ADDITIONAL CASES

CASE 20.3 PLANNING PLANERS

This was the first time that Carl Schilling had been summoned to meet with the bigwigs in the fancy executive offices upstairs. And he hopes it will be the last time. Carl doesn't like the pressure. He has had enough pressure just dealing with all the problems he has been encountering as the foreman of the planer department on the factory floor. What a nightmare this last month has been!

Fortunately, the meeting had gone better than Carl had feared. The bigwigs actually had been quite nice. They explained that they needed to get Carl's advice on how to deal with a problem that was affecting the entire factory. The origin of the problem is that the planer department has had a difficult time keeping up with its workload. Frequently there are a number of workpieces waiting for a free planer. This waiting has seriously disrupted the production schedule for subsequent operations, thereby greatly increasing the cost of in-process inventory as well as the cost of idle equipment and resulting lost production. They understood that this problem was not Carl's fault. However, they needed to get his ideas on what changes were needed in the planer department to relieve this bottleneck. Imagine that! All these bigwigs with graduate degrees from the fanciest business schools in the country asking advice from a poor working slob like him who had barely made it through high school. He could hardly wait to tell his wife that night.

The meeting had given Carl an opportunity to get two pet peeves off his chest. One peeve is that he has been telling his boss for months that he really needs another planer, but nothing ever gets done about this. His boss just keeps telling him that the planers he already has aren't being used 100 percent of the time, so how can adding even more capacity be justified. Doesn't his boss understand about the big backlogs that build up during busy times?

Then there is the other peeve—all those peaks and valleys of work coming to his department. At times, the work just pours in, and a big backlog builds up. Then there might be a long pause when not much comes in, so the planers stand idle part of the time.

If only those departments that are feeding castings to his department could get their act together and even out the work flow, many of his backlog problems would disappear.

Carl was pleased that the bigwigs were nodding their heads in seeming agreement as he described these problems. They really appeared to understand. And they seemed very sincere in thanking him for his good advice. Maybe something is actually going to get done this time.

Here are the details of the situation that Carl and his "bigwigs" are addressing. The company has two planers for cutting flat smooth surfaces in large castings. The planers currently are being used for two purposes. One is to form the top surface of the *platen* for large hydraulic lifts. The other is to form the mating surface of the final drive *housing* for a large piece of earth-moving equipment. The time required by a planer to perform each job varies somewhat, depending largely upon the number of passes that must be made. In particular, for each platen or housing, the time required has a translated exponential distribution, where the minimum time is 10 minutes and the additional time beyond 10 minutes has an exponential distribution with a mean of 10 minutes. (Recall that a distribution of this type is one of the options in the Queueing Simulator in this chapter's Excel file.)

Castings of both types arrive one at a time to the planer department. For each type, the arrivals occur randomly with a mean rate of 2 per hour.

Based on Carl Schilling's advice, management has asked an OR analyst (you) to analyze the following three proposals for relieving the bottleneck in the planer department:

Proposal 1: Obtain one additional planer. The total incremental cost (including capital recovery cost) is estimated to be $30 per hour. (This estimate takes into account the fact that, even with an additional planer, the total running time for all the planers will remain the same.)

Proposal 2: Eliminate the variability in the interarrival times of the castings, so that the castings would arrive regularly, one every 15 minutes, alternating between platen castings and housing castings. This would require making some changes in the preceding production processes, with an incremental cost of $60 per hour.

Proposal 3: Make a change in the production process that would reduce the variability in the time required by a planer to perform each job. In particular, for either type of casting, the time required now would have an Erlang distribution with a mean of 20 minutes and shape parameter $k = 10$. The incremental cost in this case would be $20 per hour.

These proposals are not mutually exclusive, so any combination can be adopted.

It is estimated that the total cost associated with castings having to wait to be processed (including processing time) is $200 per hour for each platen casting and $100 per hour for each housing casting, provided the waits are not excessive. To avoid excessive waits for either kind of casting, all the castings are processed as soon as possible on a first-come, first-served basis.

Management's objective is to minimize the expected total cost per hour.

Use simulation to evaluate and compare all the alternatives, including the status quo and the various combinations of proposals. Then make your recommendation to management.

CASE 20.4 PRICING UNDER PRESSURE

Elise Sullivan moved to New York City in September to begin her first job as an analyst working in the Client Services Division of FirstBank, a large investment bank providing brokerage services to clients across the United States. The moment she arrived in the Big Apple after graduating with an undergraduate degree in industrial engineering that included a concentration in finance, she hit the ground running—or more appropriately—working. She spent her first six weeks in training, where she met new FirstBank analysts like herself and learned the basics of FirstBank's approach to accounting, cash flow analysis, customer service, and federal regulations.

After completing training, Elise moved into her bullpen on the fortieth floor of the Manhattan FirstBank building to begin work. Her first few assignments have allowed her to learn the ropes by placing her under the direction of senior staff members who delegate specific tasks to her.

Today, she has an opportunity to distinguish herself in her career, however. Her boss, Michael Steadman, has given her an assignment that is under her complete direction and control. A very eccentric, wealthy client and avid investor by the name of Emery Bowlander is interested in purchasing a European call option that provides him with the right to purchase shares of Fellare stock for $44.00 on the first of February—12 weeks from today. Fellare is an aerospace manufacturing company operating in France, and Mr. Bowlander has a strong feeling that the European Space Agency will award Fellare with a contract to build a portion of the International Space Station some time in January. In the event that the European Space Agency awards the contract to Fellare, Mr. Bowlander believes the stock will skyrocket, reflecting investor confidence in the capabilities and growth of the company. If Fellare does not win the contract, however, Mr. Bowlander believes the stock will continue its current slow downward trend. To guard against this latter outcome, Mr. Bowlander does not want to make an outright purchase of Fellare stock now.

Michael has asked Elise to price the option. He expects a figure before the stock market closes so that if Mr. Bowlander decides to purchase the option, the transaction can take place today.

Unfortunately, the investment science course Elise took to complete her undergraduate degree did not cover options theory; it only covered valuation, risk, capital budgeting, and market efficiency. She remembers from her valuation studies that she should discount the value of the option on February 1 by the appropriate interest rate to obtain the value of the option today. Because she is discounting over a 12-week period, the formula she should use to discount the option is [(Value of the option)/$(1 + \text{Weekly interest rate})^{12}$]. As a starting point for her calculations, she decides to use an annual interest rate of 8 percent. But she now needs to decide how to calculate the value of the option on February 1.

(a) Elise knows that on February 1, Mr. Bowlander will take one of two actions: either he will exercise the option to purchase shares of Fellare stock or he will not exercise the option. Mr. Bowlander will exercise the option if the price of Fellare stock on February 1 is above his exercise price of $44.00. In this case, he purchases Fellare stock for $44.00 and then immediately sells it for the market price on February 1. Under this scenario, the value of the option would be the difference between the stock price and the exercise price. Mr. Bowlander will not exercise the option if the price of Fellare stock is below his exercise price of $44.00. In this case, he does nothing, and the value of the option would be $0.

The value of the option is therefore determined by the value of Fellare stock on February 1. Elise knows that the value of the stock on February 1 is uncertain and is therefore represented by a probability distribution of values. Elise recalls from an operations research course in college that she can use simulation to estimate the mean of this distribution of stock values. Before she builds the simulation model, however, she needs to know the price movement of the stock. Elise recalls from a probability and statistics course that the price of a stock can be modeled as following a random walk and either growing or decaying according to a lognormal distribution. Therefore, according to this model, the stock price at the end of the next week is the stock price at the end of the current week multiplied by a growth factor. This growth factor is expressed as the number *e* raised to a power that is equal to a normally distributed random variable. In other words:

$$s_n = e^N s_c,$$

where s_n = the stock price at the end of next week,

s_c = the stock price at the end of the current week,

N = a random variable that has a normal distribution.

To begin her analysis, Elise looks in the newspaper to find that the Fellare stock price for the current week is $42.00. She decides to use this price to begin her 12-week analysis. Thus, the price of the stock at the end of the first week is this current price multiplied by the growth factor. She next estimates the mean and standard deviation of the normally distributed random variable used in the calculation of the growth factor. This random variable determines the degree of change (volatility) of the stock, so Elise decides to use the current annual interest rate and the historical annual volatility of the stock as a basis for estimating the mean and standard deviation.

The current annual interest rate is $r = 8$ percent, and the historical annual volatility of the aerospace stock is 30 percent. But Elise remembers that she is calculating the *weekly* change in stock—*not* the *annual* change. She therefore needs to calculate the weekly interest rate and weekly historical stock volatility to obtain estimates for the mean and standard deviation of the weekly growth factor. To obtain the weekly interest rate *w,* Elise must make the following calculation:

$$w = (1 + r)^{(1/52)} = 1.$$

The historical weekly stock volatility equals the historical annual volatility divided by the square root of 52. She calculates the mean of the normally distributed random variable by subtracting one half of the square of the weekly stock volatility from the weekly interest rate w. In other words:

$$\text{Mean} = w - 0.5(\text{weekly stock volatility})^2.$$

The standard deviation of the normally distributed random variable is simply equal to the weekly stock volatility.

Elise is now ready to build her simulation model.

(1) Describe the components of the system, including how they are assumed to interrelate.
(2) Define the state of the system.
(3) Describe a method for randomly generating the simulated events that occur over time.
(4) Describe a method for changing the state of the system when an event occurs.
(5) Define a procedure for advancing the time on the simulation clock.
(6) Build the simulation model to calculate the value of the option in today's dollars.

(b) Run three separate simulations to estimate the value of the call option and hence the price of the option in today's dollars. For the first simulation, run 100 iterations of the simulation. For the second simulation, run 500 iterations of the simulation. For the third simulation, run 1,000 iterations of the simulation. For each simulation, record the price of the option in today's dollars.

(c) Elise takes her calculations and recommended price to Michael. He is very impressed, but he chuckles and indicates that a simple, closed-form approach exists for calculating the value of an option: the Black-Scholes formula. Michael grabs an investment science book from the shelf above his desk and reveals the very powerful and very complicated Black-Scholes formula:

$$V = N[d_1]P - N[d_2]PV[K]$$

where $d_1 = \dfrac{\ln[P/PV[K]]}{\sigma\sqrt{t}} + \dfrac{\sigma\sqrt{t}}{2}$,

$d_2 = d_1 - \sigma\sqrt{t}$,

$N[x]$ = the Excel function NORMSDIST(x) where $x = d_1$ or $x = d_2$,

P = current price of the stock,

K = exercise price,

$PV[K]$ = present value of exercise price $= \dfrac{K}{(1 + w)^t}$,

t = number of weeks to exercise date,

σ = weekly volatility of stock.

Use the Black-Scholes formula to calculate the value of the call option and hence the price of the option. Compare this value to the value obtained in part (*b*).

(d) In the specific case of Fellare stock, do you think that a random walk as described above completely describes the price movement of the stock? Why or why not?