Proceedings of the 1999 Winter Simulation Conference
P. A. Farrington, H. B. Nembhard, D. T. Sturrock, and G. W. Evans, eds.

CSCAT: THE COMPAQ SUPPLY CHAIN ANALYSIS TOOL

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ABSTRACT

In today's business environment, the dynamics of the business drive many decisions in the supply chain. Companies will buffer inventory, carry excess capacity and headcount, and have costly marketing initiatives in order to handle the dynamics of the business. In order to better analyze the business dynamics and define supply chains that are robust to changes in the business environment, Compaq has developed an internal package, called the Compaq Supply Chain Analysis Tool (CSCAT). CSCAT is an ARENA® discrete-event simulation that allows for the easy configuration of a supply chain and the analysis of the dynamics of a supply chain. CSCAT has been used in Compaq to address strategic supply chain issues and certain product-specific supply chain issues. This paper gives an overview of CSCAT.

1 INTRODUCTION

In an earlier paper, (Ingalls 1998) the first author gave an overview of the value of discrete-event simulation in modeling supply chains. The paper address several key business issues and compared the use of mathematical optimization and discrete-event simulation for analyzing supply chains. That paper concluded that optimization and discrete-event simulation both have their place in analyzing supply chains, but simulation shows its strength when the supply chain is very dynamic and has transient performance problems. Optimization simply cannot handle the complex variance problems in a supply chain. If those variance issues are pervasive, then simulation is the better tool to analyze supply chain performance. Because variance issues are critical at Compaq, we decided to use simulation as a primary way to analyze supply chains.

The paper also stated that simulating a supply can be very complex because a model must mimic several key business processes. These processes include the basic MRP process, planning and scheduling, capital acquisition, labor policies, allocation of constrained resources, etc. To model each of these business processes, the simulation becomes quite complex. However, to ignore any of these business processes leaves the simulation ignoring critical business functions that effect performance. CSCAT takes into account all of these business processes in its model.

The paper also stated that a supply chain simulation should be able to show ways to increase revenues, profitability, and service levels to the customer. The reason is that the financial and service level metrics translate into large financial advantages to the company. A model that does not take into account the financial performance of the corporation simply does not address the driving force of decision making in the company. CSCAT addresses this by automatically calculating a full profit and loss statement and return on invested capital analysis.

Combining modeling experience with operational and financial experience, CSCAT incorporates all of the important modeling needs for a complete supply chain analysis.

2 WHAT QUESTIONS ARE WE TRYING TO ANSWER?

In any analysis, one must understand the questions that are trying to be answered. Although it is certainly admirable to say that any tool will address all supply chain issues, that is simply impossible. So, for CSCAT, we decided to address the primary business issues for managing a supply chain. The questions that CSCAT primarily addresses includes:

1. What is the profitability of the corporation (or a product in the corporation) for a given supply chain configuration?
2. What are the service levels to the (end) customer for a given supply chain configuration?

Now both of these can be broken out into many subcategories, including:

1. What is the profitability of the corporation (or a product in the corporation) for a given supply chain configuration?
1.1 What are the profits for each of the products sold to the customer?
1.2 Are these profits predictable?
1.3 What are the primary costs that are accumulated through the supply chain?
1.4 What are the revenues for the corporation in the supply chain?
1.5 What tax advantages are we taking advantage of throughout the supply chain?
2. What are the service levels to the (end) customer for a given supply chain configuration?
2.1 What are the service levels to each customer throughout the supply chain?
2.2 What constraints (material, transportation, capacity) are causing service levels to be less than 100%?

These questions are just a few of those that can be answered. CSCAT collects a wide range of data that can be analyzed for a variety of performance and financial purposes.

3 THE DYNAMICS THAT COUNT

When looking at a supply chain problem, we can easily see how the dynamics of the supply chain can effect the performance. The real question is "What dynamics are critical to supply chain performance?" Again, referencing the author's paper from the 1998 Winter Simulation Conference, the most critical factor in supply chain performance "is 'demand variance' or 'forecast error'. Due to my experience at Compaq, I have become convinced that no one variable effects the movement of material through a supply chain like the demand forecast." (Ingalls 1998) If demand were easily predictable, there would be no need for inventory buffers, material expediting, labor variance, under-utilized capital equipment, or any of the other inefficiencies that cost corporations money. All of the corporate supply chain operations could be optimally planned (mathematically) and deployed. It would be a wonderful world. However, changing demand forecasts and the inability to get the customer to buy exactly what we forecasted are stark realities and must be addressed by creating robust supply chains. These supply chains must be able to react to unexpected changes and poor forecasts.

Although CSCAT has the capability to model other types of dynamic information, we have found that modeling the demand forecast changes over time is by far the most critical random component. The impact of other types of randomness in the chain is small compared to modeling the change in the forecast over time.

4 THE MODEL STRUCTURE

A CSCAT model is defined with 8 different structures. The structures are:

1. Customer - Defines a customer who demands product from the chain.
2. Company - Defines all the companies in the supply chain analysis.
3. Inventory - Defines an inventory site for products in the chain.
4. Manufacturing - Defines a manufacturing site where products are produced in the chain. Includes raw material warehousing.
5. Geo - Defines a sales component where revenue and costs are accounted for. Geos also have service and retail outlets.
6. Product Divisions - Defines the Product Divisions used in the model.
7. Products - Defines the products produced or sold in the chain, including BOM products required as raw material.
8. Capital - Defines the capital required to produce products at all manufacturing sites.
9. Countries - Defines the countries where facilities are located.

In addition, there are two additional structures that are used in the simulation. They are:

1. Animate - Defines animation displays or "score boards" for components in the chain (e.g., profits and loss information).
2. Simulate - Defines simulation control parameters for model runs.

With these structures, a supply chain can be defined and a simulation can be generated. An example of a supply chain created with these structures (or modules) is shown in Figure 1.

5 THE CRITICAL INPUTS AND OUTPUTS

Although CSCAT has some 59 tables that are used for input data and 112 output tables, there are some inputs that are critical for the initial design of the simulation and some outputs that are critical for the evaluation of a scenario.

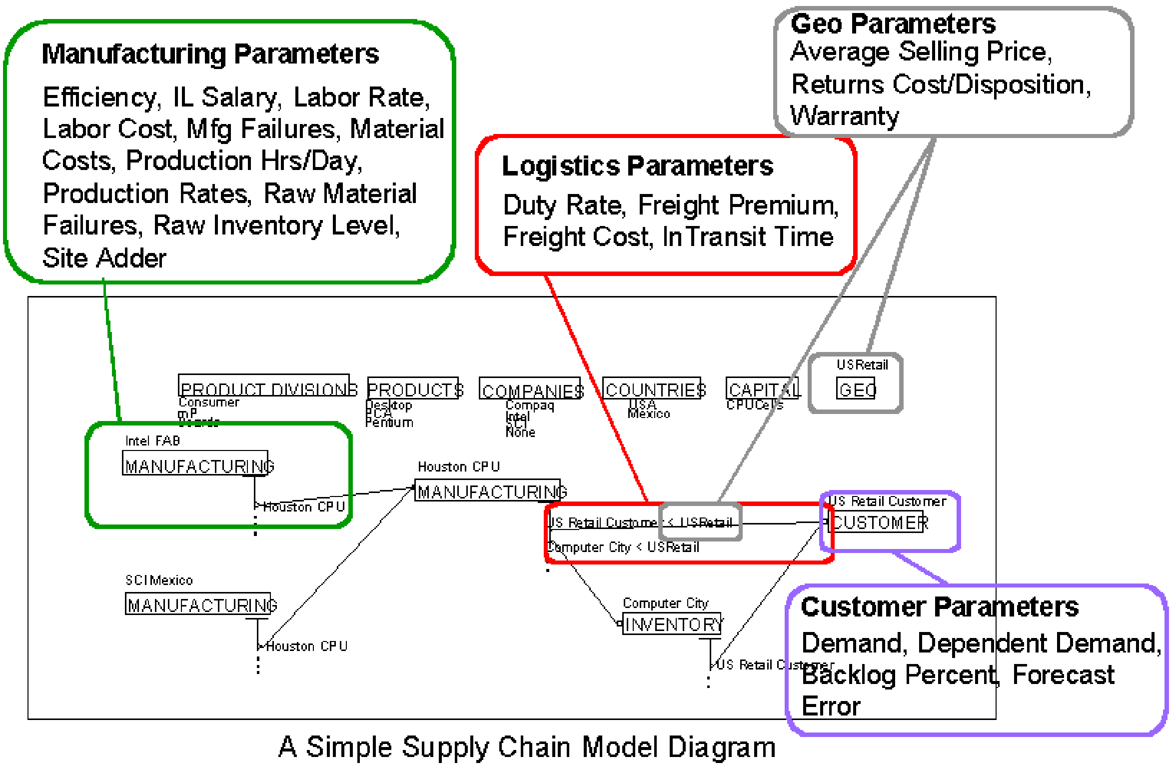

Figure 1: A CSCAT Example

5.1 Critical Inputs

On the input side, there are several tables that are absolutely necessary to run a model. The input tables that are critical include Bill Of Material, Deployment, Forecast Error, Data Collection Dates, In-Transit Days, Inventory Level, Demand, Production Cycle Time, and Simulation Parameters.

These tables can be lumped into 4 groups. The first group is those tables which define the demand process in the model. The two tables that define the demand process are Demand and Forecast Error. The Demand table shows the initial demand for each product at each customer and forecast error profile for each product at each customer. These two files combine to manage the demand forecast over time.

The second group of files gives structural information to the model. This group includes the Bill Of Material and the Deployment files. The Deployment files gives the sourcing information for each site for each of their incoming products. For example, a customer gets his desktop computer from two sources, Computer City and Fred's Computer Warehouse. The deployment data tells the model what percentage of the customer's business is given to Computer City and what percentage of the customer's business is given to Fred's over time.

The third group of files defines the timing of the supply chain. These files include In-Transit Days, Inventory Level, and Production Cycle Time. These three files are necessary because the chain cannot be properly defined without these timing files.

The last group of files that are necessary are simulation definition files. The two files that are needed for simulation definition are the Data Collection Dates file and the Simulation Parameters file. The Data Collection Dates file simply tells the simulation when to collect data. The Simulation Parameters file gives the starting and ending dates of the simulation and some other key simulation data.

5.2 Critical Outputs

In order to answer the key questions listed in section 2, there are 112 output files for analysis of financial and supply chain performance. On the question of profitability, CSCAT looks at revenue, costs, taxes, tax credits, profit before tax and profit after tax at many different levels. On the service level side, CSCAT gives service level statistics, capacity utilization statistics, inventory level statistics, and others.

What we have found in our use of the model is that there are a few key financial metrics. The first (and hopefully most obvious) is profit after tax for the corporation. We certainly want a supply chain that can deliver a good average profit and also some profit regardless of what happens in the market. This is our primary metric.

Another financial metric that is used often is obsolescence. Obsolescence is simply the material that cannot be used after a project is complete and it can be held in raw material or finished goods. In the model, the obsolescence is the material that the corporation has liability for after when the simulation comes to an end.

A third critical output of the model is service level. This includes service level to the customer and service level to any distributors that buys product from us. The service level in CSCAT is a simple calculation and is based on a simple idea: if the customer gets what he wants on the day he asks for it, then the customer's service requirements have been met. If not, then the customer is unhappy. These statistics are accumulated over time for every customer/supplier relationship in the model.

6 IMPLEMENTATION IN ARENA

The CSCAT tool consists of custom designed simulation modules that represent portions of Compaq's supply chain. These modules were defined in section 4 above. These modules are classified into two main groups: data modules and site modules. The site modules represent a component or link in the supply chain. There are three site modules, Manufacturing, Inventory and Customer. To define the structure of a supply chain, the user graphically places and connects these site modules in an Arena model window. This mimics the physical structure and flow of the product in the chain. Site modules may be used in a model multiple.

The data modules that are also placed in the model window define the objects referenced in the structure of the chain. Examples of these modules are Countries, Product Divisions, and Capital. These modules define the objects referenced in the structure of the chain.

All of the modules were custom developed by Compaq and Systems Modeling with the Arena Professional Edition software. These modules automatically create the logic that is executed when running the simulation.

The data that drives the supply chain (e.g. production rates, costs, failure rates, etc.) is defined in multiple sheets of an Excel workbook. The workbook has a pre-defined structure to speed the input of data into the model. At the beginning of the simulation run, this data is transferred into the appropriate simulation variables using VBA. For subsequent replications the data is read in from .CSV files that were created at the beginning of the run, again to increase the speed of execution.

7 SOME KEY ANSWERS

As we discussed above, the primary answers from the model have been Net Profit After Tax (NPAT), Obsolescence, and Service Level. In Figures 2-5, we show outputs that give those key statistics. In Figure 2, we give the interpretation of the graph. For each scenario, the vertical bar represents the range of outputs from (in this case) 30 iterations of the model. This gives the decision maker a feel for the risk of the scenario. This is critical in decision making. Often, the key factor is not optimizing profit as much as it is to decrease the downside risk while maintaining healthy profit. The dot near the middle of the bar is the average answer for that scenario. The two horizontal lines on each bar represent the 95% confidence interval for the scenario. This type of graph is important for the decision maker to understand the overall benefits and risks of each scenario.

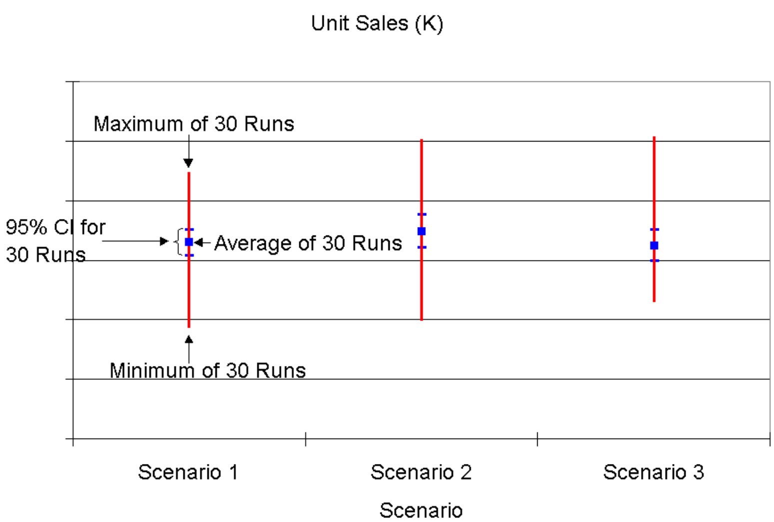

Figure 2: Units Sales Output

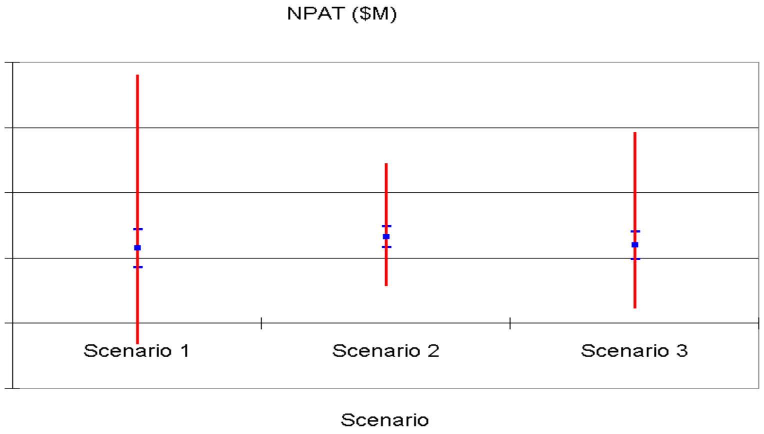

Figure 3: Net Profit After Tax Output

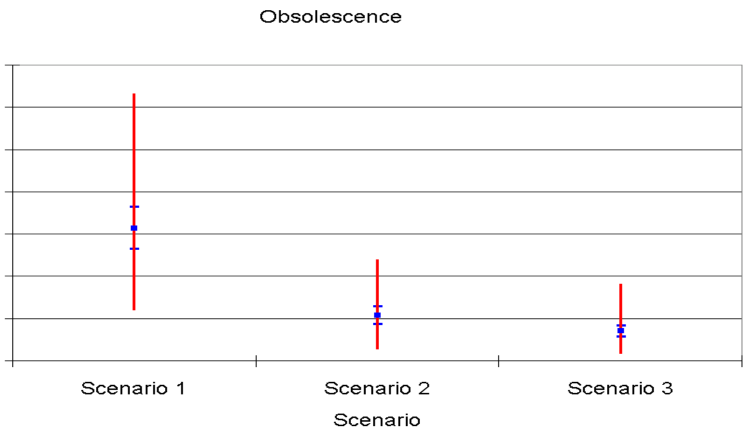

Figure 4: Obsolescence Output

Figure 5: Customer Service Level Output

8 CONCLUSION

CSCAT represents a fundamental change in how to analyze a supply chain. With its implementation in the ARENA simulation environment, it is now possible to quickly model very complex and rapidly changing supply chains. Its ongoing use and development is part of Compaq's overall analysis and improvement of its supply chain.

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