CASE 39
PIEDMONT AIRLINES: DISCOUNT SEAT ALLOCATION (A)

Marilyn Hoppe smiled as she set aside the most recent edition of the *Piedmonitor*, the company's monthly news magazine. The lead article for April 1985 (see Exhibit 1) had done an excellent job of describing the function of Marilyn's Revenue Enhancement Department, and, in general, she was pleased with it. The article was both accurate and informative, and had stressed the importance of revenue enhancement to the financial success of the company. Because of the article, Marilyn believed that it might now be a little easier to obtain the cooperation of other departments in providing the vast array of data and information needed to successfully carry out the revenue enhancement activities.

The major function of the department was to decide exactly how many discount fare seats were to be sold on each of Piedmont's flights. The financial importance of revenue enhancement meant that Marilyn and her department shouldered a considerable burden of responsibility. Although she had every reason to be pleased with her department's performance, she often wondered whether there might be room for improvement. Piedmont's new information system was as good as most in the industry, and the seven analysts were both knowledgeable and quite good at using the information to allocate discount seats. The nagging problem was that the process still relied quite heavily on the judgments of these seven. Although the analysts were indeed well-informed experts with access to huge amounts of data and information, they were still humans making numerous daily decisions in a manner that was not as "scientific" as the article might suggest.

Discount Seat Allocation

The recent practice in the airline industry was to offer a wide variety of discount fares to passengers who were willing to purchase tickets far in advance of a flight's departure. The number of discount seats was limited, however, in order that the remaining seats could be reserved for full-fare (primarily business) travelers who made plans nearer departure time.

Piedmont scheduled 836 daily departures—almost 30,000 flights a month, for which discount seats had to be allocated. The company had committed over $1 million to Marilyn's department for a sophisticated computer system tailored to provide the necessary information to make these decisions. In addition to up-to-the-minute bookings, the department's seven revenue enhancement analysts could find out fares, schedules, how each flight booked a year earlier, and what the competition was doing in each market. They could also obtain bookings trends for each flight for each day of the week. With this information, the analysts determined the number of seats to be sold at a discount.

EXHIBIT 1 Revenue Enhancement

These People Make Certain Piedmont Maximizes Its Revenue

Cathy Howe scans the screen of her reservations computer, studying Flight 364 from DCA to GSO.

To determine how the flight has done in the past, she turns to her MAPPER computer and, moments later, has data on the flight for the past 90 days. She then pulls up information from MAPPER for the flight's next 30 days.

Howe can tell you our fares, our schedules, how the flight traditionally booked a year earlier, and what the competition is doing in this market. And she knows the booking trends for this flight for each day of the week.

This historical report coupled with current and future demand data give her enough analytical material to make an important decision for Piedmont. She will allocate the number of seats that Piedmont will sell on this flight at a discount.

And Howe is responsible for making similar decisions on 109 other flights in 16 Piedmont markets.

"If I can produce just $100 additional revenue every day on each of the flights I monitor, Piedmont will realize over a $4 million annual revenue improvement," she said, "and that's why I'm here, to help maximize the revenue on each of these departures."

Major Responsibility

Howe is one of seven revenue enhancement analysts, at the department's new offices at Madison Park, who has become an expert in Piedmont's markets. Each analyst is responsible for monitoring over 100 flights a day in 15 to 20 markets. Not only do they know the history on each of their flights, they are aware of the schedules, the many fares, booking trends, and what the competition is doing in each of these markets.

The person who set up the new departure and is responsible for its day-to-day operation is Marilyn Hoppe, manager–revenue enhancement. She joined Piedmont last summer after 10 years with Republic Airlines.

Input from Others

To ensure a system of checks and balances, Hoppe monitors what the analysts are doing and reviews their regular monthly reports. In addition, input from other departments is vital to the effective operation of Revenue Enhancement, and there are frequent meetings with other areas of the Company.

"What we have is a perishable commodity," Hoppe said. "We are striving to give each individual flight in a given market a careful mixture of discount and full-fare seats and thus increase our revenue."

The department, part of our Marketing Division, works closely with the Pricing, Tariff, and Scheduling departments.

Note: Terms to Know

Capacity control—allocating seats so as to best meet demand while preventing loss of revenue.

Load factor—percentage of seats filled on our flights.

Revenue—money we receive for services.

Revenue passenger miles (RPMs)—one passenger carried one mile.

Yield—the amount of money we receive for carrying one passenger one mile.

Source: *Piedmonitor* 36, no. 3, April 1985.

EXHIBIT 1 *Continued*

"Our Pricing Department develops fare programs, sets our fares, and performs fare analysis," Swenson said. "Tariffs put the fare programs into operation, and Revenue Enhancement determines the appropriate mix of discount and full-fare seats on each flight."

Piedmont has committed over $1 million to the newly created department for a sophisticated computer system, which has been tailored to our needs. The system has been developed specifically for Piedmont with input from many areas of the company, in particular Data Processing, which continues to provide considerable support.

"Trying to manage 836 departures a day—almost 30,000 flights a month—requires a state-of-the-art system," Hoppe said. "The company has provided us with this system so we can scientifically approach our job. Since deregulation, the whole area of pricing has become extremely complicated and competitive. These tools are necessary in order to control our discount programs."

The philosophy of the department is exactly opposite from the way the industry operated prior to deregulation. The theory then was that, in the final days before a flight, airlines should sell all remaining seats at a discount in order to fill the plane.

"But since deregulation, airlines have discovered the opposite to be true. The number of discount seats should be limited, based on the individual market characteristics, and the remaining seats should be reserved for full-fare business travelers who make plans nearer departure time," she said.

Marilyn Hoppe (right) manager–revenue enhancement, Steve Nelson, an analyst, and Mary Cline, secretary for the department, go over future Piedmont flight schedules, which are being transmitted to the department from our reservations system.

EXHIBIT 1 *Continued*

"What we're doing is getting a good base with the lower fares and reserving the remaining seats for higher-yield traffic, people who make plans closer to departure. Our late-booking passengers, usually business travelers, are probably our most valued customers, our frequent fliers. They often must make plans on short notice and, by allocating fewer discount seats, we give them more flexibility," Hoppe said.

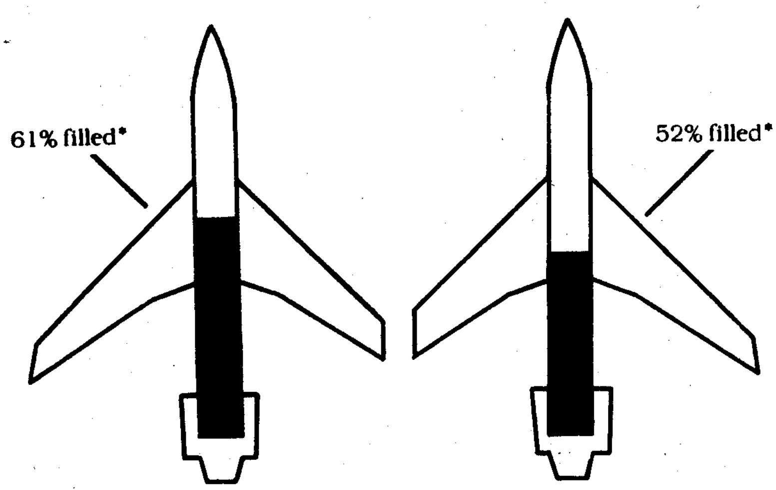
The department allocates seats for each class of service so as to best meet demand while preventing loss of revenue. In most cases, this involves providing discount seats to those passengers who book early, but systematically limiting discount seats at a specific period of time before departure.

Discount seats, in fact, are generally available for over 300 days prior to departure and will only be pulled back, if appropriate, 7 to 14 days before departure, Hoppe said. This process is capacity control and results in more revenue.

"We're offering the business person a full schedule from which to choose and the ability to change flights," Hoppe said. "If we didn't offer discounts, fewer people would travel and, in the end, the businessman or woman would have to pay more and would have fewer flights from which to choose."

Revenue Comparison

H Fare = $70	*Y Fare = $100*
100 seats sold 100 H Fare = $7,000	85 seats sold 60 Y Fare = $6,000 25 H Fare = $1,750
Revenue $7,000	**Revenue $7,750**



*based on a 727-200 with 164 seats

EXHIBIT 1 *Concluded*

"The most successful airlines in the industry, by and large, are using similar techniques employing the same logic. During the last full-blown fare war three years ago, we all learned that we have to restrict discount fares to manage them. By allocating seats we hope to keep our yield up with little impact on load factor," she added.

Revenue Enhancement is already making an impact on Piedmont's financial picture. In 1984, our load factor was 52.42 percent, down 2.4 points from the year before. Yet our total operating revenues grew 36.1 percent to a record $1.3 billion. In 1984, our yield was 17.64 cents per revenue passenger mile, compared with 15.94 cents in 1983."

Monitoring Flights

"Everyone must realize how closely we monitor flights," she emphasized. "You can't determine the performance of a flight by looking only at the number of people who board that flight. Load factor is important, but you also must consider the revenue side. We may have fewer people on a flight but that flight may produce more revenue, because more passengers are paying full fare or another higher-yield fare."

This discount-seat-allocation decision involved a critical tradeoff: If too many seats were sold at a discount, the airline could lose the difference between the full fare and discount fare for every potential full-fare passenger lost—either because the plane sold out and full-fare customers were turned away, or because customers who might otherwise have paid the full fare "diverted" to the discount fare. The loss caused by diverting was the reason Piedmont often limited the sale of discount-fare seats even in those situations where there was no chance of selling out a flight. If, on the other hand, too few seats were sold at a discount, the airline lost the discount fare for every passenger who would have taken the flight had the discount fare been available but opted instead not to take the flight at all, rather than pay the full fare. This kind of customer was called a "stimulator," because the discount fare stimulated them to take the flight. If a discount fare was not available, potential sales to stimulators were lost. In contrast, a customer who would take the flight at either fare was called a "diverter." A diverter would pay the full fare if no discount seats were available but would divert to the discount fare if it was available.

The seven analysts were repeatedly called on to evaluate the tradeoffs between lost sales due to stimulators turned away and increased revenues from diverters kept at the full fare. Even though large amounts of information were available, striking the proper balance was mostly left to their judgments. Their performance was closely monitored, and all indications were that they were having a positive impact on the company, but Marilyn still wanted to search for ways to improve. Perhaps she could provide some additional guidance for them (maybe in the form of certain decision rules) in making these important decisions. She

EXHIBIT 2 Flight 224 Historical Bookings and Revenues

	Weekday	*Weekend*	*Total*
Number of flights	56	22	78
Number of sold-out flights	11	2	13
Number of passengers	7,683	2,075	9,758
H passengers	2,017	1,112	3,129
Y passengers	5,666	963	6,629
Segment* revenue	$707,790	$174,140	$ 881,930
H revenues	$141,190	$ 77,840	$ 219,030
Y revenues	$566,600	$ 96,300	$ 662,900
Total† revenue	$856,426	$210,710	$1,067,136
H revenues	$145,592	$ 94,820	$ 240,412
Y revenues	$710,834	$115,890	$ 826,724

* Segment revenue refers to the CLT-to-BOS flight only.

† Total revenue includes segment revenues and any additional revenues from Flight 224 passengers connecting to other Piedmont flights.

decided to start by examining the booking and seat-allocation history of Flight 224 from Charlotte (CLT) to Boston (BOS), a typical Piedmont flight.

Flight 224

Flight 224 was scheduled to leave CLT each day (seven days a week) at 8:30 A.M. and arrive at BOS at 10:20 A.M. Because the flight originated in CLT and terminated in BOS, any passengers with final destinations other than BOS changed planes there and made connections to a separate flight leaving BOS for their final destination. Approximately 25 percent of the flight's passengers had these connecting flights, one-half of which were with airlines other than Piedmont.

All 164 seats on the Boeing 727-200 used for this flight were sold as a single class; that is, there was no first class/coach distinction. All seats were not sold at the same fare, however. A limited number of discount seats, called "H-fares," were available for $70. In contrast, the regular fare, called a "Y-fare," was $100. These fares were for the CLT to BOS flight only. Passengers with other final destinations paid a total fare equal to the sum of the fares for each segment of their particular flight. This particular flight had been in existence for only about three months. Marilyn compiled the data given in Exhibit 2, describing the historical bookings and revenues for this flight, and Exhibit 3 shows the company's operating-cost estimates.

After compiling these data, Marilyn met with Cathy Howe, the analyst responsible for Flight 224, to review the decision process used in allocating H-fare seats. They agreed to focus on a particular allocation decision, and Cathy was happy to walk Marilyn through the decision she was about to make regarding Flight 224, which departed a few weeks later on May 8.

EXHIBIT 3 Flight 224 Cost Estimates*

	Cost per Flight
Fuel	$2,240
Maintenance	1,470
Flight crew	770
Ground crew	250
Landing fees	105
Overhead	2,230
Total	$7,065

*Single one-way flight.

EXHIBIT 4 Recent Wednesday Departures of Flight 224

Departure Date	H Bookings	Y Bookings	H Allocation	Total
4/24	42	97	42	139
4/17	44	88	44	132
4/10	45	92	45	137
4/03	52	112	52	164
3/27	35	111	35	146
3/20	46	56	46	102
3/13	52	89	52	141
3/06	57	107	57	164
2/27	26	114	26	140
2/20	28	90	28	118
2/13	50	114	50	164

"The first thing I'd do is check historical bookings for this flight. Since this is a Wednesday flight, I'd put together a relevant history of bookings for previous Wednesday departures of this flight. Here's where I have to be careful to consider all the other factors that can influence booking patterns. For example, the strike at National Airlines meant this flight saw an unusually large number of bookings during early March." A few seconds later, Cathy had a screen full of information on recent Wednesday departures of Flight 224 (Exhibit 4). "See there, our March 6 flight sold out because of that strike, and I seriously doubt that anyone's going to strike right before the departure of this May 8 flight.

"From looking at these data, I'd draw a couple of conclusions. First, you can see that demand for this flight is hard to predict. The flights departing on February 13 and April 3 both sold out, but the load factor [percentage of seats sold] for the March 20 departure was only 62 percent. You can see that, if I set any reasonable allocation, we'd almost certainly sell them all. That 62 percent load factor on March 20 was quite low for this flight, but it still meant we sold 102 seats—most of them at full fare. If I did not limit discount-fare seats for the upcoming May 8 flight, I would predict that total demand for seats would be about 180—much higher than the capacity of the plane. By 'total demand' I mean both stimulators and diverters, anyone willing to take the flight at the discount fare. If pressed to make a judgment on what total demand for discount seats might be, I'd think in terms of the bell-shaped curve and put a 68 percent chance that demand would be between 150 and 210. Looking at the other extreme, if I did not allocate any seats to be sold at the discount fare I would have to think in terms of how many of our potential customers would pay the full fare or how many are stimulators. Because I think the diverter/stimulator mix for this flight is about 60/40, it follows that, if no seats were sold at a discount, 60 percent of the potential demand would remain. This would result in about 108 (180 × 0.6) full-fare sales. The uncertainty here is a little harder to judge, but I would say that there's a 68 percent chance we would sell between 90 and 126 seats if all seats were offered at the full fare.

"But, quite obviously, it is probably best to set the allocation somewhere between the two extremes of 164 (offer all seats at the H-fare of $70) and 0 (offer all seats at the Y-fare of $100). In reality, I always have the opportunity to reset this allocation at a later date if conditions change. But I still like to set a good initial allocation and then modify it only slightly as the time of departure draws near. One thing we never do, however, is raise the allocation once all discount-fare seats have been sold. This avoids the loss of goodwill associated with selling someone a full-fare seat, because we tell him or her no discount-fare seats are available, and then having that passenger discover that discount-fare seats were sold at a later date."

CASE 40
PIEDMONT AIRLINES: DISCOUNT SEAT ALLOCATION (B)

As Marilyn Hoppe thought about how to help Cathy Howe plan the number of discount seats to offer on Flight 224, she thought of the problem in terms of how many seats to reserve for the full-fare passengers. Past experience had been that Piedmont had virtually always been able to sell all the discount seats on Flight 224. If we reserve R seats, Hoppe reasoned, then the number of discount seats is simply 164 − R. Suppose we decide R now, well in advance of the flight, and consider it fixed for the remainder of the time before departure?

She thought about what would happen if R were set too low: Suppose it were low by one seat? Then we would lose a full-fare passenger, but that seat would have been filled by a discount passenger. So the cost of R being low by one seat is the difference between full-fare revenue and discount fare, or $30 for Flight 224.

Suppose we set R too high, however, again by one unit only? She reasoned that the seat would go empty, because there would be no full-fare passenger to fly in it. Because the discount passengers would have been restricted, they couldn't fly in it. Thus, she proposed, the cost of being over is the revenue from one discount passenger, or $70.

Marilyn now thought about what to do with these costs. Had these costs been equal, she would have simply used an R that was the mean of the distribution of full-fare demand, or 108. Because it was less costly to reserve too few full-seat fares, however, she believed that she should make R less than 108. The question was: How much less? She seemed to recall a discussion of this somewhere in her past and thought that it was best to make the relative odds of being low match the relative cost of being low. She was not sure, so she looked through a few books to find the result.

In a text on quantitative methods for business, Hoppe found the so-called *news vendor* problem, which was the question of how many newspapers to buy in the face of uncertain demand. She read that, if she knew the cost of having one newspaper too few (cost of under) and the cost of having one newspaper too many (cost of over), and if the relevant costs were constant per unit, then she should order an amount that corresponded to the critical fractile of her demand distribution. This critical fractile is the ratio of the cost of under to the total of the cost of under plus the cost of over. If she could apply this approach to her problem, the critical fractile would be 30/(30+70) = 0.30. The task was now a straightforward matter of finding the 30th percentile of Howe's assessed distribution for the number of full-fare passengers. Using a normal distribution with mean 108 and standard deviation 18, Hoppe calculated the result to be 99, to the nearest integer.

Based on this approach, the plan was to reserve 99 seats for full-fare passengers and allocate the other 65 seats to discount fares. Hoppe filed away this result for her next meeting with Howe and thought how impressed her boss would be when he learned about the new approach. She relaxed for a moment with *The Wall Street Journal*, but before 10 minutes had passed she had her notes out again on the table. Yield management made such a huge difference in bottom-line profits in her company that she had better not jump to any hasty conclusions; her reputation would be on the line.

Hoppe noted that this discount allocation of 65 was much larger than had been used before on Flight 224. Numbers don't lie, she thought; there had already been many times in her career when getting the numbers right had saved her. And she had found situations where her own analysis topped existing practice. Here, however, the use of the news vendor approach was new to her. Could it be directly applied to this situation? After all, the textbook example didn't talk about two types of customers.

She decided a Monte Carlo simulation would help her verify this new result—and allow her to test alternative plans as well. The Case 1 section of Exhibit 1

EXHIBIT 1 A Description of the Monte Carlo Simulation Model

Cell *C3*: Demand, the number of potential customers, drawn from a normal distribution with mean 180 and standard deviation 30, rounded off to the nearest integer.

Case 1

Cell *B6*: Choose R_1, the seats saved for full fare in Case 1 (59).

Cell *B7*: $Q_1 = 164 - R_1$ is the number of discount seats available (105).

Cell *B9*: If $C3 > Q_1$, then from the $C3 - Q_1$ customers that do not fit in the discount seats, determine the potential number of full-fare sales using a binomial distribution with $p = 0.6$.
If $C3 \leq Q_1$, then the number of full-fare sales is zero.

Cell *B10*: Minimum of *B6* and *B9*.

Cell *B16*: If $C3 > Q_1$, then Revenue $= 70 * B7 + 100 * B10$.
If $C3 \leq Q_1$, then Revenue $= 70 * C3$.

Case 2

Cell *D6*: Choose $R_2 > R_1$, the seats saved for full fare in Case 2 (99).

Cell *D7*: $Q_2 = 164 - R_2$ is the number of discount seats available (65).

Cell *D9*: If $C3 > Q_1$, then from the $B7-D7$ additional customers that do not fit in the discount seats for Case 2, determine the number of potential full-fare sales using a binomial distribution with $p = 0.6$ and add to *B9*.
If $C3 \leq Q_1$ and $C3 > Q_2$, then from the $C3-D7$ additional customers that do not fit in the discount seats for Case 2, determine the potential full-fare sales using a binomial distribution with $p = 0.6$.
If $C3 \leq Q_2$, the number of full-fare sales is zero.

Cell *D10*: Minimum of *D6* and *D9*.

Cell *D16*: If $C3 > Q_2$, then Revenue $= 70 * D7 + 100 * D10$.
If $C3 \leq Q_2$, then Revenue $= 70 * C3$.

Difference

Cell *C16*: $B16 - D16$

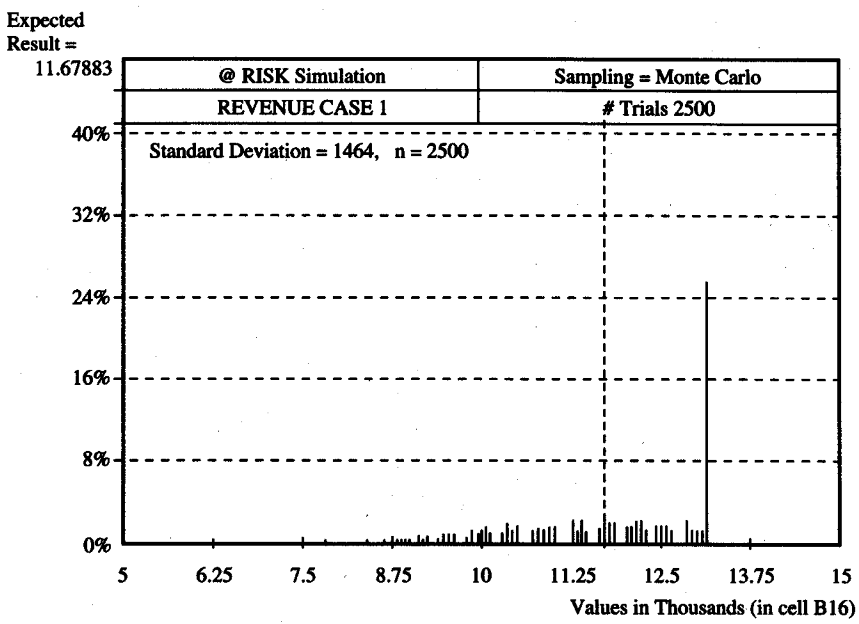
explains the important cells in the electronic-spreadsheet model she developed. The simulation first generated the demand (i.e., the number of potential customers) and used this number, along with the number of seats allocated to full-fare customers, to determine the number of discount seats sold. Then the behavior of each remaining potential customer was simulated using a 60 percent probability of diverter to determine how many would buy a full-fare seat if no discount seat were available.

After Hoppe validated the model, she tried the simulation with several different values for R. To her surprise, the best revenues were not from setting R to 99, her critical fractile level. For example, the average revenue at R = 59 was higher than the average revenue at R = 99 (see Exhibit 2). She then expanded the model so that, each time it ran, it would calculate the revenue for an R = 59 strategy (cell *B16* of Exhibit 1), the revenue for an R = 99 strategy (cell *D16*), and the difference in revenue for the two strategies for each trial (cell *C16*). Exhibit 3 shows the distribution of this difference in revenue for the same 2,500 trials used in Exhibit 2. It looked pretty convincing, from this simulation at least, that R = 59 was better than R = 99, but she was not sure that this result might not be "the luck of the draw" resulting from not enough trials.

Next, she set up an experiment to search for the optimal level. She decided to look over the range of R = 30 to R = 80 and to compare the difference in revenues for strategies that varied by increments of five seats. In other words, first she tested R = 30 versus R = 35, then R = 35 versus R = 40, and so on, all the way to R = 75 versus R = 80. The results are contained in Exhibit 4. She puzzled over them for a while, then picked up the paper again. "I'll have to mull this over," she muttered to herself.

EXHIBIT 2 Graphs of Revenues Generated from R = 59 and R = 99 Strategies

R = 59



R = 99

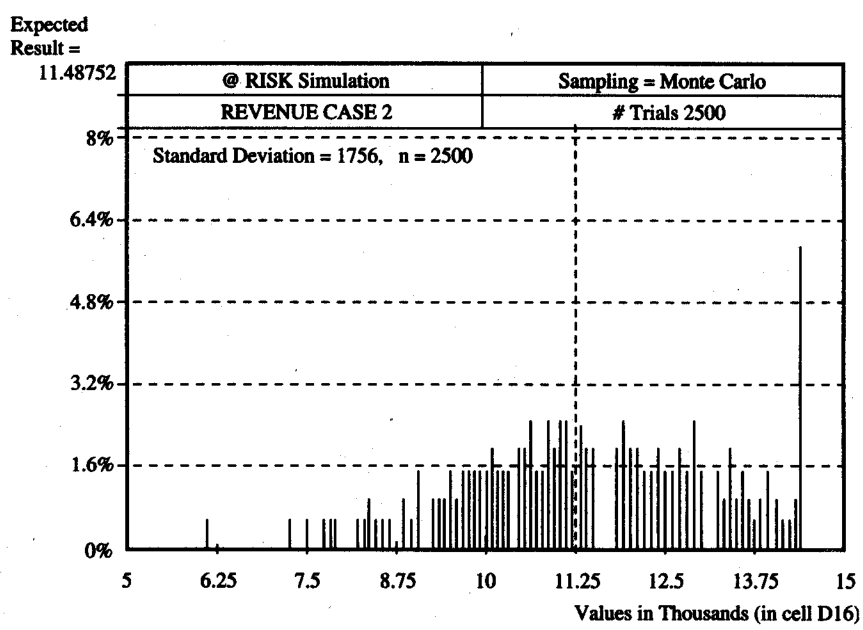


Exhibit 3 **Monte Carlo Results for Difference (Cell C16) in Revenue for the R = 59 and R = 99 Strategies**

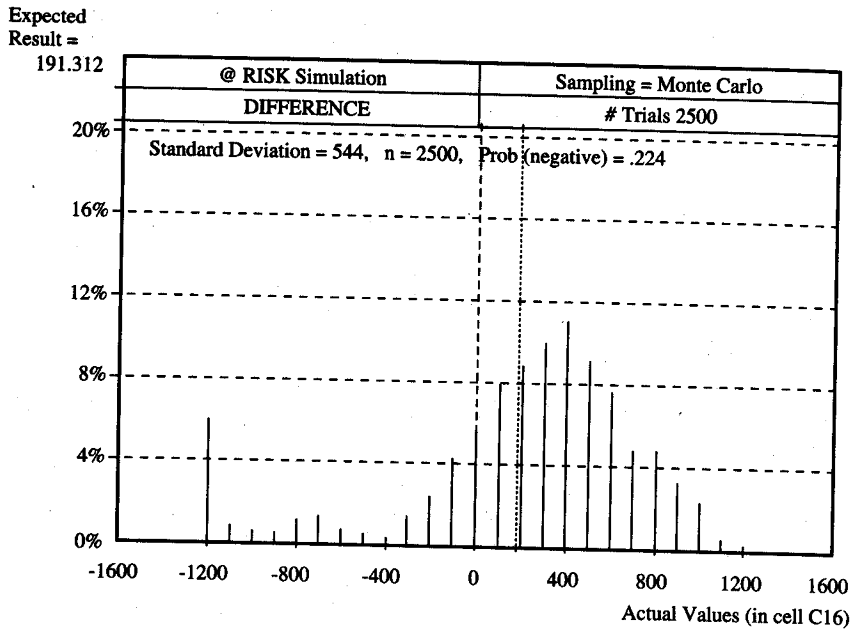


Exhibit 4 **Simulation Results for Different R-Values and for the Difference between R and R + 5**

R, Full-Fare Seats	Revenue for R		Revenue for R + 5		Difference: Revenue for R − Rev. for R + 5	
	Mean	*Std. Dev.*	*Mean*	*Std. Dev.*	*Mean*	*Std. Dev.*
30	11516	1156	11551	1215	−34.8	125
35	11550	1231	11577	1290	−27.5	126
40	11579	1289	11598	1348	−19.5	127
45	11601	1338	11611	1396	−10.3	128
50	11606	1389	11609	1442	−2.9	127
55	11584	1449	11578	1499	6.2	126
60	11617	1501	11607	1549	10.4	126
65	11609	1546	11593	1590	15.9	124
70	11583	1592	11561	1631	21.9	122
75	11553	1636	11528	1672	24.9	121

Number of trials = 16,000.