Interfaces
Vol. 34, No. 2, March–April 2004, pp. 87–96
ISSN 0092-2102 | EISSN 1526-551X | 04 | 3402 | 0087
informs®
DOI 10.1287/inte.1030.0065

Simulation Helps Maxager Shorten Its Sales Cycle

Srinagesh Gavirneni
Operations and Decision Technologies, Kelley School of Business, Indiana University, Bloomington, Indiana 47405, sgavirne@indiana.edu

Douglas J. Morrice
McCombs School of Business, University of Texas at Austin, Austin, Texas 78712, morrice@mail.utexas.edu

Peter Mullarkey
NetQoS, Inc., 6504 Bridge Point Parkway, Suite 501, Austin, Texas 78730, peter.mullarkey@netqos.com

We developed a simulation approach to reduce the time and cost of selling the Maxager system, a manufacturing decision-support system consisting of both hardware and software. To enable customers to understand the impact Maxager could have on their profitability, we used to perform pilot studies in which we installed our hardware, trained their people, collected data, and performed the analysis. These pilot studies lasted for three to six months and cost hundreds of thousands of dollars. To save time and money, we simulated Maxager's data-collection systems and used the Maxager software to analyze the data. This enabled us, with some aggregate information provided by the prospective customers, to illustrate the impact Maxager could have on their systems using simulated data of their products, processes, and operating procedures without having to install our hardware. As a result, (1) we reduced sales cycles from over 12 months long to less than six months long, and (2) we reduced the cost of a sales cycle by approximately $50,000 to $100,000. We achieved these results without a drop in the success rate of the sales process.

Key words: simulation: applications; decision analysis: systems.
History: This paper was refereed.

Maxager is the leading business-to-business software solution that enables manufacturers to sell their capacity profitably. Using real-time data collected by Maxager data stations (MDS), we provide manufacturers with up-to-date pictures of their manufacturing processes. The Maxager analysis emphasizes profit flows through the system in contrast to the traditional analysis that uses material flows. Maxager computes the realized profit of the system and compares it to the maximum realizable profit (also called the total available profit (TAP)). In addition, it computes profit velocity (potential profit per minute from using all resources to make a single product) for each product. Customers can use the resulting ranking of products to identify the product mix that would yield the greatest profit. This analysis is most useful to customers whose manufacturing environments contain a single, easily identifiable strategic control point (SCP), which is often the busiest machine on the shop floor. In April 1999 when this project was initiated, the Maxager product and the associated sales effort were directed towards such customers.

We use simulation to reduce the cost and time of the sales process. Simulation has long been a popular tool for analyzing manufacturing systems, especially those that include many processes, multiple products, long setup times, complicated routings, and randomness in capacities, processing times, lead times, and yield. Here we use simulation in a different capacity, to illustrate how our data-collection processes would operate on a manufacturing floor. Using simulations we can quickly show customers the types of data Maxager would collect from their manufacturing systems. We use the Maxager software to analyze the data we collect from a simulation and present the results to the prospective client. This process helps prospective clients to understand the benefits they could obtain with Maxager because the data is collected from simulations of their products, processes, and operating conditions.

We found that presenting the results in this manner (using simulations of prospects' manufacturing operations) tended to influence prospective customers more than presenting results based on Maxager implementations for current customers, even when those customers were in the same industry. While the results from simulations are not as accurate as results based on data collected by MDS on the shop floor, the savings in time and money were large enough to cause us to consider using simulation in place of pilot studies. We quickly realized that if the prospective customers provided accurate aggregate information, the results from the simulations and subsequent analyses also tended to be accurate, and the customers were very receptive to this strategy. This allowed us the luxury to start charging for pilot studies, in effect enabling customers to make purchasing decisions sooner. We reduced the money spent on our sales process by at least 50 percent and the length of a typical sales cycle by more than 75 percent. We achieved all of this without significantly affecting the success rate of our sales process.

We used simulation to support the sales cycle at Maxager. However, the potential benefits are much larger because many decision-support software companies face the same problem. In many multibillion dollar industries, such as enterprise resource planning, customer-relationship management, and supply-chain management, presales analysis is quite common. In our experience as practitioners and academics, however, most companies use little more than spreadsheet technology to support these sales processes. In addition, we could find no published examples of this application of simulation. We found few related examples in telecommunications network design (Damm et al. 1999), bid preparation for custom-made products (Cassaigne et al. 1997, Kromker et al. 1997), and residential home sales (Bady 1993).

The Maxager System

At Maxager, we believe that to truly maximize profitability, the company must do more than review profits at the end of the reporting period. It needs an accurate profit benchmark against which to measure success and continuous feedback on the factors that determine profit performance. The Maxager system meets both of these requirements, typically in three main steps.

Identifying the Strategic Control Point (SCP)

To quantify a plant's profitability, one must first recognize that most plants have a bottleneck operation. This bottleneck, or constraint, stems the flow of both products and profits. Any changes in productivity (throughput) at the bottleneck, such as higher utilization of equipment or slower cycle times, affect profitability more dramatically than changes at nonbottleneck operations. More important, the constraint, or control point, also gates the velocity of profit the plant is achieving and its profit-making potential. Any downtime at this point is time in which the organization could have been making money. Any increase in throughput at the bottleneck, such as faster unit cycle time, would increase profit flow and raise TAP. Once we identify this constraining operation, we label the machines at this processing step SCPs and control our future collection and analysis of data around them.

Data Collection

We use the MDS to collect data. They are specially configured high-end personal computers with Windows NT operating systems that use touch screens and bar-code scanners to limit data entry's intrusion (in time and physical space) on the manufacturing process. In addition, machine operators need little training to use the user-friendly graphical interface. Using these data-collection stations, we track the flow of material through the SCP and collect statistics on cycle time, downtime, idle time, scrap, and product mix. We transfer these data to Oracle databases, usually at night, via the available network connections.

Analysis and Decision Support

Maxager software obtains and analyzes the data from these databases and produces the necessary reports, usually at night on very fast computers so that the analysts have the reports the next morning. Maxager tracks seven factors that affect a plant's profitability: cycle time, utilization, yield, price, product mix, raw-material cost, and overhead. These factors interact dynamically to determine a plant's actual profit and its TAP. By summarizing operational and cost data in real time (it can produce more than 160 detailed reports), Maxager reduces the time managers take to make decisions that improve the bottom line. Here, we highlight two reports, the hidden profit analysis chart and the profit velocity bubble chart.

The hidden profit analysis chart shows the profit that the company could capture but is not capturing. These unrealized profits are called hidden profits. Maxager's TAP benchmark (the sum of realized and hidden profits) is the plant's profit-making potential. Once calculated, TAP provides an objective and quantifiable goal against which managers and shop-floor workers alike can measure results. Maxager then details the components of TAP, such as idle time and yield loss, so that managers can evaluate specific priorities and take action. By capturing all instances of hidden profit, Maxager can produce production reports that prioritize problems by profit impact. These production reports that specify hidden profits in dollar amounts help managers to focus on the issues that most affect profits.

The other highly useful report that Maxager provides is the profit-velocity bubble chart (Figure 1), which compares the profit velocity of each product to its standard profit. Each point or bubble represents a specific product. Standard profit per unit is plotted on the vertical axis while the horizontal axis shows how fast each product contributes cash. Standard profit-per-unit figures show a narrow range in profitability for most products, but Maxager's figures show an enormous range over which products generate cash.

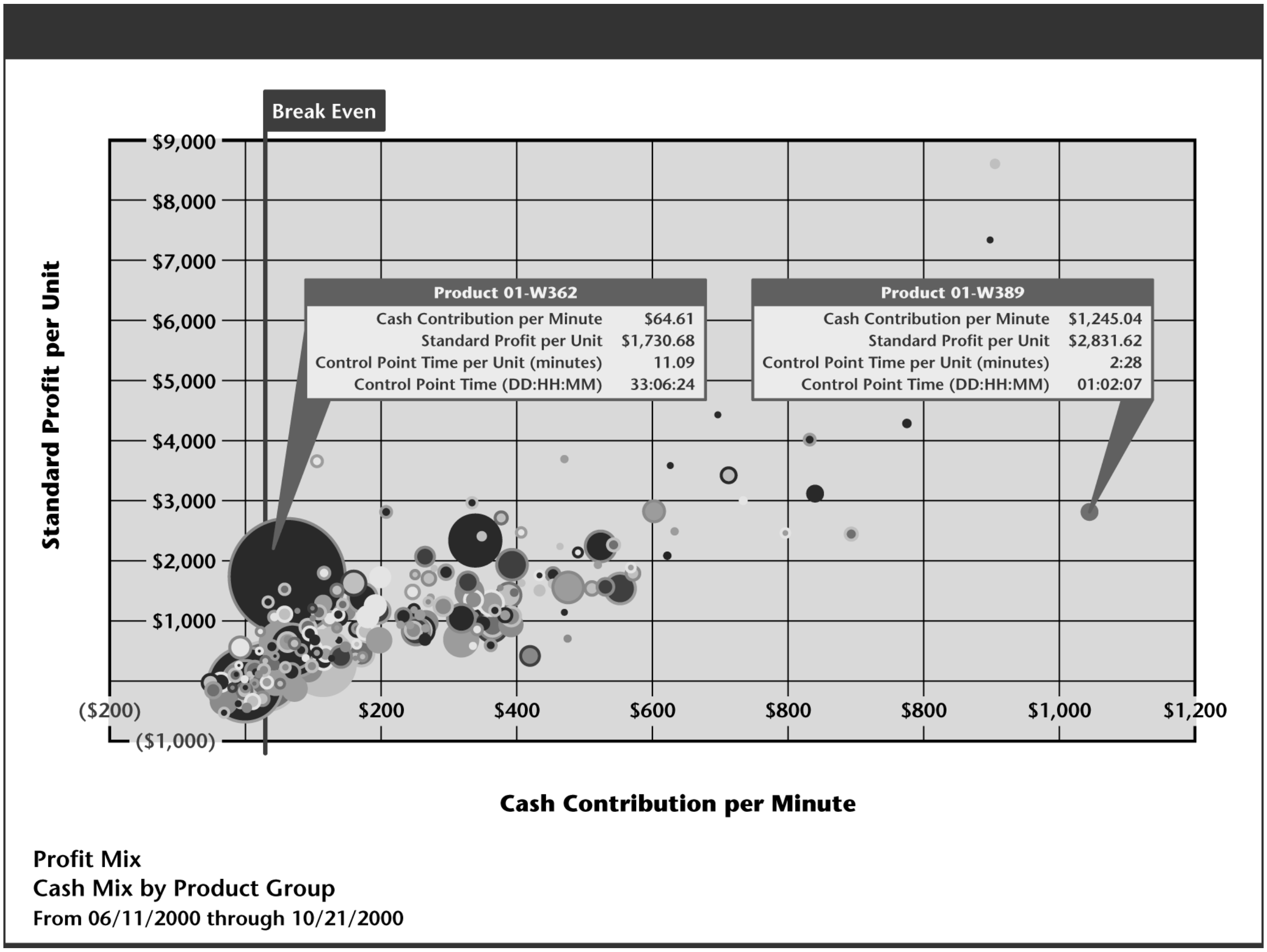

Figure 1: This is a representative bubble chart generated using Maxager. It compares the profit velocity (plotted on the horizontal axis) of each product to its standard profit (shown on the vertical axis). In this example, standard profit per unit numbers shows a narrow range in profitability for most products, but Maxager's figures show an enormous range over which products generate profit. When a user selects a bubble, the software posts all the product's details on the chart. The boxes give the details of two bubbles. For the product on the right, the standard profit per unit is only 70 percent more than the standard profit per unit of the product on the left (2,831.62 versus 1,730.68); whereas Maxager's profit-velocity-based analysis indicates that the product on the right is about 20 times as profitable as the product on the left (1,245.04 versus 64.61).

When a user selects a bubble, the software posts all its details on the chart. Thus, Maxager focuses on cash contribution per minute, the fundamental driver of earnings per quarter and return on assets. With this measurement, managers throughout the entire enterprise can align their daily decisions with corporate profitability goals.

The Traditional Sales Cycle

A sales attempt usually begins with a visit to the manufacturer by the Maxager regional sales manager. The manager generally schedules such visits after Maxager has some initial contact with the prospective client at a conference or trade show or has made marketing mailings or telephone calls. When the initial sales visit is a success, a Maxager executive (the CEO or a VP) gives a 20 to 30 minute high-impact presentation to the manufacturer's C-level (chief executive officer, operating officer, information officer, or financial officer) executives. This meeting is intended to create a relationship between the companies at a high level, and it informs the manufacturer about the Maxager Company, its philosophy, its people, and its products. In its previous sales approach, Maxager followed this meeting with a detailed presentation about the Maxager system, data collection, report generation, and decision support to the manufacturing, marketing, and financial managers of the prospective client. For this presentation, we generally relied on results from implementing Maxager at other companies (with their permission and disguised data). We tried to use data from a similar manufacturing environment and, if possible, from the same industry. Often, these presentations showed that Maxager improved those clients' operations, but they did not make the effects Maxager could have on the prospect's system obvious. The data and the analysis did not concern the prospect's products, processes, or operating procedures. To overcome this problem, we frequently offered to perform no-cost pilot studies at the prospective clients' plants. If they agreed to these free pilot studies, we installed our data stations and the necessary networking, trained their employees in the use of these stations, and collected data over a three-to-six-month period. We then analyzed the data, produced reports, and presented them to the prospective customers. Using these reports, we could show prospects the decision support the Maxager system would provide. Customers who wanted this kind of support signed multiyear contracts for the Maxager system.

The costs (for hardware, people, and customization) for such pilot studies tended to run into hundreds of thousands of dollars. And we had spent all this time and money without the customers committing a single penny. When customers did not buy the Maxager system, these investments produced no return. When Maxager was a small company looking for its first few customers, it had to offer free pilot studies to market its new product. As Maxager grew and its sales team spanned the whole world and it acquired a steady stream of prospective clients, it needed to reevaluate the free pilot studies. A number of happy customers were willing to provide references. We no longer thought we needed real-time data collection from the prospective clients' manufacturing operations to persuade them of Maxager's value for their manufacturing decisions. At the same time, after a few attempts to base presentations on other plants making similar products and using similar processes, we realized they were not effective. To balance these two issues, we decided to simulate each prospective client's manufacturing process and the associated Maxager data collection.

The Simulation Approach

Simulation has long been a popular tool for analyzing systems that are analytically intractable. Because manufacturing systems tend to be very difficult to model and solve mathematically, simulation is especially useful for decision support in manufacturing (Law and Kelton 2000). Often, simulation is the only approach available for answering such questions as (1) What effect would increasing capacity at my bottleneck process have? (2) How would changing the product mix affect revenues? and (3) Would investing in improving the yield at a process stage prove beneficial? The large number of commercially available simulation tools for analyzing manufacturing systems shows how important simulation is for such analyses. Some popular tools are Arena (Kelton et al. 1998), Witness, Promodel, and Extend.

First, we had to select a suitable manufacturing simulation package. We chose Extend based mainly on our observations that Extend

(1) Contained all the necessary modules, such as machines, queues, and statistical distributions, and other characteristics necessary for simulating a large variety of manufacturing environments;

(2) Had an extensible modeling language (ModL) and a freely available source code for Extend modeling blocks that would enable us to modify existing modules or add new modules; and

(3) Was much less expensive than comparable products, costing less than a thousand dollars per copy.

Next, we developed new modules (representing MDS) to simulate our data-collection systems and procedures. Using these modules with the standard modules in the Extend software, we could simulate almost any manufacturing environment (Figure 2). We wrote the data collected during the simulation to a file in XML format, and at the end of the simulation run, we transferred these data to an Oracle database using a special program called Integrator. Once we had the data in Oracle, we proceeded with the analysis and produced reports just as if we had collected the data using the real MDS.

Based on the amount of data we obtain from the client, we have three ways of using this methodology.

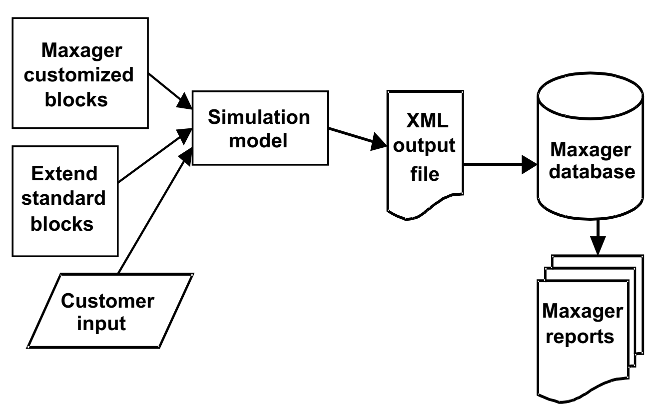

Figure 2: This is the flowchart illustrating our approach using simulation. Using standard Extend blocks and Maxager customized blocks along with the appropriate customer inputs, the simulation generates an output XML file that is read into the Maxager database using a program called the Integrator. Then this data can be analyzed using the Maxager software as if it were collected from a real manufacturing system.

In most situations, we need three to six months of transactional data from the manufacturing floor. Often customers can provide us with (1) aggregate values for the system parameters (for example, batch sizes, setup times, and processing times); (2) transactional data for a much shorter period, say one or two months; or (3) transactional data for a period longer than three to six months. In each of these cases, the way we use this simulation capability is a little different.

When the customer provides aggregate data, we use the aggregate parameters to generate min, max, and most likely values for the triangular distributions (Kelton et al. 1998, p. 140) for each of these parameters. We found that the triangular distribution was the most intuitive for our consultants and our customers. Other practitioners support the use of triangular distributions as well (Law and Kelton 2000, p. 386). We input these distributions into the simulation model, which produces the data for the required time horizon and inputs them into the Maxager database.

When the customer gives us data for a short period of time, we perform a preliminary analysis to compute various statistical measures. Using these statistics, we formulate the appropriate statistical distributions for the various system parameters. For the batch sizes, processing times, and setup time we prefer to use triangular distributions. For the demand-arrival process, we use the exponential distribution as long as it satisfies the assumptions for this process (at least approximately) (Law and Kelton 2000, p. 389). For yield loss, we use the binomial distribution. For the machine downtimes, we use Gamma distributions because theoretical and empirical justification exists for doing so (Law and Kelton 2000, p. 301). We then incorporate these distributions into the simulation model and collect the necessary data.

When the customer provides the three to six months of data we need, we must still incorporate these data into the Maxager database. Often these data are in a proprietary format and not easily input into the database. To ease this transition, we extract the various transactional data (such as processing times for the various batches and batch sizes) and directly use these data to run the simulation. Thus in this case, we do not use the statistical distributions to generate system parameters but rather perform trace-driven simulations (Law and Kelton 2000, p. 285). We can then present the customer with Maxager reports on the actual data it provided. Sometimes to obtain additional insights and to simulate over periods of time longer than the trace data, we extend these trace-driven simulations with real simulations using statistical distributions computed from the data (as we do when we have data covering only one or two months).

To ensure easy and correct use of simulation, we added two features to our system. First, we developed a small set consisting of about 20 simulation modules that Maxager consultants use frequently. Each of these modules may contain a large number of original Extend modules connected using intricate logic. Once we have defined and secured the big module, the analyst generally does not have to change the logic and can use this small number of specialized supermodules to build the necessary simulation models. Some of the supermodules we developed were the following.

The "buffered throughput channel with scrap and downtime" is an enhanced activity center with the ability to model scrap and downtime. By inputting the machine uptime percentage and the mean time to repair (MTTR), the analyst can model the stochastic downtime for the machine. Similarly, by inputting product-specific scrap rates, the analyst can also model stochastic scrap.

The "route by product type and queue" module enables users to easily model product-specific routings based on such information as product type, queue length, and a prioritization scheme.

The "control production based on queues" module allows analysts to use different machine-loading schemes at the throughput channels.

The "write MDS event with downtime" is a block that simulates a MDS writing the appropriate transactional data, based on its purpose and location in the model, to an XML file.

We also developed a dynamic, integrated, real-time, in-line output analysis procedure for controlling the simulations (especially useful when customers do not provide three to six months of data) (Mullarkey et al. 2000). This procedure ensures that the analyst runs the simulation long enough to collect the data necessary to draw statistically valid conclusions. It dynamically changes its parameters (such as statistical batch size for statistical analysis) as the simulation proceeds, prompts the analyst when the statistical conditions have been met, or extends the run length if it is too short. There are two main conditions for stopping the simulation: (1) the statistical batch size is large enough to guarantee independence between the batches and the batch means, and (2) the confidence interval of the parameter of interest is tight enough, that is, the half width of the confidence interval is within a certain prespecified percentage of the mean (the analyst chooses from a drop-down menu to specify five, 10, 15, or 20 percent).

We use the batch-means method (Law and Kelton 2000, p. 528) for computing the confidence interval and, based on Schmeiser (1982), we keep the number of batches fixed at 10. Starting with the value of 10 simulated observations (for example, cycle times for jobs) for statistical batch size (B), we increase B by 10 observations every time we find that the correlation between observations spaced B lags apart in the simulated data series (tested using a student's t-test on the correlation coefficient) or the correlation between batch means (tested using Fishman's 1978 test) is significantly different from zero. We conduct these two tests to guard against correlation and ultimately to improve the coverage of the confidence intervals.

Once we establish the independence between the batches and the batch means, we increase the batch size until the confidence interval width is less than an analyst-chosen (from the drop-down menu) multiple of the mean. Once these two stopping conditions have been met, we stop the simulation run (Figure 3). Mullarkey et al. (2000) give additional details on this procedure. With this procedure, we can ensure that the analysts use this simulation tool properly. In addition, by controlling lengths of simulation runs, we save computational effort.

Verification and Validation

In addition to constantly monitoring that the simulations behaved as modeled, we regularly reviewed the salespeople's results to ensure that the results were in line with their expectations.

For some of the cases in which we had lots of detailed data, we performed the Maxager analysis using the raw data. In addition, we generated the aggregate statistics from the raw data and used them in the simulation model. We then analyzed the results using the Maxager software to make sure the results were not statistically different from the results from the raw data.

Our sales team consisted of people who focused on specific vertical markets, such as steel, rubber, electronics, and paper. They were intimately aware of the customers and their products in the vertical markets to which they were assigned. As we developed simulations in these vertical markets, we made sure that the results were in line with the expectations of the expert in the vertical market. We were especially interested in ensuring that the product ranking we obtained using simulation was close to the one we would have obtained if we had performed a pilot study.

We have included results from these simulations in many sales presentations, and the customers' acceptance provided additional validation for our approach.

Case Study: A Steel Plant

This case study illustrates how Maxager uses the decision-support system in a technical sales process and what benefits it obtains. Although we have disguised the data and omitted some process details to protect the client's confidentiality, the description is representative.

The portion of the steel plant we analyzed manufactures and sells 5,267 products from the cold-roll stage of its manufacturing process. It sells these products to 311 customers. The managers of the steel plant were having difficulty determining the profitability of individual products. They suspected that their large volume products were not yielding large profits and wondered whether they should consider making and

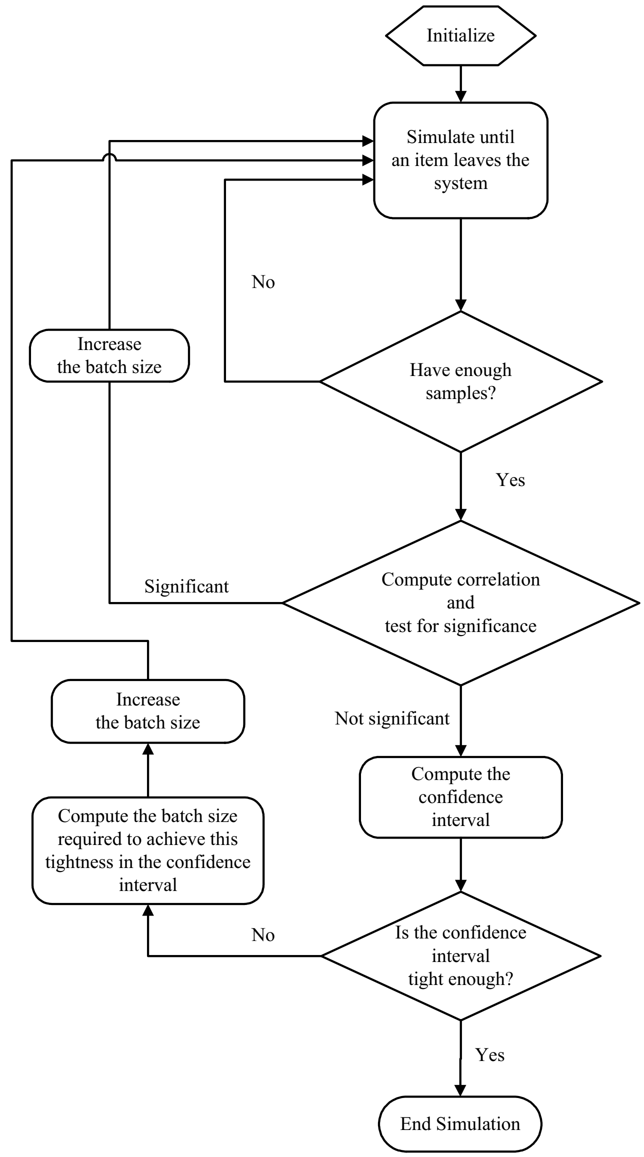

Figure 3: A flow chart showing our approach for integrated dynamic output analysis is shown. The starting size of the statistical batch is 10 and it is increased by 10 until (i) the batches and the batch means are independent; and (ii) the confidence interval is tighter than the level selected by the user.

selling more of their small volume products to realize greater profits.

This steel plant's operations consist of six major process steps: hot mill, pickling, cold rolling, annealing, tempering, and galvanizing. Each step has varying degrees of setup, downtime, and scrap. The steel starts as slabs, which go from the caster to the hot rolling mill. The plant sells some of the output of hot mill directly as hot band. The rest of the coils go into pickling. After pickling, coils go to either galvanizing or cold rolling. After galvanizing, the product is sold as galvanized coils to trade. The coils routed through cold rolling go to either annealing and the temper mill, or to galvanizing. The products sold after the temper mill are cold rolled coils that go to trade. The plant produces quite a few products through various routes. We identified the cold-rolling process step (Figure 4) as the SCP, and we decided to focus on that stage.

Over the past few years, because of the drop in steel prices and stiff competition from smaller, more responsive minimills, the revenue and profits of traditionally major steel mills worldwide have dropped. We therefore had to analyze the company's manufacturing processes in detail to understand the profitability of the various products marketed. Once we identified the profitable products, we could alter the product mixes to make sure that the plants would produce larger quantities of high-profit products and lower quantities of low-profit products. In addition, it might be possible for the firm to change the pricing of its products and realize greater profits.

This manufacturer became aware that Maxager might be able to help it deal with these issues. After we made an initial sales call and presentation to executives, both organizations realized that the company's situation presented a great opportunity for everyone involved. So that we could perform a quick profitability analysis (using simulation), we asked the firm

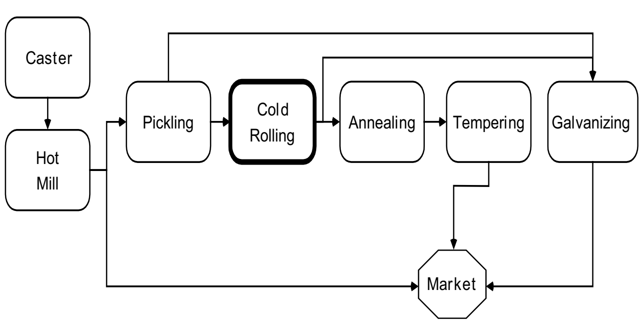

Figure 4: This is the process flow of the simulation developed for a steel plant. This steel plant's operations consist of six major process steps: hot mill, pickling, cold rolling, annealing, tempering, and galvanizing. The cold-rolling process step was identified as the strategic control point, and the simulation and the analysis focused on that stage.

to provide information on its products and processes. It had a lot of transactional data, and it provided us with a month's worth of data for the cold-rolling process step, which included six rolling mills. The data covered over 10,000 coils, representing over 5,000 products destined for over 300 customers. Once we had this transactional information (for example, product mix, processing times, setup times, yield, and downtime), we used our trace-driven simulation approach and developed a simulation model of the plant (Figure 4), collected data from the simulation run, analyzed the gathered data, and presented the results to the managers. We included a profit velocity bubble chart (taken from over 90 analysis charts we developed for the presentation) based on the simulation study (Figure 5).

Because the managers knew the transactional and financial data they had provided were accurate, they realized that our results identified some inefficiencies in their product mix that were hurting profits. To leverage Maxager's analytical power day to day, they chose it to help them maximize their firm's profitability by identifying new ways of increasing efficiencies and cutting costs.

Our analysis encompassed 10 product groups. We were able to draw the following conclusions.

Our analysis showed that the firm would greatly improve the profitability of four of these products (Figure 5). While both the firm's activity-based costing method and the Maxager simulation showed that the firm's automotive products were more profitable than its construction and containment products, the Maxager approach indicated that the firm was grossly underestimating the difference in their performance using its activity-based costing approach.

The steel company managers were under the impression that the containers product group was generating more profit than the converters product group. Our analysis indicated the opposite.

Based on our analysis, the steel manufacturer adjusted its product mix (increasing the volume of converters and automotive products it produced and reducing the volume of containers and construction and containment products) and captured more profits. Maxager's salespeople were confident that we obtained the same insights with the simulation that we would have by performing a pilot study. By using simulation, we demonstrated to the client, at a very low cost, the Maxager system's analytical power.

Testifying to the value of the Maxager decision-support system, an executive vice president of sheet products for the firm said, "It is imperative that we find new ways of increasing profitability in today's market. Maxager helps us shift our product mix towards products with a higher profit per minute so

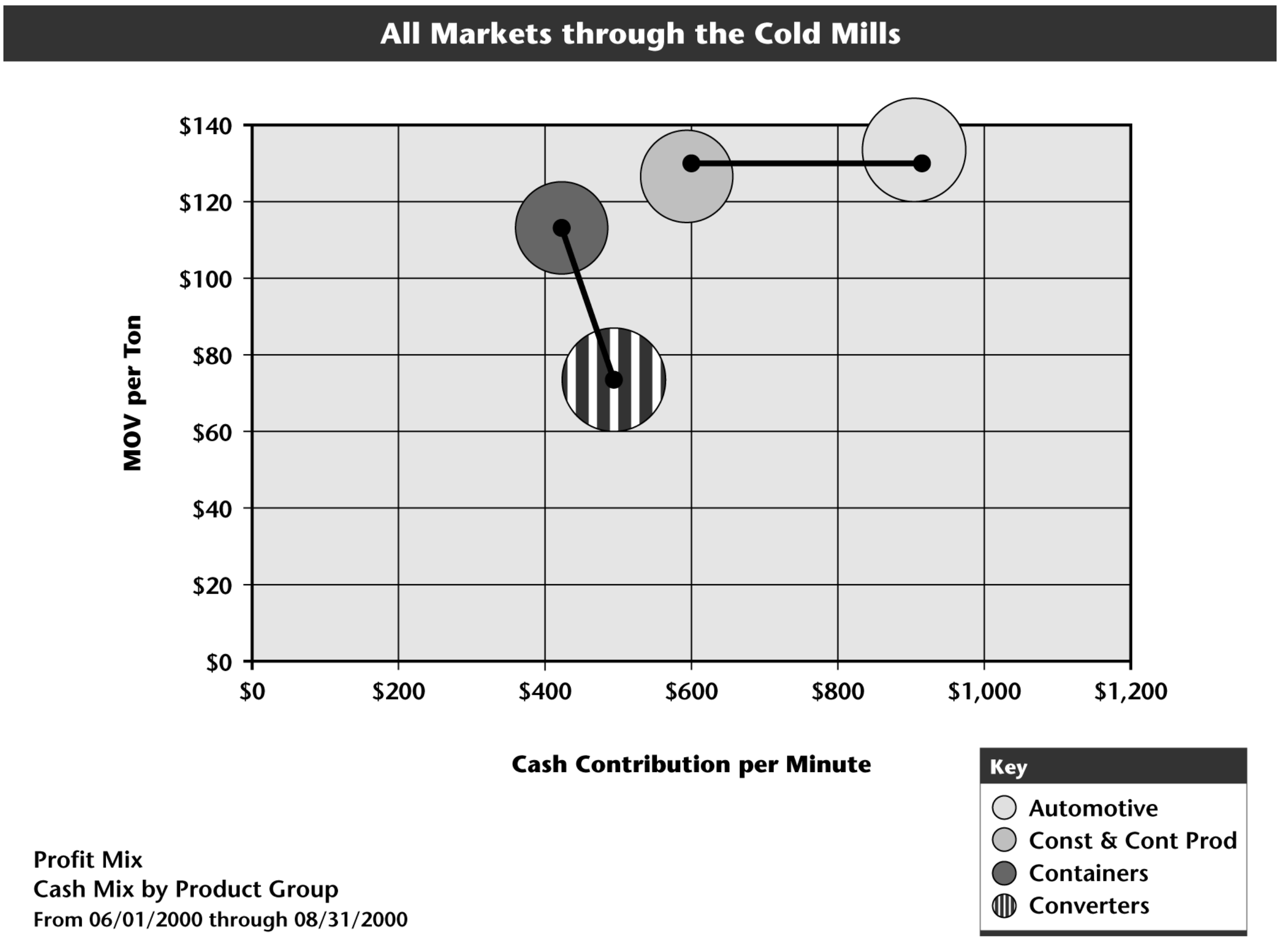

Figure 5: This is a disguised bubble chart from our sales presentation to the steel plant management. The horizontal axis represents the profit velocity while the vertical axis represents the results from the standard costing approach. While both the methods showed that the firm's automotive products were more profitable than its construction and containment products, the Maxager approach indicated that the firm was grossly underestimating their difference. In addition, standard costing approaches gave the impression that the containers product group was generating more profit than the converters product group while the Maxager analysis indicated otherwise.

we can make significant improvements in cash flow and overall profitability."

This simulation-driven sales process took around 12 weeks; the traditional sales process would have taken at least 12 months. In addition, we avoided the costs we would have incurred in a pilot study for presales installation, training, and customization.

We conceived of the idea for a simulation-driven sales-presentation process in April 1999 and implemented it in September 1999. We made our first simulation-driven sales presentation in November 1999, and since then this approach has become an integral part of the Maxager sales process. Now, the sales force uses it in preparing virtually every sales presentation. Between November 1999 and November 2001, we used the approach for around 20 customers in the electronics, steel, paper, and automotive industries. The top managers at Maxager generally concur that the simulation-driven approach has made the sales process faster and less expensive. The sales cycles that used to last around 12 months now last only three months. In addition, the simulation-driven approach has cut costs by hundreds of thousands of dollars. While we have no accurate tabulation of savings, a conservative estimate of the costs of one or two people working for nine months on the 20 sales calls is at least one million dollars.

Project Evolution

Maxager's vice president of product development first proposed this project when he realized that simulation was a powerful technique that should be used to improve the core Maxager product. The firm hired a simulation expert with over five years of experience in April 1999 to explore the possibilities, and he designed and developed the tool kit over the next six months. The expert demonstrated the first working simulation in October 1999 and, after the Maxager managers approved it, introduced it to Maxagers sales and consulting teams. A champion was identified to enable its deployment and continued use in the sales process. Mainly because of his hard work, the simulation approach has succeeded. We did, however, face a number of issues, two of which we discuss below.

Simulation is a flexible, powerful technique, and the Maxager's graphical user interface made it particularly appealing to the customers, consultants, and salespeople. However, Maxager managers worried that the simulation tool kit would attract so much attention that it would distract from the core Maxager message of time-based profitability measurement. This concern was a critical issue that we had to deal with effectively if we were to continue the simulation project. So we made everyone aware that we used simulation only during data collection and still used the core Maxager product to perform the analysis. In addition, we decided that during sales presentations and other meetings we should not emphasize the simulation model and the associated tool kit. We barely mention that we use a simulation to generate the data. This compromise has enabled us to use the simulation tool kit to complement (but not compete with) Maxager's main product.

The second major issue we faced was the need to explain simulation and its behavior to prospective customers who were not familiar with simulation methodology. When we obtained aggregate data from prospective clients to drive the simulation model, because of the randomness inherent in simulation runs, the simulation results often differed from the averages they provided. Sometimes, the prospective clients could not understand this deviation and Maxager's salespeople had to explain simulation and its behavior. Such digressions could distract prospective clients from the main product. To avoid this distraction, salespeople use a trace-driven approach whenever possible, thus eliminating the possibility of the simulation results deviating from the actual behavior. When we do not have enough data or when prospective clients are familiar with stochastic simulation, we embellish the model to include probability distributions. In such cases, we make it very clear that we derive the profitability analysis and the associated sales presentation using simulated data and that they are only representative of the type of results one could expect from Maxager. We caution them not to make any managerial decisions based on these presentations.

In spite of these obstacles, the project has evolved smoothly, largely because of the commitment and support of our top management, mainly the vice president of product development. In addition, the commitment and hard work of the champion in the sales and consulting team has caused salespeople to apply this approach widely and effectively. Without their support, the simulation tool kit would not have been as successful as it has been.

Our main focus in this project was to use simulation to shorten sales cycles. However, we recognized early on that we could leverage the simulation models built during sales cycles to promote long-term relationships with customers. For example, we could use simulation to support sales of other Maxager software packages to existing clients and offer customized simulation services for process improvement. Indeed, after we suggested these opportunities to Maxager management, the firm acted on our suggestions and now includes simulation in its capacity-planning product suite (www.maxager.com).

Conclusion

The classic sales-cycle model consists of prospecting, planning the sales call, making the sales call, strengthening the presentation, responding to objections, obtaining commitment, and building long-term partnerships (Weitz et al. 1995). Our use of simulation directly benefits all phases of the cycle except prospecting and building long-term partnerships. In particular, simulation strengthens salespeople's presentations and responses to objections. With simulation, the salespeople can make dynamic presentations and explore scenarios in real time to build prospective customers' confidence in the Maxager product. In the future, we can extend simulation into the building phase of long-term partnerships; once we build a simulation model, Maxager can reuse it in whole or in part on other projects.

References

Bady, S. 1993. 3-D simulation drives presales at an adult community. *Professional Builder* **59**(8) 21.

Cassaigne, N., M. Kromker, M. G. Singh, S. Wurst. 1997. Decision support for effective bidding in a competitive business environment. *Proc. 1997 IEEE Internat. Conf. Systems, Man, Cybernetics*, Vol. 4. IEEE, New York, 3591–3596.

Damm, G., S. Giorcelli, G. Fouquet. 1999. A simulation environment for dimensioning telecommunications management systems. *Proc. 1999 IEEE Sympos. Appl.-Specific Systems Software Engrg. Tech.* IEEE, New York, 290–293.

Fishman, S. G. 1978. Grouping observations in digital simulation. *Management Sci.* **24**(3) 510–521.

Kelton, W. D., R. P. Sadowski, D. A. Sadowski. 1998. *Simulation with Arena*. McGraw-Hill, New York.

Kromker, M., K.-D. Thoben, A. Kebbel, H. J. Shonert. 1997. An integrated system for simultaneous bid preparation. *Proc. 1997 IEEE Internat. Conf. Systems, Man, Cybernetics*, Vol. 4. IEEE, New York, 3597–3602.

Law, A. M., W. D. Kelton. 2000. *Simulation Modeling and Analysis*, 3rd ed. McGraw-Hill, New York.

Mullarkey, P. W., S. Gavirneni, D. J. Morrice. 2000. Dynamic output analysis for simulations of manufacturing environments. *Proc. 2000 Winter Simulation Conf.*, Orlando, FL.

Schmeiser, B. 1982. Batch size effects in the analysis of simulation output. *Oper. Res.* **30**(3) 556–568.

Weitz, B. A., S. B. Castleberry, J. F. Tanner. 1995. *Selling: Building Partnerships*, 2nd ed. Irwin, Chicago, IL.

Michael Demere, Maxager Technology, Inc., 751 Greeley Drive, Nashville, Tennessee 37205, writes: "Maxager had offered an innovative and unique software solution to manufacturers world-wide for approximately four years prior to Drs. Mullarkey and Gavirneni's involvement. Our solution provides Advanced Profit Analysis decision support to asset intensive manufacturers designed to dramatically improve bottom line profit. Obviously, we found introducing this new category of technology to the marketplace quite challenging. Traditional software and sales marketing methodologies met with predictably minimal advancement. At the same time, clients we were successful in engaging with were noticing significant profit improvements. We faced the obstacle of spreading the message. Potential clients simply could not "vision" their environment from a Maxager perspective. We needed something that would dramatically enhance and reduce our sales cycle.

"Drs. Mullarkey and Gavirneni used their vision, knowledge, and experience to create a simulation model that can apply across most manufacturers. This tool has the sophistication of being able to model many different environments, while being straightforward enough to be populated by individuals without any simulation background. The tool effectively converts simple manufacturing data into a format that can demonstrate Maxager's Profit Velocity perspective. The model is actually used not only in North America, but in Asian environments as well and is an integral part of our sales process today. Drs. Mullarkey and Gavirneni took a complex problem and converted it into a solution that can be commonly applied.

"The amazing result is that our sales cycle was reduced from more than one year to less than six months. Each Profit Analysis engagement resulted in a client that felt that we provided them a view of their business that they had not seen before and was innovatively insightful. We feel that application of their simulation tool is a competitive advantage in the market."