

TUTORIAL – ProductionFlowPy

Complete User Guide

TUTORIAL – ProductionFlowPy

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1. INTRODUCTION

This software is a production flow simulator based on the Python SimPy library. Its main goal is to model and analyze production flows by considering various parameters, such as random phenomena and different types of products on a production line, to enable a comprehensive analysis of the system. This software aims to assist the scientific community as well as industry professionals, such as process engineers.

Its main features are as follows:

- Visual creation of flow models
- Real-time simulation with visualization
- In-depth statistical analysis
- Data export in CSV format
- Support for shared operators across machines
- Measurement of cycle times and inter-arrival times for each system element.

The program follows a layer-by-layer model construction logic to ensure adequate performance.

Additionally, its use is designed for quick onboarding, with minimal learning time.

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2. MAIN INTERFACE

The interface is divided into several areas:

- Menu bar with its settings
- Drawing area (Canvas)
- A section on the right side of the screen containing:
 - Charts about:
 -  Pipettes
 - Time magnifiers
 -  Movements
 - Launching an analysis over long periods
 - System information
- Status bar: Information about the simulation

2.1 NAVIGATION ON THE CANVAS:

- Left click + drag: Move an element
- Right click: Context menu
- Scroll wheel: Zoom in/out
- Scroll wheel click + drag: Move the view (pan)
- Ctrl + scroll wheel: Precise zoom

2.2 CREATION OF A FLOW MODEL FLUX

2.2.1 STEP 1: Add nodes

Menu: Edit > Add a node

Or right-click on the canvas > Add a node

Available node types:

- Input flow (Source): Generates items
- Processing: Transforms items
- Output (Sink): System output points

2.2.2 STEP 2: Connect the nodes

1. Right-click on a node > 'Connect to..."
2. Select the destination node
3. The connection is created automatically

OR

Menu: Edit > Add a connection

Then click on the source node and the target node

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2.2.3 STEP 3: Configure the nodes

Double-click on a node to open its settings
(See section 8 for details)

2.2.4 STEP 4: Add measuring instruments

- Pipettes: Measure flow on connections
- Time magnifiers: Measure cycle times

3. THE DIFFERENT TYPES OF NODES

3.1 INCOMING FLOW (Source)

Generate items that enter the system.

Main parameters:

- Generation interval: Time between each generated item
- Generation mode:
 - * Constant: Fixed interval
 - * Normal: Normal (Gaussian) distribution
 - * Poisson: Poisson distribution
 - * Exponential: Exponential distribution
- Items to generate: Limit the total number (-1 = unlimited)
- Batch size: Number of items generated each cycle

3.2 PROCESSING

Transform the items. Can include multiple inputs and outputs.

Main parameters:

- Processing time: Duration to process an item
- Processing mode:
 - * Constant: Fixed time
 - * Normal: Normal distribution
 - * Skew-normal: Asymmetric distribution
- Synchronization mode:
 - * Wait for N from each branch: Wait for N items from EACH input
 - * First available: Process as soon as an item arrives
- Output multiplier: Items produced per incoming item

3.3 EXIT (SINK)

System exit point. Items that arrive there are counted and removed from the simulation.

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3.4 SPLITTER

A processing node with multiple outputs. Distributes items according to a configurable mode:

- Round-robin: Alternates between outputs
- Random: Random distribution
- First available: To the first non-full buffer

3.5 MERGER

A processing node with multiple inputs and a single output. Combines the incoming flows.

4. THE DIFFERENT TYPES OF ITEMS

In order to simulate product customization using the same production system but with different parameters, such as a red car and a blue car, a notion of item types is possible within the program. The editing and modification of item types are done from the 'Edit Item' window located in the top ribbon of the window. When creating an item, a name and a color are requested, which will be reused in the program to more easily differentiate the types.

5. IMPORTATION OF MODELS

The program allows the import of Simpy files. The difference with opening a file is that import will open and incorporate the loaded model into the existing file. Import is done via File, then Import.

6. CONNECTIONS AND BUFFERS

Connections represent the flow of items between nodes.

- Items flow from the source node to the target node
- Each connection can have a buffer (queue)

6.1 SET UP A CONNECTION

Double-click on a connection to configure:

- Buffer capacity: Maximum number of items waiting
 - If unlimited capacity is checked, then an infinite number of items can accumulate in the connection.
 - Otherwise, the capacity box allows you to set this parameter.
- Show buffer: Visualize the stock level
- Initial content: Items present at the beginning.

7. THE OPERATORS

Operators represent human resources or shared machines that need to move between multiple workstations.

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7.1 ADD AN OPERATOR

Menu: Edit > Manage Operators

Button "Add an Operator"

7.2 CONFIGURE AN OPERATOR

- Name: Operator ID
- Color: To visually distinguish it
- Assigned machines: List of machines the operator controls
- Travel time: Duration to move from one machine to another
 - * Constant: Fixed time
 - * Normal: Gaussian distribution
 - * Skew Normal: Skewed Gaussian distribution

7.3 FUNCTIONING

- A machine controlled by an operator only functions when the operator is present
- The operator automatically moves to the machines that need him
- During the movement, the operator is unavailable
- The travel time is recorded separately from the processing time

7.4 VISUALISAZION

- The operator appears as a colored circle on the canvas
- He visually moves between the machines during the simulation
- The 'Movements' tab displays the movement statistics

8. NODE CONFIGURATION

Double-click on a node to open its configuration window.

8.1 GENERAL TAB

- Node name: Identifier displayed on the canvas
- Position X, Y: Coordinates on the canvas

8.2 SOURCE TAB (*for sources only*)

- Generation interval: Time between generations
- Mode: Constant, Normal, Poisson, Exponential
- Standard deviation: For random modes
- Items to generate: -1 = unlimited
- Batch size: Items per generation

8.3 TREATMENT TAB (*for processing nodes*)

- Processing time: Duration per item

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- Mode: Constant, Normal, Log-normal
- Standard deviation: Random variation

8.4 ITEM CONSUMPTION

Several modes are possible:

- Synchronization mode:
 - * Wait for N from each branch
 - * First available
- Required units: Number of items needed
- Priority (first available):
 - * In order: According to the connection order
 - * Round-robin: Fair alternation
 - * Random: Random selection

The 'Wait for N from each branch' mode allows the creation of item combinations to simulate a processing node that can perform multiple types of operations depending on the types of items present in the buffers.

8.5 TIME LAPSE TAB

- Add magnifying glasses to measure:
 - * Cycle time: Duration at the node
 - * Inter-events: Time between successive items

9. MEASURING PROBES

The probes measure the flow of items on the connections.

9.1 ADD A PROBE

1. Right-click on a connection
2. 'Add a probe'
3. Name the pipette and choose a color

9.2 SET UP A PROBE

Double-click on the probe:

- Name: Identifier
- Color: For the chart
- Measurement mode:
 - Buffer: Instant stock level
 - Cumulative: Cumulative production

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9.3 VISUALISATION

The pipettes appear as small triangles on the connections.

The ' Probes' tab displays:

- Real-time graph of the measured flow
- Statistics (average, standard deviation, min, max)

9.4 DISPLAY OPTIONS

- Show IN/OUT (triangle): Distinguishes between inputs and outputs
- Time window: Limits the displayed period
- Chart height: Adjusts the visualization

10. TIME PROBE

The probes measure the characteristic times in knots.

10.1 TYPES OF MEASURES

- Cycle time: Total duration an item spends in the node (waiting + processing)
- Inter-events: Time between two successive items

10.2 ADD A TIME PROBE

1. Double-click on a processing node
2. 'Time Probe' tab
3. 'Add' button (cycle or inter-events)

10.3 VISUALISATION

The tab " Time Loupes" displays:

- Distribution histogram of measured times
- Statistics (average, standard deviation, min, max, number of measurements)

10.4 GOALS

- Identify bottlenecks (high cycle time)
- Check the consistency of production (inter-event)
- Compare the performance of different nodes

11. REAL-TIME SIMULATION

This mode allows you to visualize the system's behavior before running an analysis over a longer period.

11.1 SIMULATION CONTROLS

-  Play: Start or resume the simulation
-  Pause: Pause

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-  Stop: Stop and reset

11.2 SIMULATION SPEED

Speed slider: Adjusts the simulated time to real-time ratio

- 1x: Real time
- 2x: Twice as fast
- 0.5x: Twice as slow

11.3 TIME UNIT

Selector: Seconds, Centiseconds

Sets the interpretation of all configured times.

11.4 VISUALIZATION DURING SIMULATION

- Items visually circulate on the connections
- Buffers fill and empty
- Operators move between machines
- The graphs update in real time

12. IN-DEPTH ANALYSIS

The analysis allows studying the system's behavior over a long period.

Menu: Tools > Run Analysis

Or the  'Analyze' button in the toolbar (Information section on the right side of the screen)

ANALYSIS PARAMETERS

- Simulation duration: Total period to simulate

The analysis runs in accelerated mode (no real-time visualization).

ANALYSIS RESULTS

A window opens with several tabs:

- Buffers
 - Stock level evolution
 - Connection statistics
- Stocks
 - Item accumulation in the system
 - Identification of blockages
- Production
 - Cumulative production curves
 - Outflow rate per node
- Utilization

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- Machine and operator occupancy rates
- Identification of underutilizations
- Distributions
 - Histograms of measured times
 - Statistical analysis
- Timeline
 - Chronological view of events
 - Machine and operator statuses

13. DATA EXPORT

After an analysis, you can export the results. Click on "Export" in the analysis window. Three files are generated:

1. analysis_system_states.csv
 - System states at each moment
 - Buffer levels
 - Machine states (ON/OFF)
 - Operator actions
2. analysis_time_probes.csv
 - Time probe measurements
 - Statistics by route
 - Detailed measurements
3. analysis_conditions.txt
 - Complete report of the configuration
 - Analysis parameters
 - System description

CSV FORMAT

- UTF-8 with BOM encoding (compatible with Excel)
- Separator: comma
- Importable into Excel, LibreOffice, Python (pandas), R, etc.

14. GENERAL SETTINGS

Menu: Settings > General Settings

14.1 LANGUAGE

- French / English
- Some elements require a restart.

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14.2 SIMULATION

- Analysis timeout: Maximum duration of a simulation
- Debug mode: Displays messages in the console

14.3 PERFORMANCES

- Measure limit: Avoid slowdowns
- Animations: Enable/disable visual effects
- Animation steps: Smoothness vs performance

14.4 GRAPHICS

- Default height
- Number of histogram columns
- Display options

14.5 CANVAS

- Canvas size (width x height)
- Movement threshold

15. TIPS

15.1 MODELIZATION

- Start simple, add complexity gradually
- Name your elements descriptively
- Use consistent colors for the pipettes
- Place buffers strategically to avoid blockages
- Ctrl + long click allows you to select a group of elements.

15.2 SIMULATION

- First, test over a short period before launching a more in-depth analysis.
- Use the pause to observe the system's condition
- Pipettes help identify problems

15.3 ANALYSIS

- Simulate long enough to reach a steady state
- Check the utilization rate to identify bottlenecks
- Compare cycle times to goals
- Export data for further analysis

15.4 PERFORMANCE

- Disable animations if the window freezes
- Use larger analysis intervals

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- Limit the number of stored measurements

15.5 *SAVE*

- Save regularly (Ctrl+S)
- The .simpy format contains the entire model
- Keep versions of your important models

16. KEYBOARD SHORTCUTS

16.1 *File*

Shortcut	Action (EN)
Ctrl+S	Quick save

16.2 *Edit Modes*

Shortcut	Action (EN)
W	Selection mode
A	Add incoming flow node (Source)
S	Add processing node
D	Add exit node (Sink)
X	Add splitter
C	Add merger
Q	Add connection
E	Add measurement probe
R	Add time probe
Z	Add operator

16.3 *Simulation*

Shortcut	Action (EN)
Space	Start / Pause simulation
V	Stop simulation

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16.4 Navigation Canvas

Shortcut	Description (EN)
Mouse wheel	Zoom in/out
Click + Slide	Move node (selection mode)
Right Click	Context menu
Click empty + Slide	Pan view
Double-click	Edit node or connection
Delete	Delete selected element

For more information or to report a bug:

Check the README.md file