

SAS/OR® Software -- What is It? & What Can It Do?

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ABSTRACT

This paper gives an overview of the project management and resource allocation capabilities of SAS/OR. The paper gives examples of the types of operations research (OR) problems that SAS/OR can solve. These problems are found in management of complex projects and when making important decisions via math programming.

INTRODUCTION

This paper answers these questions:

1. What is SAS/OR? 2. What types of problems can SAS/OR solve? 3. What project management problems can SAS/OR solve? 4. What math programming problems can SAS/OR solve?

1. SAS/OR is..

SAS/OR provides the capability to solve operations research problems. Operations research is concerned with making optimal usage of scarce resources, e.g., raw materials, manpower, time, and money. SAS/OR is useful for (1) managing complex projects and for (2) allocating scarce resources (using math programming). First, SAS/OR has project management procedures that produce efficient schedules for the usage of scarce resources in managing a complex project. Second, SAS/OR has procedures that optimally allocate scarce resources to competing requirements (using math programming). Thus, SAS/OR provides an extensive range of decision support procedures for solving management science problems.

2. SAS/OR can solve..

SAS/OR provides procedures to solve problems involved in (1) managing projects and (2) allocating scarce resources (using math programming).

Project management involves planning, monitoring, and controlling a complex project. A complex project is one that consists of many activities, each of which requires multiple types of manpower and other resources (including time) to accomplish it. Furthermore, a complex project has activities that are

interrelated; that is, there are precedence and time constraints as well as the aforementioned resource constraints. For example, planning the construction of an airport, planning the production of a new software product, and planning the relocation of a production facility are complex projects that require careful management of manpower, equipment, time, and money. SAS/OR has project management procedures that enable an analyst to efficiently manage such projects.

Math programming is concerned with allocating scarce resources towards the accomplishment of some objective. OR analysts can optimize (either maximize or minimize) some quantifiable objective that is subject to some constraints. For example, corporations often want to maximize a their total profit subject to payroll, production, and distribution capacities. SAS/OR has math programming procedures that enable an OR analyst to determine the best way to accomplish a quantifiable objective using a math program. The math program is a statement of a business problem in math (equation) form.

3. Project Management..

The procedures for project management are PROCs CPM, GANTT, NETDRAW, & DTREE. SAS/OR enables a manager to plan for the accomplishment of a complex project in an efficient manner. The major procedure for project management is PROC CPM (Critical Path Method). PROC CPM schedules an efficient project subject that complies with the precedence, time, and resource constraints that are given it. The manager then uses this schedule to monitor and control project resources. PROC GANTT displays the computed schedule and PROC NETDRAW displays the interrelated activity network.

PROC DTREE is used to solve decision tree models, i.e., to analyze the costs of making various decisions often under conditions having various probabilities.

PROC CPM requires input SAS data sets containing information on the activities, their required resources,

and a planning (calendar) time. PROC CPM produces a schedule and resource usage information. Traditional project management involves very large complex projects that span months if not years. For example, building an airport will require a huge number of very expensive and specialized pieces of equipment as well as large and varying manpower force. Thus, corporations can use Base SAS to access and handle the large amounts of data for such a project and SAS/OR can be used to efficiently schedule and manage that project. Base SAS can then report the schedule and resource usage in reports, tables, and graphs.

To show that the CPM procedure is not limited to traditional project management, R. Kulkarni wrote a paper, "Exploiting the Scheduling Algorithms in SAS/OR Software," for the 19th SAS User Group International Conference. In that paper she showed how several heuristic algorithms used in job shop or flow shop scheduling can be easily programmed using PROC CPM. For example, many production facilities require their products to flow through (flow shop) a number of machines to make the final product. On the other hand, some manufacturing processes do not require all jobs (job shop) to be machined in the same order. These flow shop and job shop problems are get very complex even with a few number of machines and products. Furthermore, SAS/OR User's Guide: Project Management shows how to solve other (non-traditional) scheduling problems. This manual has an example on how to schedule course to teacher combinations using PROC CPM. Analysts can solve this resource allocation problem using either a project management technique (PROC CPM) or using a math programming technique (PROC LP).

4. Math Programming..

There are many decision problems that can be formulated as a math program. Managers are often faced with the important problem of allocating scarce resources in an optimal manner.

Even individuals face optimization problems daily. For example, finding the shortest way to work is a decision most of us face. Alternatively, perhaps we are more concerned with finding the cheapest, fastest, safest, least interrupted, or environmentally clean-

est way to work. Another important decision problem many of us face in getting to work is whether to purchase or lease a car. After that decision is made, deciding on the most car for our money becomes another decision problem.

Now, individuals do not usually analyze their decisions with math programs. However, managers must efficiently use their resources to optimize their business' productivity or else someone else will drive them (no pun intended) out of business.

SAS/OR has procedures that contain algorithms to solve these decision problems. Some classic industrial engineering, production management, and business problems are listed below.

Product mix problems are concerned with determining how many of each product to produce, subject to limited raw materials, so as to maximize profit. That is, we determine which mix of several products to produce. In other words, we want to find the mix of products that generates the largest return when there are several products that compete for limited raw materials.

On the other hand, blending problems find the mix of ingredients to be used to make a single product so that it meets standards at minimum cost. One of the earliest math programs calculated a diet that would meet nutritional standards at minimum cost.

Network flow problems find the optimal distribution of supplies to demands. Many real world management problems can be formulated and solved as network flow problems. Networks are an extremely flexible math modeling technique. There may be constraints on some of the flows of supply to demand. Furthermore, there may be intermediate (transshipment) points in the network. Because network flow problems can be graphically displayed as a network of points (nodes) connected by lines (arcs), they are easy to conceptualize, formulate, and to communicate. Also, their mathematical structure is special and so algorithms used to solve these problem are very fast. Thus, this is an extremely important and widely used class of problems.

There are a couple of problems that are subsets of the network problem. The assignment problem is a special type of

network flow problem where all the supply and demands are one. The classic example is assigning individuals to jobs. Shipping finished goods from factories to sales points is the transportation problem. The transportation problem is another special type of network flow problem where there are only supply and demand points, that is, there are no transshipment points.

Another an important class of problems are called multi-period planning problems. Production & inventory problems calculate the production rates and inventory levels during each repeating period (month or year) that will meet demand during each period at minimum cost subject to limited production capacity per period. If we consider cash holdings as an inventory with investments and dividends in different periods, determining an optimal investment strategy is an important example of a production & inventory problem.

Capital budgeting problems find the set of projects that will return the greatest profit subject to a capacity constraint. Similarly, plant location problems are concerned with determining the set of sites at which plants should be located and which site should service each customer. These problems involve very important yes/no decisions. Thus, these are another class of important problems having integer (discretely-valued) variables.

Staffing (or covering) problems meet the requirements of different staff levels during different periods while not exceeding available resources.

The procedures for math programming are PROCs LP, NETFLOW, ASSIGN, TRANS, & NLP. Generally, the SAS programmer presents these problems to the SAS/OR procedures in the form of one or more SAS data sets. The SAS data sets contain the mathematical formulation of the decision problem. The SAS/OR procedure solves the problem contained in the data set(s) and outputs the best answer in another answer SAS data set. Base SAS can then report the answer in a report, table, or graph. Now, if the SAS programmer is also an OR analyst, then the same person can recognize, define, formulate, and code the problem in Base SAS. SAS/OR solves the problem. Then, the SAS programmers read the answer SAS data set to report the best solution.

Math programs can be described as being either linear or non-linear depending primarily upon the relationships and types of the variables. PROC LP is the procedure that solves the general linear program. PROC LP also handles the especially difficult class of integer problems. PROCs NETFLOW, TRANSPORT, & ASSIGN are special cases of PROC LP. PROC NLP handles the non-linear programs.

PROC NETFLOW is the primary procedure for network problems. See the author's "Optimal Distribution of Army Officers with SAS/OR Software" and "Insuring Down-Sizing is Right-Sizing with SAS/OR Software" in the 19th and 20th SUGI proceedings, respectively, for actual applications. As aforementioned, the assignment problem and transportation problem are special cases of the network flow problem. PROC ASSIGN and PROC TRANS solve those problems.

The OR analyst must use PROC LP to solve linear problems that do not fall into the network programming category. PROC NLP is the newest math programming procedure in SAS/OR and is used to solve non-linear problems.

CONCLUSION

SAS/OR is a powerful and flexible addition to The SAS System. SAS/OR is a collection of procedures that solve project management and resource allocation (decision) problems. A data analyst can manage the corporation's data using Base SAS. The operations research analyst can then formulate and solve management problems using SAS/OR. Finally, the analyst can report the solution again using Base SAS to produce reports and high quality graphics. Many other operations research software tools are not part of a large integrated information delivery system and often cost much more than SAS/OR. Thus, SAS/OR is a powerful and very economical addition to the analyst's suite of SAS products.

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