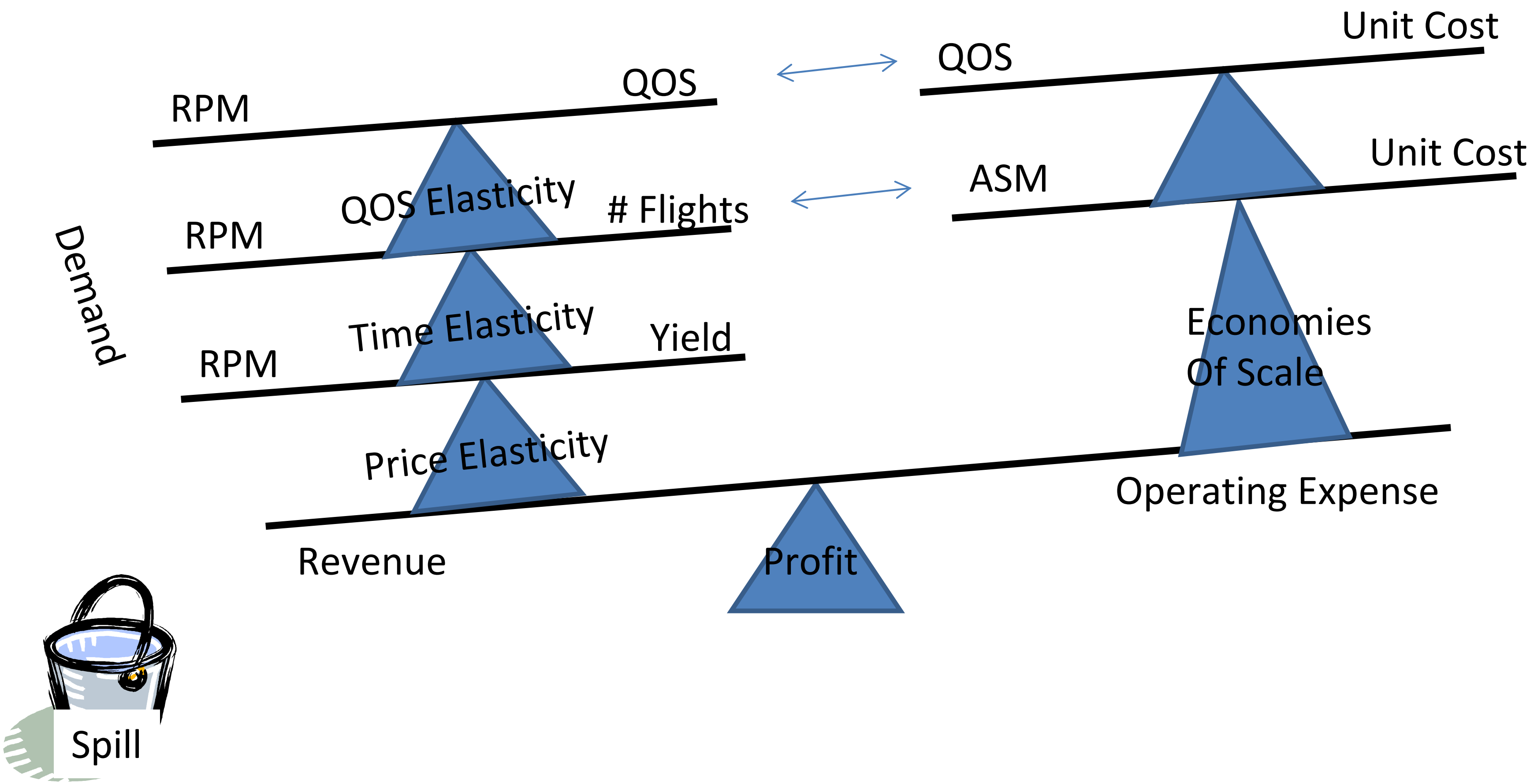
# Chapter 3 Review



# Fundamentals of Pricing and Revenue Management
## Chapter 4

Lesson 3

# Outline

- Airline Pricing and O-D Markets
  - Pricing Strategies
  - Price Discrimination vs. Product Differentiation
- Airline Differential Pricing
  - “willingness to pay”(WTP)
- Airline Revenue Management

# Airline Pricing and O-D Markets
# Pricing Strategies

# Airline Prices and O-D Markets

- **Pricing** – refers to the process of determining fare levels, combined with various service amenities and restrictions, for a set of fare products in an origin-destination market
- **Revenue Management** – is the subsequent process of determining how many seats to make available at each fare level
- **Regulated Pricing** – the Civil Aeronautics Board (CAB) used a mileage-based formula to ensure equal prices for equal distances
- **“Deregulated” or Liberalized Pricing** – Different O-D markets can have prices not related to distance traveled, or even the airline’s operating costs, as airlines match low-fare competitors to maintain market presence and share of traffic
  - Its possible that low-volume O-D markets are more costly to serve per passenger basis will see higher prices than high-density O-D markets, even if similar distances are involved

# Theoretical Pricing Strategies

- For determining prices to charge in an O-D market, airlines can utilize one of following economic principles:
  - Cost-based pricing
  - Demand-based pricing
  - Service-based pricing
- In practice, most airline pricing strategies reflect a mix of these theoretical principles:
  - Prices are also highly affected by competition in each O-D Market
  - In the US, severe competition in some markets has led to "price-based costing", meaning airlines must reduce costs to be able to match low-fare competitors and passengers' price expectations

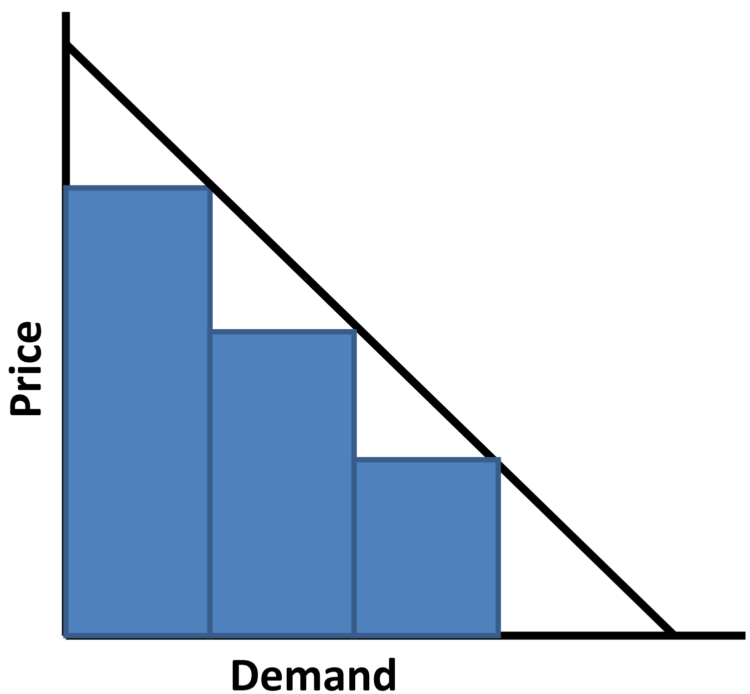
# Price Discrimination vs. Product Differentiation

- **Price discrimination:**
  - The practice of charging different prices for same product with same costs of production
  - Based solely on different consumers' "willingness to pay"
- **Product differentiation:**
  - Charging different prices for products with different characteristics and costs of production
- **Current airline fare structures reflect both strategies:**
  - Differential Pricing based on differentiated fare products
  - But higher prices for fare products targeted at business travelers are clearly based on their willingness to pay

# Airline Pricing Practices

- Differential pricing presents a trade-off to customers between inconvenience and price levels:
  - Business travelers are “willing” to pay higher fares in return for more convenience, fewer restrictions on use of tickets
  - Leisure travelers less “willing” to pay higher prices, but accept disutility “costs” of restrictions on low fare products
- Economic concept of “willingness to pay”(WTP) is defined by the theoretical price-demand curve:
  - “Willingness” does not mean “happiness” in paying higher prices
  - Differential pricing attempts to make those with higher WTP purchase the less restricted higher-priced options

# Differential Pricing Theory (circa 2000)




- **Market segments with different "willingness to pay" for air travel**
- **Different "fare products" offered to business versus leisure travelers**
- **Prevent diversion by setting restrictions on lower fare products and limiting seats available**
- **Increased revenues and higher load factors than any single fare strategy**

# Airline Differential Pricing

# Why Differential Pricing?

- It allows the airline to increase total flight revenues with little impact on total operating costs:
  - Incremental revenue generated by discount fare passengers who otherwise would not fly
  - Incremental revenue from high fare passengers willing to pay more
  - Studies have shown that most "traditional" high-cost airlines could not cover total operating costs by offering a single fare level
- Consumers can also benefit from differential pricing:
  - Most notably, discount passengers who otherwise would not fly
  - It is also conceivable that high fare passengers pay less and/or enjoy more frequency given the presence of low fare passengers
- If airline could charge a different price for each customer based on their WTP, its revenues would be close to the theoretical maximum

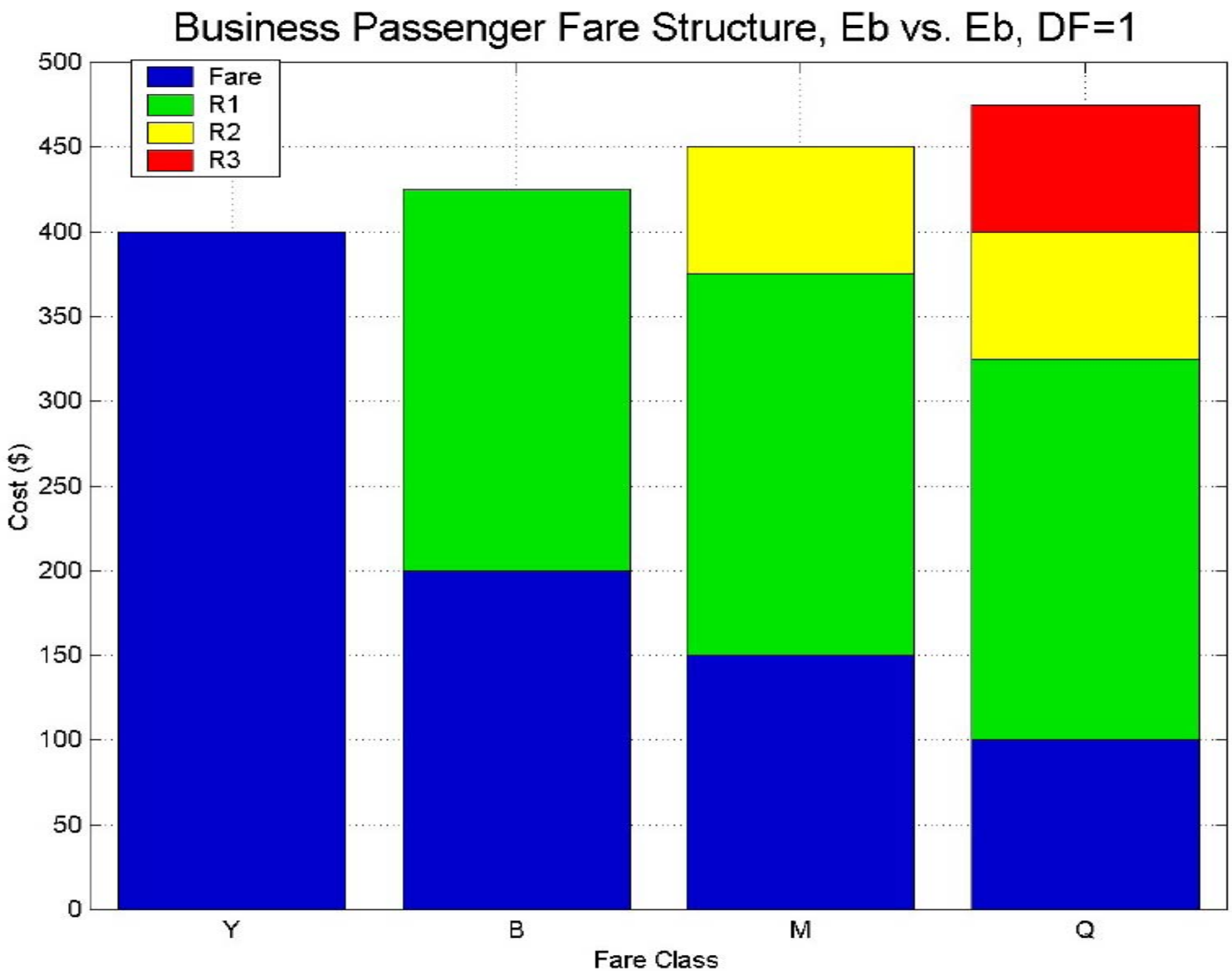
# Market Segmentation

- Business and Leisure travelers are the two traditional segments targeted by the airlines in their different pricing efforts
  - First Class, Business Class, and Economy
  - Restrictions on advance purchase, use, and refundability
- A wide enough range of fare product options at different price levels should be offered to capture as much revenue potential from the market price-demand curve as possible

# Traditional Approach: Restrictions on Lower Fares

- Progressively more severe restrictions on low fare products designed to prevent diversion:
  - Lowest fares have advance purchase and minimum stay requirements , as well as cancellation and change fees
  - Restrictions increase the inconvenience or "disutility cost" of low fares to travelers with high WTP, forcing them to pay more
  - Studies show "Saturday night minimum stay" condition to be most effective in keeping business travelers from purchasing low fares
- Still, it is impossible to achieve perfect segmentation:
  - Some travelers with high WTP can meet restrictions
  - Many business travelers often purchase restricted fares

# Example: Restriction Disutility Costs



# Example: BOS-SEA Traditional Fares

| Round-Trip Fare ($) | Cls | Advance Purchase | Minimum Stay | Change Fee? | Comment |
|---|---|---|---|---|---|
| $458 | N | 21 days | Sat. Night | Yes | Tue/Wed/Sat |
| $707 | M | 21 days | Sat. Night | Yes | Tue/Wed |
| $760 | M | 21 days | Sat. Night | Yes | Thur-Mon |
| $927 | H | 14 days | Sat. Night | Yes | Tue/Wed |
| $1001 | H | 14 days | Sat. Night | Yes | Thur-Mon |
| $2083 | B | 3 days | None | No | 2xOW Fare |
| $2262 | Y | None | None | No | 2xOW Fare |
| $2783 | F | None | None | No | First Class |

Figure 4.5

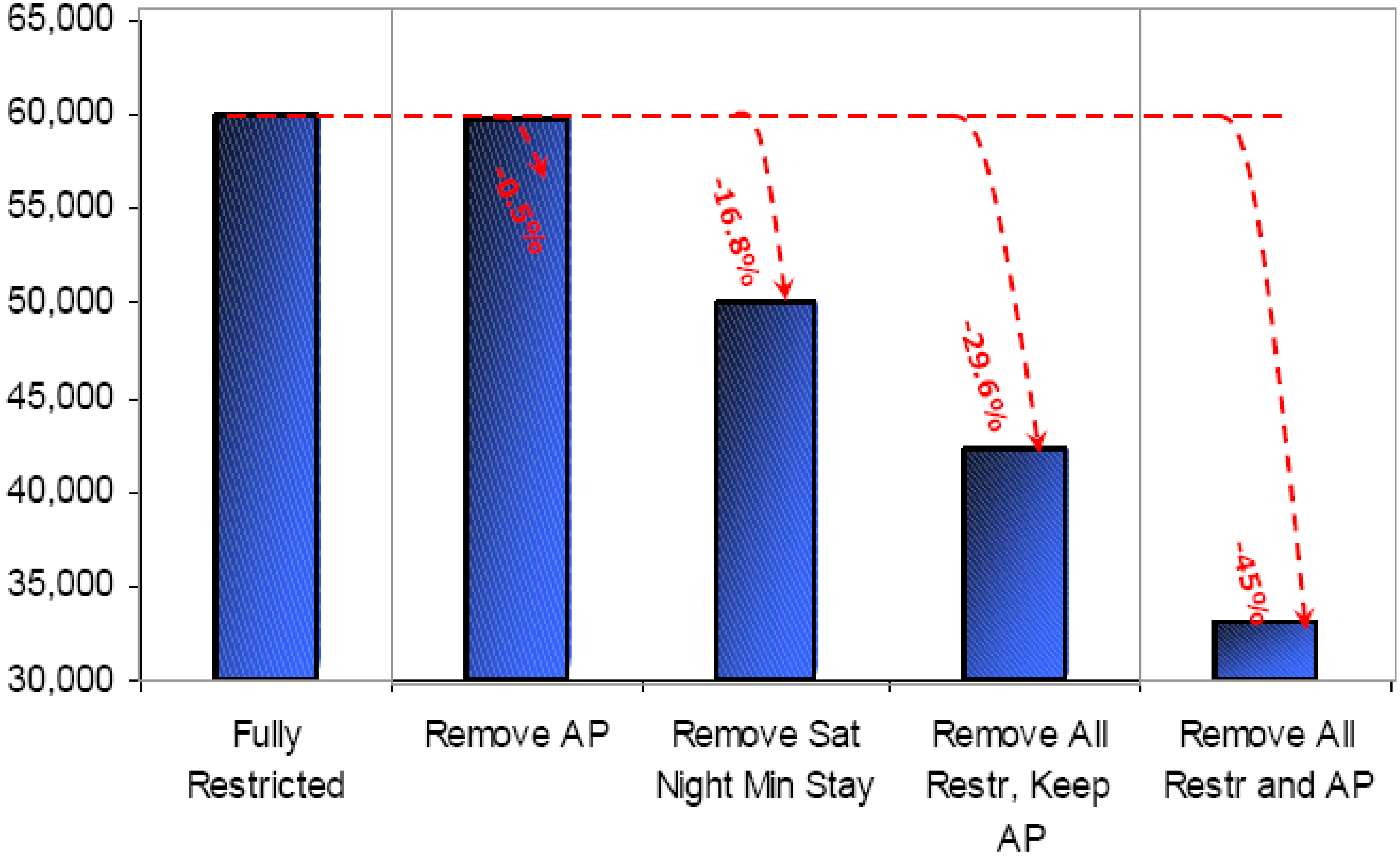
# Fare Simplification: Less Restricted and Lower Fares

- Recent trend toward "simplified" fares –compressed fare structures with fewer restrictions
  - Initiated by some LFAs and America West, followed by Alaska
  - Most recently, implemented in all US domestic markets by Delta, matched selectively by legacy competitors
- Simplified fare structures characterized by:
  - No Saturday night stay restrictions, but advance purchase and non-refundable/change fees
  - Revenue management systems still control number of seats sold at each fare level
- Higher load factors, but 10-15% lower revenues:
  - Significantly higher diversion with fewer restrictions

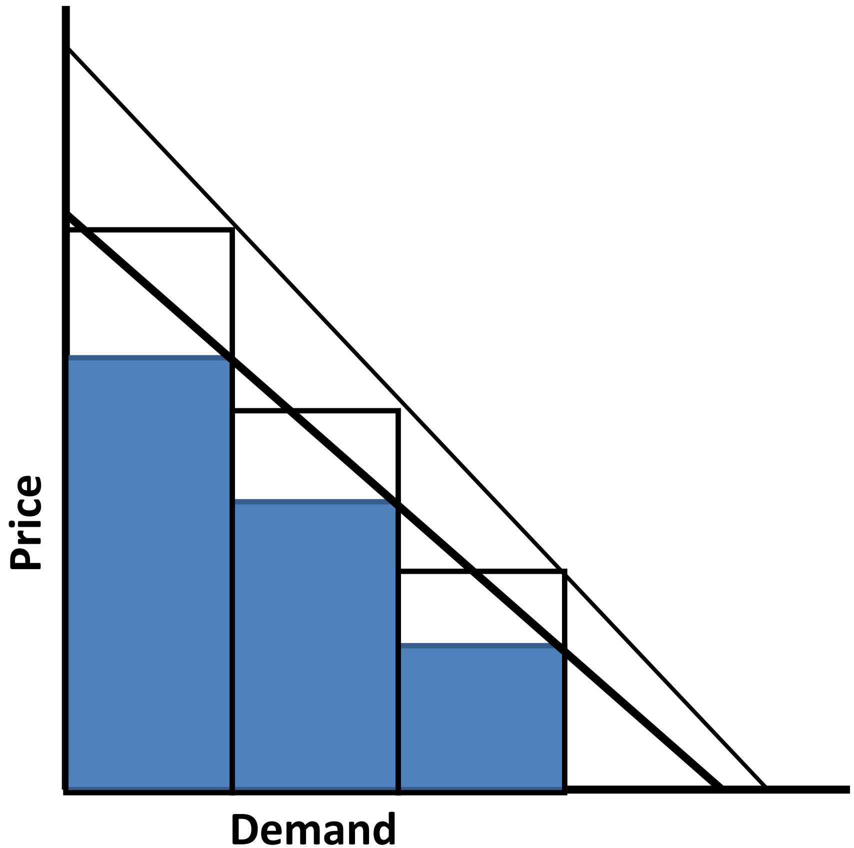
# Example: BOS-ATL Simplified Fares Delta Air Lines, April 2005

| One Way Fare ($) | Bkg Cls | Advance Purchase | Minimum Stay | Change Fee? | Comment |
|---|---|---|---|---|---|
| $124 | T | 21 days | 0 | $50 | Non-refundable |
| $139 | U | 14 days | 0 | $50 | Non-refundable |
| $184 | L | 7 days | 0 | $50 | Non-refundable |
| $209 | K | 3 days | 0 | $50 | Non-refundable |
| $354 | B | 3 days | 0 | $50 | Non-refundable |
| $404 | Y | 0 | 0 | No | Full Fare |
| | | | | | |
| $254 | A | 0 | 0 | No | First Class |
| $499 | F | 0 | 0 | No | First Class |

# Revenue Impact of Each “Simplification”



# Impacts on Differential Pricing Model




- Drop in business demand and willingness to pay highest fares
- Greater willingness to accept restrictions on lower fares
- Reduction in lowest fares to stimulate traffic and respond to LCCs
- Result is lower total revenue and unit RASM despite stable load factors

# Airline Revenue Management

# Airline Revenue Management

- Two components of airline revenue maximization:

  Differential Pricing:
  - Various “fare products” offered at different prices for travel in the same O-D market

  Yield Management (YM):
  - Determines the number of seats to be made available to each “fare class” on a flight, by setting booking limits on low fare seats
- Typically, YM takes a set of differentiated prices/products and flight capacity as given:
  - With high proportion of fixed operating costs for a committed flight schedule, revenue maximization to maximize profits

# Why Call it "Yield Management"?

- Main objective of YM is to protect seats for later-booking, high-fare business passengers.
- YM involves tactical control of airline's seat inventory:
  - But too much emphasis on yield (revenue per RPM) can lead to overly severe limits on low fares, and lower overall load factors
  - Too many seats sold at lower fares will increase load factors but reduce yield, adversely affective total revenues
- Revenue maximization is proper goal:
  - Requires proper balance of load factor and yield
- Many airlines now refer to "Revenue Management"(RM) instead of "Yield Management"

# Seat Inventory Control Approaches

**EXAMPLE: 2100 MILE FLIGHT LEG** **CAPACITY = 200**

**NUMBER OF SEATS SOLD:**

| FARE CLASS | AVERAGE REVENUE | YIELD EMPHASIS | LOAD FACTOR EMPHASIS | REVENUE EMPHASIS |
|---|---|---|---|---|
| Y | $420 | 20 | 10 | 17 |
| B | $360 | 23 | 13 | 23 |
| H | $230 | 22 | 14 | 19 |
| V | $180 | 30 | 55 | 37 |
| Q | $120 | 15 | 68 | 40 |
| | TOTAL PASSENGERS | 110 | 160 | 136 |
| | LOAD FACTOR | 55% | **80%** | 68% |
| | TOTAL REVENUE | $28,940 | $30,160 | **$31,250** |
| | AVERAGE FARE | $263 | $189 | $230 |
| | YIELD (CENTS/RPM) | **12.53** | 8.98 | 10.94 |

Figure 4.11

# Computerized RM Systems

- **Size and complexity of a typical airline's seat inventory control problem requires a computerized RM system**
- **Consider a US Major airline with:**

  **500 flight legs per day**

  **15 booking classes**

  **330 days of bookings before departure**

- **At any point in time, this airline's seat inventory consists of almost 2.5 million booking limits:**
  - **This inventory represents the airline's potential for profitable operation, depending on the revenues obtained**
  - **Far too large a problem for human analysts to monitor alone**

# Typical 3rd Generation RM System

- Collects and maintains historical booking data by flight and fare class, for each past departure date.
- Forecasts future booking demand and no-show rates by flight departure date and fare class.
- Calculates limits to maximize total flight revenues:
  - Overbooking levels to minimize costs of spoilage/denied boardings
  - Booking class limits on low-value classes to protect high-fare seats
- Interactive decision support for RM analysts:
  - Can review, accept or reject recommendations

# Example of Third Generation RM System

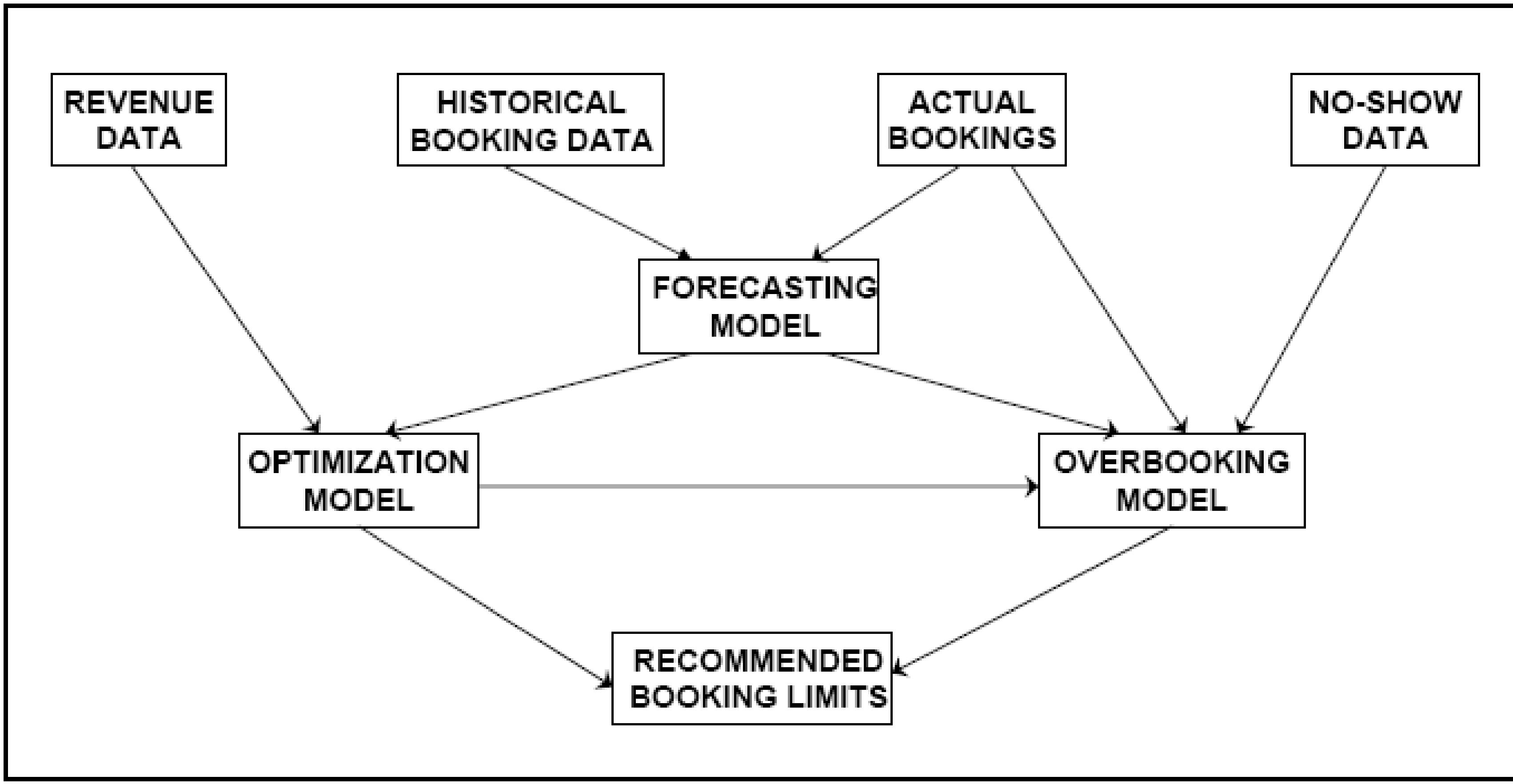



Figure 4.12

# Revenue Management Techniques

- **Overbooking**
  – Accept reservations in excess of aircraft capacity to overcome loss of revenues due to passenger "no-show" effects
- **Fare Class Mix (Flight Leg Optimization)**
  – Determine revenue-maximizing mix of seats available to each booking (fare) class on each flight departure
- **Traffic Flow (O-D) Control (Network Optimization)**
  – Further distinguish between seats available to short-haul (one-leg) vs. long-haul (connecting) passengers, to maximize total network revenues

# Flight Overbooking

- **Determine maximum number of bookings to accept for a given physical capacity.**
- **Minimize total costs of denied boardings and spoilage(lost revenue).**
- **U.S. domestic no-show rates can reach 15-20 percent of final pre-departure bookings:**
  - **On peak holiday days, when high no-shows are least desirable**
  - **Average no-show rates have dropped, to 10-15% with more fare penalties and better efforts by airlines to firm up bookings**
- **Effective overbooking can generate as much revenue gain as fare class seat allocation.**

# Overbooking Terminology

- Physical Capacity — CAP
  - Actual # of seats on the flight, usually maximum capacity of the aircraft
- Authorized Capacity — AU
  - Maximum # of bookings that an airline is willing to accept
- Confirmed Bookings — BKD <= AU
  - Total # of passenger reservations that have been accepted
- No Show Rate — NSR
  - Mean % of passengers with confirmed bookings that do not show up
- Denied Boardings — DB
- Spoilage — SP
- Show up Rate — SUR

# Overbooking Models

- Overbooking models try to minimize:
  - Total costs of overbooking (denied boardings plus spoilage)
  - Risk of “excessive” denied boardings on individual flights, for customer service reasons
- Mathematical overbooking problem:
  - Find OV > 1.00 such that AU = CAP * OV
  - But actual no-show rate is highly uncertain

# Manual/Judgmental Approach

- Relies on judgment of human analyst to set overbooking level:
  - Based on market experience and perhaps recent no-show history
  - Tendency to choose OV = 1+NSR (or lower)
  - Tendency to focus on avoidance of DB
- For CAP=100 and mean NSR=.20, then:

  AU = 100 (1.20) = 120

# Deterministic Model

- Based on estimate of mean NSR from recent history:
  - Assume that BKD=AU (“worst case”scenario)
  - Find AU such thatAU -NSR*AU = CAP
  - Or, AU = CAP/(1-NSR)
- For CAP=100 and NSR=0.20, then:

  AU = 100/(1-.20) = 125

# Probabilistic/Risk Model

- Incorporates uncertainty about NSR for future flight:
  - Standard deviation of NSR from history, STD
- Find AU that will keep DB=0, assuming BKD=AU, with a 95% level of confidence:
  - Assume a probability (Gaussian) distribution of no-show rates
- Keep show-ups less than or equal to CAP, when BKD=AU:
  - Find SUR*, so that AU x SUR* = CAP,

    and Prob[AU x SUR* > CAP] = 5%
- From Gaussian distribution, SUR* will satisfy:

$$Z = 1.645 = \frac{SUR^* - SUR}{STD}$$

where SUR = mean show-up rate

STD = standard deviation of show-up rate

# Probabilistic/Risk Model (cont.)

- Optimal AU given CAP, SUR, STD with objective of DB=0 with 95% confidence is:

$$AU = \frac{CAP}{SUR + 1.645\ STD} = \frac{CAP}{1 - NSR + 1.645\ STD}$$

- In our example, with STD= 0.05 & NSR=.20:

$$AU = 100 / (1-0.20 + 1.645*0.05) = 113$$

- The larger STD, the larger the denominator and the lower the optimal AU, due to increased risk/uncertainty about no-shows.

# More Overbooking Terminology

| | |
|---|---|
| • Waitlisted passengers | WL |
| • Go-show passengers | GS |
| • Stand-by passengers | SB |
| • No-shows | NS |
| • Show-ups | SU |
| • Passengers Boarded | PAX |
| • Voluntary DB | VOLDB |

# Probabilistic Model Extensions

- Reduce level of confidence of exceeding DB limit:
  - Z factor in denominator will decrease, causing increase in AU
- Increase DB tolerance to account for voluntary DB:
  - Numerator becomes (CAP+ VOLDB), increases AU
- Include forecasted empty F or C cabin seats for upgrading:
  - Numerator becomes (CAP+FEMPTY+CEMPTY), increases AU
  - Empty F+C could also be "overbooked"
- Deduct group bookings and overbook remaining capacity only:
  - Firm groups much more likely to show up
  - Flights with firm groups should have lower AU

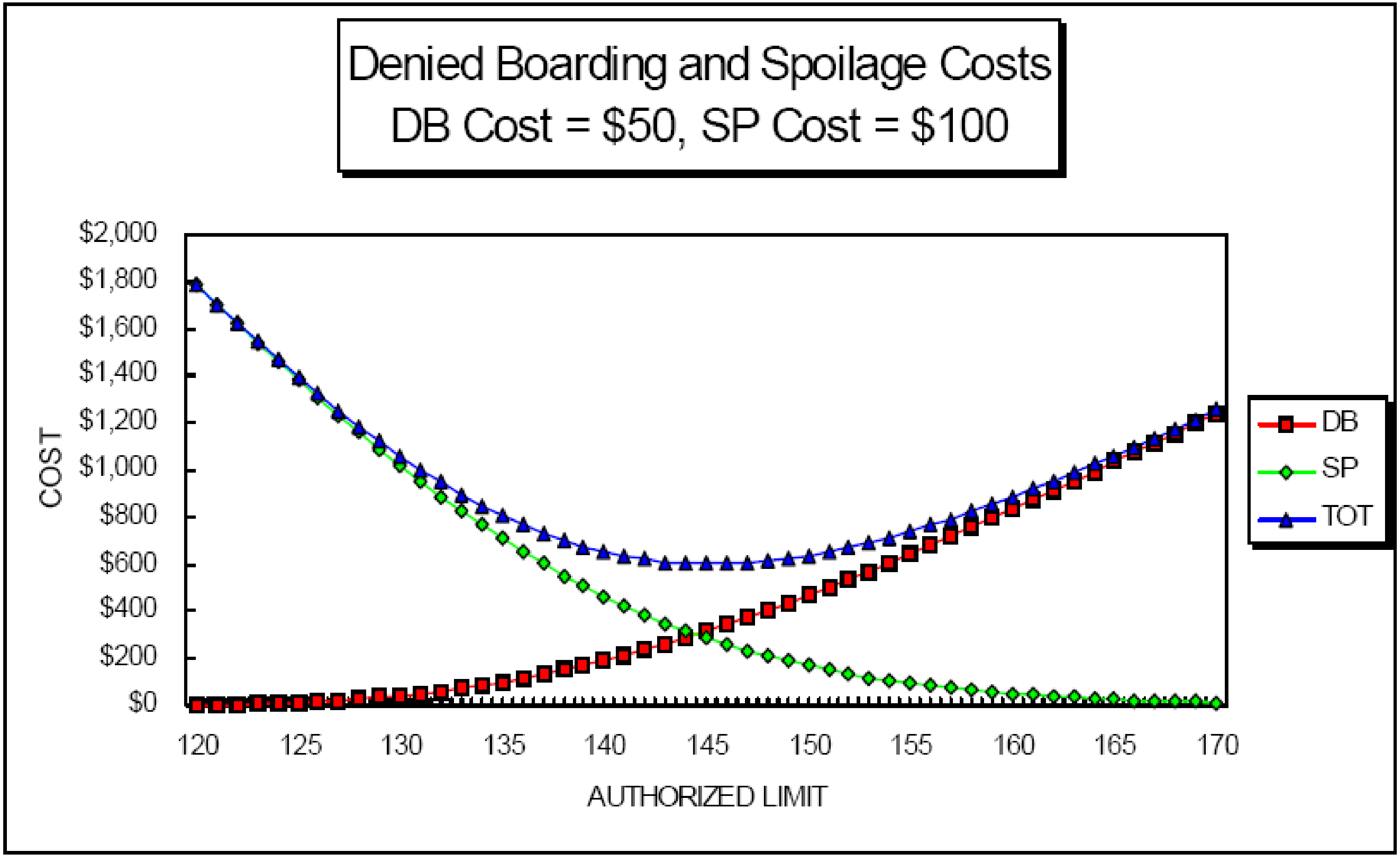
# Cost-Based Overbooking Model

- **Find AU that minimizes :**
  **[Cost of DB + Cost of SP]**

- **For any given AU:**
  **Total Cost = $DB * E[DB] + $SP * E[SP]**
  **$DB and $SP= cost per DB and SP, respectively**
  **E[DB] = expected number of DBs, given AU**
  **E[SP] = expected number of SP seats, given AU**

- **Mathematical search over range of AU values to find minimum total cost.**

# Example: Cost-Based Overbooking Model



# Cost Inputs to Overbooking Model

- Denied Boarding Costs:
  - Cash compensation for involuntary DB
  - Free travel vouchers for voluntary DB
  - Meal and hotel costs for displaced passengers
  - Space on other airlines
  - Cost of lost passenger goodwill costs
- Many airlines have difficulty providing accurate DB cost inputs to these models.

# Dynamic Revision and Intervention

- **RM systems revise forecasts and re-optimize booking limits at numerous "checkpoints" of the booking process:**
  - **Monitor actual bookings vs. previously forecasted demand**
  - **Re-forecast demand and re-optimize at fixed checkpoints or when unexpected booking activity occurs**
  - **Can mean substantial changes in fare class availability from one day to the next, even for the same flight departure**
- **Substantial proportion of fare mix revenue gain comes from dynamic revision of booking limits:**
  - **Human intervention is important in unusual circumstances, such as "unexplained" surges in demand due to special events**

# Current State of RM Practice

- Most of the top 25 world airlines (in terms of revenue) have implemented 3rd generation RM systems.
- Many smaller carriers are still trying to make effective use of leg/fare class RM
  - Lack of company-wide understanding of RM principles
  - Historical emphasis on load factor or yield, not revenue
  - Excessive influence and/or RM abuse by dominant sales and marketing departments
  - Issues of regulation, organization and culture
- About a dozen leading airlines are looking toward network O-D control development and implementation
  - These carriers could achieve a 2-5 year competitive advantage with advanced revenue management systems

# Single-Leg Seat Allocation Problem

- **Given for a future flight leg departure:**
  - Total booking capacity of (typically) the coach compartment
  - Several fare (booking) classes that share the same inventory of seats in the compartment
  - Forecasts of future booking demand by fare class
  - Revenue estimates for each fare (booking) class
- **Objective is to maximize total expected revenue:**
  - Allocate seats to each fare class based on value

# Cost Inputs (cont'd)

- Spoilage Costs:
  - Loss of revenue from seat that departed empty
- What is best measure of this lost revenue:
  - Average revenue per seat for leg?
  - Highest fare class revenue on leg (since closed flights lose late-booking passengers)?
  - Lowest fare class revenue on leg (since increased AU would have allowed another discount seat)?
- Specifying spoilage costs is just as difficult.

# Voluntary vs. Involuntary DBs

- **Comprehensive Voluntary DB Program:**
  - Requires training and cooperation of station crews
  - Identify potential volunteers at check-in
  - Offer as much "soft" compensation as needed to make the passenger happy
- **US airlines very successful in managing DBs:**
  - 2007 involuntary DB rate was 1.12 per 10,000
  - Over 90% of DBs in U.S. are volunteers
  - Good treatment of volunteers generates goodwill

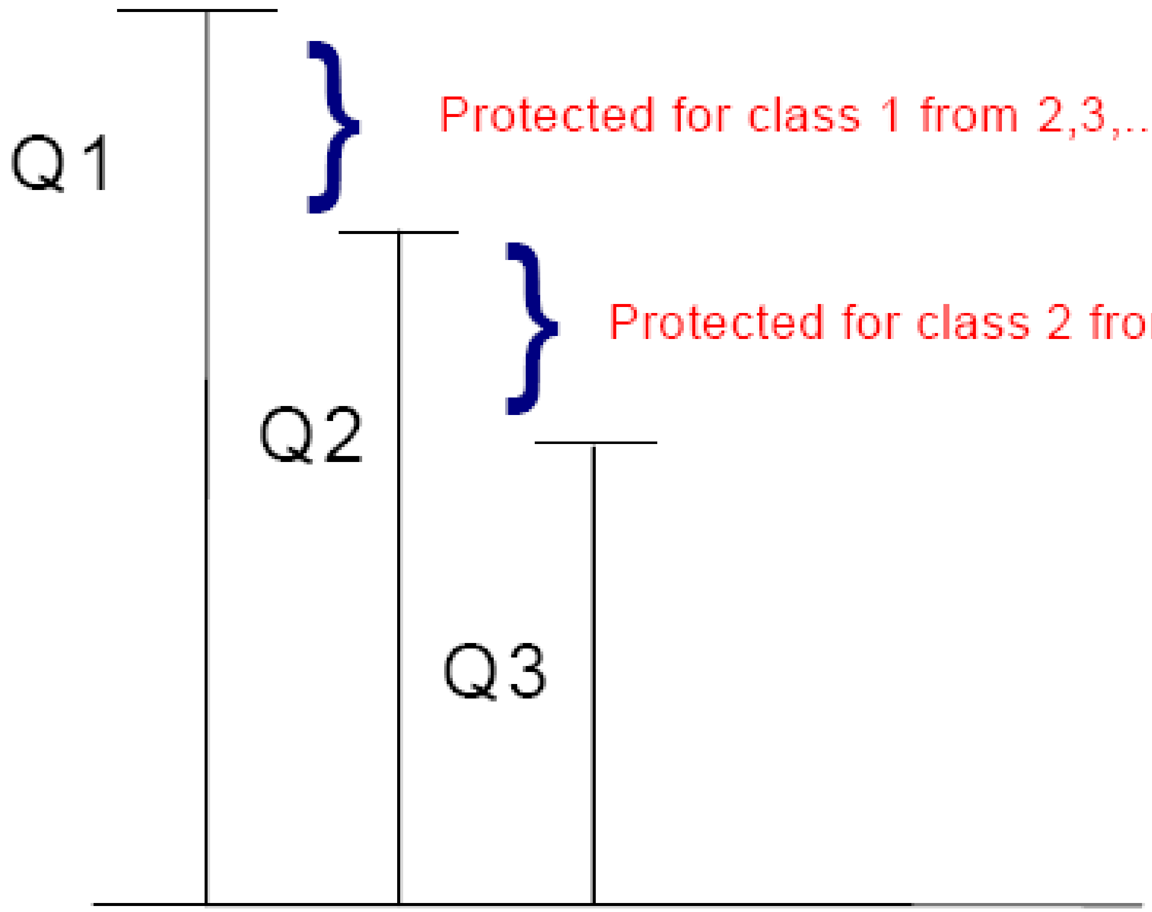
# Flight Leg Revenue Optimization

- Given for a future flight leg departure:
  - Total booking capacity of (typically) the coach compartment
  - Several fare (booking) classes that share the same inventory of seats in the compartment
  - Forecasts of future booking demand by fare class
  - Revenue estimates for each fare (booking) class
- Objective is to maximize total expected revenue:
  - Allocate seats to each fare class based on value

# Partitioned vs. Serial Nesting

- **In a partitioned CRS inventory structure, allocations to each booking class are made separately from all the other classes.**
- **EXAMPLE(assuming uncertain demand):**
  - **Given the following allocations for each of 3 classes--Y = 30, B = 40, M = 70 for an aircraft coach cabin with booking capacity = 140.**
  - **If 31 Y customers request a seat, the airline would reject the 31strequest because it exceeds the allocation for the Y class**
  - **It is possible that airline would reject the 31st Y class customer, even though it might not have sold all of the (lower-valued) B or M seats yet!**
- **Under serial nesting of booking classes, the airline would never turn down a Y fare request, as long as there are any seats (Y, B or M) left for sale.**

# Serially Nested Buckets



# Deterministic Seat Allocation/Protection

- If we assume that demand is deterministic (or known with certainty), it would be simple to determine the fare class seat allocations
  - Start with highest fare class and allocate/protect exactly the number of seats predicted for that class, and continue with the next lower fare class until capacity is reached.
- EXAMPLE: 3 fare classes (Y, B, M)
  - Demand for Y = 30, B = 40, M = 85
  - Capacity = 140
- Deterministic decision: Protect 30 for Y, 40 for B, and allocated 70 for M (i.e., spill 15 M requests)
- Nested booking limits Y=140 B=110 M=70

# EMSRb Model for Seat Protection: Assumptions

- Basic modeling assumptions for serially nested classes:
  - demand for each class is separate and independent of demand in other classes.
  - demand for each class is stochastic and can be represented bya probability distribution
  - lowest class books first, in its entirety, followed by the next lowest class, etc.
  - booking limits are only determined once (i.e., static optimization model)

# EMSRb Model Calculations

- Because higher classes have access to unused lower class seats, the problem is to find seat protection levels for higher classes, and booking limits on lower classes
- To calculate the optimal protection levels:

  Define Pi(Si) = probability that Xi>Si,

  where Siis the number of seats made available to class i, Xiis the random demand for class i

# EMSRb Calculations (cont'd)

- The expected marginal revenue of making the Sth seat available to class i is:
  - EMSRi(Si ) = Fi* Pi(Si ) where Ri is the average revenue (or fare) from class i

- The optimal protection level, π1for class 1 from class 2 satisfies:
  - EMSR1(π1) = F1* P1(π1 ) = R2

- Once π1 is found, set BL2= Capacity -π1.
- Of course, BL1= Capacity (authorized capacity if overbooking)

# Example Calculation

- Consider the following flight leg example:

| Class | Mean Fcst. | Std. Dev. | Fare |
|---|---|---|---|
| Y | 10 | 3 | 1000 |
| B | 15 | 5 | 700 |
| M | 20 | 7 | 500 |
| Q | 30 | 10 | 350 |

- •To find the protection for the Y fare class, we want to find the largest value of πY for which $EMSR_Y(\pi_Y) = F_Y * P_Y(\pi_Y) > R_B$

# Example (cont'd)

$EMSR_Y(\pi_Y) = 1000 * P_Y(\pi_Y) > 700$ $P_Y(\pi_Y) > 0.70$

where $P_Y(\pi_Y)$ = probability that $X_Y > \pi_Y$.

- **If we assume demand in Y class is *normally distributed with mean, standard deviation given earlier, then we can create a standardized normal random variable as (XY -10)/3.***

# Probability Calculations

- Next, we use Excel or go to the Standard Normal Cumulative Probability Table for different "guesses" for $\pi_Y$. For example,

for $\pi_Y = 7$, Prob $\{ (X_Y - 10)/3 > (-10)/3 \} = 0.8417$
for $\pi_Y = 8$, Prob $\{ (X_Y - 10)/3 > (-10)/3 \} = 0.7478$
for $\pi_Y = 9$, Prob $\{ (X_Y - 10)/3 > (-10)/3 \} = 0.639$

- So, we can see that $\pi Y = 8$ is the largest integer value of $\pi Y$ that gives a probability $>0.7$ and therefore we will protect 8 seats for Y class!

# Network Revenue Management: Origin-Destination Control

- **Vast majority of world airlines still practice “fare class control”:**
  - **High-yield (“full”) fare types in top booking classes**
  - **Lower yield (“discount”) fares in lower classes**
  - **Designed to maximize yields, not total revenues**
- **Seats for connecting itineraries must be available in same class across all flight legs:**
  - **Airline cannot distinguish among itineraries**
  - **“Bottleneck”legs can block long haul passengers**

# Yield-Based Fare Class Structure (Example)

| BOOKING CLASS | FARE PRODUCT TYPE |
|---|---|
| Y | Unrestricted "full" fares |
| B | Discounted one-way fares |
| M | 7-day advance purchase round-trip excursion fares |
| Q | 14-day advance purchase round-trip excursion fares |
| V | 21-day advance purchase or special promotional fares |

# Connecting Flight Network Example

FLIGHT LEG INVENTORIES

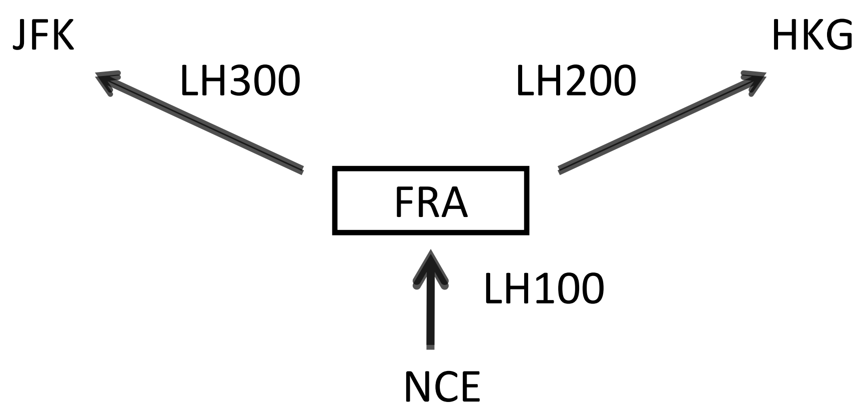
| LH 100 | NCE-FRA |
|---|---|
| CLASS | AVAILABLE |
| Y | 32 |
| B | 18 |
| M | 0 |
| Q | 0 |
| V | 0 |

| LH 200 | FRA-HKG |
|---|---|
| CLASS | AVAILABLE |
| Y | 142 |
| B | 118 |
| M | 97 |
| Q | 66 |
| V | 32 |

| LH 300 | FRA-JFK |
|---|---|
| CLASS | AVAILABLE |
| Y | 51 |
| B | 39 |
| M | 28 |
| Q | 17 |
| V | 0 |

ITINERARY/FARE AVAILABILITY

| | | | | | | |
|---|---|---|---|---|---|---|
| NCE/FRA | LH 100 | Y | B | | | |
| NCE/HKG | LH 100 | Y | B | | | |
| | LH 200 | Y | B | M | Q | V |
| NCE/JFK | LH 100 | Y | B | | | |
| | LH 300 | Y | B | M | Q | |



# The O-D Control Mechanism

- **Revenue maximization over a network of connecting flights requires two strategies:**
  1. **Increase availability to high-revenue, long-haul passengers, regardless of yield;**
  2. **Prevent long-haul passengers from displacing high-yield short-haul passengers on full flights.**
- **Revenue benefits of (1) outweigh risks of (2):**
  - **Probability of both connecting flights being fully booked is low, relative to other possible outcomes**

# What is O-D Control?

- The capability to respond to different O-D requests with different seat availability.
- Can be implemented in a variety of ways:
  - Revenue value buckets ("greedy approach")
  - EMSR heuristic bid price
  - Displacement adjusted virtual nesting
  - Network "optimal" bid price control
- All of the above can increase revenues, but each one has implementation trade-offs.

# Revenue Value Bucket Concept

- Fixed relationship between fare type and booking class is abandoned:
  - Booking classes ("buckets") defined according to revenue value, regardless of fare restrictions
  - Each itinerary/fare type (i.e.., "ODF") assigned to a revenue value bucket on each flight leg
  - ODF seat availability depends on value buckets
- Value concept can be implemented within existing classes or through "virtual" classes

# Value Bucket Implementation

- **Within Existing Booking Classes:**
  - Fare codes need to be re-published according to revenue value; no changes to inventory structure
  - Does not require seamless CRS links, but can be confusing to travel agents and consumers
- **Development of Virtual Inventory Classes:**
  - Substantial cost of new inventory structure and mapping functions to virtual classes
  - CRS seamless availability links are essential

# Virtual Class Mapping by ODF Revenue Value

**FARE VALUES BY ITINERARY**

| NCE/FRA | |
|---|---|
| CLASS | FARE (OW) |
| Y | $450 |
| B | $380 |
| M | $225 |
| Q | $165 |
| V | $135 |

| NCE/HKG (via FRA) | |
|---|---|
| CLASS | FARE (OW) |
| Y | $1415 |
| B | $975 |
| M | $770 |
| Q | $590 |
| V | $499 |

| NCE/JFK (via FRA) | |
|---|---|
| CLASS | FARE (OW) |
| Y | $950 |
| B | $710 |
| M | $550 |
| Q | $425 |
| V | $325 |

**MAPPING OF ODFs ON NCE/FRA LEG TO VIRTUAL VALUE CLASSES**

| VIRTUAL CLASS | REVENUE RANGE | MAPPING OF O-D MARKETS/CLASSES | |
|---|---|---|---|
| 1 | 1200 + | Y NCEHKG | |
| 2 | 900-1199 | B NCEHKG | Y NCEJFK |
| 3 | 750-899 | M NCEHKG | |
| 4 | 600-749 | B NCEJFK | |
| 5 | 500-599 | Q NCEHKG | M NCEJFK |
| 6 | 430-499 | V NCEHKG | Y NCEFRA |
| 7 | 340-429 | B NCEFRA | Q NCEJFK |
| 8 | 200-339 | V NCEJFK | M NCEFRA |
| 9 | 150-199 | Q NCEFRA | |
| 10 | 0 - 149 | V NCEFRA | |

Figure 4.17

# Value Bucket O-D Control

- **Allows O-D control with existing RM system:**
  - Data collection and storage by leg/value bucket
  - Forecasting and optimization by leg/value bucket
  - Different ODF requests get different availability
- **But also has limitations:**
  - Re-bucketing of ODFs disturbs data and forecasts
  - Leg-based optimization, not a network solution
  - Can give too much preference to long-haul passengers (i.e..., “greedy” approach)

# Displacement Cost Concept

- Actual value of an ODF to network revenue on a leg is less than or equal to its total fare:
  - Connecting passengers can displace revenue on down-line (or up-line) legs
- How to determine network value of each ODF for O-D control purposes?
  - Network optimization techniques to calculate displacement cost on each flight leg
  - Leg-based EMSR estimates of displacement

# Value Buckets with Displacement

- Given estimated down-line displacement, ODFs are mapped based on networkvalue:
  - Network value on Leg 1 = Total fare minus sum of own-line leg displacement costs
  - Under high demand, availability for connecting passengers is reduced, locals get more seats
- Revision of displacement costs is an issue:
  - Frequent revisions capture demand changes, but ODF re-mapping can disrupt bucket forecasts

# Alternative Mechanism: Bid Price

- **Under value bucket control, accept ODF if its network value falls into an available bucket:**

  **Network Value > Value of Last Seat on Leg; or**

  **Fare -Displacement > Value of Last Seat**

- **Same decision rule can be expressed as:**

- **Fare > Value of Last Seat + Displacement, or**
- **Fare > Minimum Acceptable “Bid Price”for ODF**

- **•Bid Prices and Value Buckets are simply two different O-D control mechanisms.**

# O-D Bid Price Control

- **Much simpler inventory control mechanism than virtual buckets:**
- **–Simply need to store bid price value for each leg**
- **–Evaluate ODF fare vs. itinerary bid price at time of availability request**
- **–Must revise bid prices frequently to prevent too many bookings of ODFs at current bid price**
- **•Bid prices can be calculated with network optimization tools or leg-based heuristics**

# Example: Bid Price Control

A-------B-------C-------D

- Given leg bid prices

A-B:$35 B-C:$240 C-D:$160

- Availability for O-D requests B-C:

| Bid Price = $240 | | Available? |
|---|---|---|
| Y | $440 | Yes |
| M | $315 | Yes |
| B | $223 | No |
| Q | $177 | No |

- A-B:$35 B-C:$240 C-D:$160

| A-C | Bid Price =$275 | Available? |
|---|---|---|
| Y | $519 | Yes |
| M | $374 | Yes |
| B | $292 | Yes |
| Q | $201 | No |

| A-D | Bid Price = $435 | Available? |
|---|---|---|
| Y | $582 | Yes |
| M | $399 | No |
| B | $322 | No |
| Q | $249 | No |

# Network vs. Heuristic Models

- Estimates of displacement costs and bid prices can be derived using either approach:
  – Most O-D RM software vendors claim “network optimal” solutions possible with their product
  – Most airlines lack detailed data and face practical constraints in using network optimization models
  – Still substantial debate among researchers about which network O-D solution is “most optimal”
- Revenue gain, not optimality, is critical issue