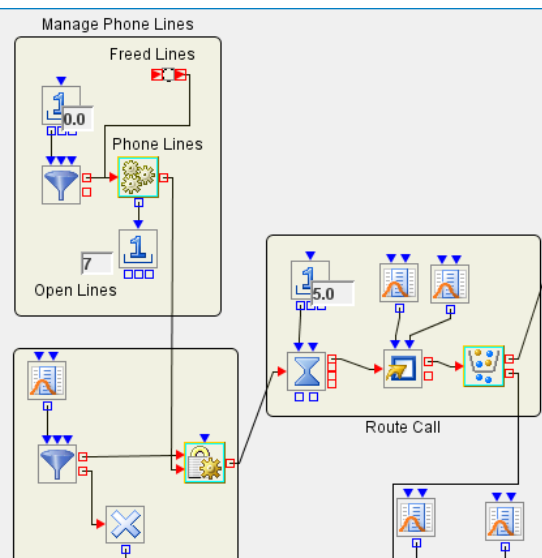


# SAS® Simulation Studio

Simulate and understand complex systems with discrete-event simulation modeling and analysis tools



Many real-world systems involve the movement of individuals or objects through a series of steps or locations that make up a workflow structure. These systems often feature complex logical rules and relationships, including random elements and interactions between objects or individuals that move through the systems. Discrete-event simulation lets you model dynamic systems whose state changes only when distinct, discrete events occur.

For instance, a large restaurant chain may need to understand operations at a particular location. How many cashiers, cooks, service lines and drink stations are needed? Or maybe a manufacturer is unable to meet goals for units delivered. There are bottlenecks affecting production, but where? Discrete-event simulation software can help you build models that mimic the behavior of complex, real-world systems so you can improve them. SAS Simulation Studio enables you to model and analyze critical operational systems to study and better understand their behavior. The graphical user interface requires no programming.

## What does SAS® Simulation Studio do?

SAS Simulation Studio provides a graphical modeling and analysis environment for discrete-event simulation. You can model, analyze and understand complex real-world systems and processes.

## Why is SAS® Simulation Studio important?

It enables you to model complex systems that are difficult or impossible to model using traditional analytical techniques. It integrates with other SAS products for source data, distribution fitting, experimental design and analysis of simulation results.

## For whom is SAS® Simulation Studio designed?

SAS Simulation Studio is designed for a wide range of users - from novices to expert analysts - in any industry. If you are trying to mimic and model dynamic systems whose state changes when events occur at distinct points in time, SAS Simulation Studio can help.

## Benefits

- **Model the behavior of complex real-world systems.** Analytic modeling methods often fall short of providing detailed depictions of systems with complex relationships and random variations. SAS Simulation Studio provides the tools you need to model all of the important elements of a system. The simulated data produced by the model is as realistic as possible.
- **Use with a broad range of industries and behaviors.** Health care, telecommunications, marketing, retail, manufacturing, banking and public agencies - all of these and more industries have systems that benefit from discrete-event simulation modeling.
- **Build models interactively.** Drag-and-drop, object-oriented modeling in a graphical environment lets you build, debug, verify and enhance your models step-by-step. You can add complexity and detail as you go. Animation, diagnostic messages, detailed traces of model runs, and graphical and numeric display features are included.

- **Create faster, better insights.** You can explore alternate scenarios for a system, varying operating conditions, system configurations, routing logic and other factors that are likely to affect system performance. Through integration with SAS and JMP® analytics, it's easy to examine simulated data to assess which factors are most influential. Then you can determine which choices are most likely to produce the best performance.

## Overview

A prime motivation for building and running a discrete-event simulation model is to create realistic data on a system's performance. Discrete-event simulation is faster, cheaper and less risky than building and observing possibly several versions of a real-world system.

SAS Simulation Studio, a Windows application, is included as part of SAS/OR® software. It provides a full set of tools for building, executing and analyzing the results of your discrete-event simulation models, along with a GUI that requires no programming.

A broad array of modular blocks, each with customizable options, lets you build detailed, realistic simulation models. You can model resources in stationary or mobile form to increase a model's realism.

Experimental design (manual and automatic) facilitates what-if analysis and more extensive exploration of how system controls and operating conditions affect key performance metrics. SAS Simulation Studio can integrate with JMP statistical discovery software for experimental design and input analysis, and with JMP and SAS for source data and analysis of simulation results.

## Discrete-event simulation modeling

Discrete-event simulation is often used to model queueing systems, where entities (representing objects or individuals) receive some sort of time-consuming service, wait to receive service or otherwise move through a system. Examples include emergency rooms (entities are patients; services are medical treatments), retail checkout areas (customers are served by cashiers), and manufacturing operations

(parts and assemblies are combined to create finished products).

The overall structure of a discrete-event simulation model resembles a flowchart or network. Nodes are linked by directed arcs. Usually, the nodes represent the entities' experiences in the system: entering or exiting, waiting in a queue, spending time while receiving service, and so on.

Movement along the arcs that link the nodes can represent physical movement between locations in the system or it can represent a transition from one status to another.

## Graphical interface elements

The most notable elements of the SAS Simulation Studio interface are the block template display area and project desktop.

The default block templates are the Standard, Advanced, Data and Display, Resource, and Output Analysis templates. You can also create custom templates.

The project desktop contains the Project window for the currently active project. Each Project window contains of at least one

Model window and one Experiment window. In the Experiment window, you specify the start time, stop time and number of replications for the model. A project can have multiple models and experiments. This is helpful if you are trying to compare two or more systems. At the bottom of the Project window are the Log, Trace and Animation tabs, which provide feedback and debugging capabilities.

## Modeling features

To build a model, simply drag blocks from block templates to a Model window. Configure and connect the individual blocks by creating links between their input and output data and entity ports. This adds flexibility to the modeling process.

Modeling in SAS Simulation Studio is hierarchical. You can assemble blocks into compound and submodel blocks. These blocks (expanded or collapsed) help control the level of detail that is displayed. They also facilitate component reuse, and can greatly reduce visual complexity. Both compound and submodel blocks can be copied and pasted like regular blocks. Compound blocks can be edited individually. You can edit the definition of a submodel block to alter all of its instances at once, making broad updates easier.

The screenshot displays the SAS Simulation Studio interface. The main window shows a project desktop with a flowchart model for a call center. The model includes blocks for 'Manage Phone Lines', 'Phone Lines', 'Route Call', 'Operator', 'Cust. Svc.', and 'To Hang Up'. The interface also features a 'Projects' pane on the left, a 'Standard' block template pane, and an 'experiment' log table at the bottom.

PointName	StartTime	EndTime	phone_in	operators	order_ops	cs_ops	Replicates	order_comp	cs_comp	order_hu	cs_hu	op_hu	busy_sig
point1	0	86,400	5	2	3	1	5	672	382.8	16.6	395.6	0	1,513
point2	0	86,400	15	3	4	1	5	1,218.9	431.6	202.6	995	0.2	66.2
point3	0	86,400	10	2	1	3	5	351.4	1,079.8	873.4	134	3.8	445.2
point4	0	86,400	5	4	3	3	5	687.4	711.4	21.6	-3.8	0	1,456.6
point5	0	86,400	10	2	4	4	5	1,122	1,170.2	83.6	27.4	3	490.4
point6	0	86,400	5	3	1	1	5	329.4	392.6	372.2	308	0	1,487.8
point7	0	86,400	5	1	4	4	5	719	715.4	0.6	0.2	33.8	1,420.8
point8	0	86,400	15	1	1	4	5	354.2	1,238.5	972.6	62.2	225.8	30.4
point9	0	86,400	10	3	2	2	5	672.6	894.4	512.6	371.8	0	524.6
point10	0	86,400	15	3	3	4	5	987.8	1,312.8	432.4	81.6	0.4	69
point11	0	86,400	15	4	4	2	5	1,223	832	189.4	556.8	0	84.2

The graphical interface of SAS Simulation Studio makes it easy to model complex systems and operations to study and improve their performance.

SAS Simulation Studio provides stationary resources (such as the Queue, Server, and Delay blocks) that have fixed locations. It also provides mobile resources - a special type of entity that can flow through the model and carry attributes just like regular entities, and is processed by the same blocks as regular entities. Mobile resources can be seized and released by other entities as required, and their availability levels and operational status can be controlled via scheduling features.

Pre-emption is highly configurable. Holding-type blocks (Queue, Server, and Delay)

enable other blocks to inspect the entities they hold. Entities to be pre-empted can be specified by their type and attribute values. Entities can also be pre-empted due to a change in the capacity or state of a resource.

## Model execution

In addition to controlling the start and stop time and number of replications to run for a simulation model, you can use the Experiment window to create experimental designs, specifying factors (inputs) and responses (outputs) for a model and listing multiple design points (defined by differing factor values) in the rows of the Experiment window.

For model verification and debugging, animation can be a valuable tool. Animation in SAS Simulation Studio can be configured extensively. You can animate specific sections of the model only at specified times during the run. This lets you focus on the areas and times of greatest interest.

With the SAS Program block, you can execute a SAS program or JMP script at any point during a simulation run. Analyze simulated data automatically during or at the end of a run. The analysis might be purely informational or could play a direct role in the decision structure of the model.

SAS Simulation Studio models can be run within the graphical interface or in batch mode using a command line executable program. If a multicore processor is available, a parallel mode in the graphical interface enables design points and their replications to be executed simultaneously on multiple cores.

## Large models and experiments

Large models present a number of challenges to simulation modeling – creating models, exploring them, and managing different model levels. SAS Simulation Studio addresses these challenges. A snapshot view provides a complete,

scaled-down view of large models that may be far larger than one screen.

For exploration of large models, a search facility identifies and locates blocks by type and name. From the search results, you can open the Properties dialog box for each identified block and edit its settings.

For large experiments, SAS Simulation Studio offers an alternative Experiment window view that enables large numbers of factors and responses to be displayed more easily.

## Data management and analysis

SAS Simulation Studio can input stored data to a model, reading in single values or single rows. You can also store an entire data set and query it as needed (specifying the desired column, row or cell) during the simulation run.

Data generated by a SAS Simulation Studio model can be collected and saved either through the Experiment window or through data collection by an individual block. At the end of a run, you can save the data collected by any block. In addition, Boolean input data ports on several data collection blocks enable you to collect event-driven data that corresponds to a specific portion of the run. You can also select Save Design from the Experiment window pop-up menu to save the experiment data to a file.

Each block that collects data can send output to a data visualization block. Both graphical and tabular displays are provided. An additional set of blocks collects data (general or specific to resources, queues or servers) and computes statistics. There is also a block for computing statistically valid confidence intervals for responses that are generated from a steady-state simulation.

For analysis of simulated data, SAS Simulation Studio is integrated with both SAS and

JMP to take advantage of their rich and powerful data processing and analysis capabilities.

## Experimental design and input analysis with JMP®

In simulation modeling, you often need to study the impact of changes in model input parameters on the simulation output. Experimental design techniques can generate an efficient and effective plan to guide your simulation runs.

Once factors and responses are defined for your model, JMP can be used to generate an experimental design. SAS Simulation Studio interfaces with JMP to create a default design with the JMP custom designer. The design is automatically passed back to the Experiment Window in SAS Simulation Studio. You can modify this design by adding, for example, interaction terms or new design points, and then send the modified design back to SAS Simulation Studio.

The accuracy of the analysis of any output generated by a simulation model is highly dependent on the appropriateness of the inputs that drive the model. Often, you want to use available data to estimate the parameters of a theoretical distribution and then sample from that fitted distribution to generate inputs to your model. SAS Simulation Studio provides direct access to the automatic distribution-fitting capabilities in JMP. Once you have specified the data source and variable of interest, JMP enables you to investigate and select from among multiple distributions. Your distribution choice and its parameter values are sent back to SAS Simulation Studio for use in the model run.

## Key Features

### Graphical user interface

- Programming-free GUI.
- All the tools you need to build, execute and analyze discrete-event simulation models.
- Suitable for users from novice to expert in virtually any industry.

### Modeling features and model execution

- Hierarchical modeling, including compound and submodel blocks.
- Control the level of detail that is displayed.
- Animation aids model verification and debugging.
- Create experimental designs with multiple design points.
- Control start and stop times and number of replications.
- Design points and their replications can execute simultaneously on multiple computational cores.
- Models can be run within the GUI or in batch mode.

### Innovative resource modeling: mobile resource entities

- Complements block-based stationary resources.
- Regular entities seize resource entities.
- Multiple resource entities can be seized and held at once.
- Resource entities can move independently in the model.
- Resource entities can be scheduled and pre-empted.

### Integrated with SAS® and JMP® analytics

- SAS and JMP: input data; analysis of simulated data.
- JMP: input analysis; automated, interactive experimental design.
- SAS and JMP: execute code during model execution.

### Precise, flexible data management and analysis

- Flexible access to stored input data.
- Numerous data collection facilities.
- Event-driven output data creation.
- Graphical and tabular data display features.
- A state-of-the-art, steady-state analysis capability.

### Support for large models and large experiments

- Navigation and search.
- Hierarchical modeling.
- Compound blocks and submodels.

### TO LEARN MORE »

To learn more about SAS Simulation Studio system requirements, download white papers, view screenshots and see other related material, please visit [sas.com/simulation-studio.html](http://sas.com/simulation-studio.html).

To contact your local SAS office, please visit: [sas.com/offices](http://sas.com/offices)

