# THE BASICS OF REVENUE MANAGEMENT

# **IDeaS**

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## WHAT IS REVENUE MANAGEMENT?

#### WHEN IS ITS USE APPROPRIATE?

Revenue Management is an economic discipline appropriate to many service industries in which "market segment pricing"<sup>1</sup> is combined with statistical analysis to expand the market for the service and increase the revenue "revenue" per unit of available capacity.

The intelligent use of revenue management principles can be used to increase top line revenue and bottom line profitability in any service industry possessing the following characteristics<sup>2</sup>:

- Demand for the service can be divided into clear market segments and sensitivity to prices varies among the market segments.
- The firm's capacity is relatively fixed; it is expensive or impractical to add or subtract inventory in the short run, though there may be some ability to shift it.
- There is a time dimension to the provision of the service once that time has passed, the inventory loses all of its value.
- The cost of selling an additional unit of the existing capacity is low relative to the price of the service.
- There is an opportunity to evaluate and accept or reject order requests in advance of the performance of the service,

or

There is considerable flexibility to adjust prices quickly to reflect variations in the balance of supply and demand.

• There are definite peaks and valleys in demand, which can be predicted, but not with a high degree of certainty.

<sup>&</sup>lt;sup>1</sup>Economic Price Discrimination to an economist.

<sup>&</sup>lt;sup>2</sup>This list was originally compiled by Dr. Sheryl Kimes of Cornell and was included in her paper "Revenue Management: A Tool for Capacity-Constrained Service Firms" in the <u>Journal of Operations Management</u>, October, 1989.

The most familiar and well developed example of revenue management in practice is the Airline industry where:

#### SEGMENTED MARKETS

• Demand is segmented into business and leisure market segments using discount fare restrictions. Relatively price insensitive business travelers are charged higher fares than more price sensitive leisure travelers.

#### FIXED CAPACITY

• The number of seats on a flight is fixed once schedules are set.

#### **PERISHABLE INVENTORY**

• Once a flight has departed, the unsold seat inventory has no value.

#### LOW MARGINAL SERVICING COSTS

• The out-of-pocket cost of adding a passenger to a flight is very low. (Meals and servicing expenses of less than \$10.)

#### ADVANCE SALES

• Booking requests are tendered in advance of departure and can be evaluated using logic programmed into the computerized reservation system. Fares can be changed on short notice.

#### **UNCERTAIN DEMAND FORECASTS**

• Passenger demand varies by season, day-of-week, and time-of-day and can be forecast by flight and fare category, but not precisely.

Airlines that practice revenue management well have found that they have added as much as five to ten percent to their bottom line revenues. Airlines consider their revenue management systems to be strategic systems and they continue to invest heavily in them.

Revenue management has also taken hold widely throughout the rest of the Travel industry as well. Almost all major Hotel, Car Rental Agencies, Cruise Lines and Passenger Railroad firms have, or are developing, revenue management systems. Other industries that appear ripe for the application of revenue management concepts include Golf Courses, Freight Transportation, Health Care, Utilities, Television Broadcast, Spa Resorts, Advertising, Telecommunications, Ticketing, Restaurants and Web Conferencing. Let us go through the checklist to see if revenue management is applicable to your industry. Are some or all of the following characteristics applicable to your business?

- ?? Perishable inventory
- ?? Relatively fixed capacity
- ?? High fixed costs, low variable costs
- ?? Advance reservations
- ?? Time variable demand
- ?? Appropriate cost and pricing structure
- ?? Segmentable markets

If your answer is yes, then your business will profit from the application of revenue management principles and systems.

# SOME INDUSTRIES THAT MEET CRITERIA FOR APPLICATION OF REVENUE MANAGEMENT

REVENUE	Industry:	HOTELS	CAR RENTAL	FREIGHT	HEALTH	BROAD-	TELEPHONE	GOLF
MANAGEMENT	AIRLINES			TRANSPOR-	CARE	CASTING		
CRITERION				TATION				
Market	Market is	Can pursue	Can pursue airline	Market is	Time Sensitive	Guaranteed	Businesses vs.	Member
Segmentation	segmented	airline strategy	strategy	segmented by	Care vs.	Spots vs.	Residences	vs. Guest or
	between			type of	Postponable	Preemptable	Wire or Landline	Walk In
	business and			commodity to be	Care, Clinical	Spots vs.	VS.	Senior vs.
	leisure travel			transported	Care vs.	Rotatable Spots	Wireless or	Adult vs.
	using Discount				Surgical Care		Satellite	Child
	Fare							
	Restrictions		~ 7					a 10 a
Unit of Fixed	Flight	Hotel	Car Fleet	Truck, Train	Hospital	Television Show	Phone Network	Golf Course
Capacity								
Unit of	Departing Seat	Room Night	Car Day	Trailer/Boxcar	OR Room	Advertising	Line Minute	Tee Time
Perishable				Departure	Hour/	Second or	vs.	
Inventory				Labor	Bed Night	Minute	Airtime	
Low Marginal	Passenger	Order	Order	Order	Order	Order	None?	Order
Costs for	Meals,	Processing,	Processing,	Processing,	Processing,	Processing		Processing
Incremental	Processing	Room	Car Cleaning	Freight Handling	Meals,	Distribution		
Sales		Cleaning		Gas	Supplies	Channel		
<b>Bookings Taken</b>	Yes	Yes	Yes	Yes, but often	Yes, for	Yes	Not usually	Yes
in Advance	(up to a year)			close to	elective			
				departure	procedures			
Demand								
Forecasting								
Cycles:	Yes	Yes	Yes	Yes	?	Yes	Yes	Yes
Seasonal	Yes	Yes	Yes	Yes	?	Yes	Yes	Yes
Day-of-Week	Yes	Not usually	Sometimes	Sometimes	?	Yes	Yes	Yes
Time-of-Dav	-	-	-	-	?	Popularity of	-	
Other						show		

# SOME INDUSTRIES THAT MEET CRITERIA FOR APPLICATION OF REVENUE MANAGEMENT

REVENUE	RETAIL	PASSENGER	ELECTRIC			
MANAGEMENT		RAILROAD	POWER			
CRITERION		MILAOID	I O WER			
	Ctone /Domo growhi	Low Fores on	Driving Deals			
Market	Store/Demographi	Low Fares on	Pricing Peak			
Segmentation	c based market	Price Sensitive	versus Non-			
	segmentation,	Segments,	Peak Hours,			
	multiple stores in	Fare	Peak versus			
	multiple locations	Restrictions	Non-peak			
		and Discount	Seasons,			
		Allocations,	Residential			
		Optimizing	versus			
		Mix of Short	Commercial			
		versus Long	versus			
		Haul	Industrial			
			Customers			
Unit of Fixed	SKU	Maximizing	Central Plant			
Capacity		Profit by	or Distributed			
		Optimal	Generation			
		Capacity				
		Utilization				
Unit of	Maximizing	Seat/Track	Lost Energy			
Perishable	Supplier Deals	Network				
Inventory	with Distribution	Oriented				
	and Clearance	Traffic Mix				
	Optimization	Optimization				
Low Marginal	Base Price	Order	Pricing based			
Costs for	Optimization,	Processing	on Demand &			
Incremental	Promotion	U	Supply, Load			
Sales	Optimization,		and			
Salos	Clearance		Distribution			
	Optimization and		Management			
	Category		Ũ			
	Management					

REVENUE MANAGEMENT CRITERION Bookings Taken in Advance	<b>RETAIL</b> Not usually	PASSENGER RAILROAD Yes but usually with very Short Booking Lead Times	ELECTRIC POWER UTILITIES Energy Storage			
Demand Forecasting Cycles: Seasonal Day-of-Week Time-of-Day Other	Yes Yes Yes Store Based and Cross Shopping Patterns	Yes Yes Yes Network Oriented Traffic Mix Forecasting and Optimization	Yes Yes Yes Yes Balancing of Demand and Supply			

# HOW DOES IT WORK?

#### MARKET SEGMENT PRICING

The first step in a revenue management program is to define the various segments of the market for your service. Then you can design ways in which you can charge different prices to the different market segments, a practice which economists refer to as economic price discrimination. The objective is to expand your market and increase your revenue potential by charging higher prices to those market segments which are not responsive to changes in price leve<sup>3</sup> and lower prices to those market segments which will respond to a price reduction by increasing their purchases by a large enough amount to more than offset the revenue reduction occasioned by the discount<sup>4</sup>.

In the travel industries, the business travel segment of the market is less sensitive to price levels than the leisure segment. Service providers offer discounts to the leisure segment of the market. Business travelers are largely precluded from taking advantage of these discounts through the imposition of advance purchase and length-of-stay requirements. Travel companies know that these restrictions do not suit normal business travel characteristics<sup>5</sup>.

CHARACTERISTICS	BUSINESS TRAVEL	LEISURE TRAVEL		
Advance Booking	Booked close to departure.	Booked well in advance of		
		departure.		
Stay at Destination	Rarely includes a weekend.	Usually includes a weekend.		

Obviously these types of devices will not work in other service industries; however, it is likely that there is some way, often more direct, to segment the market in most industries:

INDUSTRY	METHOD OF MARKET SEGMENTATION
Freight Transportation	Vary rates by commodity being shipped.
Health Care	Time sensitive care vs. postponable care.
Broadcasting	Guaranteed spots vs. preemptable spots vs. rotatable spots.
Utilities	Urgent, non-discretionary service vs. non-urgent, interruptible
	service.

<sup>&</sup>lt;sup>3</sup>Economists refer to these people as being price inelastic.

**<sup>4</sup>**Economists refer to these people as being price elastic.

 $<sup>^{5}</sup>$ These restrictions are not foolproof and other restrictions, e.g., family travel, night time travel, cancellation penalties, are also used.

The reduced price offered to the price sensitive segment of the market may also be associated with the grade or class of service or reduced cost of delivering the service, but this is not necessary when employing market segment pricing.

#### PEAK/OFF-PEAK PRICING

Quite often, a time element is added to the pricing of a service. Demand for a service is managed by raising prices during periods of peak demand and discounting prices during periods of slack demand<sup>6</sup>. Some examples of this in various industries include:

INDUSTRY	TYPE OF DISCOUNT
Air Travel	Night Coach fares.
Car Rental/Hotel	Weekend discounts in major cities (not resorts).
Telephone Companies	Reduced long distance rates on nights and weekends.
Theaters	Discounted Matinees.
Golf	Discounted off peak tee times.

Peak/Off-Peak Pricing is complimentary to other revenue management techniques that will be discussed in later sections. There are often practical limitations on the application of peak/off-peak pricing which are posed by the limited ability of service consumers to digest rate schedule complexity. These limitations do not seem to be as severe for the forms of revenue management that employ inventory rationing, which we will discuss next. Advanced revenue management techniques such as those designed by IDeaS can provide precise feedback for the fine-tuning of peak/off-peak pricing strategies.

#### FORECASTING DEMAND

Once the market has been segmented and the initial rate structure has been put into place, the other elements of revenue management come into play. The first of these is the Demand Forecasting process.

In most service industries, demand for the product exhibits one or more regular patterns – either cyclic in nature (such as time-of-day, day-of-week or season-of-year), or trends (growth in demand due to growth in the economy at large), which can be projected forward in order to estimate future demand in each market segment. The forecasts that can be produced by analyzing these patterns are seldom precise.

<sup>&</sup>lt;sup>6</sup>Economists refer to this practice as Peak Load Pricing.

The most that one can usually say is that we are 99% confident that the demand for the service on a particular future day and/or time will be "50" plus or minus "25" percent. Or that we feel that there is an "80" percent probability that demand will be at least "40."

It is this uncertainty about the future demand for the service that gives revenue management its revenue advantage and makes it a challenge. It is the management of this uncertainty that is the essence of revenue management. The uncertainty is managed by:

- Minimizing the uncertainty by producing the best possible forecast of demand and its degree of unpredictable variation.
- Acknowledging the uncertainty and reflecting it in the decision analysis process. When we make decisions about pricing our service as if we could know with certainty that we will be offered a specific level of demand when, in fact, there is only some probability that it may materialize, we make many bad decisions which, over time, are sure to cost us money.

#### INVENTORY ALLOCATION BASICS

The objective of revenue management is to allocate inventory among price levels/market segments to maximize total expected revenue or profits in the face of uncertain levels of demand for your service.

If we reserve a unit of capacity (an airline seat or a hotel room or 30 seconds of television advertising time) for the exclusive use of a potential customer who has a 70 percent probability of wanting it and is in a market segment with a price of \$100 per unit, then the expected revenue for that unit is \$70 (\$100 x 70%). Faced with this situation 10 times, we would expect that 7 times the customer would appear and pay us \$100 and 3 times he would fail to materialize and we would get nothing. We would collect a total of \$700 for the 10 units of capacity or an average of \$70 per unit.

Suppose another customer appeared and offered us \$60 for the unit, in cash, on the spot. Should we accept his offer? No, because as long as we are able to keep a long-term perspective, we know that a 100 percent probability of getting \$60 gives us expected revenue of only \$60. Over 10 occurrences we would only get \$600 following the "bird in the hand" strategy.

Now, what if instead the customer in front of us was offering \$80 cash for the unit. Is this offer acceptable to us? Yes; because his expected revenue (100% x \$80 = \$80) is greater than that of the

potential passenger "in the bush". Over 10 occurrences, we would get \$800 in this situation or \$80 per unit.

If the person offers exactly \$70 cash we would be indifferent about selling him the unit because the expected revenue from him is equal to that of the potential customer (100% x \$70 = 70% x \$100 = \$70). The bottom line is that \$70 is the lowest price that we should accept from a customer standing in front of us. If someone offers us more than \$70, we sell, otherwise we do not. This is one of the key concepts of Revenue Management.

We should never sell a unit of capacity for less than we expect to receive for it from another customer, but if we can get more for it, the extra revenue goes right to the bottom line.

What would have happened in this case if we had incorrectly assumed that we "knew" with certainty that the potential \$100 customer would show up (after all, he usually does!). We would have turned away the guy who was willing to pay us \$80 per unit and at the end of 10 occurrences, we would have \$700 instead of \$800.

Thus we can see that by either ignoring uncertainty and assuming that what usually happens will always happen, or by always taking "the bird in the hand" because we are afraid to acknowledge and manage everyday risk and uncertainty as a normal part of doing business, we lose money.

#### ESTIMATING EXPECTED REVENUE

Obviously, the key to effective revenue management is the accurate estimation of the expected revenue of each unit of capacity for each available sale date. How is this number calculated?

One of the key principles of revenue management is that as the level of available capacity increases, the marginal expected revenue from each additional unit of capacity declines. If you offer only one unit of capacity for sale the probability of selling it is very high and it is very unlikely that you will have to offer a discount in order to sell it. Thus, the expected revenue estimate for that first unit will be quite high. However, with each additional unit of capacity that you offer for sale, the probability that it will be sold to a customer goes down a little (and the pressure to discount it goes up) until you reach the point where you are offering so much capacity that the probability of selling the last additional unit is close to zero, even if you practically give it away. At this point the expected revenue estimate for that seat is close to zero (\$0

 $x \ 0\% = \$0$ ). Economists call this phenomenon the Expected Marginal Revenue Curve, which looks something like this:



The exact shape of the curve is determined from the probabilities of achieving each level of demand (which is estimated in the forecasting process) and the rate structure<sup>7</sup>.

Note that EMR values can also be interpreted as the "Opportunity Costs" of the marginal units of inventory. They represent the alternative revenue opportunities that are foregone when we sell the marginal unit of inventory. It may be useful to think of the EMR value in these terms as you read the next sections.

#### APPLYING THE EXPECTED MARGINAL REVENUE PRINCIPAL

Once the EMR curve has been calculated for all of the available units of capacity offered for sale together (e.g., all of the seats on one airline flight, all of the rooms available for rent at a hotel for one night, or all of the advertising minutes available on one episode of a television show), the information stored in the curve can be used in one of two different ways.

The first way is to use the curve to ration units of capacity between market segments/rate classes. In this method, which has historically been used in the Airline industry; the EMR curve is employed as follows.

Units of capacity (e.g., seats) are reserved incrementally for customers in the highest rate class, one at a time, until the Expected Marginal Revenue for the next unit, if reserved for a customer in this rate category, is equal to or less than the next lower rate. Going back to our earlier example, if the full rate is

<sup>&</sup>lt;sup>7</sup>The EMR concept has been popularized by Dr. Peter Belobaba of MIT. See his paper "Airline Travel Demand and Airline Seat Inventory Management," <u>Flight Transportation Laboratory Report R87-7</u>, MIT, May, 1987.

\$100 and our discount rate is \$70, we would continue to reserve units for the exclusive use of customers in the \$100 rate class until the probability of selling one more unit to such customers dropped to 70 percent. If that point was reached after reserving 10 units for the exclusive use of customers in the \$100 rate class, we would say that the "protection level" for the first rate class was 10 units. The remaining units could be sold to customers in either rate class on a first come first served basis. In essence, with this approach you start on the left end of the EMR curve and move down to the right, reserving seats until you reach the point of indifference.



This is the typical way airlines currently determine discount seat allotments.

The second more direct and preferable way to apply the EMR principle to revenue management is a new approach championed by IDeaS and referred to as the "Bid Price" approach<sup>8</sup>. In the Bid Price approach, the EMR value of the last (marginal) unit of capacity is applied directly to define the lowest acceptable price (the Bid Price) for the next unit to be sold. As long as the rate requested is above the EMR Bid Price, the sale is permitted. Each time a unit is sold the number of available units shrinks by one and the EMR increases. In essence, you start at the right end of the EMR curve and move up and to the left, selling units at discount and shrinking the amount of capacity remaining available until the EMR for the remaining units of capacity reaches the point of indifference. At that point, you would stop selling units at the discount rate.

 $<sup>^{8}</sup>$ Other names for the Bid Price approach include: Shadow Price approach, Value Based Revenue Management, and the Continuous Nesting approach.



In our simple example, the result would be the same under either the rationing or Bid Price approach. You will end up selling the same number of Full Rate and Discount Rate units under either approach and the resulting revenue will be identical. The Bid Price approach is preferable because the complexities of real life revenue management situations can be much more simply, directly and intuitively incorporated into practical revenue management systems under the Bid Price approach<sup>9</sup>.

These examples have been oversimplified in order to illustrate a single principle. They would only be literally true for a very limited scenario in which there were only two fare classes and all of the discount booking requests were tendered first and in a single transaction. In the real world, there are usually several fare classes and bookings in each class come in gradually over time. There are frequent opportunities to reforecast demand and recalculate EMR values. At each such revision point, what is forecast is the remaining orders to come, and the relevant inventory for which EMR values are recalculated is the inventory which remains available for sale. Past orders and inventory that has already been ordered are irrelevant<sup>10</sup>. In general, more frequent revisions result in greater revenue (though there is a point of diminishing returns).

#### RATE MANAGEMENT

#### PRICING

When rate structures are flexible, the EMR values produced by the revenue management model itself can provide invaluable feedback to the rate setting process itself.

**<sup>9</sup>**The use of the Rationing approach in the Travel industry is a historical accident that will be corrected over the next several years.

<sup>10</sup> Unless one has reason to believe that there is some correlation between orders on hand and orders to come.

When EMR values are consistently higher than your published rates, it is a clear sign that your rates are too low and should be raised to at least the EMR value. The implementation of your revenue management program should prevent the sale of units at these uneconomic rates anyway, but why risk alienating your customers by posting a price that is never available?

As long as discount pricing can be successfully limited to truly price sensitive market segments, price reductions which move a rate downward towards a low EMR will result in increased revenue. Where high price sensitivity can be combined with the flexibility to pursue involved peak/off-peak pricing strategies with numerous variations in prices by time period, revenues will be maximized by setting prices right at the level of the EMR.

In the most extreme case where prices can be set on the spot rather than being pre-set in a rate schedule, the EMR value would tell your firm's negotiator what the lowest acceptable price would be for a particular unit of inventory at that point in time.

Several operators in the travel distribution channel are attempting to establish a shadow market in airline seats wherein potential customers would submit bid solicitations to be carried from one city to another within a given time frame. The customer would submit a proposed price with his request and participating carriers would decide to accept or reject the bid by comparing it to the EMR values on qualifying flights. The first airline to accept the bid would get the booking.

#### **CONTRACT/PROMOTION EVALUATION**

The EMR values produced by the Revenue Management system are also an essential ingredient in the proper evaluation of corporate contracts and other marketing promotions. Each time a unit is sold pursuant to a corporate contract or other marketing promotion, record both the EMR value of the unit that was sold and the actual revenue received from the sale. The difference represents the "economic profit" derived from the sale – the difference between the opportunity cost of the unit and the actual revenue received. If you then sum these "profits" (or losses) for all of the bookings made pursuant to a particular contract (or program) you'll know at the end whether or not the contract or program generated more revenue than it displaced from other existing sources of business. If it did not, then clearly the contract or program cannot have been profitable, even if one assumes that in the absence of the contract, all of that customer's business would be lost to a competitor.

Sometimes competitive pressures will force you to enter into a contract in which the customer is guaranteed access to any available seats regardless of discount availability. While these "last unit availability agreements" erode the effectiveness of a revenue management program and should be avoided if at all possible, there are ways to minimize their damage if you're stuck with them or if they were put in place to generate other revenue streams or business reason. Similarly sometimes service providers offer guaranteed availability that again is not a good yield management practice. If you must offer guaranteed availability, you can minimize the damage as follows: Forecast the demand for seats pursuant to these contracts and remove an equivalent amount of available seats from inventory before valuing the remaining capacity and establishing allocations or bid prices. In essence, you remove this class of demand from the equation and optimize the remainder. Contracts with a last unit availability clause are much less likely to turn an economic profit than "capacity controlled" contracts.

The second key question which needs to be answered in order to judge the success of a contract or program is: Did the contract or program generate enough new customers at the reduced price to more than offset the discount offered and result in more total net revenue than before, considering the additional cost of conducting the program and servicing the extra customers. The answer to this question is usually found by statistical analysis or passenger surveys.

A contract or program cannot be judged a success unless *both* of these calculations have a positive result.

A sample "Contract/Program Effectiveness Statement" follows which describes one possible structured framework for answering these questions. In the statement, your "Baseline" figures represent your best estimate of what would happen without the contract or program while your "Actual" represents your actual experience with the contract or program. (A pro-forma statement could be produced before the contract or program became effective in order to evaluate program profitability under various scenarios.)

The sample statement illustrates a program that generated an increase in gross revenue, but was unprofitable nonetheless once increases in both cash and opportunity costs were taken into account.

# SAMPLE CONTRACT/PROGRAM EFFECTIVENESS STATEMENT

BASELINE	PER CUSTOMER	TOTAL
Customers		5,000
Customer Revenue	\$300	\$1,500,000
Opportunity Costs (EMR Values)	\$100	\$500,000
Revenue Related Costs 11	\$24 (8%)	\$120,000
Customer Related Costs <sup>12</sup>	\$10	\$50,000
Program Related Costs (promotion, administration)	-	-
NET PROFIT	\$166	\$830,000

ACTUAL	PER CUSTOMER	TOTAL
Customers		8,000
Customer Revenue	\$200	\$1,600,000
Opportunity Costs (EMR Values)	\$100	\$800,000
Revenue Related Costs	\$16 (8%)	\$128,000
Customer Related Cost	\$10	\$80,000
Program Related Costs (promotion, administration)	\$5	\$40,000
NET PROFIT	\$69	\$552,000

CHANGE	PER CUSTOMER	TOTAL
Customers		3,000
Customer Revenue	(\$100)	\$100,000
Opportunity Costs (EMR Values)	n.c.	\$300,000
Revenue Related Costs	(\$8)	\$8,000
Customer Related Cost	n.c.	\$30,000
Program Related Costs (promotion, administration)	\$5	\$40,000
NET PROFIT	(\$97)	(\$278,000)

<sup>11&</sup>lt;sub>Distributor</sub> commissions, credit card fees, etc..

<sup>12&</sup>lt;sub>Supplies</sub>, liability insurance, fuel, customer processing, etc.

#### **COMMON COMPLICATING FACTORS**

Of course, the real world is never as "tidy" as the world inhabited by theoreticians, and the real world of revenue management is no exception. There are a number of practical complexities that overlay the basic framework that must be solved before a revenue management program can be successfully instituted. Many of these issues have parallels in most, or all, of the service industries susceptible to the practice of revenue management. The solutions to these common problems can be modeled in a similar fashion in each industry.

#### NETWORK EFFECTS

Sometimes it is necessary to jointly consume more than one unit of inventory in order to provide the desired service. For example, in order to route a telephone call from Milwaukee to Los Angeles, time may be consumed on one cable running from Milwaukee to Minneapolis and simultaneously consumed on a second cable running from Minneapolis to Los Angeles. The capacity available on each cable can alternatively be used to help satisfy demand in a number of other city pairs (e.g., Milwaukee-Seattle or Los Angeles-Duluth) and possibly in other rate classes in combination with other cables (the Minneapolis-Seattle and Minneapolis-Duluth cables). In addition, it may be possible to route Milwaukee-Los Angeles calls via Chicago or via a satellite circling the earth.

These "network effects" exist in one form or another in almost all of the revenue management target industries, and they greatly complicate the task of finding the true EMR value of the marginal unit of inventory in each of them.

Network effects are obvious in the transportation and communications industries where the existence of transfer hubs is common. In the above example you could substitute the word "flight" for the word "cable" and you would have a clear description of the same phenomenon in the Airline industry.





However, analogous "networks" also exist in the other target industries as well. When a Hotel or Car Rental customer requests a room or a car for three days/nights starting Monday, the room/car he uses on Monday could have been sold to other customers requesting to occupy the unit for any combination of days from one day to two (or more) weeks and in any number of rate classes.



Let us take a simple Hotel industry example to illustrate this aspect of the revenue management equation. Consider a typical hotel catering to business travelers in a major city. As is common for such a hotel, it's down to its last two rooms for this coming Monday and Tuesday, but there are plenty of rooms available the rest of the week.

Four customers arrive at the front desk simultaneously to request a booking. *Customer A* needs a room for Monday night and would pay the full rate of \$100 per night. *Customer B* needs a room for Tuesday night and would also pay the full rate. *Customer C* wants a room both Monday and Tuesday and qualifies for a two-day package rate of \$150 (\$75 per night). *Customer D* would stay all week and pay the weekly rate of \$350 (\$50 per night).

Which combination of bookings should be accepted to produce the highest revenue? The answer is: Customers A, B and D, which would produce a total revenue of \$550 dollars. Can you find a better combination? Can you figure out a rule that could be used to find the right combination? Can you imagine trying to find the best solution for an airline hub network where 40 arriving flights connecting to 40 departing flights create 1,600 different city pair combinations, each of which may have 10 fare classes for a total of 16,000 possible city pair/class combinations to evaluate?

Believe it or not, there are rules and it is possible to solve this problem (*IDeaS has done it*). A couple of simple rules: To the extent that you can sell an equal number of single, full rate units on all parts of your "network," you should generally do so. To the extent that demand for single full rate units is unbalanced across the network you are generally better off making discounted multi-unit sales instead. These rules assume that the multi-unit rate is greater than the single unit rate in absolute terms, but less in rate per unit terms.

For example, to the extent that a flight from Milwaukee to Minneapolis to Los Angeles can be filled with full fare passengers traveling from Milwaukee to Minneapolis for \$200 and from Minneapolis to Los

Angeles for \$400 (total = \$600), you should do so rather than accepting Milwaukee-Los Angeles passengers for \$500.

However, to the extent that Minneapolis-Los Angeles demand (\$400) exceeds Milwaukee-Minneapolis demand, the excess should be turned away to accommodate Milwaukee-Los Angeles passengers (\$500) instead.



If total demand exceeds supply on the Minneapolis-Los Angeles leg of the flight but not on the Milwaukee-Minneapolis leg, then higher revenue will be produced by allocating scarce Minneapolis-Los Angeles seats to \$500 Milwaukee-Los Angeles passengers.

If total demand exceeds supply on both legs of the fight, then higher revenue will be produced by allotting seats to a combination of Milwaukee-Minneapolis and Minneapolis-Los Angeles passengers (\$200 + \$400 =\$600) and denying seats to \$500 Milwaukee-Los Angeles customers.

The mathematics involved in finding networked revenue management solutions is extremely challenging. This is the current "frontier" in airline revenue management research. The problem bears a superficial resemblance to other transportation logistics problems that are commonly solved **u**ing traditional linear programming techniques. However, the revenue management problem is essentially statistical in nature because of the necessity of working with probabilities (not certainties) of achieving different levels of demand for your service, and the traditional linear programming models are incapable of incorporating uncertainty. Hybrid statistical linear programming models that have been developed require too much computer power to be practical or cost effective in everyday commercial use.

IDeaS has discovered a unique new type of mathematical formula for solving networked revenue management problems. With the IDeaS method, even large airline networks can be optimized using desktop computer hardware.

The IDeaS approach produces a Network EMR value for each unit of capacity. In the "Bid Price" approach to revenue management the Network EMR represents the lowest price at which the next unit of inventory should be sold, either alone or in combination with other units of inventory.

In our earlier Hotel example, the Network EMR value for the last rooms on both Monday and Tuesday would be \$100. It would be close to zero on the other days that never fill up. These "Bid Prices" would cause you to accept each of the single day Customers A and B since their \$100 rate is equal to the \$100 Bid Price; reject Customer C because his \$150 two day rate is less than the combination of Monday's and Tuesday's Bid Prices (\$100 + \$100 = \$200); and accept Customer D because his \$350 weekly rate exceeds the sum of the week's Bid Prices (\$100 + \$100 + \$0 + \$0 ... = \$200). As we said earlier, this is the correct choice of bookings to accept. It turns out that for every network, no matter how large or complicated, there is a unique set of Network EMR values, which, if applied as Bid Prices, will cause you to accept the unique set of customers that will revenue you the most revenue. The IDeaS software will find these Network EMR values for your networked revenue management problem.

The IDeaS software can also be used to determine discrete inventory allotments for use in an inventory "rationing" revenue management approach, but in most cases the output is much more difficult, if not totally impractical, to successfully implement. Each network combination (e.g., an airline city pair/fare class/flight itinerary combination or a hotel day of arrival/length of stay/rate class combination) requires its own discrete inventory allotment. In the airline example, the resulting unit allotment for a city pair/fare class/itinerary combination with a low demand forecast may be one unit (or less, which is impossible to implement). What happens if the next several booking requests for this combination are all for parties of two?

If you move to group the many small allotments,  $\alpha$  "nest" the lower revenue inventory allotments within the higher revenue allotments to make the output more manageable, the resulting compromise solution may produce less revenue than the uncompromised Bid Price solution.

#### MULTIPLE UNIT ORDERS

Not all order requests are for single units of inventory. In the travel industries, booking requests may be tendered for individuals, couples, families, or entire busloads of tourists. In order to evaluate an order for multiple units of inventory you should calculate and sum the EMRs for the next "N" marginal units of inventory, where N is the number of units requested. If the sum of the revenue you would receive from the order request exceeds this amount, you should accept the order.

In the Bid Price control approach this is exactly what you would actually do. You would either a) precalculate and store the next several EMR values for future use, or b) precalculate a simple formula that would allow you to closely estimate the next several EMR values<sup>13</sup>.

In the inventory rationing approach your rate class order limits are precalculated. However, a problem comes in when, for example, your order limit is three units and the next order request is for four units. The finite order limit may be precluding you from accepting an order that, on closer analysis, you find you should take.

When a significant proportion of the total demand comes in the form of large clumps which are tendered on an irregular basis, like airline tour groups, it can also make the demand forecasting problem much more difficult.

#### MARGINAL COST CONSIDERATIONS

In most of the target service industries for revenue management, the marginal out-of-pocket cost of accommodating an additional customer using existing inventory is quite small. However, in some cases, such as travel agency commissions in the travel industries, it is important enough to incorporate into the model. It is handled quite simply by deducting these expenses from the gross revenue received from the customer and using the remaining net revenue per customer as the rate level input to the inventory allocation process.

In international markets commission expenses and net revenue after currency conversion may vary widely depending on the source of the order. These variations should also be factored into the evaluation process in the same manner.

#### ANCILLARY REVENUE AND PROFIT CONSIDERATIONS

Sometimes the opposite is true, that is to say that sometimes the acceptance of a customer booking for the basic service may result in additional revenues being indirectly generated to the firm, such as from the sale of meals, drinks, tickets and tee times to hotel customers. The expected profit per customer (*price of product – cost of product x probability of purchase*) from ancillary services should be added to the net revenue per customer used as the rate level input to the inventory allocation process. Sometimes the level

<sup>&</sup>lt;sup>13</sup>Essentially, the derivative of the EMR value.

of expected ancillary profit varies by customer market segment. For example, persons attending a meeting at the hotel are more likely to take their meals there than are independent vacation travelers.

#### **REFLECTING SUBJECTIVE VALUE**

A revenue management system should have some mechanism that allows the revenue manager to explicitly evaluate subjective or 'difficult to quantify' considerations in an informed manner in reaching decisions about when to sell or not sell a unit of inventory. Suppose the system is flashing a "don't sell" signal but the manager knows that this is an important client whose continued goodwill is worth a considerable amount of money down the road? To account for these cases the system should be designed to quantify the immediate negative revenue implications of accepting the sale so that it can be balanced against future revenue considerations. For example, if the system can tell the revenue manager that accepting this sale will cause an expected revenue loss of \$200 (the price requested is \$300 while the EMR for the requested unit of inventory is \$500) the manager is now in a much better position to make an informed decision. (Is this customer's good will worth at least \$200 in future sales?)

You would follow up on this decision by tracking the customer's future purchases. Ideally, you would want to capture the EMR value associated with each sale and compare it to the revenue actually received from the sale. The higher the cumulative "profit" (actual revenue less the EMR value of the inventory consumed) the more valuable the customer. In this manner you may find that you have lower volume customers that pay high prices for low value inventory that are adding much more to your bottom line than are other high volume customers that always pay low prices for high value inventory.

A firm could also measure the total revenue displacement occasioned by the use of free frequent customer vouchers in this manner and thereby conduct a much more rigorous evaluation of the economics of their frequent customer program. The "profits" from the qualifying purchases that were made to earn the award could be balanced against this "loss".

#### MULTIPLE RATE CATEGORIES

The examples used to introduce the EMR principle in earlier sections were oversimplified for purposes of illustration. When there are more than two rate classifications (it is common to have *many* more in the Travel industry) the calculation of the correct EMR value becomes considerably more complex. Published mathematical formulas, which correctly calculate the EMR value when there are multiple rate classes require too much computer processing power to be of practical use. However, IDeaS has developed a

proprietary formula for determining the correct EMR value that is efficient enough to run on desktop computers.

#### MULTIPLE PRODUCT CATEGORIES

In many cases in the target industries there may be multiple quality levels to the basic service product offering. Examples include First Class and Coach air travel, concierge, and standard floors in hotels, the various classes of rental cars, private vs. semi-private rooms in hospitals, etc. While demand should be forecast and inventory allocations produced for each product line, it is necessary to recognize that in some circumstances it is possible to substitute one product line for another by "upgrading" the customer from an inferior product line to a superior one at no extra charge.

It will sometimes be the case that forecast demand for the superior product category is so low that the EMR value for the marginal units in the category will fall to a level below the EMR value for the marginal inventory units in an inferior product category with high forecasted demand. For example, there may only be a 25 percent probability that anyone will rent the last Cadillac for \$100 per day (EMR = \$25) while there is a 75 percent probability that someone will want the last Chevrolet at \$60 per day (EMR = \$45). When this is the case, inventory units in the superior category should be artificially transferred to the inferior category (i.e., pretend that Cadillac's are Chevrolets) until the EMR value of the last unit to be transferred is the same whether it is sold as a superior class unit or an inferior class unit. Customers are unlikely to mind if the Chevrolet they reserved turns out to be a Cadillac.

If the firm is willing to accept the associated customer ill will, it can apply the same concept in reverse and occasionally downgrade a customer against his will. If this practice is to be pursued, the expected "cost" of ill will should be factored into the equation.

The astute reader will have observed that, in this case, the revenue management system is providing important feedback to the capacity planner. If the system consistently turns Cadillac's into Chevrolets (figuratively), it is telling the fleet buyer that the next time he buys cars, he should buy fewer Cadillac's and more Chevrolets.

#### ABILITY TO FINE TUNE CAPACITY

While we earlier noted that the inability to adjust capacity in the immediate term is a common characteristic of the revenue management target industries, in several of them it is possible to at least fine tune capacity over a slightly longer planning horizon. The assignment of aircraft to flights in an airline

schedule can be juggled, cars can be shifted from one rental location to another, and trucks, ships, and rail cars can be moved around, all without changing the firm's overall level of productive capacity. In certain hotel environments that also offer timeshare it is possible to fine tune capacity.

To the extent that it is practical to shift capacity in this manner, the guiding principle is this: Shift inventory from low EMR locations to higher EMR locations until EMR values are equalized for all locations, taking into account any marginal out of pocket expenses involved in shifting the capacity. As long as the EMR value for this unit at location B exceeds its EMR value at location A over some period of time by more than the cost of moving it from A to B, you should make this move<sup>14</sup>. Airlines are currently evaluating a concept known as "Demand Driven Dispatch". In this concept the airline would generically schedule a set of roundtrip flights departing and returning to a hub city at about the same time to be operated with "737" equipment. As the day of departure approached and the level of demand for each flight became more certain, a specific model of 737<sup>15</sup> would be assigned to each flight in the set so as to equalize the EMR values of each flight.

Over an even longer planning horizon it is possible to buy and sell incremental units of production in these industries in order to further fine-tune the level of available inventory. The guiding principle is this: You should buy more (or larger) units of capacity as long as the (sum of) EMR value(s) of the incremental units of inventory that can be produced exceeds the marginal cost of operating the additional (or larger) capacity by an amount sufficient to warrant the capital investment.

For example, the fleet buyer should continue to buy Chevrolets for a location as long as the EMR value for one more Chevrolet exceeds the cost of servicing the car by an amount equal to the net capital cost of the car after resale over its expected service life with the firm.

It is common for capacity planners in these industries to base their capital investment decisions on easily calculated average revenue values per customer and simple rules of thumb about the amount of demand that is turned away at varying levels of capacity utilization at the company level. By providing the capacity planner with an accurate source of information about the marginal revenue contribution of incremental units of capacity, the revenue management system can provide a side benefit of enormous value in these capital-intensive industries. The untapped value of the potential improvements in the quality of capital

 $<sup>{14}{\</sup>rm In}$  practice, there are usually numerous practical constraints which must be accounted for when contemplating such shifts.

<sup>15</sup>A 110 seat 737-500, a 130 seat 737-300 or a 150 seat 737-400. 737 flight crews are qualified to fly any model, so their schedules can be set earlier.

investment planning and capacity level planning that the revenue management perspective can provide may be greater than the direct value of revenue management itself.

#### SELL-UP POTENTIAL

There is usually some probability that a customer, when denied a booking at a lower rate class, will agree to buy the requested service at the applicable rate for a higher rate class. For example, if the "ultra saver" airfare of \$200 is "sold out," he may be willing to buy the \$250 "super saver" airfare in order to ride on the flight of his choice. This possibility also needs to be factored into the EMR formula. To do this one need merely to reflect the fact that the expected revenue from a turned away potential "ultra saver" passenger isn't zero, it's the \$250 "super saver" rate times the probability that he will opt to pay that higher fare. Sales process can be developed to proactively steer demand .

To see how this affects the inventory allocation process, let us take the example of a hypothetical airline flight with very low demand such that the EMR value for the marginal seats on this flight is near zero. The only decision facing the revenue manager for this flight is "should we go for the \$200 'bird in the hand' from this customer or should we try for the \$250 'bird in the bush.'" The decision the revenue manager makes will depend on his perception of the probability that the customer will accept the \$250 rate instead of booking with another airline. In order to go for the \$250 bird in the bush he has to believe that there is at least an 80 percent probability that the customer will accept the higher rate because: \$250 x 80% = \$200 x 100% = \$200. Since the actual probability of successful "sell up" is unlikely to be anywhere near 80 percent for an Airline industry discount fare shopper, the best course of action for the revenue manager will be to accept the customer at the lower \$200 rate.

In the above example, the application of sell up rates is simple and straightforward. Let us consider a slightly more complicated case where sell up potential tips the balance in a marginal situation. In this example, there is one unit of inventory remaining available for sale. There is a 40 percent probability that a \$100 full rate customer will ultimately order this last unit. There is a customer standing in front of you who is willing to buy it right now for \$50, however, there is also a 25 percent probability that he will pay the full \$100 rate if you tell him that he can't buy it for \$50. Should you sell him the unit for \$50? If you do you will get an expected revenue of \$50 ( $100\% \times $50 = $50$ ). If you do not your expected revenue will be \$65 ( $40\% \times $100 = $40$  from the potential future customer, *plus 25% x \$100 = \$25* from the guy standing in front of you) so you should *not* sell the unit for \$50.

In the early years of airline revenue management it was widely misperceived that the primary revenue benefit from the application of revenue management would come from mining "sell up" potential through bait and switch sales tactics. However, early attempts to practice this strategy were such dismal financial failures that the consideration of sell up potential was quickly put into its proper perspective. Suppose that in the first example the actual probability of successful sell up was a more realistic 40 percent (half the "breakeven" rate). If this was the case, he would *lose* an average of \$100 per prospective passenger each time he held out for the higher fare because  $$250 \times 40\% = $100$  while  $$200 \times 100\% = $200$ .

The over optimistic assessment of sell up potential is one of the greatest potential dangers in a revenue management program. The overzealous application of bait and switch strategies can result in a revenue management program that *loses* money for the firm. In a properly designed revenue management program, the appropriate reflection of sell up potential in the system has a relatively minor impact on inventory allocations and bottom line revenue.

Most people are surprised to learn that the proper application of revenue management often results in significantly higher sales and revenue per unit of capacity, but *lower* revenue per customer.

#### SPILL RECAPTURE POTENTIAL

In several target industries there will be some probability that a customer, when denied a booking in his requested rate category at his preferred time, will choose to purchase the same product in the requested rate category from your firm but at a different time period. For example, an airline customer who is unable to secure a booking at the super saver rate on the 5 PM flight may elect to book at the super saver rate on the 7 PM flight as his second choice. We say that this customer has been "spilled" from the 5 PM flight to the 7 PM flight. The probability that this may occur has an impact on the inventory allocation process that is similar to that of the sell up concept and is handled in a similar manner in the valuation model.

#### **OVERBOOKING**

The travel industries in particular are plagued by the problem of "no-shows" – people who book inventory and then do not show up to use it (or pay for it). The attachment of cancellation penalties to airline discount fares and the spread of "guaranteed reservations" programs in the Hotel industry are attempts to mitigate this problem which have met with some success.

To compensate for no-shows, travel firms "overbook" their capacity, trading off the possibility of empty units if they don't overbook enough against the ill will and out-of-pocket compensation to customers that occurs when customers are "bumped" (airlines) or "walked" (hotels).

This tradeoff should be considered in the following manner. First, the probabilities of incurring various noshow rates must be forecasted in much the same manner that demand is forecasted. In the Travel industry, no-show rates often vary by rate class/market segment and time period. The "cost" of failing to honor a customer's booking, including both out of pocket costs such as cash compensation to "bumped" airline passengers and a consideration of the potential loss of future revenue from the disgruntled customers, must also be calculated. (Airlines attempt to minimize customer ill will by compensating passengers who voluntarily relinquish their reservations with free tickets.)

With this information the expected oversale cost (probable number of oversales times the total cost per oversale) can be calculated for any level of overbooking above the actual number of inventory units available for sale.

The "correct" level of overbooking is where the expected cost of an oversale for the next unit to be sold is equal to the EMR value for the next unit to be sold. As long as the EMR value is higher than the marginal expected cost of an oversale, it will pay to allow another unit to be sold for at least the EMR value.

# **REVENUE MANAGEMENT CHALLENGES BY INDUSTRY**

<b>INVENTORY</b>	Industry:	HOTELS	CAR RENTAL	FREIGHT	HEALTH CARE	BROAD-	TELEPHONE	GOLF
CHALLENGES	AIRLINES			TATION	CARE	CASIING		
Network Effects	Multiple Flight Itineraries	Multiple Night Stays	Multiple Day Rentals	Multiple Segment Itineraries	Multiple Night Stays	Bundled Program Packages	Multiple Line Routings	Number of holes 9 vs. 18 holes
Marginal Costs	Commissions, Currency Exchange, Meals, Passenger Processing	Commissions, Room Cleaning	Commissions, Car Cleaning	Commissions	Meals, Room Servicing Care			Golf Course Maintenance
Ancillary Revenues	In-flight Sales	Meals, Drinks	Collision Damage Waiver	Insurance	Diagnostic Services F&B			Caddy Club House
Multiple Rates	Numerous Fare Categories	Numerous Published & Negotiated Rates	Numerous Published & Negotiated Rates	Numerous Specific Commodity Rates	Numerous Negotiated Rates	Numerous Negotiated Rates	Several Rate Tariffs	Several Rates Seasonal and Time of Day
Multiple Products	First Class/ Business Class/ Coach	Multiple Room Categories	Multiple Car Size Categories	Multiple Delivery Time Categories (e.g., Overnight vs. 2nd Day)	Private vs. Semi-Private	Program Popularity & Demo-graphics	WATS, Private Lines, etc.	9 vs. 18 holes
Spill Recapture	From One Flight to Another	From One Location in a City to Another	From One Location in a City to Another	To a Later Departure	To a Later Date (Elective)	To Another Show	To an Alternative Line	
Sell Up Potential	Yes	Yes	Yes	Yes	Yes	Yes		
Capacity Fine Tuning	Reassignment of Aircraft Sizes to Flights	No	Reassignment of Cars to Rental Locations	Deadheading Trailers, Boxcars to Alternate Pick Up Points	No	No	No	
No-Shows	Yes	Yes	Yes	Limited	Limited	Limited	Unused minutes	Yes

INVENTORY ALLOCATION CHALLENGES	Industry: AIRLINES	HOTELS	CAR RENTAL	FREIGHT TRANSPOR- TATION	HEALTH CARE	BROAD- CASTING	TELEPHONE	GOLF
Multiple Unit Orders	Yes	Yes	No	Yes	No		No	Yes
Subjective Values	Yes	Yes	Yes	Yes	Yes	Yes		

#### DEMAND FORECASTING CHALLENGES

Good demand forecasting is an essential aspect of revenue management. Improvements in the demand forecasts used as inputs to the inventory allocation process translate directly into increased revenue in the form of higher average rates per customer, without a loss in orders. This is because the more confident you are that a high rate class customer will materialize, the lower the risk entailed in reserving a unit of capacity for him. Consequently, the search for improved forecasting techniques continues to attract a considerable and ongoing level of investment, even among airlines with relatively mature revenue management programs. A demand-forecasting model is unlikely to ever be considered truly "finished".

The demand forecasting process should also be considered the focal point of all human intervention in the revenue management process. While human oversight over the forecasting process is essential, it is often counterproductive in other stages of the process.

A potential side benefit of developing a good demand forecasting capability for revenue management is that the resulting customer volume forecasts can often be put to good use elsewhere in the firm as well. Functions such as supply ordering and staffing can often be more optimally planned with access to the detailed customer forecasts produced by a revenue management system.

Forecasting demand for the revenue management process entails a few unique challenges, which must be addressed in a successful program.

#### ESTIMATING UNCONSTRAINED DEMAND

In order to correctly estimate EMR values it is necessary to know the estimated total demand for the service, not just the observed demand. This is a problem in those industries where the number of rejected orders cannot be directly measured. For example, in the travel industries it is common for services to be sold from an automated display of available inventory. Flights or properties that are already sold out on the requested date do not even make the display. How can we know how many customers would have requested those services had they been available for sale?

In order to illustrate this issue, we will first introduce it in an oversimplified manner. In an ideal world, you would notice that once the cycles and trends in your data are properly adjusted for, the distribution of the level of demand for the service would be randomly clustered around the average level of demand for the

service, with most cases being closer to the average 16. The plot of this distribution would approximate the "familiar bell shaped curve".



However, when the level of observed demand is constrained because of occasional shortages in capacity, the distribution would look more like this:



If the real world problem were this simple, it would be relatively easy to extrapolate an estimate of the true "unconstrained" distribution of demand and its standard deviation using textbook mathematical techniques. Most vendors of revenue management software use such techniques to estimate unconstrained demand in their forecasting models.

However, IDeaS has discovered that the real problem is not this simple. The distributions of demand that we observe in actual leg level airline data are actually combinations of several distributions of Origin, Destination and Fare Class level data. These distributions may have hidden constraints on connecting legs that are not under scrutiny and the constraints may vary as unit allocation/bid prices are adjusted from week to week.

<sup>16</sup> i.e., the level of demand is normally distributed, or some variation such as log normal or gamma.

When these individual distributions of demand are rolled up into a single distribution, the combined distribution may appear to be normal and not constrained although many of the component distributions clearly *are* constrained. Consequently, IDeaS has concluded that the accurate estimation of the mean and standard deviation of the true unconstrained demand cannot be done with out reference to the manner in which the inventory evaluation strategy actually employed would have influenced the observed distribution of bookings. In other worlds, the process of inventory evaluation and unconstrained demand estimation are inextricably linked. We believe that we are the only vendor of revenue management software to address the issue in this manner.

The consequence of failing to properly identify instances of constrained demand in higher revenue classes is that the inventory optimization process will fail to protect adequate inventory for passengers in those revenue classes.

#### **NO-SHOW FORECASTING**

In addition to forecasting bookings, it is also necessary to forecast no-show rates (and standard deviations) in order for the Inventory Optimization model to determine appropriate levels of overbooking.

Like demand forecasts, no-show rates may vary by flight, time-of-day, day-of-week, or season. They are also influenced by variations in the mix of bookings by rate or customer type. In general, speculative bookings made many months in advance tend to exhibit higher no-show rates than bookings made closer tin. No-show rates tend to increase during peak seasons as customers make multiple bookings in order to preserve their options during these periods of scarce supply.

Group bookings tend to exhibit very low no-show rates because they have usually been "firmed" up several times. However, the group firming process, in which the group organizer is called at several "checkpoints" in the booking profile to obtain actual customer names and to obtain the release of inventory, which the group organizer cannot sell, can contribute significantly to the *booking countdown* effect, which is often seen.

Booking Countdown is a phenomenon in which total bookings rise up to a particular point in the booking profile and then decline as the number of new bookings is exceeded by the number of cancellations of existing bookings. In the airline industry this effect is common in long haul, leisure markets with high load factors because both individual passengers and travel distributors tend to book more reservations than they will use in order to preserve their options on flights where seats are scarce. As departure date approaches and their needs become more certain, they cancel the reservations they will not use causing the booking countdown effect.

This effect can be dealt with as if these cancellations represented a kind of advance no-shows in the Inventory Optimization Model, provided that any firming activity which is performed (either group or individual) is consistently performed at the same revision point in the booking profile. A "no-show rate" at each point in the booking profile can then be reliably calculated and used to vary overbooking levels at different points in the profile. It is very important to perform firming very consistently, or not at all. The object of firming is not to reduce the no-show rate. The object of firming is to make the no-show rate more consistent and predictable (i.e., to reduce its standard deviation) so that a more accurate overbooking level can be set, regardless of the expected no-show rate itself. Sporadic firming is actually counterproductive because it makes the no-show rate more unpredictable.

#### ESTIMATING LOW LEVELS OF DEMAND

Very low levels of demand also create difficult forecasting challenges. In some of the target industries like the telephone or airline industries, demand may be "high" in the aggregate but very "low" at the disaggregate level at which it must be forecasted in order to capture any "network effects" that exist. In these industries demand must be forecast by city pair, rate class and time period. At this level of detail the average demand for the service may be one call/passenger per day or less in smaller markets. The degree of random variation in demand will necessarily be small in absolute terms but very large in relative terms. Saying that forecast demand is 2 plus or minus 1 is like saying that forecast demand is 100 plus or minus 50<sup>17</sup>. In order to produce meaningful forecasts of demand in such cases, a certain amount of reaggregation of the demand data may be necessary. Any such reaggregation of the data will improve the quality of the demand forecast, but will simultaneously sacrifice the capture of some of the potential network effect revenues in the process. This tradeoff between the measurable revenue gains which can be achieved through more accurate forecasting and the measurable revenue losses that will occur as the ability to discern and capture network effects is blurred needs to be addressed explicitly, as it is in the IDeaS approach to revenue management.

#### MEASURABLE INFLUENCES ON DEMAND

In addition to the predictable cycles and trends that can usually be detected in the historical demand data, demand for the service is often directly affected (sometimes dramatically) by changes in price levels, in

<sup>17</sup>In addition, the demand distribution is likely to be skewed towards zero.

conditions of sale, in levels of capacity or other factors such as strikes, transportation constraints and economic changes. You or your competitor may instigate these changes. It is important to analyze the effect of these changes when they occur so that when they next reoccur you are in a position to promptly make the appropriate adjustments to your forecasts.

#### HUMAN INTERVENTION IN THE FORECASTING PROCESS

More than one ambitious revenue management project has failed to gain the acceptance of those charged with running the completed program because the demand-forecasting module of the system did not produce credible estimates for input into the inventory valuation module. In these cases, it is common for the revenue managers to adjust or disregard the recommended inventory allocations produced by the system, when the more appropriate corrective action would be to make appropriate adjustments to the demand forecasts instead.

Forecasting will always be part art, part science, because there will always be unprecedented events which will significantly effect demand for the service which cannot be easily assimilated by a computer program. It is difficult for a computer to recognize the potential impact of extraordinary influences on the demand as would be occasioned by a war or a major fare or schedule change. However, human beings can assimilate the consequences of these phenomena, and it is entirely necessary and appropriate that they should intervene in the forecasting process when they know that such events are likely to occur. It is essential that the forecasting module of the revenue management system be designed to facilitate this intervention. One of the necessary features of the forecasting module is a *threshold reporting* facility, which automatically identifies flights/markets where deviations from the expected booking profile are signaling that such an event may be occurring. The criteria used by this facility should be objective and should minimize the volume of unnecessary "flags" raised for analyst review.

Adjustments made by the analysts to the demand and no-show forecasts produced by the system should be tracked, and management reports should be generated indicating each analyst's skill at improving upon the base forecasts produced by the system. This information could be expressed in terms of approximate revenue impact. These reports should be the primary basis for evaluating the job performance of the revenue managers.

From a psychological point of view it is critical to the success of the revenue management program for the revenue management professionals who will run the system to accept ownership of the forecasting process and accept responsibility for the quality of the forecasts that it produces. To achieve acceptance of this responsibility, the revenue manager must understand and accept the basic forecasting methodology.

Just as important, he must have the proper tools at his disposal that allows him to monitor and intervene in the process when appropriate. In a properly developed revenue management program, the revenue manager is primarily a forecaster; his intervention in other phases of the process, especially the inventory valuation process, will usually be counterproductive because the human mind is incapable of assimila ting the volumes of data and complexities of calculation that are involved in those steps. The importance of this point <u>cannot</u> be overemphasized.

In addition, managers usually feel comfortable making subjective judgments about the quality of demand forecasts based on intuition. However, they are typically more reticent about criticizing the output of the mathematically complex "black box" which "magically" produces recommended inventory allocations or bid prices. Consequently, the forecasting process often becomes the focal point for the normal resistance to change that is associated with the introduction of any major new process to a firm. In dealing with this issue it is important to get across to the skeptics the point that the impossibility of forecasting demand with perfect prescience is acknowledged; that this uncertainty about the level of demand is, in fact, an intrinsic part of the concept which must be expressly addressed in the process; and that rather than invalidating the revenue management concept, the existence of this uncertainty reinforces its value.

# FORECASTING CHALLENGES BY INDUSTRY

FORECASTING CHALLENGES	Industry: <i>AIRLINES</i>	HOTELS	CAR RENTAL	FREIGHT TRANSPOR- TATION	HEALTH CARE	BROAD- CASTING	TELEPHONE	GOLF
Constrained Demand	Yes	Yes	Yes	Yes		Yes		Yes
Low Demand	Yes			Yes			Yes	Yes
Measurable	Competitive	Competitive	Competitive	Competitive	Competitive	Competitive	Competitive	Competitive
Influences	Fares, Capacity	Rates	Rates, Capacity	Rates, Capacity	Rates	Rates,	Rates	Rates
						Program		
						Ratings		
Special Events	Conventions,	Conventions,	Conventions,	Acts of God	Acts of God	Acts of God	Acts of God	Holidays,
	Sports Events,	Sports Events,	Sports Events,					Convention,
	Acts of God	Acts of God	Acts of God					Acts of God

#### PRACTICAL PREREQUISITES

In order to implement a revenue management program there are a number of practical prerequisites that must first be met.

#### ACCESS TO DATA

In order to forecast demand and allocate inventory, current and historical information must be available at the level of detail at which the inventory is to be controlled concerning:

- 1) Demand
  - a) Orders/Sales
  - b) No-Shows
- 2) Capacity
- 3) Rates

This data is commonly extracted from the order taking system (e.g., a Travel industry reservations system) and the rate quotation or revenue accounting systems.

The assembly of the necessary databases in order to perform forecasting research and business modeling is usually the first order of business in the development of a revenue management system.

#### ORDER PROCESSING SYSTEM

Frequently an order taking system must be built from scratch or modified significantly in order to efficiently incorporate revenue management into the order taking process. In the Travel industry, it has been common for reservations system modifications in order to accommodate new revenue management strategies to demand a majority of the project resources. Order system design should be taken up early in the project, as it is likely to be a "critical path" item. Limits in the architecture of the order taking system may pose serious constraints on the choice of revenue management strategies to be pursued. For example, in order to pursue a "Bid Price" strategy, rate information must be stored within (or accessible to) the order taking system for reference. IDeaS believes that it will usually be cheaper and more

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effective to capture "network effects" through an order taking system built around the bid price approach, especially if the order taking system is being built from scratch.

In the software development process, the order taking, data extraction, storage, and decision support capabilities should be designed and built as a set if possible.

#### HOW TO SELL A REVENUE MANAGEMENT PROGRAM

The development of a revenue management program is likely to be an ambitious and costly process. Unless the discipline is already established in your industry, convincing senior management of the strategic necessity of investing in revenue management technology is likely to initially be a tough sell, although the economics are very compelling.

Investments in revenue management generally have a very short payback period because almost all of the revenue increases generated goes straight to the bottom line. A \$10 million investment in revenue management that revenues only a 2 percent revenue improvement on a revenue base of \$1 billion would pay for itself in six months. The hard part is to convince senior management that the two percent *is really there*. The problem is that in order to precisely quantify the revenue improvement you may first have to spend the money and build the system – catch 22!

To get around this problem a considerable amount of research has gone into the design of mathematical simulation models which can estimate the revenue impact of pursuing various revenue management strategies (or no revenue management strategy at all). It may be possible to develop a credible benefits estimate for your firm from such a simulation. Before relying on the results of a simulation to justify your project be careful to closely examine the underlying assumptions, which are incorporated into the model. It is common for mathematicians to make "simplifying assumptions" to cut down on the amount of computer power needed to run the simulation. If these assumptions are not valid, they can throw off the results considerably. A simulation is valid only to the extent that it mimics the reality of your particular economic environment. IDeaS are quite proud of its own simulation models. With the appropriate capacity, demand, and rate information from your firm, IDeaS is confident that it can produce a realistic and credible estimate of the value of revenue management to your firm.

The degree of revenue management leverage obtainable by your firm will depend on the size and complexity of your firm and the degree to which each of the various principles and complicating factors of revenue management apply. However, on the basis of actual experience in the Airline and Hotel

industries it is likely that your revenue improvement will be on the order of five percent plus or minus three percentage points. When circumstances are such that there are also opportunities to refine pricing and capacity planning through application of revenue management principles the potential benefits are likely to be considerably larger.

When you design your revenue management system be sure to build a benefits measurement capability so that you can claim the proper credit when the system is installed and revenues improve!

As a practical matter it is usually the case that the easiest way to persuade key decision makers that a major investment in systems development is necessary is to convince them that your competitors are already doing it and you're going to be competitively disadvantaged if you don't. This is an easy sell to make in the Airline industry where Donald Burr, founder of People's Express, has publicly stated that the failure of his firm to adopt revenue management was the primary cause of the demise of this company. The sophisticated revenue manage ment programs of his larger competitors gave them a decisive competitive advantage, which more than offset People's Express' significant cost advantage.

Revenue management will eventually come to be viewed as a strategic necessity in all of the target service industries. It is rapidly reaching that point in the Hotel and Car Rental industries already. Those firms in each industry, which take the lead in developing revenue management programs, will earn "the innovator's profits" for as long as they maintain their lead, ala American Airlines. Those firms, which fail to embrace revenue management, will wither and die, ala People's Express.

# HOW TO KEEP SENIOR MANAGEMENT SUPPORT

Once you have senior management support for your revenue management project, how do you keep it? Failure to address the following obstacles and pitfalls will undermine support for your project and greatly reduce your chances for success.

# MAKE CONTINUOUS AND VISIBLE PROGRESS IN THE DEVELOPMENT OF THE SYSTEM

Because of the cost of developing a revenue management system, you should expect pressure from senior management to produce revenue benefits quickly. It will not be easy to meet these expectations and you should be careful to not promise too much, too fast.

Building a complex decision support system to support a new business process is much more difficult than modeling an existing, well documented administrative process. Traditional software development methodologies are unlikely to be suited to the task. We believe that the best approach is to undertake a short high level conceptual design effort to identify synergies and interdependencies between system components followed by a staged iterative design of individual program modules in order to be able to deliver the first phases of the system (usually the databases and data analysis tools) quickly.

Be careful about how you choose to phase your project, however. While you should definitely keep the 80/20 rule in mind (80 percent of the benefits can usually be realized with 20 percent of the effort), you should be careful not to foreclose the possibility of getting that last 20 percent of the benefits down the road. It is likely to still be worth going after at a later time. Also, be careful about the selection of which "complicating factors" will be included and excluded from early releases to the system. It is, in fact, possible to build a revenue management system that will actually lose money for your firm in some cases if you oversimplify the modeling of your true economic circumstances.

It is important not to overextend either the depth or the breadth of the information systems development resources that can realistically be brought to bear on the project. Be careful to allow time for hiring and training of new project members in your project plans or due dates will be missed. This is especially true because it is possible, if not likely, that expertise in technologies that are new to the firm will need to be developed or hired. (Most commercial revenue management programs are now developed in C/UNIX to be run on scientific workstations.)

Any firm that embarks on a revenue management project should seriously consider incorporating commercially available revenue management software into their new system as a means of shortcutting the development process and producing revenue benefits more quickly.

#### **OVERCOME NORMAL RESISTANCE TO CHANGE**

The revenue management innovator should expect to meet a normal amount of resistance to change to the new concept and should be prepared to deal with it in a constructive manner. As with any new process, the people who will resist the innovation are those who are concerned that their existing skills and corporate status may be devalued by the new procedures, and/or those who find that the innovation creates new obstacles to the achievement of their existing goals.

Your sales force is likely to fall into the latter category. The first time that a salesperson has a "bird in the hand" order rejected by a revenue manager looking for a more profitable "bird in the bush" he is likely to

begin seeing the revenue management department as an "enemy" that's keeping him from meeting his sales quota.

This contention should be deflected by reorienting the sales department's goals away from gross sales targets towards cumulative "economic profit". Each time a salesperson makes a sale, record both the EMR value of the units of inventory sold, and the actual revenue received from the sale. The difference is the "economic profit" of the sale. If the sales force is rewarded for maximizing this number they will make every effort to direct sales towards inventory with a low EMR value and the revenue management program will be reinforced rather than undermined.

It may also be useful to get across the point that while the sales force may initially see the revenue managers as adversaries, in reality they are merely arbitrators between salespersons who are competing to sell the same inventory. They ensure that the salesperson that can get the best price makes the sale instead of the person who merely sells faster.

The second possible category of resisters is composed of your current order takers and order evaluators. These are the people who are most likely to feel threatened by the potential devaluation of their skills. Some of them are likely to have developed their own rules of thumb for evaluating the profitability of order requests, and these people may fear that the new system will supplant their expertise and render them unimportant or even superfluous.

It is also common for these people to fear that they may not be smart enough or well educated enough to manage this economically and mathematically "sophisticated" new process. This fear is generally groundless and can be overcome by coaching as explained later.

You do not have to be a rocket scientist to do day to day revenue management work. Anyone who can understand the basic revenue management concepts at the level at which they are presented in this paper is qualified to become a revenue manager. Indeed, airlines that have attempted to staff their revenue management programs with MBAs or persons with advanced degrees in mathematics find that they have a high rate of staff turnover. These people tend to move on to more challenging positions within the company relatively quickly. A revenue management program often becomes an analytical training ground serving the entire firm. At the other extreme, Hotel revenue management is usually the responsibility of the on-site property manager. It is common for this responsibility to be delegated to a back office reservations clerk with no more than a high school education and an average tenure on the job of about three months. With the proper training and tools, such a person can be an effective revenue manager. The key to successfully overcoming this source of resistance to change is to convince your order evaluators that they are capable of making the progression to revenue manager, and that this change will enhance the importance and visibility of their role within the company. The leaders among the current order evaluators should be given prominent roles in the development and introduction of the new program to secure their support.

Insufficient education is not a serious obstacle to effective revenue management. Fear of insufficient education is.

In order to overcome this fear, the "basic training" for a new revenue manager should include an unthreatening and non-technical introduction to the basic economic and statistical principals described in this paper so that they gain a fundamental, intuitive understanding of what's going on in the "black box" that values the inventory. The bulk of revenue management training should deal with the management of the demand forecasting process. Forecasting oversight will be the revenue manager's primary responsibility and, as already noted, is likely to be the focal point for expressions of discontent with the system.

For the same reason, the design of the user interface through which the revenue manager interacts with the forecasting system is as important to its ultimate success as all of the mathematical sophistication of its economic models. No effort should be spared to develop a window into the system that makes the revenue managers feel at home and in control. Allow for the development of the interface to be a time consuming and iterative process.

If insufficient emphasis is placed on these human aspects of a revenue management program, "passive resistance" to the program may emerge among order evaluators. While they will go through the motions of employing the new revenue management system, in reality they will go on making decisions the way they always have, and none of the potential benefits will be realized. It is not uncommon for airline revenue managers to ignore the recommendations produced by their "sophisticated" revenue management systems and set unit authorizations based on their individual rules of thumb.

This possibility increases the importance of building an objective method of evaluating revenue manager performance into your system. The evaluation process should be based on either their effectiveness at improving upon the base demand forecasts produced by the forecasting module of the system, upon the percentage of theoretically obtainable revenues actually achieved, or both.

#### **AVOID PITFALLS IN THE APPLICATION OF REVENUE MANAGEMENT**

Once the revenue management system is up and running, there are two main pitfalls to be avoided in applying revenue management principles. The first, which has already been discussed, is the overzealous use of "bait and switch" sales tactics to exploit "sell up" potential. It is important to downplay the significance of this aspect of revenue management in the course of selling the concept to senior management. Otherwise, there will always be the danger than an uninformed policy position emphasizing the practice may be promulgated at any time in response to inadequate profit margins. The normal consequence of such a dictate is marginally higher average rates, plummeting sales and alienated customers.

The second major risk is that once the revenue management program is in place, the firm may become sloppy about its pricing practices. An attitude can develop that the improved inventory allocation process will provide a safety net if the rate structure becomes uneconomic.

A clear sign that this dangerous form of complacency is setting in is when one begins to hear things like "so what if the prices are too low; we just won't sell any inventory at those price levels!" The problem is that the competitors probably will be selling inventory at those price levels, so if you do not, your market share and revenues will evaporate. Despite the best efforts of firms in the target industries to differentiate their service products based on quality or features, brand preferences tend to be weak. By and large, consumers view these services as commodities and they will freely substitute one brand for another on the basis of small price differentials. The implementation of a revenue management program does not eliminate this competitive reality. Just as a competitive price premium is almost impossible to maintain in a commodity industry, it is also impossible to accomplish the same result through arbitrary restrictions on the supply of low price inventory.

Rather than viewing the implementation of a revenue management program as an opportunity to relax pricing vigilance, you should view it as an opportunity to strengthen your pricing program as well. As previously mentioned, the revenue management system will provide the rate setter with important feedback concerning minimum acceptable price levels and opportunities to improve revenues through selective discounts on low EMR value inventory. The trend in the Airline industry is to combine the demand forecasting, pricing, and revenue management functions into a single job to take advantage of these synergies. (The person performs all three functions for a particular route area.) This is an organizational model that we strongly recommend to anyone establishing a revenue management program for the first time.

#### SUMMARY

Revenue Management is a proven discipline with a track record of significant revenue improvement in various sectors of the Travel industry. Its potential applicability extends to a number of other service industries with similar economic characteristics.

It is not the dark, mysterious art that it is sometimes portrayed to be. Rather it represents the application of a number of straightforward economic and statistical principles that anyone can understand.

A well-developed Revenue Management program is already a strategic necessity in the Airline industry. In the coming years it is likely to become necessary to corporate survival in the other service industries as well.