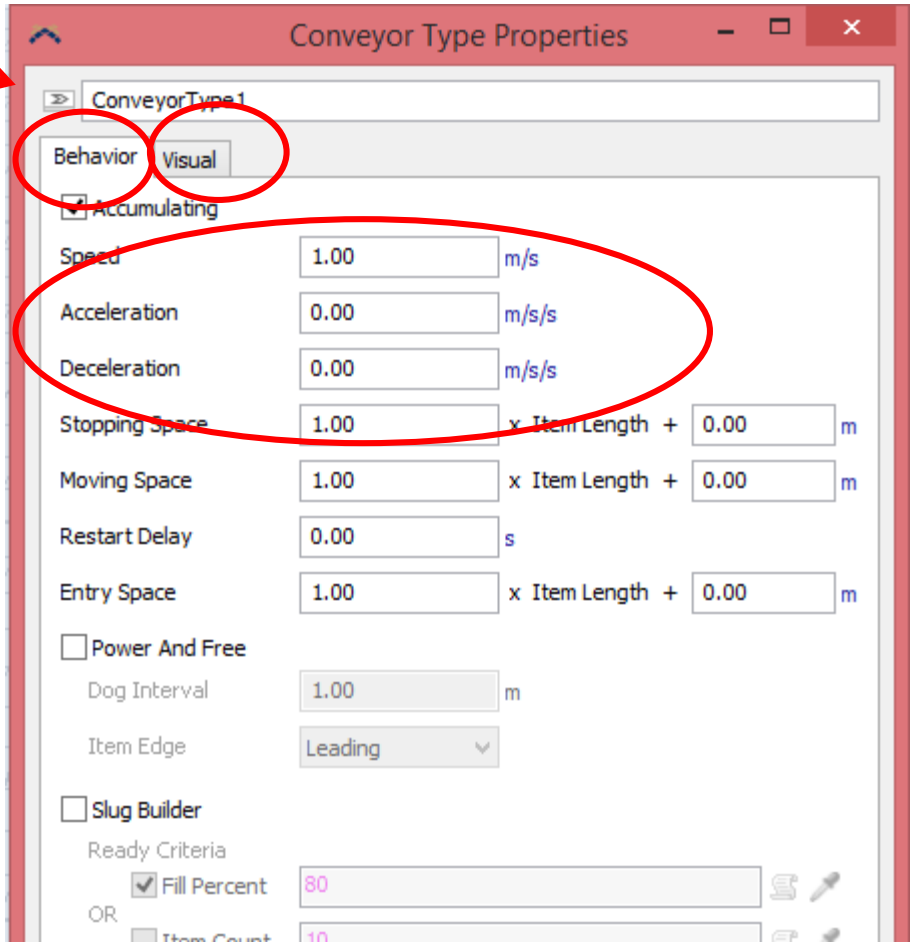
- To join 2 straight conveyors using a curved section, click ‘Join Conveyor’ and then click one conveyor followed by the other conveyor to join them



Simulation Techniques - Conveyor

- The behaviour (such as speed) and visual (such as width) properties can be edited through Conveyor Type Properties.





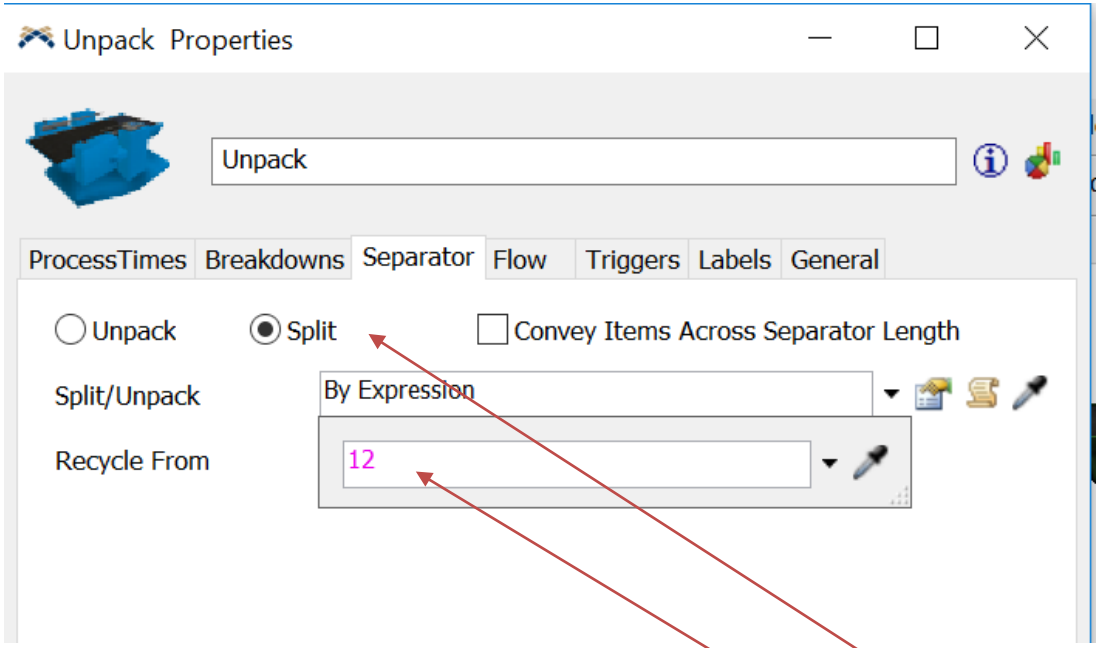
Set Arrival Schedule

- Every half an hour a batch of 60 crates of bottles will be sent to the line for cleaning. A total of 20 batches is forecasted per day.

- *Create the arrival schedule in the model. What is the arrival time of the last batch?*

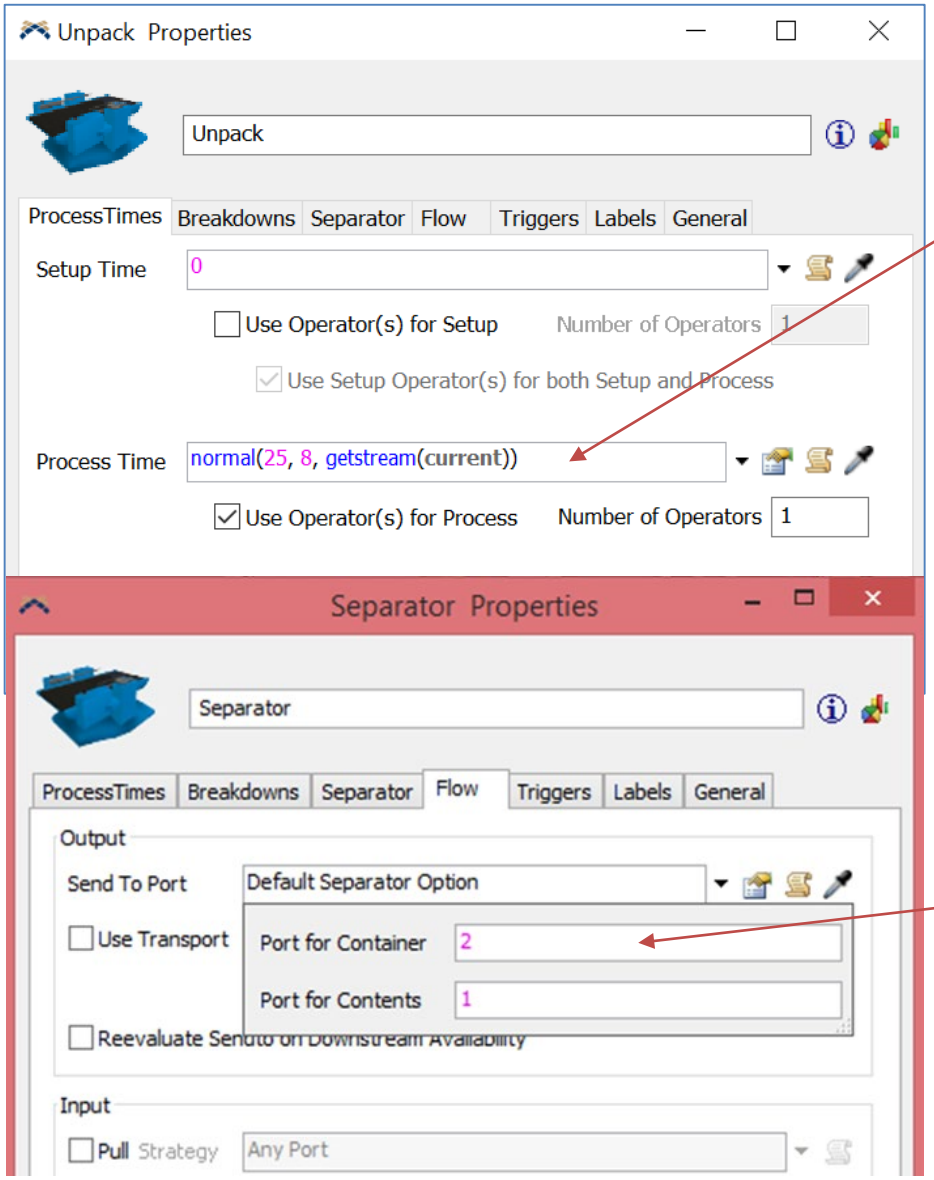
Simulation Techniques – **Separator**

- The separator is used to separate a flowitem into multiple parts. This can either be done by unpacking a flowitem that has been packed by a combiner or by making multiple copies of the original flowitem.



1. Choose Split option
2. Set number of bottles from unpacking = 12

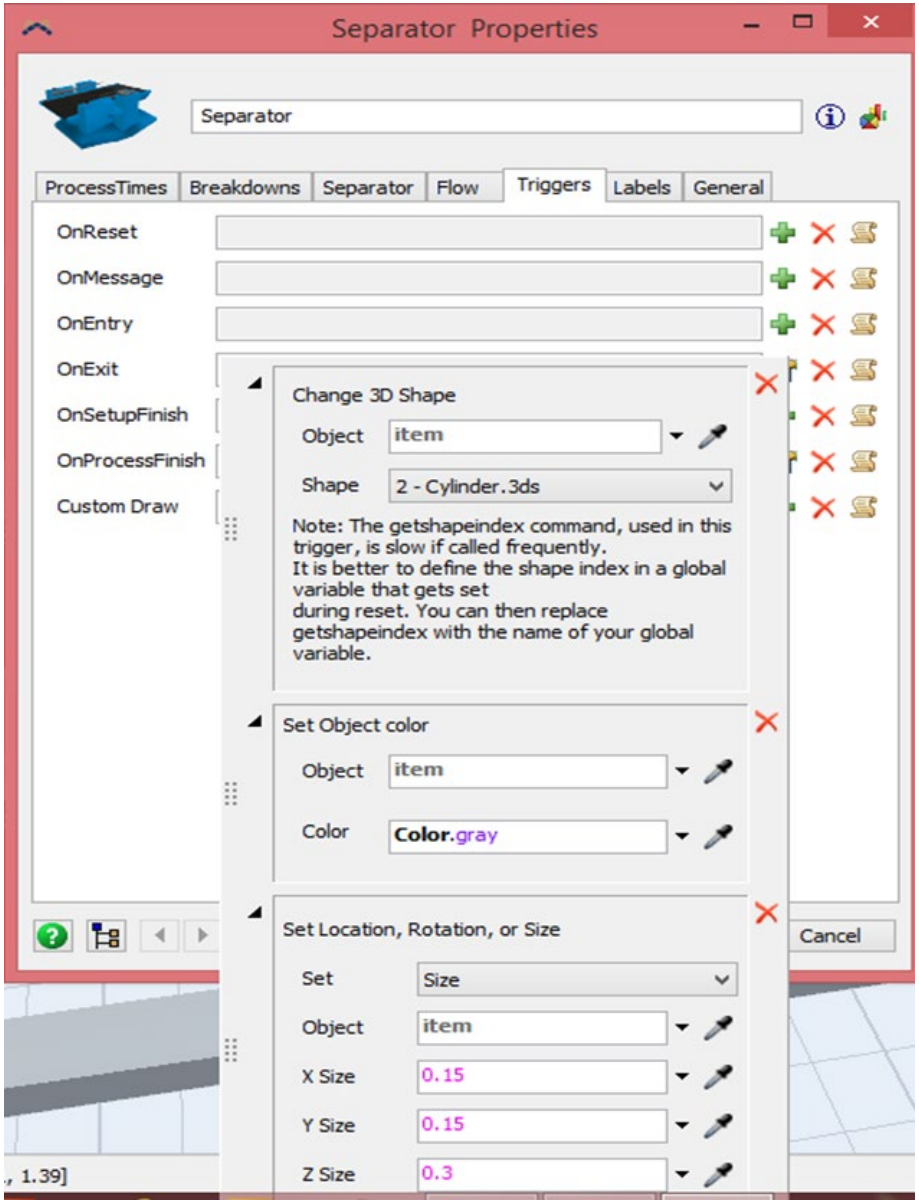
Set Separator Properties



1. Set process time ~ normal distribution with mean of 25s and std dev of 8s.
2. Click on use operator for process.
3. Pull an operator from Library and connect him/her to the separator accordingly

- Use “Default Separator Option” for “Send to Port”: Port for container: 2, Port for contents: 1.

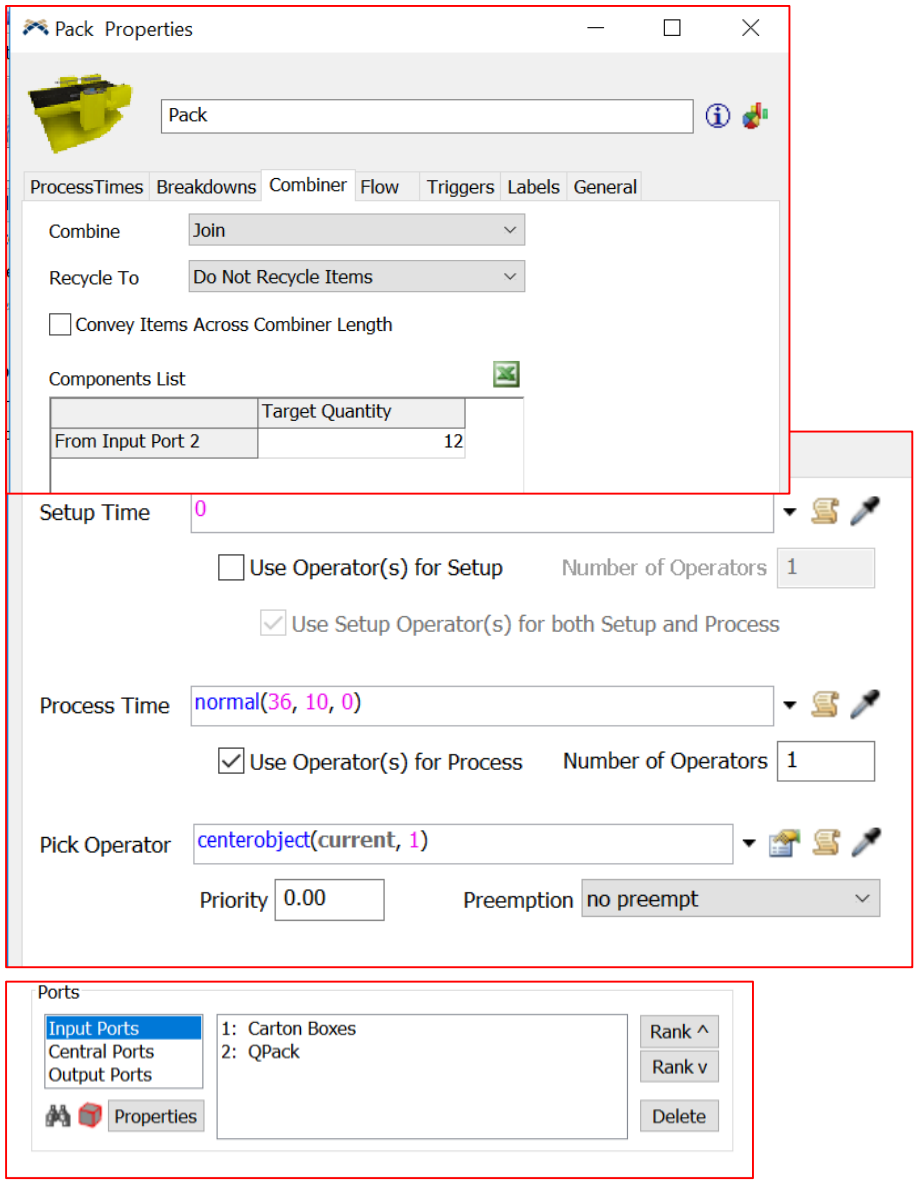
Set Separator Properties



OnExit trigger:

1. Change 3D Shape: shape index '2-Cylinder' for products unpacked from cartons.
2. Set Color: Gray
3. Set Size; 0.15, 0.15, 0.3

Set Combiner Properties



1. Use 'Join'
2. Key in 12 as target quantity to pack
3. Setup time = 0s
4. Process time: normal distribution with mean of 36s and std dev of 10s
5. Use operator for process
6. Carton Box source should be connected to Port 1

Set Processor Properties

	CleanSterilizeDry	FillCapLab	QC
Batch	12	12	12
Process Time	15s (constant)	20s (constant)	10s (constant)
OnExit, set colour to:	Green	Blue	Either Green or Red*

*Set as green for now.

→ Perform Buddy Check

Send to Port Rule – Conditional Port

- Send item to a port based on a Condition:

  if ***True*** send item to port ***x***

  if ***False*** send item to port ***y***

- The condition must be an equation containing the '==' sign which is used to compare LHS with RHS

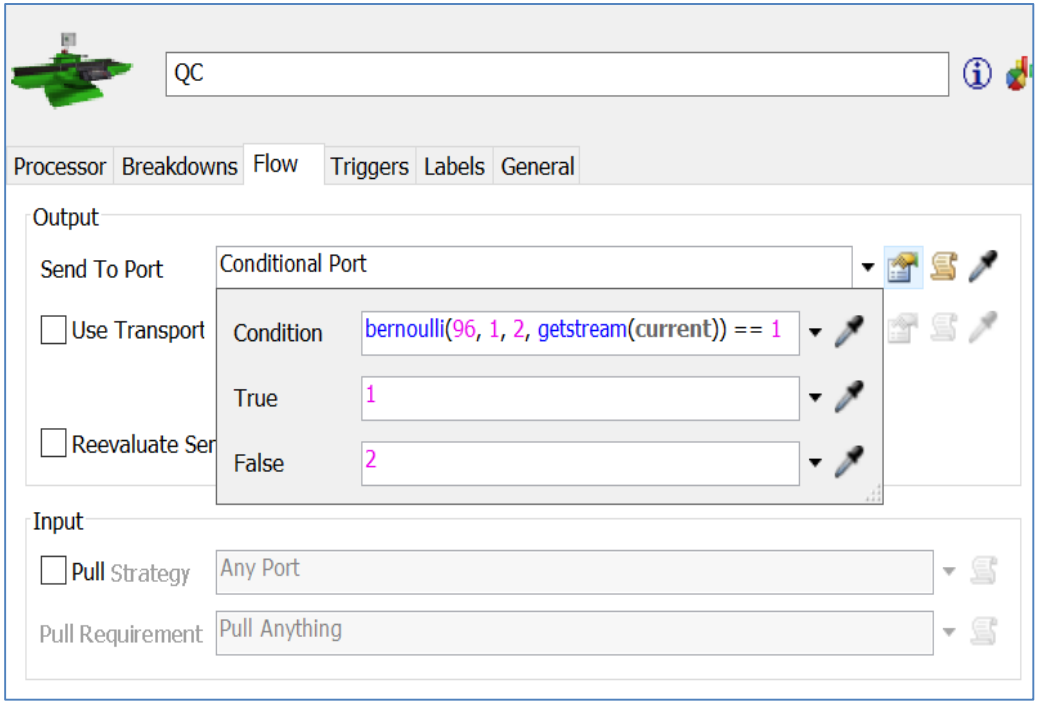
Conditional Port using Bernoulli Condition

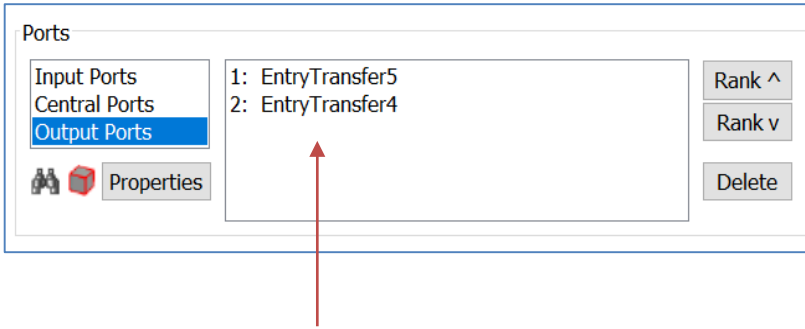
Bernoulli command: bernoulli (n, x, y)

- This command has 3 parameters and returns one of two possible values (x or y) depending on the probability (n%)
- The first parameter (n) is the ‘Success’ percentage value between 0 and 100. The second and third parameters are ‘Success’ and ‘Failure’ values, and represent the two possible values to be returned.
- For example, bernoulli (60,1,2), 60% of the time the bernoulli command will return a 1 (parameter 2) and 40% of the time it will return a 2 (parameter 3).

Set QC Properties

- Send to Port 1 for packing if bottles pass the QC
- Send to Port 2 for reclaim if bottles fail the QC
- Use conditional port and statistical distribution (Bernoulli distribution) to indicate the percentage of bottles directed to each port
- Check that the output ports are connected correctly

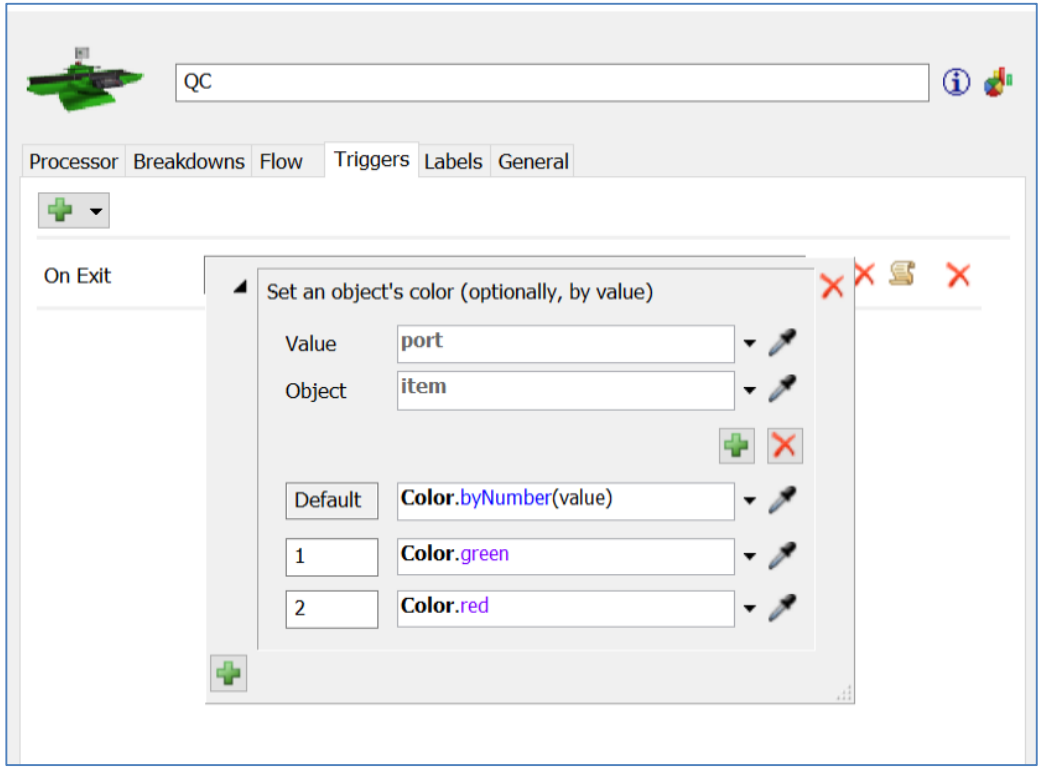




EntryTransfer ports are those found on Conveyor entry points

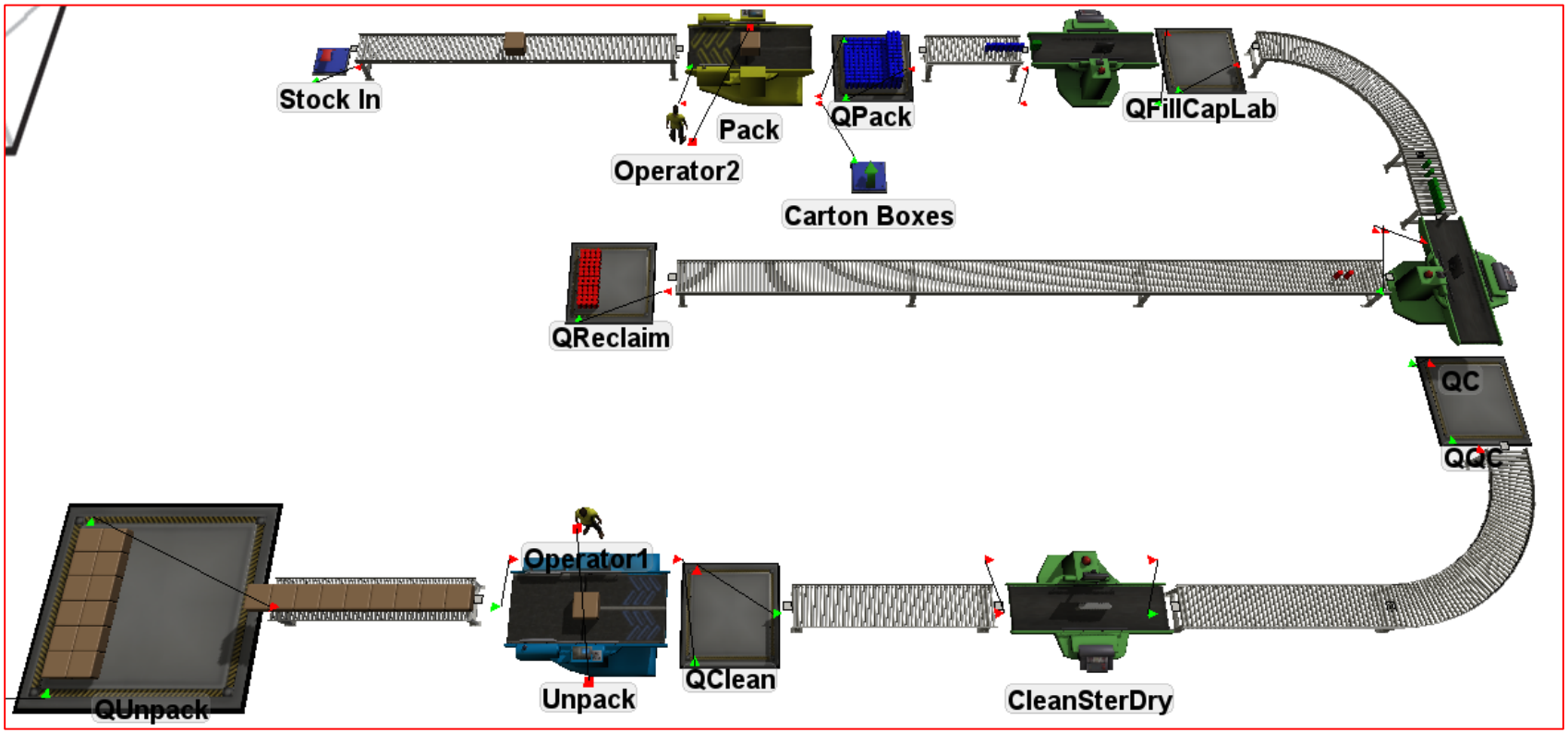
Set QC Properties

- OnExit, set colour of item to: green if it is sent to port 1; red if sent to port 2



- Run your model and get your buddy to check!

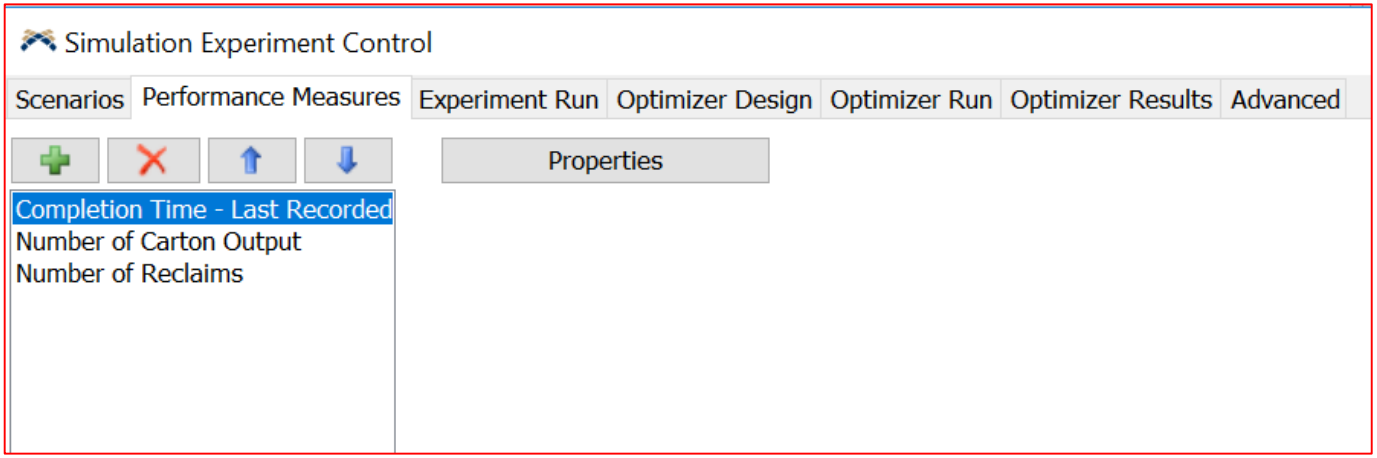
Run your model!



Buddy check:

1. Item flows
2. Item colours
3. Stats: Number of reclaims, number of stock-in and total run-time

Set Up Experimenter



Performance measures:

1. Completion Time – set Completion Time as Model Time at Stock In and QReclaim

2. Number of Carton Output/ Reclaims – use Standard Performance Measures and statistic by individual object

3. Run 10 replications

Record Results

Performance measures:

1. 95% confidence interval of Completion Time
2. 95% confidence interval of Number of Carton Output
3. Calculate the average reclaim rate

Compare your results with your team mates and discuss the performance of current process.

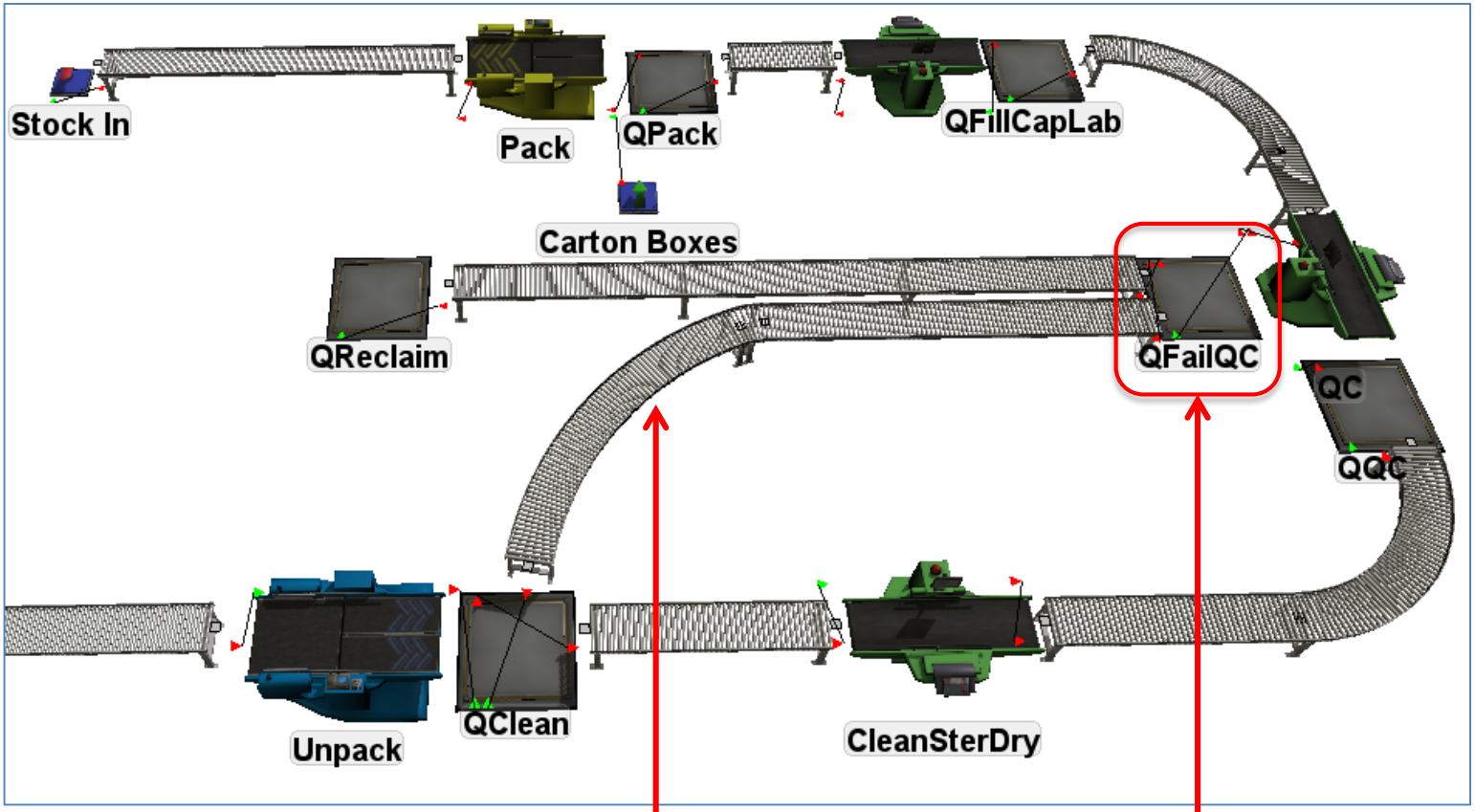
Proposed Process

New Bottling Process

Read the new process description.

- Identify the differences between the current and new process.
- What changes are needed in the model?

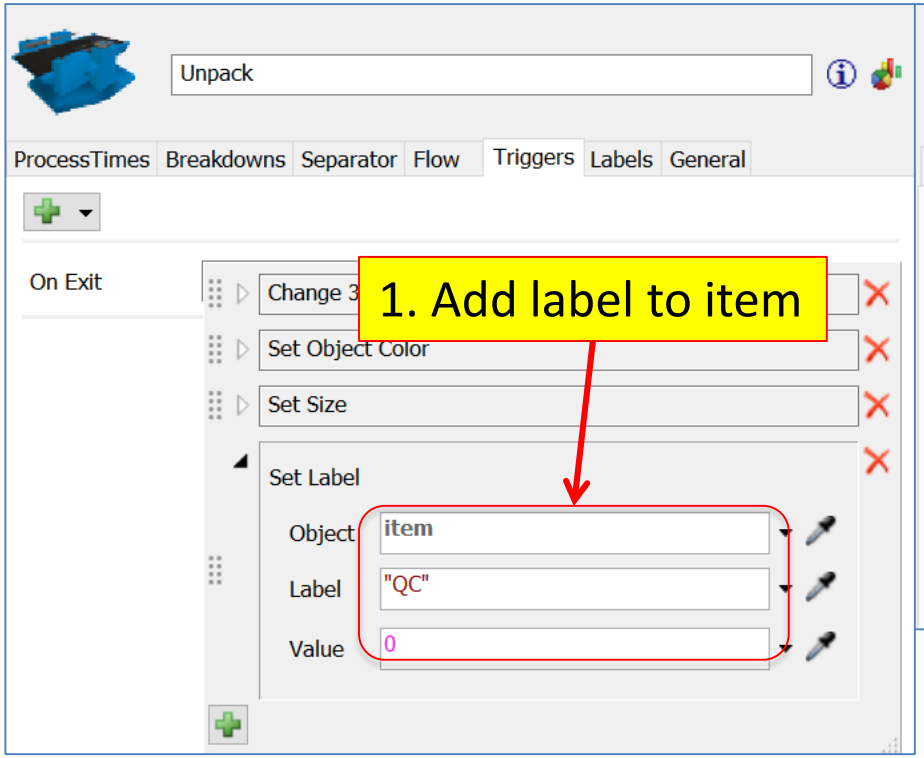
Rework: Lay Down Queue and Conveyor

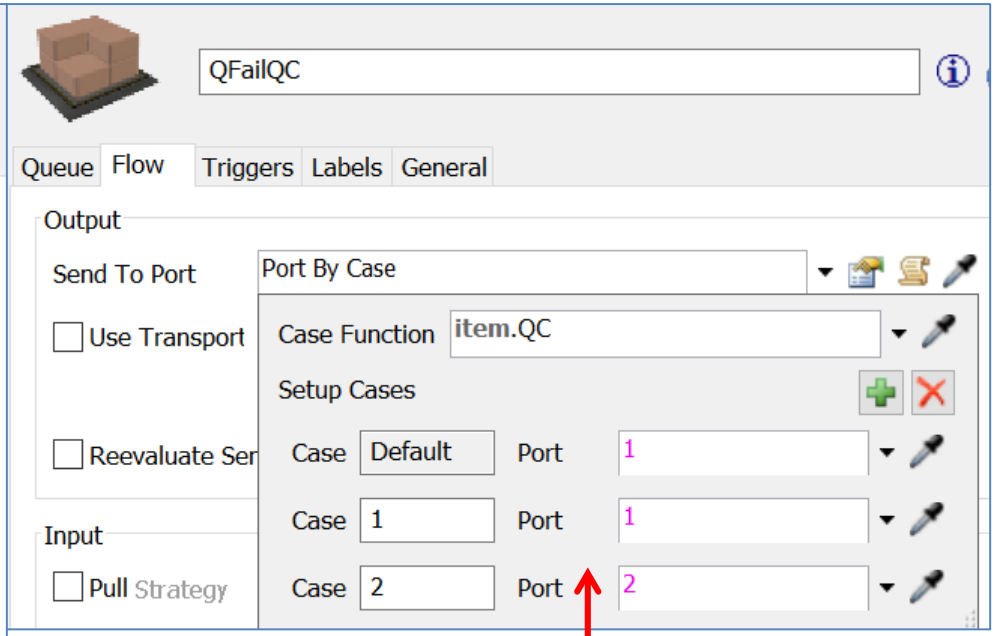


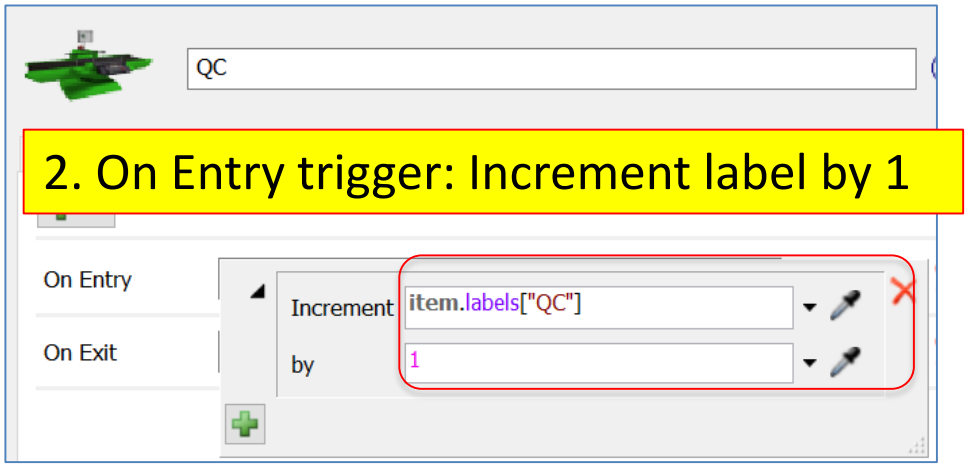
Conveyor to connect back to QClean

Virtual queue for routing

Rework – Track No. of QC by Item Label



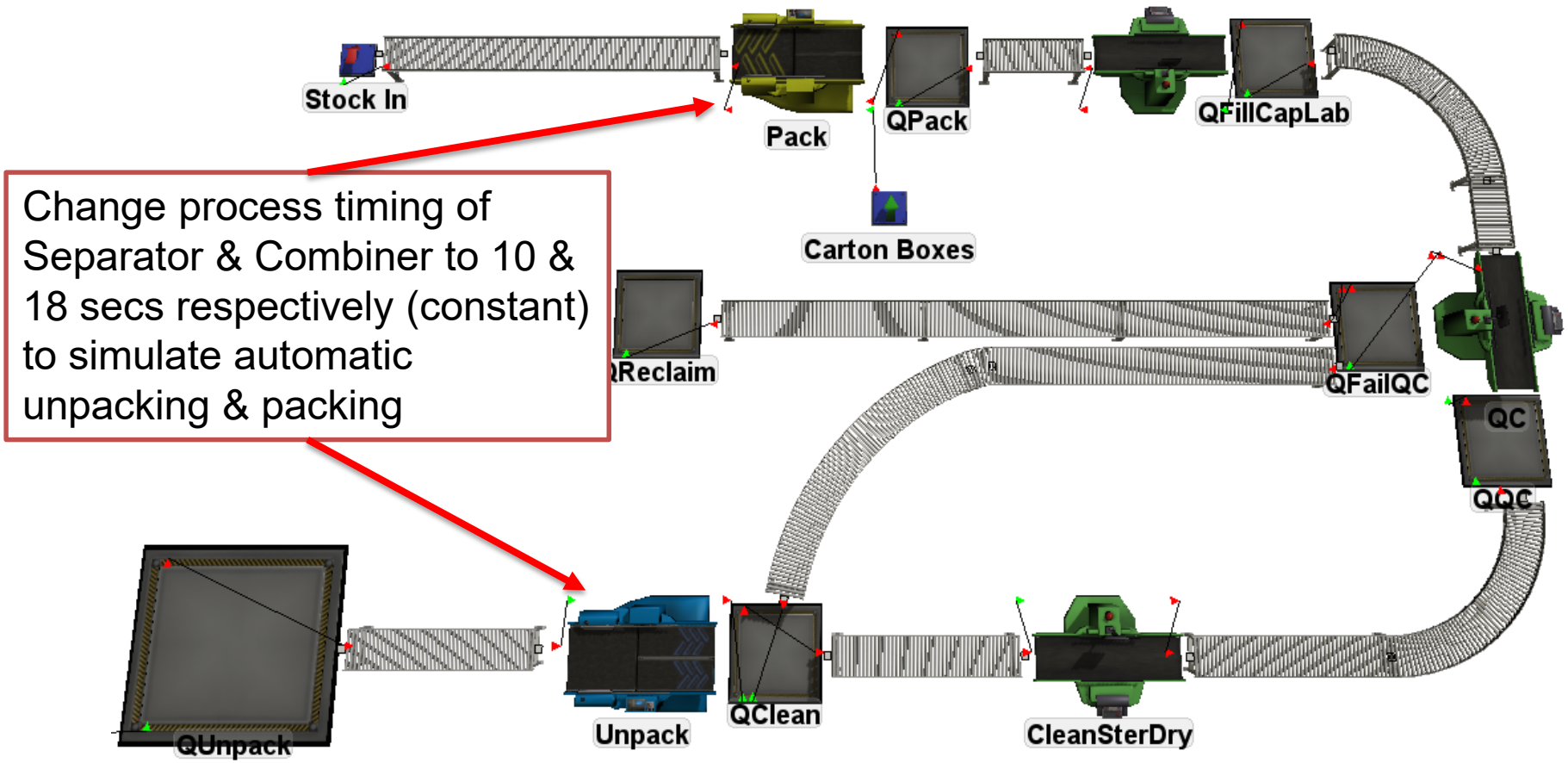




3. Send to Port 1 or 2 depending on item label value

4. Check the output port connections are correct

Automate Unpack and Pack



Submission Exercise

- Assign a different item colour to bottles that have failed QC once [Hint: use the same technique employed in QC processor]

- Run the Experimenter for 10 replications

- Create a table in Excel to compare the results (Average Output, Average no. of Reclaim and Average Cycle Time) between current and new process

Submit i) the Excel file and ii) current and proposed process Flexsim models (with the Experimenter results generated)

Performance Comparison

- Based on simulation output of 10 replications
  - Total output will be increased from 1152 to 1197 cartons;
  - Average number of bottles sent for reclaim reduced from 561 (3.9%) to 22.1 (0.15% ~ 3.9%*3.9%).
  - Average cycle time (time taken for all batches of bottled drink to move from input to output): 41482s (current) to 35364s (new); decreased by 6118 seconds with the introduction of automatic unpacking and packing processes.

In the simulation model, Bernoulli distribution is used to generate % of bottles that fail QC and this introduces randomness into the simulation output.

Learning Objectives

- Construct a more complex simulation model of a bottling line from unpacking, product cleaning, quality check (QC) to reclaim or packing depending on QC outcome
- Model and simulate the unpacking and packing operations using ‘separator’ and ‘combiner’ in Flexsim
- Model using conveyors to route items, including routing of failed products to be reworked and retested
- Use item labels to track item status in order to control item flow routing and colour
- Use appropriate statistics from objects to determine performance measures

Overview of E211 Operations Planning II Module