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Yield Management in the Airline Industry

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FORUM

YIELD MANAGEMENT IN THE AIRLINE INDUSTRY

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"This is it! This is a shot across our bow! If we don't invent a way to deal with (yield management), we're history!"
– Donald Burr, Former CEO of People's Express

Immersed in the age of the internet, most prospective travelers have searched for, and have purchased airline tickets online. In doing so, a varying range of prices and restrictions were inevitably discovered. One week, a roundtrip ticket on a given flight may be quoted at $280, a week later at $360, and a week prior to the flight, $840! The constant fluctuation in price is due to the practice of yield management, sometimes referred to as revenue management. The airline industry was the first to develop and implement this system, and its use has resulted in substantial revenue gains for the industry as a whole.

The purpose of this paper is to examine the history of yield management in the airline industry, and to exemplify its utilization and importance as the most influential practice developed and implemented in the post-deregulation era of the airline industry. Beginning with a historical summary, this paper will present the progressive development of yield management, discussing the roles of the Sabre reservation system, DINAMO, and Sabre AirMax®. Furthermore, this paper will present the fundamentals of demand, a working definition of yield management, the features common amongst industries utilizing yield management systems, and the strategies of overbooking and discount seat allocation. Some of our time will be spent solving a common yield management problem as a means of displaying the quantitative nature of the practice. To finish, the paper will conclude with a presentation of the challenges that continue to hinder yield management systems today.

To provide some historical perspective, yield management arose out of airline deregulation in 1979. In the 1960's, American Airlines developed the first on-line reservation system named Sabre (Semi-Automated Business Research Environment). The Sabre reservation system dealt with centralizing and controlling reservation activity (Voneche). By deregulation, Sabre was overflowing with priceless historical data from over ten years of bookings. As competition intensified in the post-deregulation era, Robert Crandall, the former CEO of American Airlines, set out to devise a system that would vary the proportion of discount and full-fare seats on a day by day, departure by departure basis (Petzinger, 303). The Sabre system provided the platform for designated American Airline's employees to monitor the rate of actual booking in various fare categories, to compare them to the predicted rate, and then adjust the inventory of variously priced seats accordingly (Petzinger, 304). Crandall would later name this process "yield management."

The yield-management process has developed considerably, becoming almost exclusively automated. By 1988, American Airlines fully implemented Dinamo (Dynamic Inventory and Maintenance Optimizer), a module that aggregates overbooking, discount allocation, and traffic management (Voneche). As a result of the Dinamo implementation, calculated spoilage was estimated at only 3%, and Yield-Management Analyst production increased by 30% (Voneche). Analyst production increased because these specialists could make better revenue decisions, as the job transitioned to Dinamo identifying the problems instead of the Analysts, and the Analysts would fix the problems with the help of software that allows for flight specific analysis and re-optimization (Voneche).

Today, Sabre Airline Solutions™ boasts the Sabre AirMax® as the most current form of automated yield management. Sabre AirMax® supports the entire range of yield management applications, including reservations data collection, offline data collection, forecasting, overbooking, optimization, performance measurement, and reporting

(Sabre Airline Solutions). Some additional features include the Day-of Departure Manager, the Group Manager (Traffic Management), and the Sabre® Availability Processor™, all of which allow Analysts to act quickly and effectively on various areas of the yield management process (Sabre Airline Solutions, Revenue Management). Sabre Airline Solutions™ proclaims a 5% to 7% revenue enhancement gained through the use of Sabre AirMax® Revenue Manager (Sabre Airline Solutions, Revenue Management). Both American Airlines and Delta Airlines credit yield management techniques for revenue increases of $500 million per year and $300 million per year respectively (Netessine & Shumsky, 2).

Before one can grasp the concept of yield management, a basic knowledge of demand is necessary. Demand is defined as the various amounts of a product or service that consumers are willing and able to purchase at various prices over a particular time period (Wells, 329). Basic economics provides that an inverse relationship exists between price and demand. Simply stated, when the price of a product falls, the corresponding reaction is a rise in the quantity of the product or service demanded. Alternatively, when price increases, the corresponding reaction is a decrease in the quantity of the product or service demanded. This inverse relationship between price and quantity has been labeled the law of demand by Economists (Wells, 329). As it pertains to the airline industry, if the price of a roundtrip airline ticket is reduced from $330 to $260, the quantity of tickets demanded will increase. Subsequently, when the price of a roundtrip airline ticket is raised from $330 to $405, the quantity of tickets demanded will decrease.

The law of demand provides that a consumer will respond to price declines and increases; however, the degree to which a consumer will respond to changes in price may vary considerably (Wells, 333). The measure of how responsive, or sensitive, consumers are to changes in price is called the elasticity of demand. Some consumers are relatively responsive to changes in price; therefore their demand for the product or service is defined as elastic demand. Other consumers are less responsive to changes in price; therefore their demand for the product or service is defined as inelastic demand.

In the airline industry, elasticity of demand tends to parallel the two main market segments; business travelers and leisure travelers. Business travelers tend to be less responsive to price changes, therefore their demand is inelastic. Leisure travelers tend to be more responsive to price changes, therefore their demand is elastic. From a pricing perspective, airlines have little reason to discount inelastic demand; however, airlines should encourage as much elastic demand as possible, typically by offering discounted airfare with restrictions to "protect" inelastic demand (Wardell). If inelastic and elastic demand is not managed properly, the result will be higher costs incurred by the given airline. If too much discount inventory is allocated, seats will be taken from the higher paying business travelers. Likewise, if too little discount inventory is allocated, seats will go unused. The management of elastic and inelastic demand provides the foundation for yield management.

Yield management is defined as the techniques used to allocate limited resources among a variety of customers in order to optimize the total revenue or "yield" on the investment capacity (Netessine & Shumsky, 1). In the case of an airline, the limited resources are the seats on a future flight, and the variety of customers is business and leisure travelers. In Hard Landing, Thomas Petzinger, Jr. states that, "An airline seat is like fresh food – a grapefruit, say – in that it spoils after so much time on the shelf (Petzinger, pp. 57)." Once an aircraft departs, all seats that remain empty become worthless. Thus, the strategy behind yield management in the airline industry is to sell the right seat to the right type of customer, at the right time and for the right price (Voneche). The key is to find the tradeoff between selling discount tickets as a means to filling up the aircraft completely, and selling full fare tickets and only filling up a portion of the aircraft (Voneche).

Industries that have successfully implemented yield management techniques tend to have certain features in common. The products of these industries are perishable, their supply is limited, their demand varies with time, their market can be segmented, their product or service can be sold in advance, and their marginal costs are low. As mentioned previously, airline seats are perishable, as they cannot be sold after a specific point in time (i.e. – departure of a flight). Yield management minimizes wasted inventory without weakening revenue.

Supply is limited in the airline industry, as it is costly and difficult to increase capacity. Due to the difficulty and cost associated with the addition of capacity, airlines have a physical limit on the number of passengers that can be accommodated at any one time (The Rubicon Group). Furthermore, because capacity is limited, varying demand can be managed best with price fluctuation. Lower prices tend to increase the quantity demanded, just as high prices tend to decrease the quantity demanded. Yield management can effectively manage both limited supply, and varying demand, by dynamically controlling price and inventory, and capturing as much of the revenue opportunity as possible (The Rubicon Group).

The inherent differences between business and leisure travelers allows for the segmentation of markets in the airline industry. The product, in this case, seats on an aircraft, cannot be viewed as a physical entity. Airlines exploit segmentation by offering premium services, such as unrestricted airfares, that consumers are often willing to pay for. The result is different prices for the same basic service. Yield management ensures the availability of different products (i.e. – service levels on a flight) at different prices to guarantee the generation of maximum revenue from the existing capacity (The Rubicon Group).

Another characteristic that is common amongst industries that successfully incorporate yield management is the ability of the product or service to be sold in advance. Undoubtedly, the airline industry follows this criterion, as airline tickets can be purchased well in advance of the travel date. Leisure travelers tend to purchase tickets well in advance of their travel date, while business travelers tend to book close to their date of travel. Yield management allows for prediction of the timing and type of demand, and allocates inventory accordingly (The Rubicon Group).

The final feature that is common amongst industries that successfully incorporate yield management is the fact that marginal costs are low. This feature goes hand-in-hand with the perishable product feature. For industries with low marginal costs, it is better to sell a product than to let it go to waste. Yield management ensures that as much inventory as possible is sold at optimum price to ensure maximum revenue and minimum wastage (The Rubicon Group).

Two strategies associated with yield management, as it pertains to the airline industry, are the practices of overbooking and discount allocation. Overbooking is the procedure of intentionally selling more seats than are available to offset passenger cancellations and no-shows, and to maximize ridership (DePew & Stripling, 1). The airlines estimate that, on average, a sold out aircraft will leave the gate with 15% of its seats empty due to no-shows and cancellations. Therefore, the optimal overbooking point is reached when the marginal revenue from accepting one more reservation on a flight equals the marginal cost of an additional overbooking (Davis). Because the expected cost of each additional excess booking exceeds what it can add in revenue, the total revenue will begin to decline after this point (Davis).

Overbooking allows the airlines to maximize revenue by filling the seats left empty by no-shows and cancellations; however, this practice comes with some inherent risks. On occasion, more ticket possessing passengers will arrive for a flight than the aircraft can accommodate. As a result, some of these passengers will have to relinquish their seats on the flight, often in exchange for vouchers for free flights, meals, and hotel rooms. If overbooked passengers can be rebooked with the same airline on a later flight that day, the cost incurred by the airline is minimal. On the contrary, if flight vouchers, meals, and hotel rooms are required, the cost to an airline can be quite significant. The greatest cost of all is the potential loss of customer good will (Davis). Contradicting this industry standard, JetBlue Airways has adopted a no overbooking policy as a means to alleviate passenger anxiety, to nullify the potential costs involved with the practice, and to promote customer loyalty.

The second strategy associated with yield management is discount seat allocation. Simply stated, discount allocation is the practice of limiting the number of discounted airfares in order to reserve seats for higher-revenue customers on the same flight (DePew & Stripling, 1). Full fares for last minute bookings, and discounted fares for bookings made well in advance are determined through pricing strategy. On the other hand, yield management determines the number of seats that will be offered for each fare category, in order to maximize revenue (DePew & Stripling, 1). Vigorous yield management systems have the ability to monitor reservation activity on each flight for each type of customer, allowing for accurate demand forecasting (DePew & Stripling, 1). These changes in forecasted demand will further allow the yield management system to adjust discount allocations, overbooking rates, and the availability of the different types of airfares.

Equipped with the fundamentals of yield management, one can explore how yield management works in a real life situations. Suppose that an airline has established two fare classes, commonly referred to as buckets: full fare and discount fare (Netessine & Shumsky, 4). The Airbus A320 has a capacity of 156 seats. Seats are currently being sold for a flight that is scheduled to take place on May 3 (today is April 3). The airline yield managers have the option of selling all 156 seats at the discounted rate, and although this would result in full capacity, revenue would suffer. These same yield managers are aware that higher paying business passengers will purchase tickets at a later date; therefore, a certain number of seats on the aircraft must be protected and maintained at full fare. Knowing this, Airline Yield/Revenue Managers segment the market, allowing the airline to charge different prices to leisure and business travelers.

As a means of differentiating between the two market segments, the airline will introduce booking rules that create barriers or "fences" between the market segments (Netessine & Shumsky, 4). An example of a fence often used by the airlines is a required Saturday-night stay in order to receive a discounted fare. Because price-sensitive leisure travelers are more likely to travel over the weekend, and less price-sensitive business travelers are more likely to return home on the weekend, the required Saturday-night stay allows the airline to sell as many seats to the high-paying business travelers as possible while maintaining high capacity (Netessine & Shumsky, 5).

Airline Yield/Revenue Managers also limit the maximum number of seats that can be sold at a discount, called the booking limit. The remaining seats, reserved for higher paying patrons, are referred to as the protection level. Assuming that most leisure travelers will purchase seats before most business travelers, the booking limit constrains the number of seats that can be sold at discounted fares: once the booking limit is met, the remaining seats, or protected level, will be sold at full fare (Netessine & Shumsky, 5). In the above referenced airline example, there are 156 seats on the Airbus A320 aircraft and two fare classes. Considering this example from a mathematical standpoint, the booking limit equals the number of total seats minus the protection level (booking limit = 156 – protection level). Therefore, the airline's task is to determine either the booking limit or a protection level, because knowing one will allow calculation of the other (Netessine & Shumsky, 5).

Solving a Real-Life Yield Management Problem

In order to demonstrate the quantitative nature of yield management, a problem used in Serguei Netessine's and Robert Shumsky's "Introduction to the Theory and Practice of Yield Management" has been manipulated in order to pertain to the airline industry.

Assumptions:

- The airline considers protection level 'Q' instead of current protection level Q+1 (Q might be anything from 0-155).
- 156-Q-1 seats have already been sold (see Figure 1).

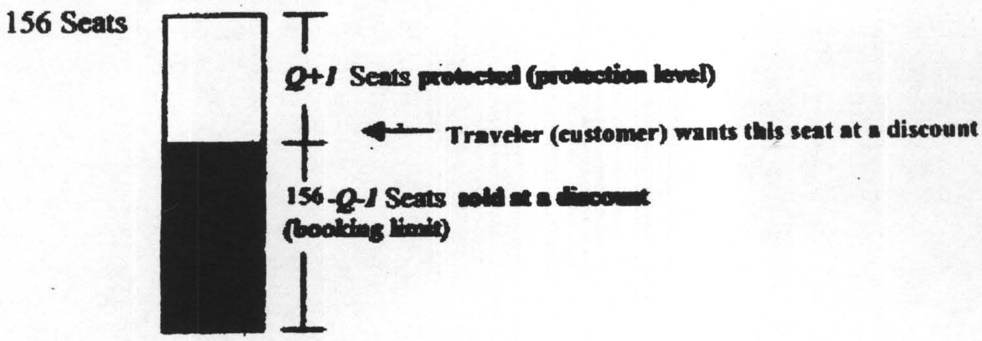

Figure 1. Protection Level and Booking Limit on the Aircraft

Scenario:

- A prospective leisure traveler calls, desiring to purchase the first 'protected' seat at the discounted price.

Question:

- Should the airline lower the protection level from Q+1 to Q, therefore allowing the booking of the (Q+1)th seat at the discounted fare? Or should the airline refuse the booking to gamble that it will be able to sell the very same seat to a full price business traveler in the future?

Note: The answer depends on (i) the relative amounts of the full and discounted airfare and (ii) the anticipated demand for full fare seats.

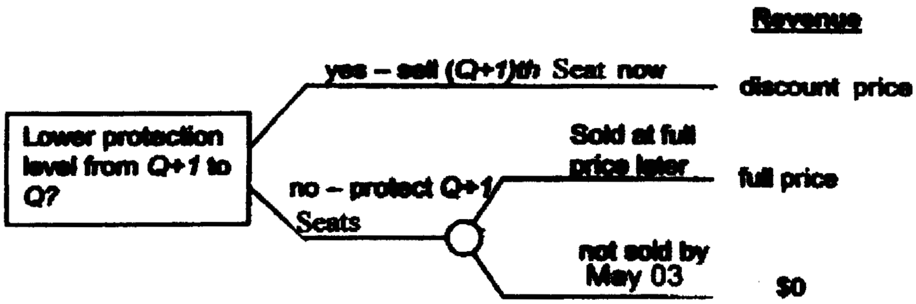

Figure 2. Evaluating the Protection Level

Solution:

In order to determine the value of each branch of the decision tree in Figure 2, the probability for each 'chance' branch and the values at the end of the branches must be known. For the purpose of this problem, the discounted fare will be set at $250 roundtrip while the full fare will be set at $399 roundtrip. To find the probability on each branch, define random variable *D* to represent the anticipated demand for seats at full fare. The airline may estimate the distribution of *D* from historical demand, as well as from forecasts based on the day of the week, whether there is a holiday, and other predictable events. In this example, it will be assumed that the distribution is derived directly from 123 days of historical demand, as shown in Table 1. The 'cumulative probability' is the fraction of days with demand at or below the number of seats in the first column (Q).

Demand for *Seats* at full fare (Q)	# Days with Demand	Cumulative Probability *F(Q)* =*Prob{D≤Q}*
0 - 70	12	0.098
71	3	0.122
72	3	0.146
73	2	0.163
74	0	0.163
75	4	0.195
76	4	0.228
77	5	0.268
78	2	0.285
79	7	0.341
80	4	0.374
81	10	0.455
82	13	0.561
83	12	0.659
84	4	0.691
85	9	0.764
86	10	0.846
above 86	19	1.000
Total	123	1.000

Table 1. Historical Demand for Seats at the Full Fare.

Now consider the decision displayed in Figure 2. If we decide to protect the (Q+1)th seat from sale, then that seat may, or may not, be sold later. It will be sold only if demand *D* at full fare is greater than or equal to Q+1, and this event has probability 1-F(Q). Likewise, the protected seat will not be sold if demand is less than or equal to Q, with probability F(Q). Figure 3 shows our decision with these values included.

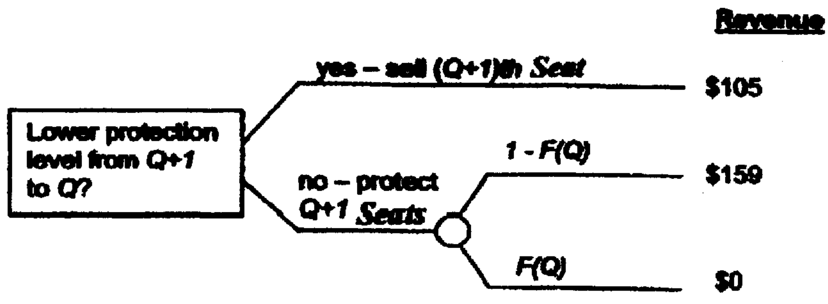

Figure 3. Protection Level Decision with Data

Given figure 3, the value of lowering the protection level from Q+1 to Q can be calculated. Lowering the protection level results in selling the (Q+1)th seat at a discount fare which guarantees a revenue of $250. Protecting Q+1 seats has as expected value equal to:

$$(1\text{-}F(Q))(\$399) + F(Q)(\$0) = (1\text{-}F(Q))(\$399)$$

Therefore, the protection level should be lowered to Q as long as:

$$(1\text{-}F(Q)(\$399) \leq \$250$$

or

$$F(Q) \geq (\$399 - \$250) / \$400 = 0.373$$

Now, F(Q) is the third column in Table 1. Simply scan from the top of the table towards the bottom until the smallest Q with a cumulative value greater than or equal to 0.373 is found.

Answer:

The answer to this problem is that the optimal protection level is Q*=80 with a cumulative value of 0.374. The booking level can now be evaluated: 156(seats) – 80 = 76. If a larger Q* is chosen, then the airline would be protecting too many seats thereby leaving too many seats unsold on average. If Q* was set at a smaller value, the airline is likely to sell too many seats at a discounted fare thereby turning away too many high paying business travelers on average.

As demonstrated above, yield management systems can be extremely beneficial to an airline, yet the implementation of such a system can entail a number of complications and challenges. In the example above, historical demand was used exclusively as a means for calculating future demand; however, in real-life scenarios, more elaborate demand models are needed to generate a more accurate demand forecast (Netessine & Shumsky, 11). Day of the week, seasonality, special events including holidays are predictable events that are also taken into consideration. Furthermore, the rapid change in customer preference can lead to a greater emphasis on the most recent demand patterns (Netessine & Shumsky, 11). Clearly, accurate demand forecasting is a formidable challenge for yield management systems in all industries.

Another complication that arises through the implementation of yield management is the variation and mobility of capacity. The above referenced example assumed that all 156 seats aboard the Airbus A320 were identical. Some airlines, such as JetBlue Airways, Southwest Airlines, and Frontier Airlines offer a single fare class configuration on all their aircraft, but the majority of the airline industry offers a varying class configuration. First-class, business-class, and economy class (coach) are examples of the different configurations offered by airlines, such as American, Delta, and United, to name a few. Moreover, airlines are similar to car rental firms in that, they are able to mobilize capacity to different locations to accommodate surges in demand (Netessine & Shumsky, 11). The variation and mobility of capacity in the airline industry, while beneficial to the generation of revenue, complicates the practice of yield management.

Dynamic booking limits present additional challenges to yield management practices. Many airlines will execute the capabilities of their yield management systems by modifying booking limits over time in response to the latest demand information (Netessine & Shumsky, 11). For example, if the demand for business-class seats on a given flight is lower than originally projected, the airline can counter this lack in demand by raising booking limits. Thus, during one week a potential leisure traveler may be told that economy-class seats are sold-out, but by the following week, economy-class seats are available (Netessine & Shumsky, 11). The ability to modify booking limits in response to demand information leads to changes in the optimal booking limit, which presents additional complication to an airline yield management system.

Mobility of customer segments can complicate yield management systems as well. Just as the example above displays, booking limits by nature prevent some leisure travelers from acquiring discount fares. Often, customers who are unable to purchase an airline ticket at a discounted rate will choose to fly with a competitor, or not at all. There are some leisure travelers that will opt to purchase the airline ticket at full-fare as opposed to exploring other options. Although modern systems tend to take such passenger movements into account, the possibility that a leisure traveler will 'buy-up' can obscure airline yield management models (Netessine & Shumsky, 12).

Traffic management practices can present formidable challenges to yield management systems. After deregulation, most airlines adopted the hub-and-spoke concept as a way to serve more markets. The purpose of a hub-and-spoke system is to connect passengers at a central hub airport, and then transfer those passengers to other flights on the same line, carrying them towards their final destinations (Wells, 77). Adoption of the hub-and-spoke system by the majority of air carriers has significantly complicated yield management practices. Demand patterns are more difficult to forecast, and the variability of revenue within a fare class has become large since a single flight does not typically represent a passenger's entire trip (Voneche). Airlines such as Southwest, that operate point-to-point systems, avoid much of the complexity that is inherent in hub-and-spoke operations. By offering point-to-point operations, an airline can maximize revenue through the exclusive manipulation of overbooking levels and discount allocation (Voneche).

Despite the complications and challenges that affect yield management practices, the airline industry has greatly benefitted from its implementation. As indicated previously, the airline industry includes the common features of perishable product, limited supply, varying demand, market segmentation, advance sale of product, and low marginal cost that commonly parallel the successful incorporation of yield management systems. Furthermore, the airline industry fosters the practices of overbooking and discount seat allocation. Since its introduction in the post-deregulation era, yield management practices have continued to develop, and have found their way into other industries, namely the hospitality and car rental industries. In the post 9/11 era, yield management will continue to have a significant affect on the airline industry. With increased fuel prices, security costs, and low-cost carrier competition, the industry needs yield management more now than ever, as it continues to cut costs and maximize revenue. Modern times require the airline industry to explore new ways to adapt to a rapidly changing landscape, but it is safe to contend that the practice of yield management will continue to benefit this vital industry for years to come.✈

Anthony Donovan resides in New Berlin, Wisconsin, and is a graduate of the University of Wisconsin-Madison. Anthony's aviation experience includes a Private Pilot's License, and graduate course work in aviation science at Embry-Riddle Aeronautical University. Commencing his pursuit of an MBA in the fall of 2005, Anthony aspires to work in the airline industry, hoping one day to achieve management status with an air carrier. The author attributes his interest in yield/revenue management to Mr. Douglas Parker (President and CEO of America West Airlines) and Mr. David Neeleman (Founder and CEO of JetBlue Airways), both of whom recently advised Anthony to pursue this avenue as a strong point of entry into the industry.

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