MIT ICAT

Introduction to the Airline Planning Process

Dr. Peter Belobaba

16.75/1.234 Airline Management

February 8, 2006

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:**

  RPM = 140 passengers X 1000 miles = 140,000

  ASM = 200 seats X 1000 miles = 200,000

- **Assume total revenue = $16,000; total operating expense = $15,000:**

  Yield = $16,000 / 140,000 RPM = $0.114 per RPM

  Unit Cost = $15,000 / 200,000 ASM = $0.075 per ASM

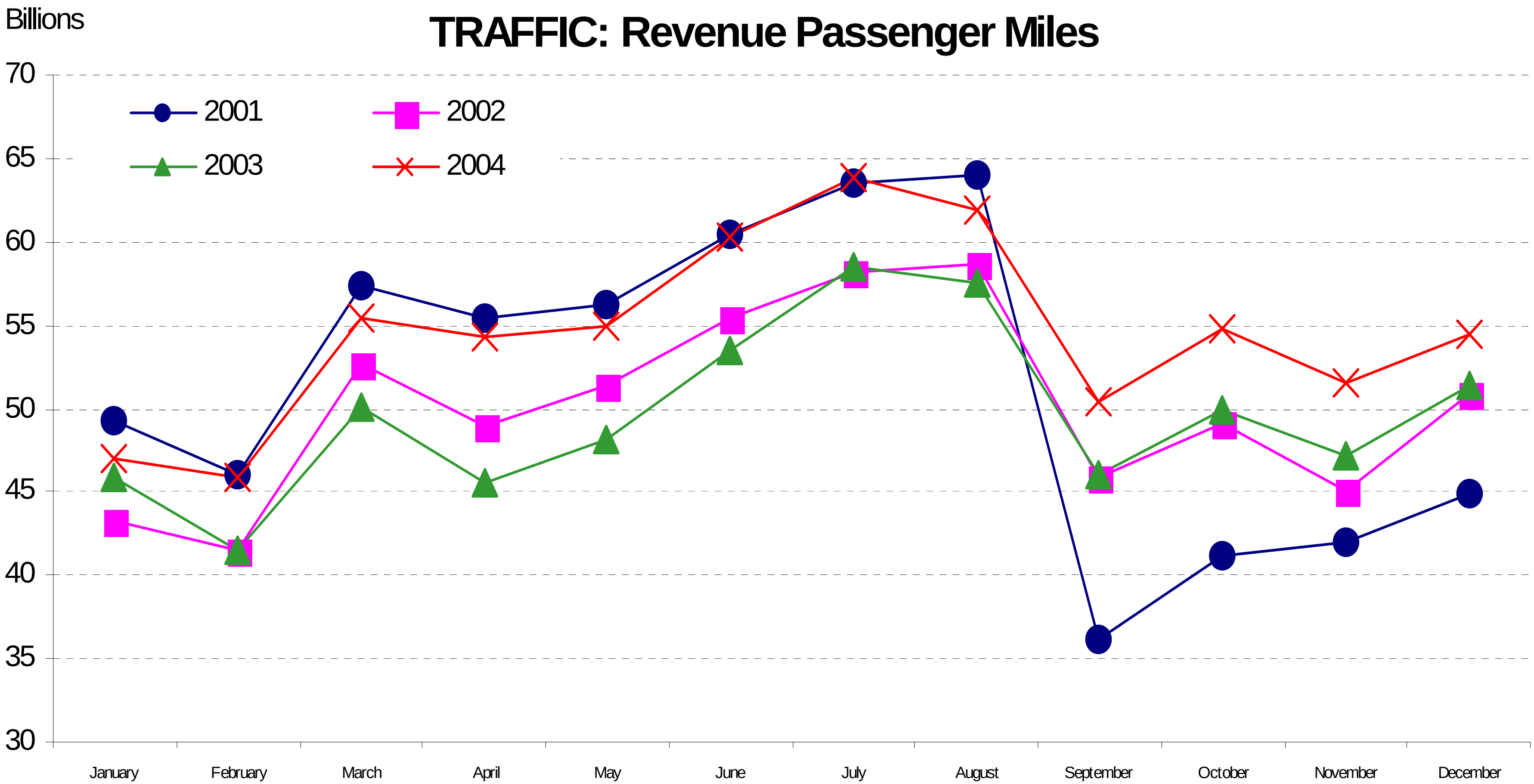
  Unit Revenue = $16,000 / 200,000 ASM = $0.080 per ASM

- **Average Load Factor = RPM / ASM**

  ALF = 140,000 / 200,000 = 70.0%

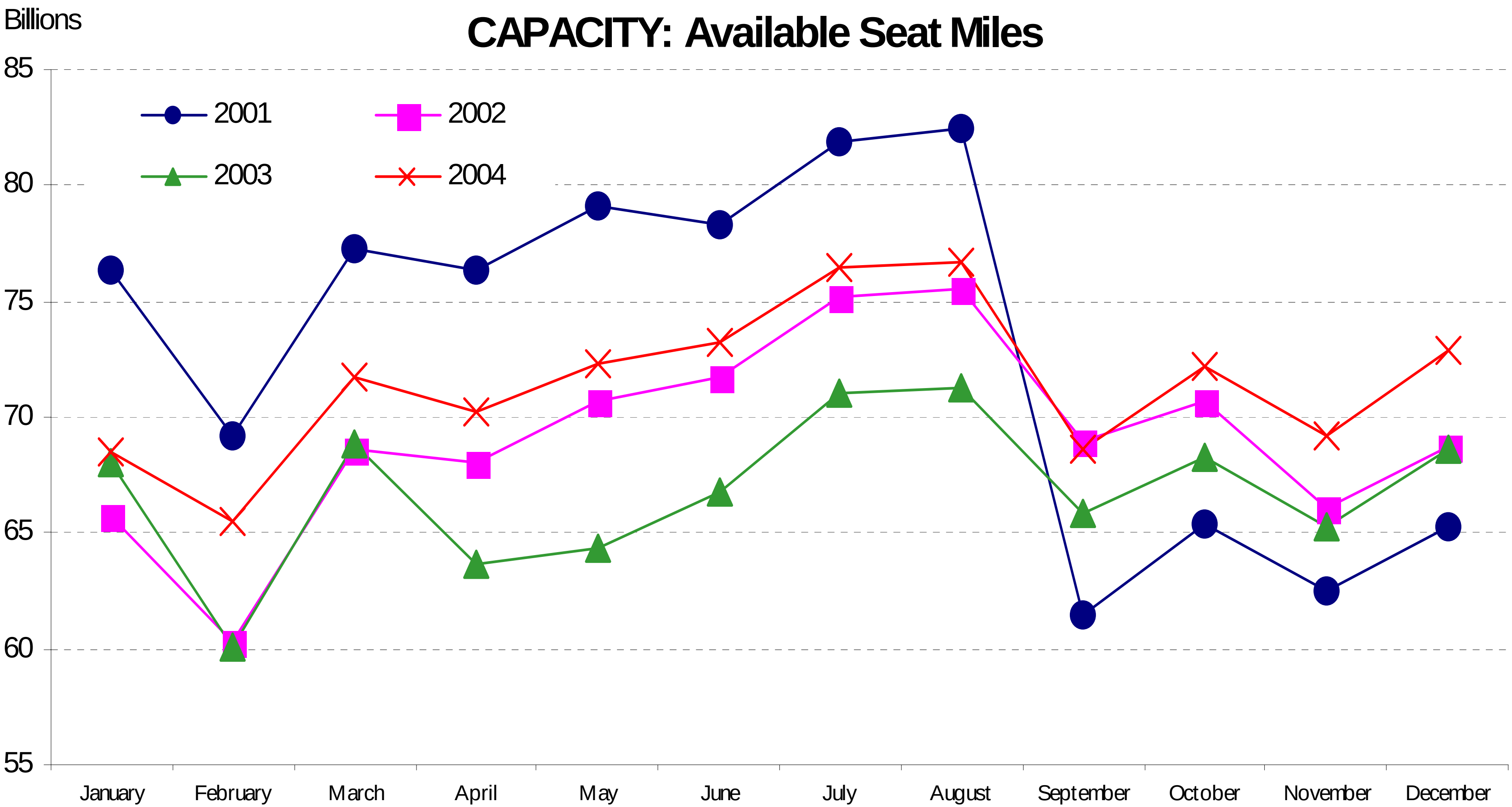
  - For single flight, also defined as passengers / seats

US Airline Traffic 2001-2004



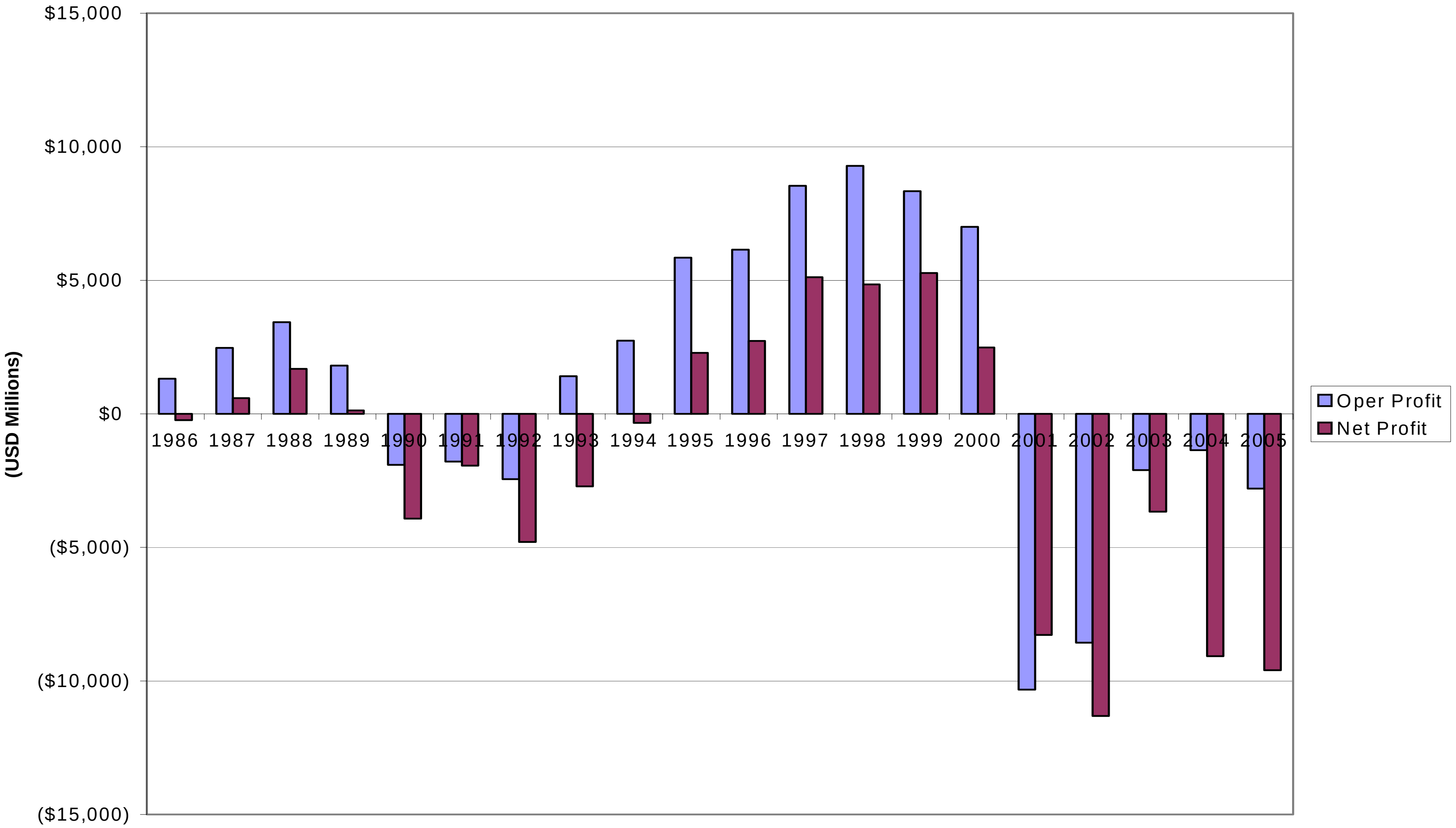
SOURCE: AIR TRANSPORT ASSOCIATION

US Airline Capacity 2001-2004

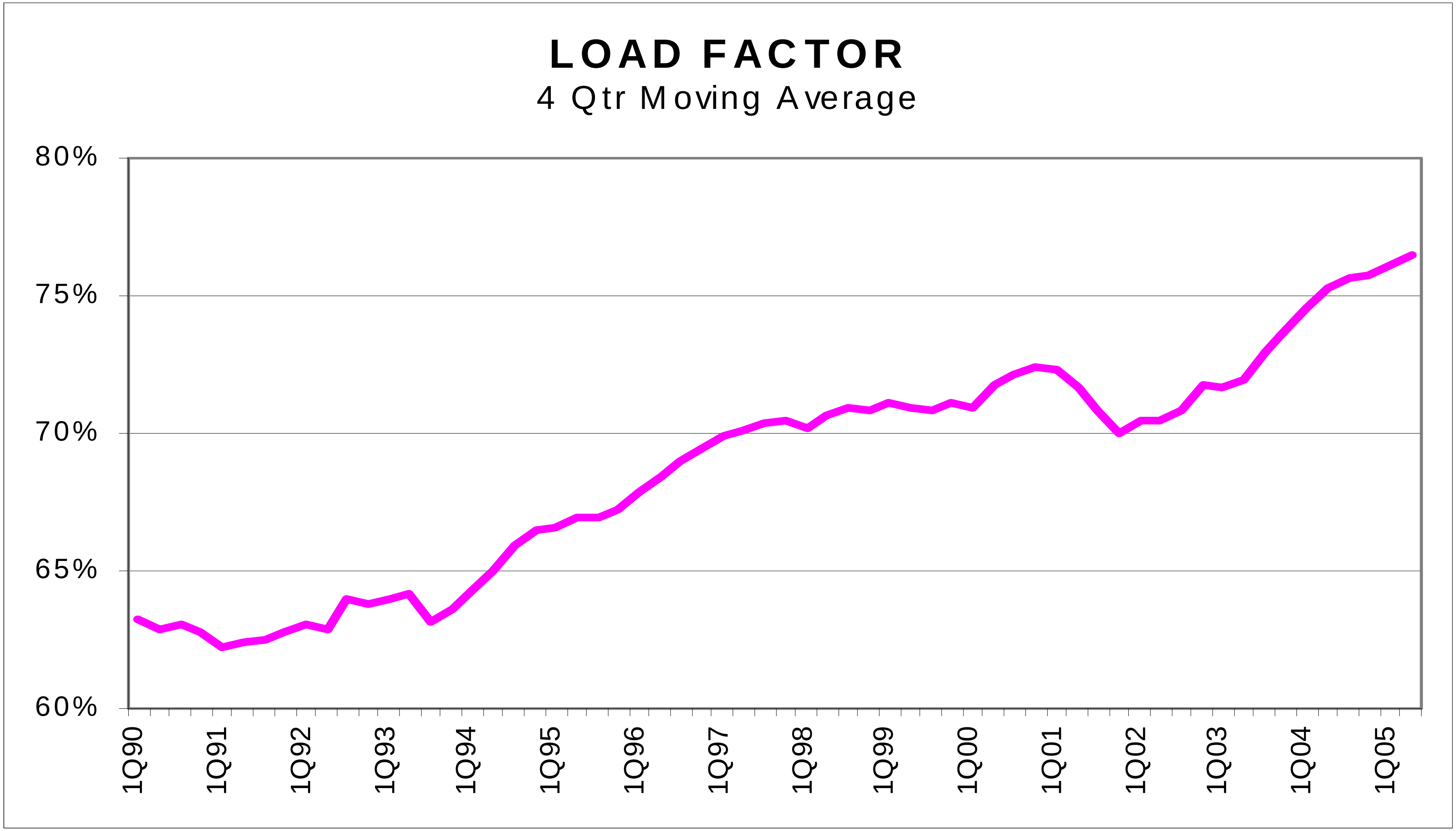


SOURCE: AIR TRANSPORT ASSOCIATION

US Airline Losses Almost $40 Billion From 2001 to 2005

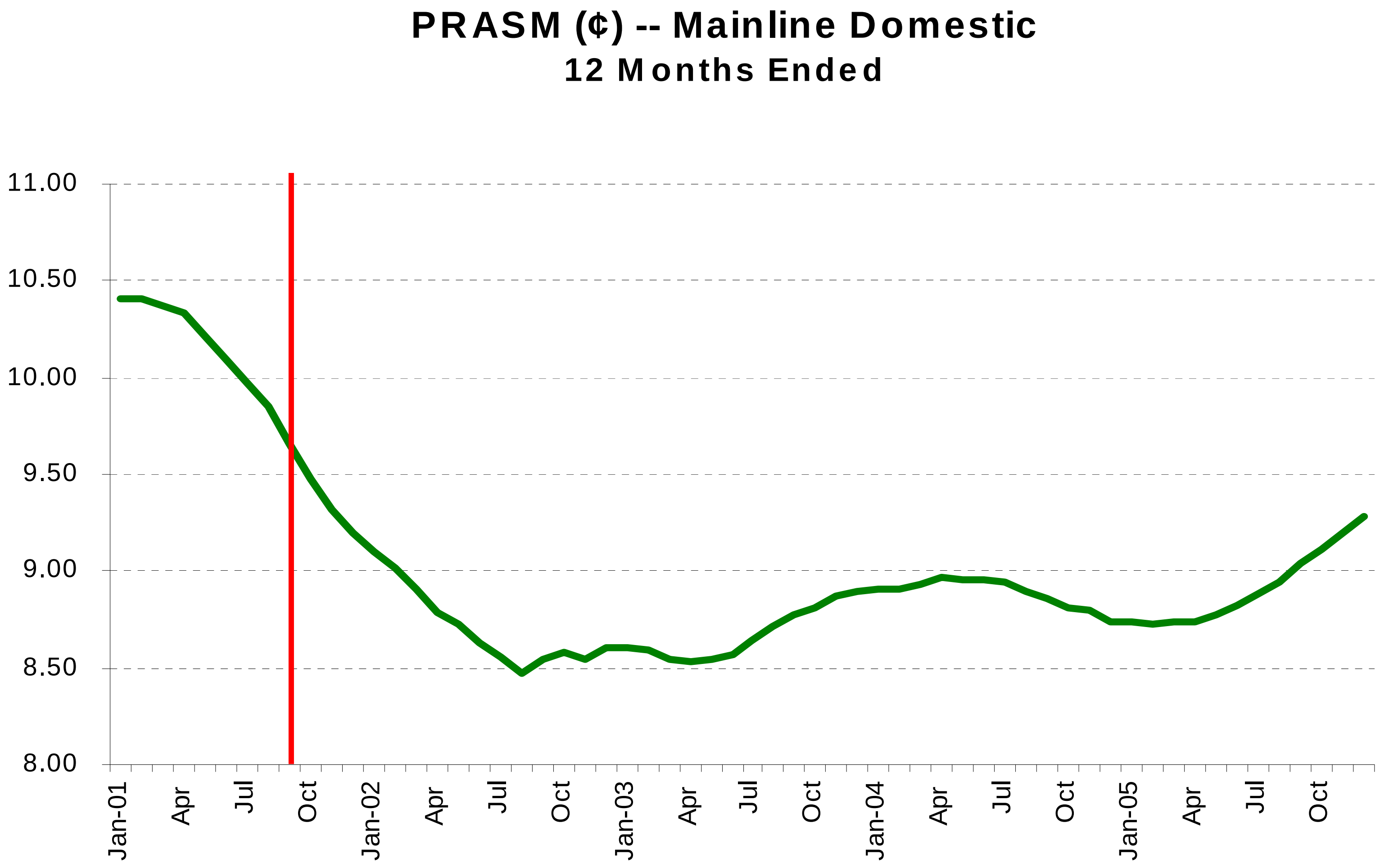


Load Factors are at Record Levels



Source: ATA data

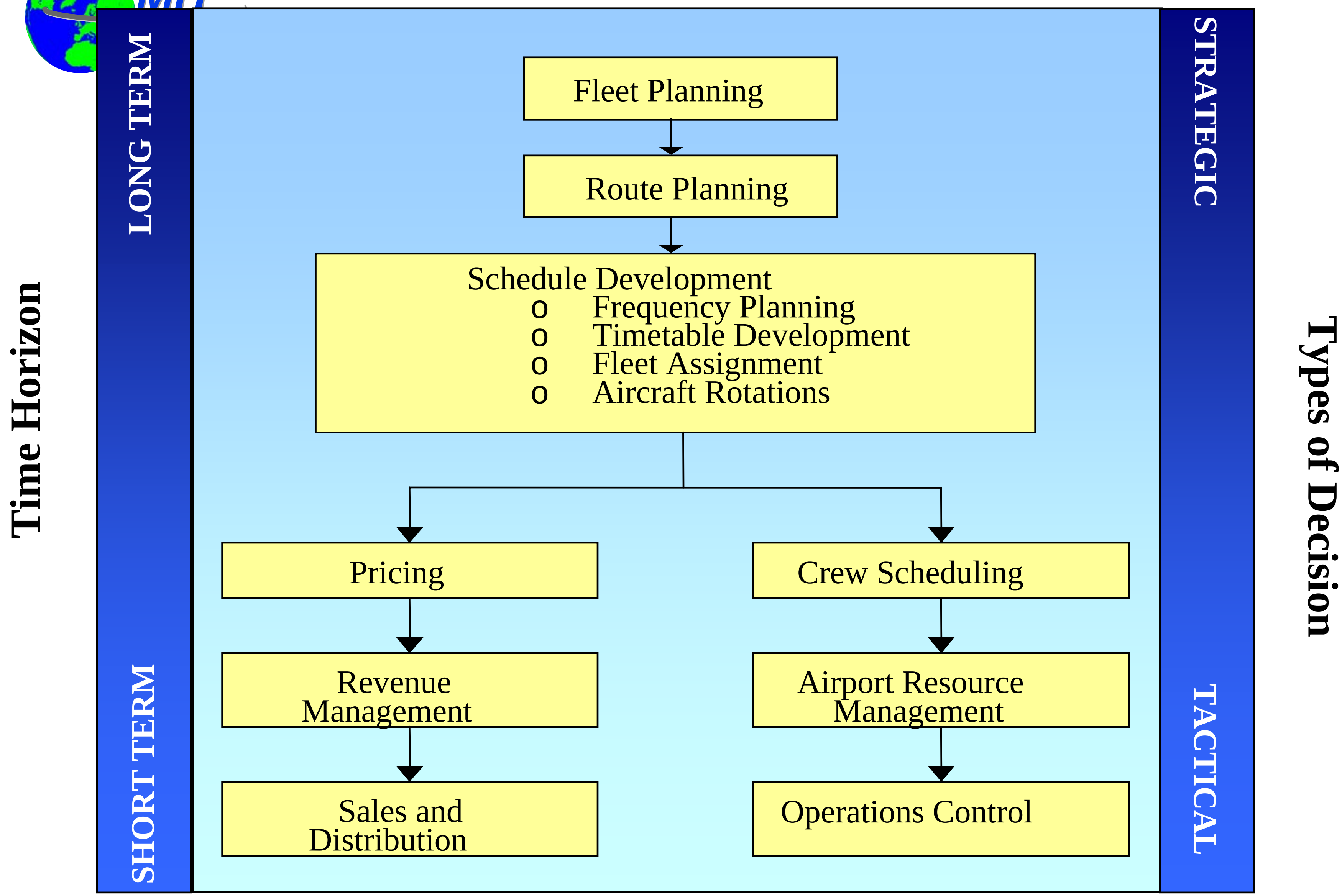
US Domestic Unit Revenues



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)



SOURCE: Prof. C. Barnhart

MIT ICAT

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:**
  - <u>Frequency Planning</u>: Number of departures to be offered on each route, non-stop versus multi-stop
  - <u>Timetable Development</u>: Flight departure and arrival times, including connections at airline hubs
  - <u>Fleet Assignment</u>: Aircraft type for each flight, based on demand and operating cost estimates
  - <u>Aircraft Rotation Planning</u>: Links consecutive flights to ensure balanced aircraft flows on the network.

OR Models in Airline Scheduling

- **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:**
  - <u>Stimulation</u> of new demand; increased market share for airline
  - <u>Diversion</u> 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

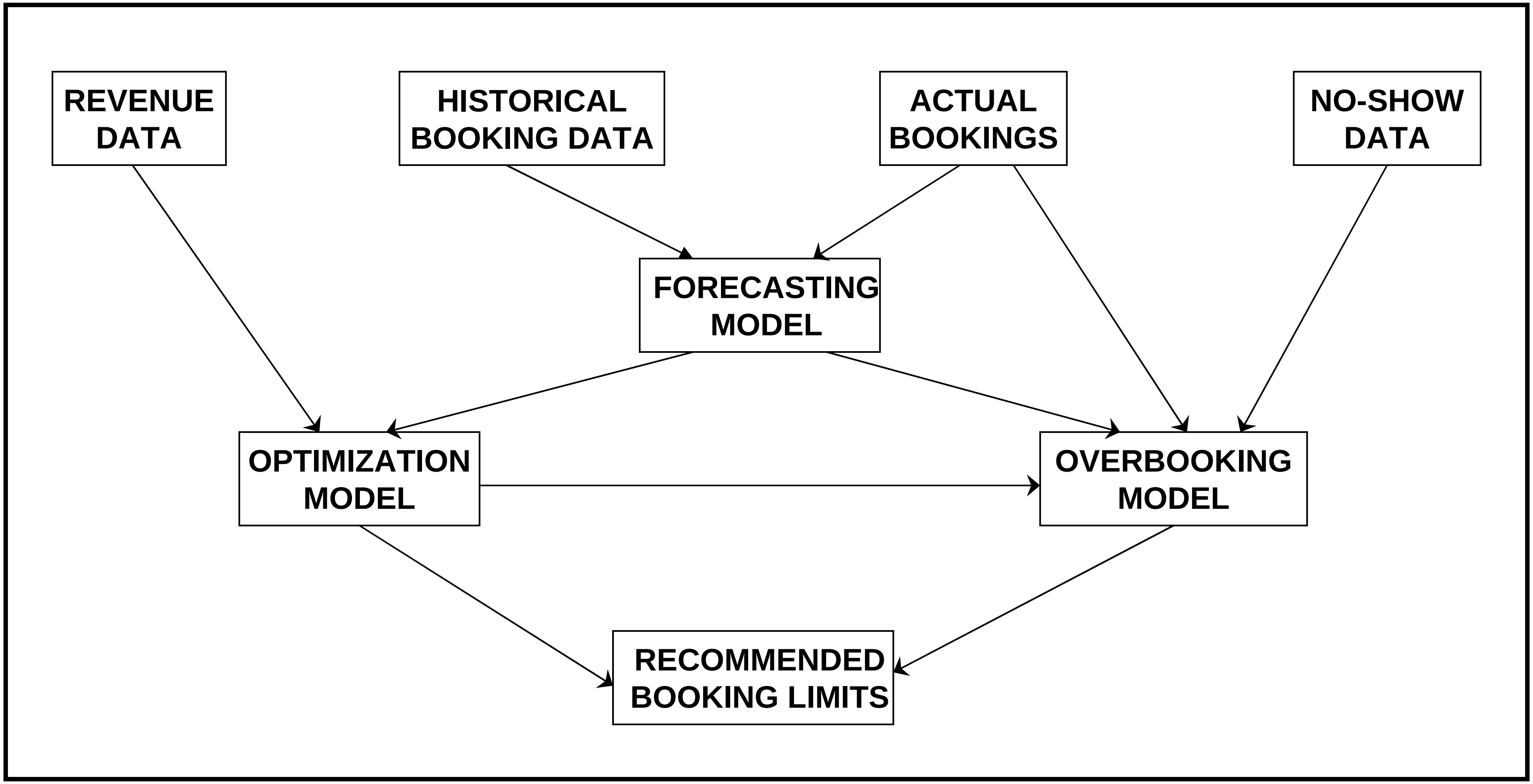
Pricing Models

- **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



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