Introduction to the Airline Planning Process

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Airline Terminology and Measures

• **Airline Demand**
  
  RPM = Revenue Passenger Mile
  
  • One paying passenger transported 1 mile

  Yield = Revenue per RPM
  
  • Average fare paid by passengers, per mile flown

• **Airline Supply**
  
  ASM = Available Seat Mile
  
  • One aircraft seat flown 1 mile

  Unit Cost = Operating Expense per ASM (“CASM”)
  
  • Average operating cost per unit of output

• **Average Load Factor = RPM / ASM**

• **Unit Revenue = Revenue/ASM (“RASM”)**
Example: Airline Measures

• A 200-seat aircraft flies 1000 miles, with 140 passengers:
  
  \[ \text{RPM} = 140 \text{ passengers} \times 1000 \text{ miles} = 140,000 \]
  \[ \text{ASM} = 200 \text{ seats} \times 1000 \text{ miles} = 200,000 \]

• Assume total revenue = $16,000; total operating expense = $15,000:
  
  \[ \text{Yield} = \frac{16,000}{140,000} \text{ RPM} = \$0.114 \text{ per RPM} \]
  \[ \text{Unit Cost} = \frac{15,000}{200,000} \text{ ASM} = \$0.075 \text{ per ASM} \]
  \[ \text{Unit Revenue} = \frac{16,000}{200,000} \text{ ASM} = \$0.080 \text{ per ASM} \]

• Average Load Factor = RPM / ASM
  
  \[ \text{ALF} = \frac{140,000}{200,000} = 70.0\% \]
  
  • For single flight, also defined as passengers / seats
US Airline Capacity 2001-2004

CAPACITY: Available Seat Miles

SOURCE: AIR TRANSPORT ASSOCIATION
US Airline Losses Almost $40 Billion From 2001 to 2005

Oper Profit
Net Profit
Load Factors are at Record Levels

LOAD FACTOR
4 Qtr Moving Average

Source: ATA data
Airline Supply Terminology

• **Flight Leg (or “flight sector” or “flight segment”)**
  – Non-stop operation of an aircraft between A and B, with associated departure and arrival times

• **Flight**
  – One or more flight legs operated consecutively by a single aircraft (usually) and labeled with a single flight number (usually)
  – NW945 is a two-leg flight BOS-MSP-SEA operated with a B757

• **Route**
  – Consecutive links in a network served by single flight numbers
  – NW operates 2 flights per day on one-stop route BOS-MSP-SEA

• **Passenger Paths or Itineraries**
  – Combination of flight legs chosen by passengers in an O-D market to complete a journey (e.g., BOS-SEA via connection at DTW)
Fleet Planning

Route Planning

Schedule Development
  o Frequency Planning
  o Timetable Development
  o Fleet Assignment
  o Aircraft Rotations

Pricing

Crew Scheduling

Revenue Management

Operations Control

Airport Resource Management

(Source: Prof. C. Barnhart)
Airline Planning Decisions

1. FLEET PLANNING: What aircraft to acquire/retire, when and how many?

2. ROUTE EVALUATION: What network structure to operate and city-pairs to be served?

3. SCHEDULE DEVELOPMENT: How often, at what times and with which aircraft on each route?

4. PRICING: What products, fares and restrictions for each O-D market?

5. REVENUE MANAGEMENT: How many bookings to accept, by type of fare, to maximize revenue on each flight and over the network?
1. FLEET PLANNING

• Long-term strategic decision for an airline:
  – Affects financial position, operating costs, and especially the ability to serve specific routes.

• Huge capital investment with lasting impacts:
  – US $40-60 million for narrow-body aircraft
  – $200+ million for wide-body long-range 747-400
  – Depreciation impacts last 10-15 years
  – Some aircraft have been operated economically for 30+ years
Fleet Planning Decisions

• Fleet planning is an optimal staging problem:
  – Number and type of aircraft required
  – Timing of deliveries and retirement of existing fleet
  – Tremendous uncertainty about future conditions

• Aircraft evaluation criteria for airlines include:
  – Technical and performance characteristics
  – Economics of operations and revenue generation
  – Marketing and environmental issues
  – Political and international trade concerns
2. ROUTE PLANNING

• Given a fleet, selection of routes to be flown

• Economic considerations dominate:
  – Forecasts of potential demand and revenues
  – Airline’s market share of total forecast demand
  – Opportunity cost of using aircraft on this route
  – Network implications for costs, revenues and “profit”

• Practical considerations just as important:
  – Aircraft with adequate range and proper capacity
  – Performance and operating cost characteristics
  – Operational constraints and aircraft/crew rotation issues
  – Regulations, bilaterals, and limited airport slots
“Route Profitability Models”

• OR models designed to perform such route evaluations, used by some airlines:
  – Demand, cost and revenue forecasts for specific route, perhaps for multiple years into the future
  – Select routes to maximize profits, given set of candidate routes and estimated demands
  – Subject to fleet and capacity constraints
  – Assessments should be based on total network impacts

• Built on highly simplified assumptions:
  – Profit estimates entirely dependent on accuracy of demand estimates and market share models
  – Ability to integrate competitive effects is limited
3. SCHEDULE DEVELOPMENT

• Involves several interrelated decisions, which to date have not been fully integrated:

  Frequency Planning: Number of departures to be offered on each route, non-stop versus multi-stop

  Timetable Development: Flight departure and arrival times, including connections at airline hubs

  Fleet Assignment: Aircraft type for each flight, based on demand and operating cost estimates

  Aircraft Rotation Planning: Links consecutive flights to ensure balanced aircraft flows on the network.
• Airline scheduling problems have received most operations research (OR) attention

• Use of schedule optimization models has led to impressive profit gains in:
  – Aircraft rotations; fleet assignment
  – Crew rotations; maintenance scheduling

• Current focus is on “solving” larger problems:
  – Timetable optimization is still not feasible--too many dimensions and constraints
4. PRICING DECISIONS

• “Differential pricing” by airlines is universal:
  – Classes of service (First, Business, Coach)
  – Different “fare products” within the coach cabin, with different restrictions, at different prices
  – Virtually every airline in the world offers multiple price points (even low-fare carriers with “simplified” fare structures)

• Economic trade-off in pricing decisions:
  – Stimulation of new demand; increased market share for airline
  – Diversion of existing demand to lower fares; reduced revenues
  – Recent pricing difficulties of network airlines due in part to greater diversion of revenues than stimulation of demand
Pricing Models

• Pricing theory has not kept pace with airline competitive pricing practices
  – Difficult to estimate price elasticity, willingness to pay, potential for stimulation and diversion
  – No practical tools for airlines to determine “optimal” prices

• Some airlines are now implementing “Pricing Decision Support Systems”
  – Primarily monitoring of price changes
  – Little competitive modeling of pricing impacts

• Dominant practice is to *match* low fares to fill planes and retain market share.
5. REVENUE MANAGEMENT

• “Inventory control” for airlines:
  – Given a scheduled flight, capacity and prices, how many bookings to accept by fare type
  – Objective is to maximize revenue -- fill each seat with highest possible revenue

• Computerized RM systems used by airlines to increase revenues by 4-6%:
  – Generate forecasts by flight date and fare class
  – Optimize seat allocations to different fare classes
  – Overbooking models to minimize costs of denied boardings and “spoilage”
Example of Third Generation RM System

- REVENUE DATA
- HISTORICAL BOOKING DATA
- ACTUAL BOOKINGS
- NO-SHOW DATA
- FORECASTING MODEL
- OPTIMIZATION MODEL
- OVERBOOKING MODEL
- RECOMMENDED BOOKING LIMITS
Integrated Airline Planning Models

- As described, current practice is to perform scheduling, pricing and RM sequentially.

- Integrated models would *jointly* optimize schedules, capacity, prices, and seat inventories:
  - Better feedback from pricing and RM systems can affect optimal choice of schedule and aircraft
  - Better choice of schedule and capacity can reduce need for excessive discounting and “fare wars”
The Ultimate Challenge

- Joint optimization and planning is a big challenge, both theoretically and practically:
  - Few airlines have “corporate databases” with consistent and detailed demand/cost data
  - Research is still required to identify models that can capture dynamics and competitive behaviors
  - Organizational coordination within airlines and willingness to accept large-scale decision tool
  - Might never be possible to integrate all subtleties of airline planning decisions into a useful tool