SAS/OR® Software

Optimize business processes and address management science challenges with enhanced operations research methods

What does SAS/OR® software do?

SAS/OR software provides a powerful array of optimization, simulation and project scheduling techniques to identify the actions that will produce the best results, while operating within resource limitations and other relevant restrictions.

Why is SAS/OR® important?

SAS/OR enables organizations to consider more alternative actions and scenarios, and determine the best allocation of resources and the best plans for accomplishing goals. Incorporating operations research analytics not only adds structure and repeatability to decision-making processes, but also better utilizes your analytic and business intelligence investments and delivers a competitive edge.

For whom is SAS/OR® designed?

SAS/OR is designed for people in any industry with operations research (or management science) experience who build decision-guidance models by applying operations research techniques to solve real-world problems. Adding well-designed user interfaces can open up these methods for use by people who interact with the problems on a business level.

Choosing the actions that produce the best outcomes requires the ability to create, consider and evaluate alternate scenarios. SAS/OR software helps model, solve and communicate the best solutions to complex planning problems quickly and effectively.

SAS/OR brings together essential optimization, simulation and scheduling solution capabilities in an integrated and adaptable environment. Combining power and accessibility with the SAS® foundation of data handling, analytical (statistics, forecasting, data mining, etc.) and reporting features, SAS/OR enables you to coordinate directly with these critical supporting and follow-on activities as you build, use, maintain and update a wide range of models.

Customers worldwide use SAS/OR software to solve planning problems and address business challenges such as:

- Resource allocation and management.
- Production and inventory planning.
- Product mix and composition.
- Staffing allocation and scheduling.
- Project execution monitoring and tracking.
- Supply chain management and optimization.
- Capital budgeting, asset allocation and portfolio selection.

Key Benefits

- **Apply a wide range of operations research methods.** SAS/OR offers the broadest available spectrum of operations research modeling and solution techniques, and includes state-of-the-art methods for mathematical optimization. The depth of detail and realism in SAS/OR software's modeling capabilities, control of optimization, simulation and scheduling processes, and integrated approach to data access and information delivery enable organizations to identify and apply the best answers to complex planning problems.
- **Build models interactively and experiment with data**. SAS/OR lets you build models interactively, modifying constraints or variables and experimenting easily with the effects of changes to underlying data. In mathematical optimization, a specialized modeling language enables you to work transparently and directly with symbolic problem formulations, and an appropriate solution method for the current problem can be automatically chosen. This allows problems to be formulated and solved intuitively and efficiently whether they are linear, nonlinear or quadratic.
- **Easily incorporate more data**. With SAS/OR it is easy to indicate where and how input data will be used in a model. Data/model separation is maintained, which is critical when reusing models or model components. Users can select the aspects of the solution to be reported and can control the form in which they are reported.
- **Generate quicker, better answers**. SAS/OR includes analytic and solution methods that are tuned to address large, complex, real-world problems.

Product Overview

With SAS/OR software, modelers transform real-world scenarios into mathematical models. When altering models to better reflect the key elements of business problems, they can consider various options, leveraging essential modeling, optimization, simulation and scheduling capabilities from within SAS.

Most SAS/OR capabilities are surfaced within a common language and all use a common data format, which allows analysts to seamlessly utilize data mining, data cleansing, forecasting, experimental design, Monte Carlo simulation or any of the hundreds of statistical functions offered by SAS Analytics, and avoid the hassles of dealing with multiple niche software packages. Operations research is never performed in isolation; it is part of a continuum that begins with data integration, grows by informing decision makers with descriptive and predictive analytics, and builds on those analyses to deliver proactive decision guidance.

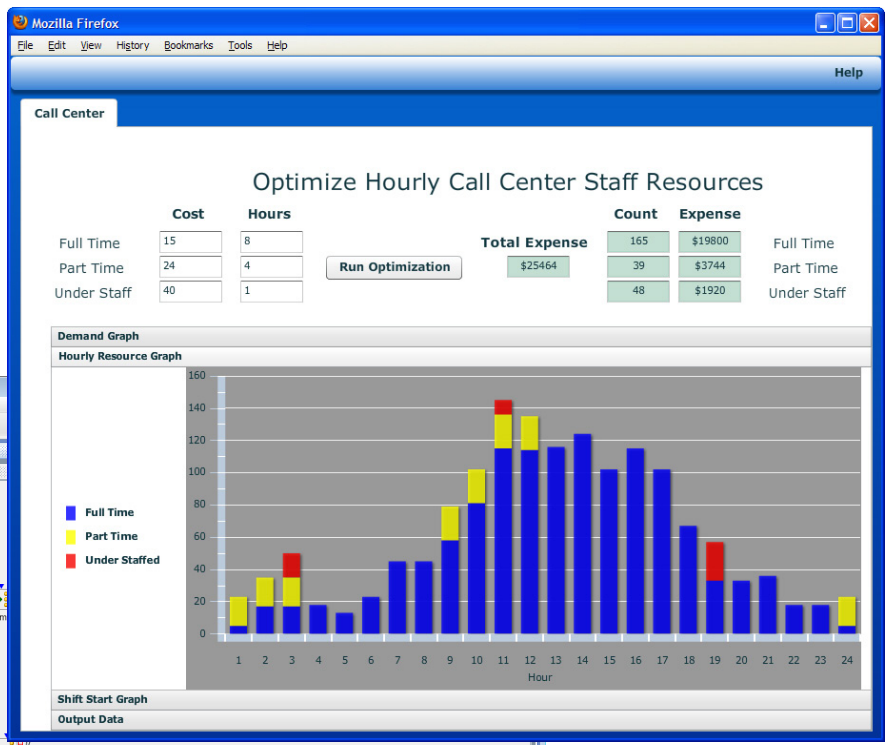
Mathematical Optimization

SAS/OR contains sophisticated mathematical programming techniques that can help determine the best use of limited resources to achieve desired goals and objectives. It provides:

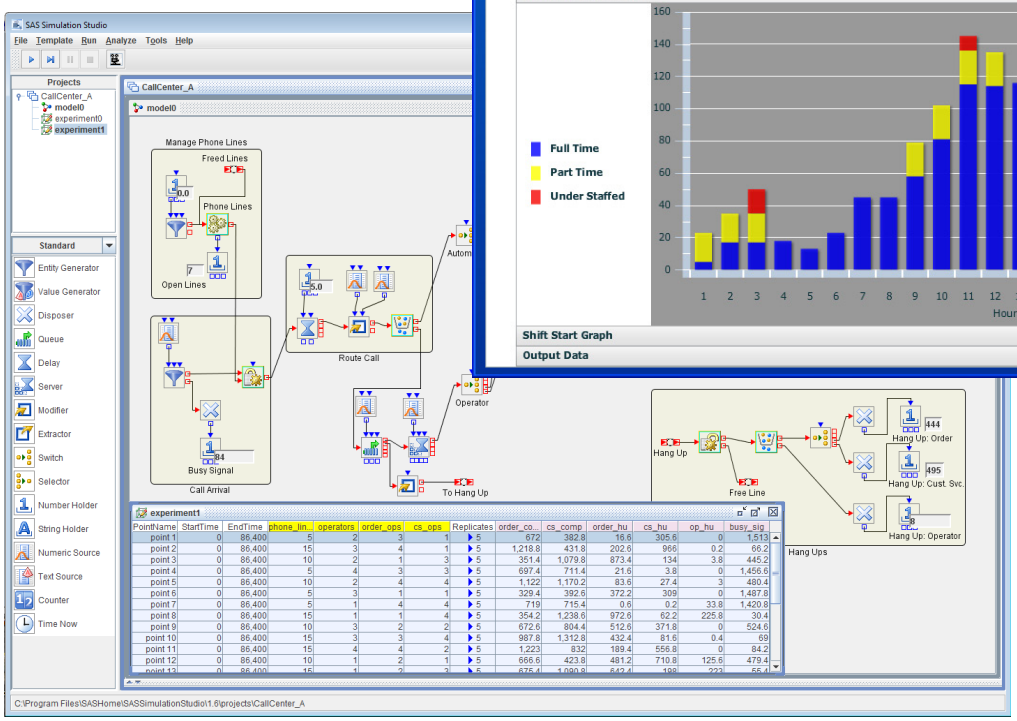
- Algebraic, symbolic optimization modeling that transparently represents model formulations.
- A single modeling language for linear, integer, mixed-integer, nonlinear and quadratic programming.
- Powerful optimization solvers and presolvers.
- An interactive mathematical modeling and solution environment.

Algebraic, symbolic optimization modeling language

SAS/OR includes the OPTMODEL procedure, providing a rich optimization modeling language with specialized syntax and constructs that enable problems to be represented directly and efficiently. This makes it easier to review models for initial validation, make subsequent adjustments or run models with new data. This clarity is critical if optimization models are to be distributed for use across many departments or divisions, or if analysts are reassigned and pass planning models to their colleagues to carry on with implementation and/or adaptation for alternate scenarios.



(Above) Sample interface demonstrates the use of SAS/OR to optimize workforce allocation, factoring in shift hours, pay rates and the opportunity cost of unmet demand.



The SAS Simulation Studio graphical interface provides interactive model building and experimental design capabilities.

Linear, integer, mixed-integer, nonlinear and quadratic programming

SAS/OR users need to learn only one set of statements and commands to build and solve a wide range of optimization models. Optimization models often evolve during the implementation process, and as analysts adjust their formulations to address slightly different business cases, constraints and/or the objectives can change from linear to nonlinear expressions and vice versa. With SAS/OR, users don't have to worry about switching modeling environments or employing different syntax to use appropriate solution algorithms.

Powerful optimization solvers and presolvers

SAS/OR provides a suite of solvers that is streamlined for simplicity and tuned for significant reductions in the time needed to find optimal solutions. This enables you to tackle even larger enterprise problems and solve them more quickly. Optimization solvers include primal and dual simplex, network simplex, interior point, branch-and-bound and nonlinear solvers that are especially suited to handle large, sparse problems.

Multistart method helps identify better solutions

In nonlinear optimization it is common that either or both of the objective functions and one or more of the constraint functions are noncovex as well as nonlinear. In such cases, the optimization problem might have many locally optimal solutions that are not globally optimal. To increase the likelihood of identifying a globally optimal solution, a multistart method can be used to select and begin optimization from each. The best solution found among all starting points is reported.

Interactive modeling and solution environment

In the OPTMODEL language you can modify your optimization model interactively, dropping or restoring constraints, fixing decision variables at specified values, or altering the underlying data. This enables you to try out different versions of the same model and experiment easily with the effects of changes. You can also define and name multiple models to solve individually or as part of a larger solution strategy. Intermediate solutions can be saved for use in future optimizations. All aspects of intermediate and optimal solutions are fully accessible for examination, analysis and reporting.

Genetic Algorithms and Constraint Programming

SAS/OR includes two options for those confronting some of the most challenging optimization-related problems. Genetic algorithms apply principles of natural selection and evolution in working with groups of solutions to optimization problems. Constraint programming solves constraint satisfaction problems using powerful consistency algorithms, tailored for specific classes of constraints, along with a choice of search strategies. Each approach can be useful for problems that are difficult or impossible to formulate and solve with standard methods.

Discrete Event Simulation

SAS Simulation Studio features a graphical user interface that requires no programming and provides all the tools needed for building, executing and analyzing discrete event simulation models. A broad array of modular blocks, each with customization options, enables you to build detailed, realistic simulation models. You can model resources in static or mobile form, further increasing the realism of your models. Experimental design (manual and automatic) facilitates what-if experimentation and more extensive exploration of how system controls and operating conditions affect key performance metrics. SAS Simulation Studio can integrate with JMP® for experimental design and input analysis and with JMP and SAS for analysis of simulation results.

Project and Resource Scheduling

SAS/OR software's project scheduling capabilities give you the flexibility to plan, manage and track project and resource schedules through a single, integrated system. The software is adept at handling complicated situations involving multiple project record keeping, resource priorities, complex project and resource calendars, substitutable resources with skill pools, multiple and nonstandard precedence relationships and activity deadlines. Single- and multiple-project schedules can be easily created and updated, incorporating structural, time and resource constraints. Inputs to the scheduling process include hierarchical project structures, resource requirements, and work shift/calendar/holiday information for activities and resources. Both replenishable and consumable resources are supported, and resources can be assigned in teams as needed. Extensive control over the scheduling process is provided. Output includes detailed project schedules and profiles of resource usage and availability across timelines. Graphics include Gantt charts and network diagrams.

Earned value management analysis

SAS/OR includes earned value management capabilities that enable you to track, analyze and predict the cost and schedule performance of projects in progress. A set of metrics based on comparing actual versus planned progress and costs detects deviations from

schedule/budget early in the project, providing a factual basis for targeted corrective action.

Decision analysis

Decision trees help structure decision-making processes under uncertain conditions by enabling you to examine and compare all possible outcomes. In input data sets you describe the problem structure, the probabilities of various outcomes and the associated payoffs. SAS/OR analyzes the decision problem, incorporates utility functions and attitudes toward risk, and identifies an optimal decision strategy.

Bill of material processing

Bills of material are used in manufacturing to detail the relationships linking parts and materials, subassemblies, assemblies and finished products. SAS/OR performs bill of material processing, reading product and component structure data and composing the information into single-level, multiple-level and indented bills of material. Summarized reports show quantities of all items needed to fill orders for finished goods. These capabilities can work in conjunction with SAS/OR software's project scheduling features to determine the impact of parts availability on production and delivery schedules.

SAS/OR® Software System Requirements

To learn more about SAS/OR and SAS Simulation Studio system requirements, download white papers, view screenshots and see other related material, please visit www.sas.com/or.

Key Features

Mathematical optimization

- OPTMODEL procedure:
  - Flexible algebraic syntax for intuitive model formulation.
  - Support for the transparent use of standard SAS functions.
  - Direct invocation of linear, nonlinear, quadratic and mixed-integer solvers.
  - Support for the rapid prototyping of customized optimization algorithms, including support for named problems and subproblems.
  - Use of industry-standard MPS/QPS format input data sets.
- Aggressive presolvers to reduce effective problem size.
- Linear programming solvers:
  - Primal simplex and dual simplex.
  - Interior-point with (experimental) crossover.
  - Network simplex.
- Branch-and-bound integer and mixed-integer programming solver with cutting planes and primal heuristics.
- General nonlinear programming solvers:
  - Interior-point trust region method with line search.
  - Active-set trust region method with line search.
  - Multistart capability.
- Quadratic programming with state-of-the-art solver tailored for large-scale optimization.
- Network flow optimization: shortest path, maximum flow, minimum cost flow.
- Genetic algorithms for local search optimization.

Discrete event simulation

- Versatile, graphical modeling capabilities; create and save custom components.
- Ability to model both static and mobile resources.
- Automated experimental design and input analysis via integration with JMP.
- Ability to drive models with historical data in SAS data sets or JMP tables.
- Integrate with SAS or JMP for analysis of results.

Project and resource scheduling

- Critical path method and CPM-based, resource-constrained scheduling.
- Calendars, work shifts and holidays for determining resource availability and schedules.
- Full support for nonstandard precedence relationships.
- Ability to include PERT estimates of duration.
- Versatile reporting, customizable Gantt charts and project network diagrams.
- Earned value management analysis for project execution tracking.
- Decision analysis:
  - Create, analyze and interactively modify decision tree models.
  - Customize utility functions, including risk aversion/tolerance.
  - Calculate value of perfect information (VPI) and value of perfect control (VPC).
- Bill of material (BOM) processing:
  - Read from standard product structure data files and part master files, or combined files.
  - Account for lead times, lead time offsets, scrap factors, quantities on hand.
  - Produce single- or multiple-level bills of material, including indented and summarized BOM.
  - Produce summarized parts, listing items and quantities required to meet the specified plan.
- Constraint programming capabilities with scheduling and resource features.

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