ABSTRACT:

SAS/OR® software brings together several solution techniques used in Operations Research. This paper describes several implemented applications at ICI Americas Inc. which use SAS/OR software. We will discuss why we chose to use SAS/OR software and what the unique advantages SAS/OR software has over other products. Successful implementations of OR techniques can increase productivity, improve manufacturing efficiencies, reduce costs and improve profits.

INTRODUCTION:

ICI is one of the world's largest chemical companies. The geographic diversity of ICI, with manufacture in more than 40 countries and sales in over 150, is the broadest of all the chemical majors. ICI has sales in excess of $21 billion and employs over 133,000 people worldwide.

In the U.S., ICI Americas Inc., is a wholly-owned ICI operating subsidiary and one of the fastest growing chemical companies. Headquartered in Wilmington, Delaware, ICI Americas has sales of approximately $4.5 billion and employs some 17,000 people at manufacturing sites, research centers, laboratories and offices throughout the U.S. This paper will discuss applications implemented in two of the operating divisions: ICI Films and ICI Pharmaceuticals.

Project Scheduling

A customized project scheduling system was developed for the Investigational Materials Section (IMS) of the ICI Pharmaceuticals Group. IMS is responsible for coordinating, packaging, labeling and shipping the pharmaceutical requirements for the company’s clinical research programs. IMS must meet each study's due date using their available manpower and machinery resources. From a programming point of view, each study is consistent as far as the number of tasks involved, the task dependencies, and the resources required. The difference between studies is the degree of difficulty and the volume of the drug to be packaged. Several templates were set up to identify the various types of activities which would be scheduled. This volume determines the duration of the tasks for a study. Each study is made up of 5–6 tasks and there could be greater than 100 studies active at any point in time. We wanted to develop a system which required minimal user input. The user is only required to enter the study type, volume of study and any due dates. Daily the user updates the schedule to mark those tasks which have been performed and runs the schedule for the following day.

SAS was chosen to solve this problem because:

1) Ability to generate detail task data from study information and the ability to edit tasks via screens and menus with SAS/AF® software and SAS/FSP® software.

2) Availability of a CPM procedure (Critical Path Method) in the SAS/OR software.

3) Capability to produce customized reports.

In short, SAS® software provided us the flexibility to produce a comprehensive scheduling system in a short time. The users did not require SAS software training and since the application was menu-driven, training was reduced.

The CPM procedure within SAS/OR software is very powerful and flexible. In this application we have many studies which will not begin to a future date, many which must conclude before a future date and some studies which are on hold. Resources considered are three manpower skill levels, four types of equipment and floor space. All of the resource availabilities change over time because of vacations and machine breakdowns. We have three teams at the plant and a holiday schedule. PROC CPM can schedule the task requirements, the resources requirements and we have complete control of which type and at what level of output is required.

As an added feature, we allow the user to archive completed studies for further data analysis. This gives the user the opportunity to report on the historical manpower and resources consumed over time. This option has been valuable through its use in justifying additional manpower and capital needs, evaluating workload patterns and measuring on-time performance.

The entire system has been in use for over two years on a day-to-day basis. It gives the user control over study completion dates and the ability to realign resources for crunch periods.

Production Planning

ICI Films manufactures MELINEX® polyester film in its plant in Hopewell, Virginia. The MELINEX product range is made up of more than 150 grades of film with a wide variety of optical, physical and surface characteristics available in an infinite combination of thickness, width and length.

Many times the manufacturing plant needs to evaluate changes affecting the production process and profitability which include:

1) Changes in forecasted sales volume and price.

2) Changes in production and efficiency rates for individual products on different manufacturing lines.

3) Changes in raw material costs.

4) Changes in manufacturing line availabilities allowing for preventive maintenance and new product development trials.

5) Changes in assignment of products to a manufacturing line.
6) Determine which products are less productive when
the plant is at full capacity.

In addition to doing case studies, long-range production plans are
also prepared by the plant.

To help in this analysis, a Linear Programming model was written
to model the process. Items which make the model formulation
more sophisticated than the textbook production planning LP are:

1) Recycle of raw material.

2) Multiple product grades produced simultaneously on
one line.

The model is completely data driven, meaning that the size of the
LP is controlled by the product detail entered by the user. Typically,
the LP is extremely dense with 1300 constraints and over
2000 variables. PROC LP of SAS/OR software is used to solve
this problem. The procedure solves this problem very quickly and
creates output data sets which are easy to use for customized re­
porting. PROC Tabulate is a great companion procedure for
PROC LP in reporting results at various levels of detail.

Formulating an LP is no problem with the string manipulation ca-
pabilities available in the SAS software data step. The SPAR­
SEDATA format is used with PROC LP. This model has improved
line loading assignments, manufacturing efficiency and the ability
to produce accurate and timely studies.

SAS/OR was chosen for this application because:

1) Most of the input data requirements already resided in
other SAS software applications.

2) The SAS software provided easy to use data manipu­
ation and report generation capabilities.

3) The LP procedure within SAS/OR software solved the problem in a quick and robust fashion.

As an extension to this model there was the requirement to pro­
duce a twelve-month plan on a monthly basis. This added
the requirements that we needed to model the multi-time period
aspects of production and also consider inventories and world­
wide sourcing of products. Again, SAS/OR software was chosen
as the tool to use. Solutions obtained are used as starting points in
developing the longer range plans. For this application the LP
grew to over 2000 constraints and 4000 variables. Solutions using
PROC LP were obtainable, but CPU times on an IBM 3094 were
above nine minutes. To provide solutions in an interactive ses­
sion, we reformulated the production planning LP into a minimum
cost network flow formulation with side constraints. The network
formulation turns out to be very straightforward and easily under­
stood by the users. Solution times using PROC TNETFLOW (or
NETFLOW in Version 6) were reduced to two minutes. Typically,
the number of nodes = 1900, the number of arcs = 3800 and the
number of side constraints = 950.

An added benefit of using PROC NETFLOW is that the node and
arc names can be 40 byte character strings. This allows for very
easy data reporting based on well formulated node and arc
names. Again, PROC Tabulate is a good companion procedure
for reporting the results at various levels.

One positive feature of SAS/OR software is that it is completely in­
tegrated into the SAS software. Once we decided to switch from
PROC LP to PROC NETFLOW, it required very little effort since
the data was already available within the SAS software environ­
ment. Because of this flexibility and the robustness and efficiency
of PROC NETFLOW and PROC LP, SAS/OR software turned out
to be a good choice for these applications.

Core Cutting

The polyester film produced by ICI Films is delivered to the cus­
tomer on various diameter cores. The cores can be purchased in
various lengths. Once the cores are in-house, we cut them to
meet each film order's width requirement. To lessen the trim waste
associated with this cutting stock problem, we built a model to de­
terminethe "best" cutting patterns.

SAS/OR software was chosen as the tool because:

1) We did not know exactly which solution technique
would be the best to use and SAS software would be
flexible in testing different methods.

2) SAS/AF software and SAS/FSP software would pro­
vide easy to use interface for the users.

3) Ease of access to an external data base.

Initially, we used a mixed integer linear programming (MIP) for­
umlation. Data preparation was made possible with a complex pat­
tern generator built in a SAS software Data step. We used PROC
LP available in SAS/OR software to solve the problem. In order to
reduce solution times, we did not solve the MIP initially, but solved
an LP where the variables were not required to be integer. This
solution was scanned for the "best" candidate patterns and, the
problem size reduced and then solved again with PROC LP with
the integer variables included.

Because of more complicated rules concerning core cutting, we
developed a heuristic procedure within a SAS software Data Step
to solve the problem. The implemented program reduces trim
waste, reduces parent core inventory and reduces labor involved
in cutting the cores.

SAS software and SAS/OR software proved to be the right choice
of software because of their flexibility and ease-to-use.

Conclusion

We have been able to solve several business problems using SAS/
OR software as a tool. SAS/OR software is a complete tool for
solving problems because it is integrated with Base SAS software,
SAS/FSP software, and SAS/AF software. The procedures within
SAS/OR software are very powerful, flexible and comprehensive.
In addition, the programs are portable between mainframe com­
puters and personal computers. In conclusion, SAS/OR software
has provided us the tools to successfully implement solution tech­
niques to several real-world business problems.

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