# *Modeling Passenger Choice of Flight Options*

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*Strategic Planning*

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# *Lecture Outline*

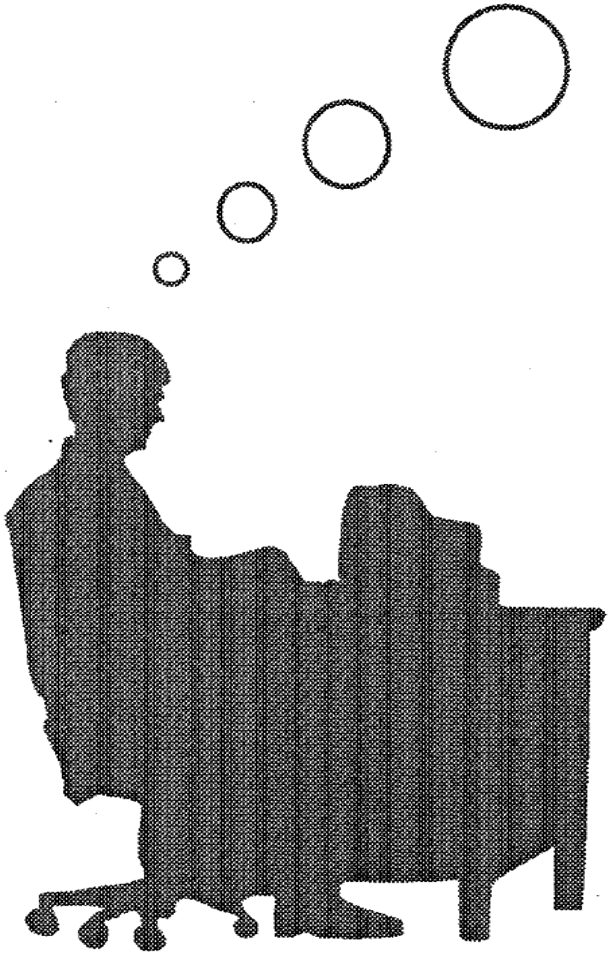
- **Boeing Decision Window Model (DWM)**
  - Traveler Decision Process
  - Decision Windows
  - Passenger Choice of Path Options
  - Airline Image Factors
  - Schedule vs. Airline Decision Orientation
- **Passenger Origin-Destination Simulator (PODS)**
  - Simulation Process
  - Inputs and Assumptions – Demand by Passenger Type
  - Passenger Choice Representation
  - Disutility Model for Fare Restrictions
  - Total Generalized Cost

# *Boeing Decision Window Model (DWM)*

- **An approach for estimating passenger preference for different flight alternatives in a schedule**
  - DWM assumes a model of the decision making process of individual travelers

- **Given an estimate of the total daily demand for air travel in a directional O-D market**
  - What is the expected share of this demand that will prefer each alternative “path” (itinerary)
  - Path preference based on time of day demand distributions and path quality of schedule alternatives (non-stop vs. connect, etc.)
  - Assume “all else equal” – competing airlines have same fares, same product quality, same aircraft preferences

# *The Traveler Decision Process*



**Day**
**Departure Time**

**Duration**
**Airline**
**Flights**

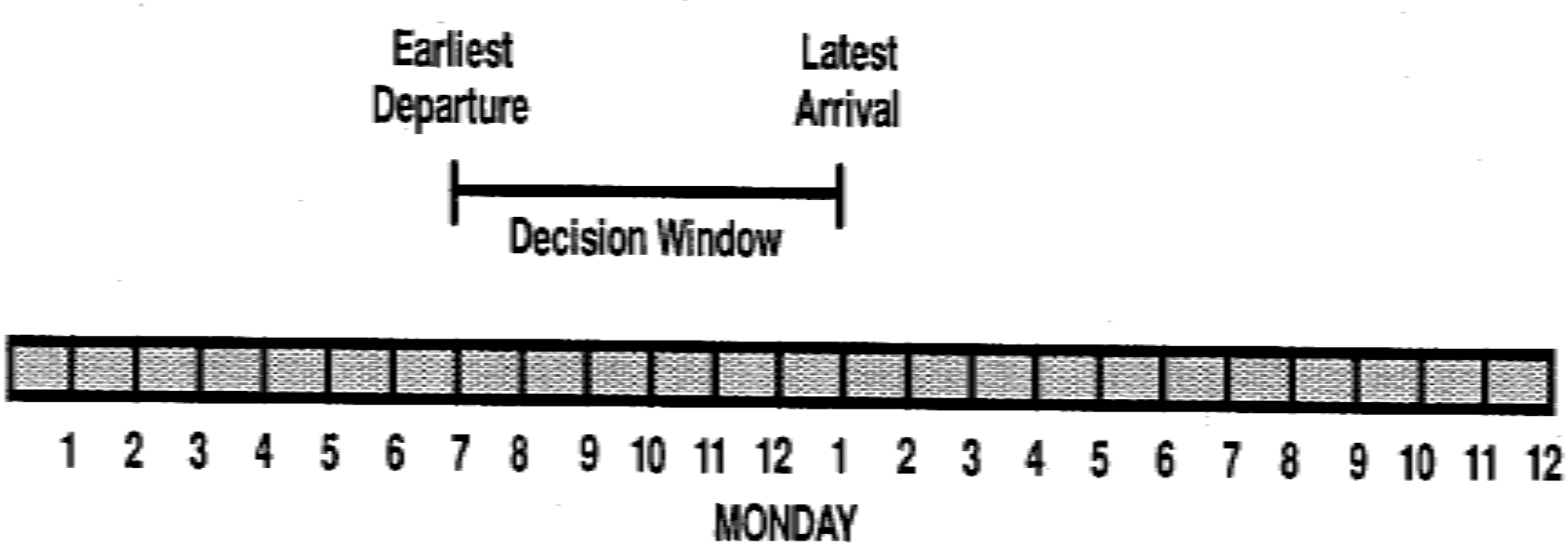
**Arrival Time**

***Travelers have some knowledge of the characteristics of their planned trips***

***Source: Boeing***

# *Each Passenger has a Decision Window*

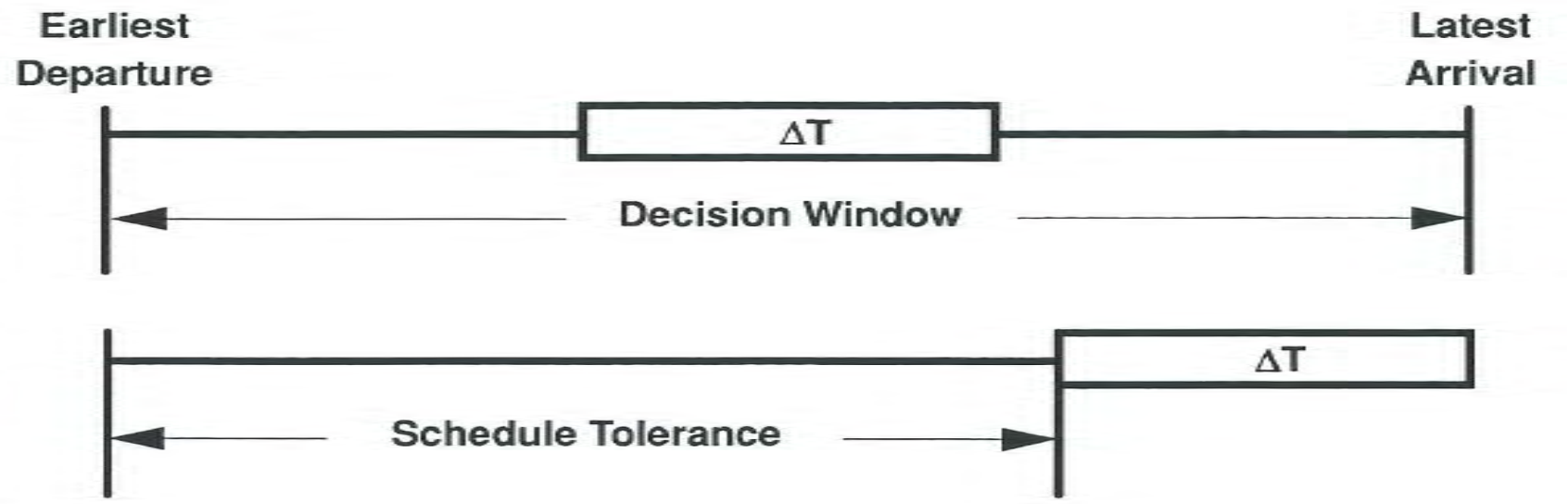
- **Bounded by earliest departure and latest arrival time**
  - Window is situated on the preferred travel day
  - Window is wider than the perceived (actual) travel time required
  - All departure and arrival times in the window are acceptable to the traveler




***Source: Boeing***

# *Decision Window Size*

- **"Delta-T": Difference between local departure time and local arrival time at destination**
  - Represents perceived duration of flight
- **Schedule Tolerance: Amount of flexibility in passenger's preferred travel schedule**
  - Will differ by passenger type (business vs. leisure)

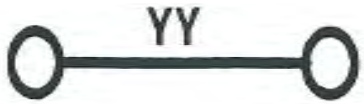



***Source: Boeing***

# *Airline Schedules Create Paths*

- **Paths are flights and itineraries that are available for travel from the passenger's origin to destination**

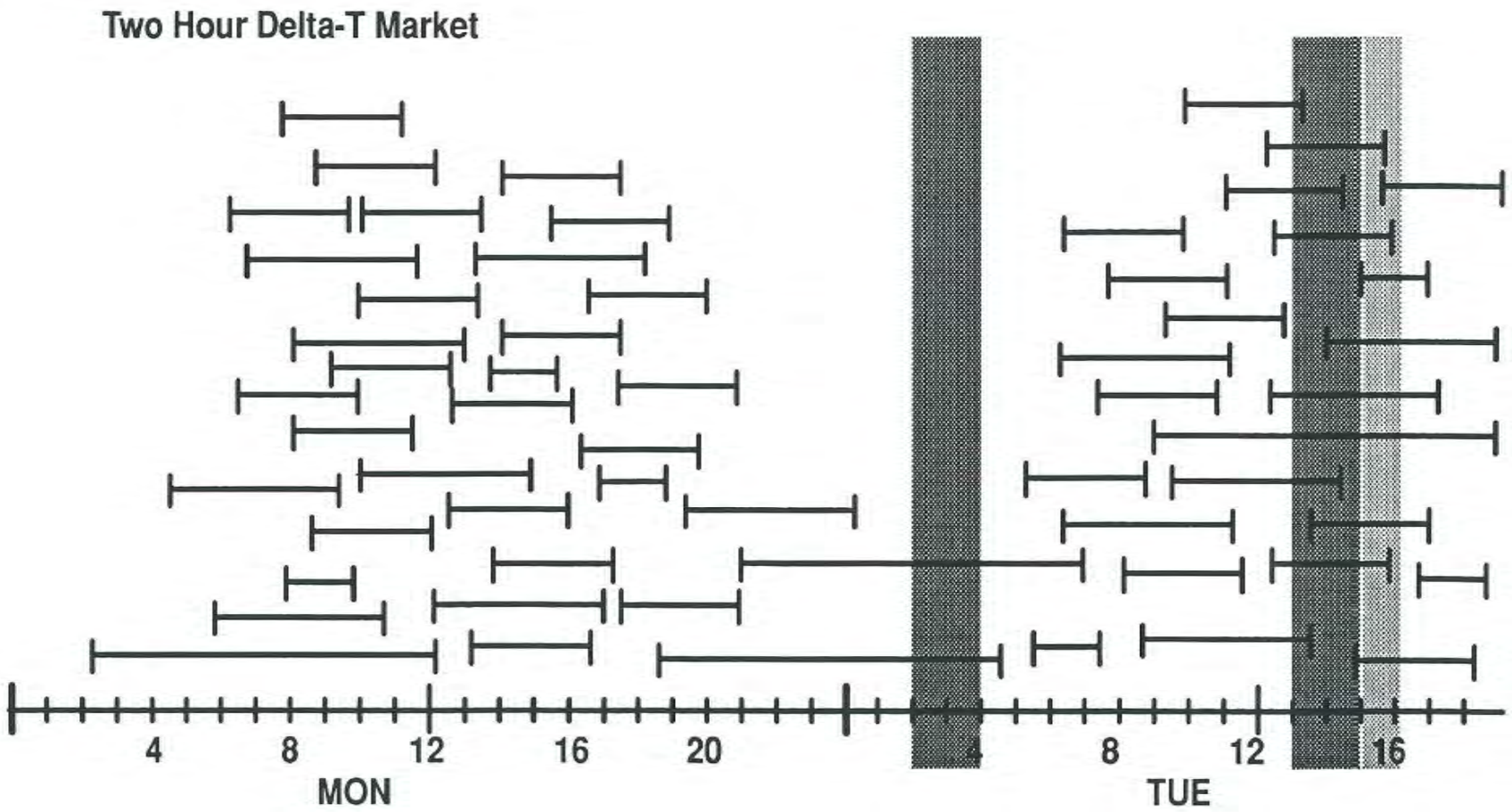
The Schedule

| | | | | | |
|---|---|---|---|---|---|
| SEA-SFO | YY | 08:00-10:00 | 0 |  | Non-stop |
| SEA-SFO | ZZ | 14:30-17:30 | 1 |  | One-stop |
| SEA-PDX | CC | 12:00-12:30 | 0 |  | Connect |
| PDX-SFO | CC | 13:00-15:00 | 0 | | |
| SEA-ODM | EE | 20:30-21:30 | 0 |  | Interline Connect |
| ODM-SFO | CC | 23:00-23:15 | 0 | | |

***Source: Boeing***

# *Many Individuals Make Up Total Demand in a Market*

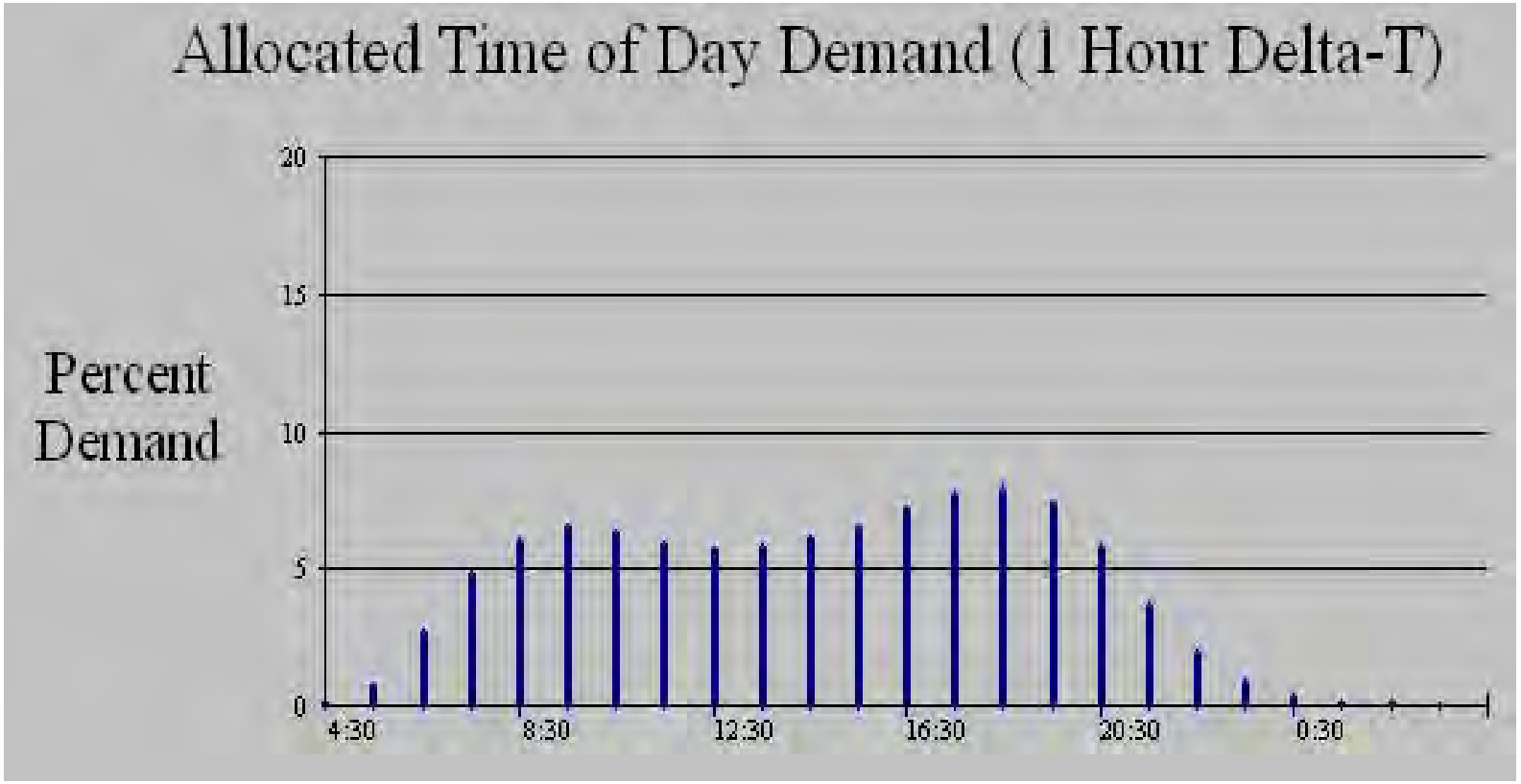
- **For example, a distribution of decision windows**




***Source: Boeing***

# *Time of Day Demand – Preferred Departure Times by Passengers*

- **Two peaks of preferred departure times (0900 and 1800) in this short-haul (1-2 block hours) example.**




***Source: Boeing Decision Window Model (DWM)***

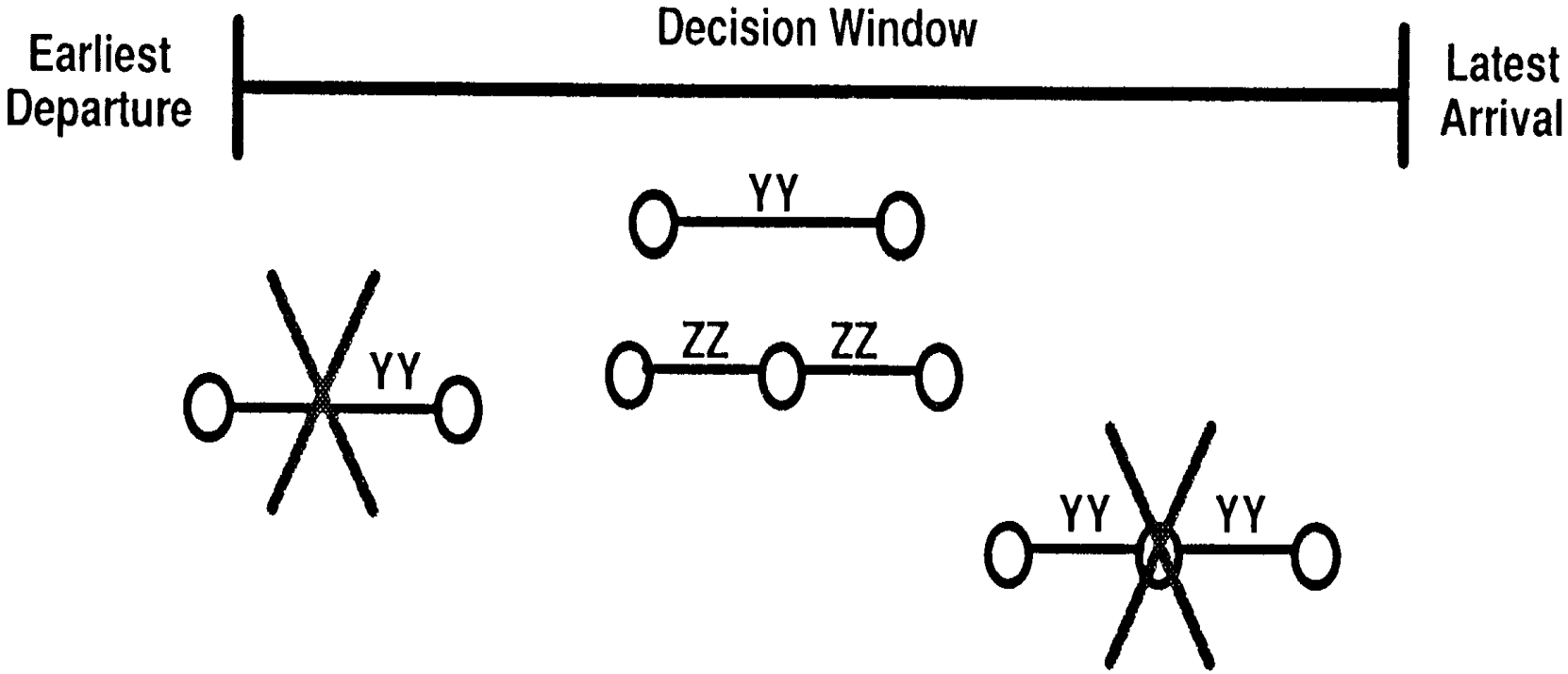
# *Decision Windows Capture Key Characteristics of Airline Markets*

- **More frequencies are good**
  - More flight options at different times increase the likelihood each traveler will find at least one path in his decision window
- **Frequency saturation exists**
  - At some point, adding more flights satisfies the same travelers that were willing to choose another flight
- **Shorter paths (non-stop) are good**
  - Long (multiple stop or connecting) paths are less likely to fit into the decision window of most travelers
- **Timing of flights is important**
  - Paths departing at popular times will be within the decision window of more travelers

***Source: Boeing***

# *Passenger Choice of Path Options*

- **Acceptable paths must fit within decision window**
- **Path choice based on path quality and airline image**



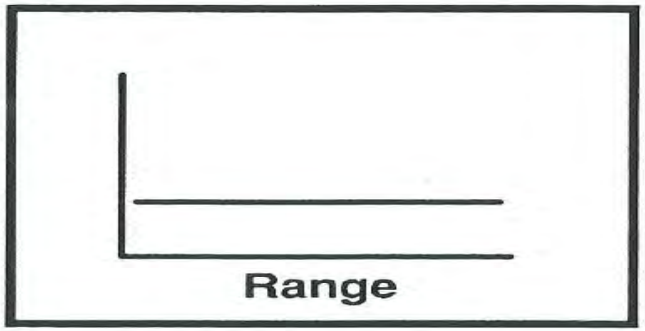

*Source: Boeing*

# *Factors Affecting Airline Image*

- **Importance of different factors varies with distance of the trip being considered**

**Availability/Reliability**


**Marketing Programs**




**Service Quality**


**Passenger Environment**


***Source: Boeing***

# *Decision Orientation Affects Path Choice*

## Schedule Oriented

- Chooses the best path quality
- Chooses preferred airline

## Airline Oriented

- Chooses preferred airline
- Chooses best path quality

***Source: Boeing***

# *Insights from Decision Window Model of Path Choice*

- **Path Quality is important**
  - Paths with lower PQI are less likely to be chosen
  - Lower PQI means increased total travel time
  - Lower PQI can also mean greater risk and lower image (e.g., missed connections, baggage problems)

- **Trip Distance (range) determines the importance of different factors**
  - The longer the range, the more important are airline service quality and passenger environment (including aircraft type)
  - Differences in path quality are less important at longer range

***Source: Boeing***

# *Passenger Origin Destination Simulator*

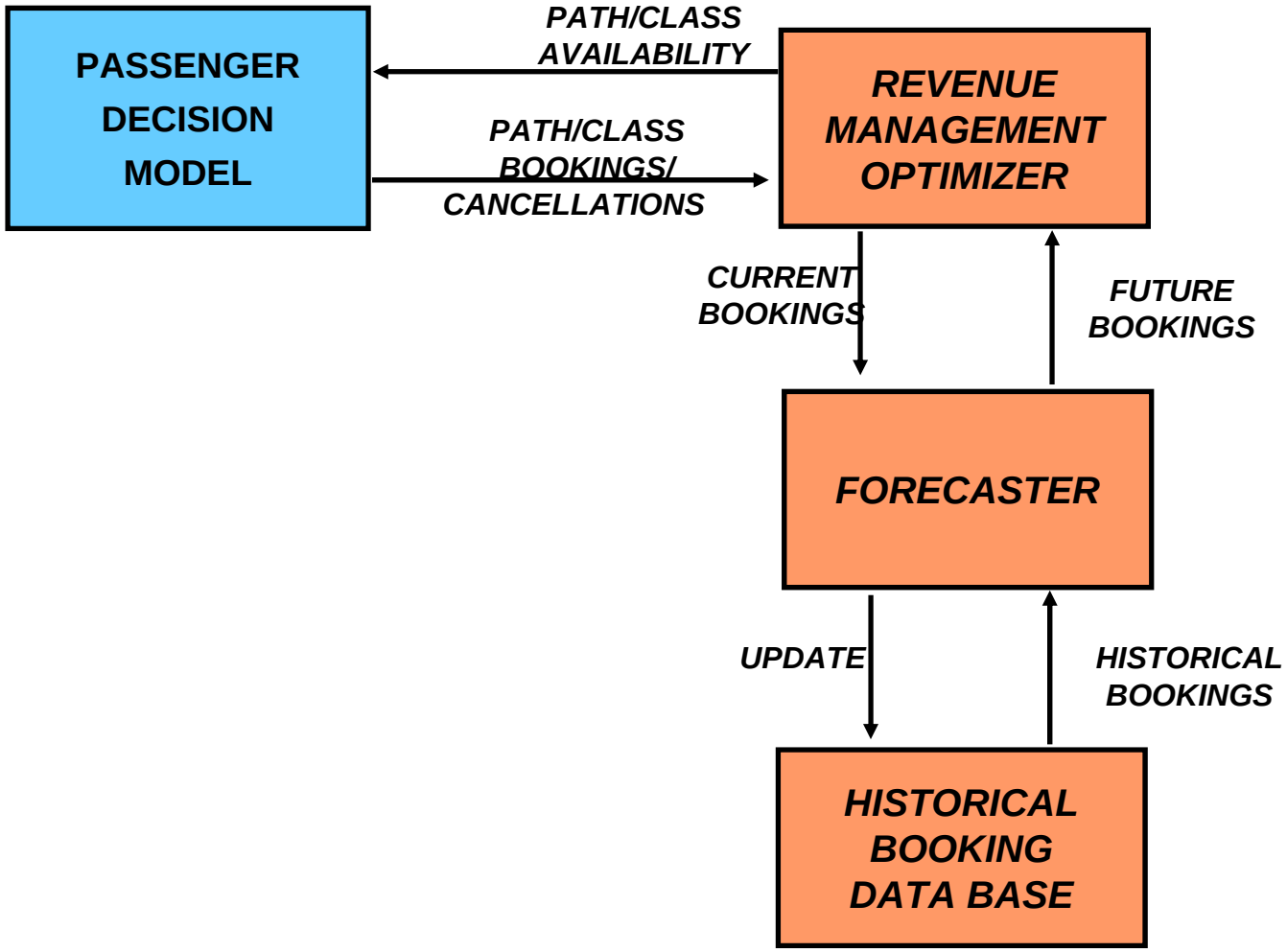
- **Passenger Origin Destination Simulator developed by Boeing in early 1990s**
  - Originally simulated passenger choice based on Decision Window Model
  - MIT (Belobaba) helped to integrate pricing and airline Revenue Management models in mid-1990s
- **PODS simulates interaction of RM and passenger choice in *competitive* markets:**
  - Airlines must forecast booking demand from actual (previously simulated) historical data
  - RM systems set booking limits by leg/class or path/class (O+D) given demand forecasts and optimization/control scheme
  - Passengers choose among O-D paths/fare types and airlines based on prices, restrictions and RM availability

# *Overview of PODS Architecture*

- **Multiple iterations (samples) of pre-departure booking process and departure day:**
  - Stationary process (no trends)
  - Initial input values for demands, then gradual replacement with direct observations
  - “Burn” first n observations in calculating final scores

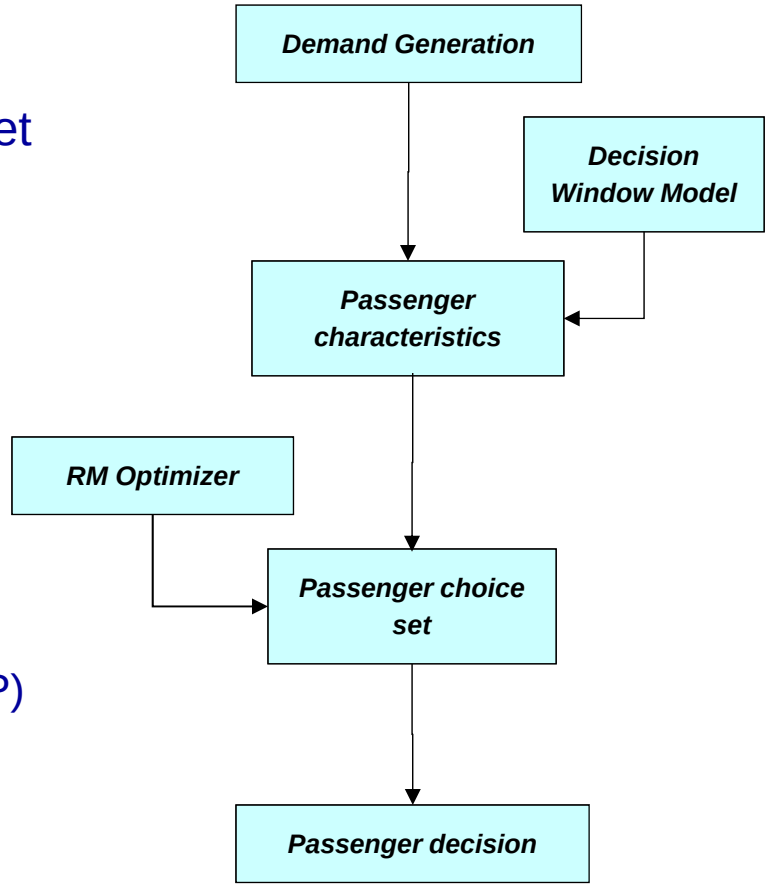
- **Pre-departure process broken into time frames:**
  - RM system intervention at start of each time frame
  - Bookings arrive randomly during time frame
  - Historical data base updated at end of time frame

# Basic Schematic



# *Passenger Choice Model*

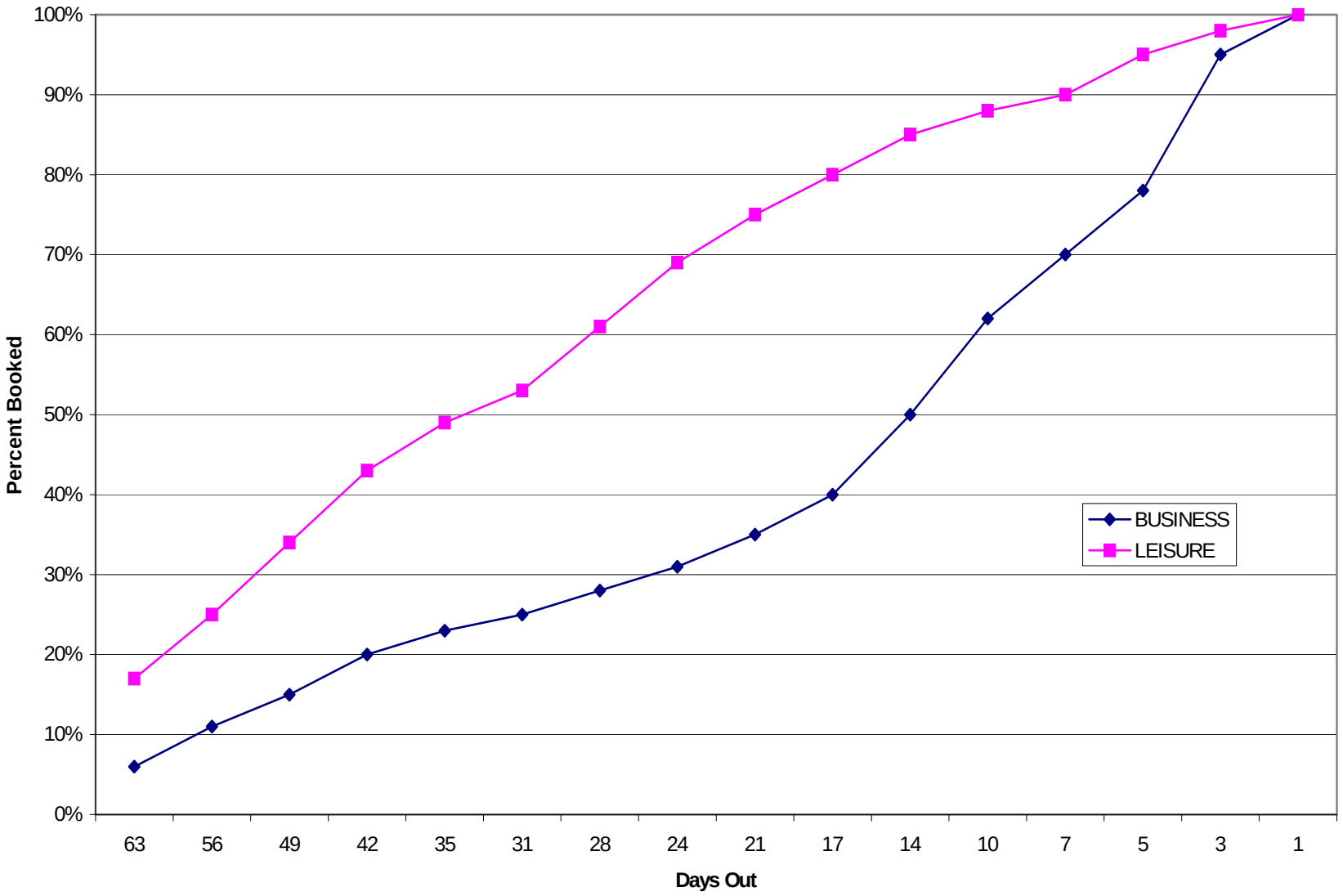
- **Demand generation**
  - Total demand for air travel per O-D market per passenger type per departure date
- **Passenger characteristics**
  - Passenger type, Decision window, WTP, disutilities
- **Passenger choice set**
  - Available travel alternatives
    - ➔ Advance purchase requirements
    - ➔ Affordable travel alternatives (Fare > WTP)
    - ➔ Path/class open/closed status
- **Decision rule**
  - Choose alternative (path/class) that has the lowest generalized cost (Fare + disutilities)



## *PODS Inputs and Parameters*

- **Total daily demand for an O-D market, by passenger type (business vs. leisure):**
  - Time of day demand and schedule tolerance
  - Maximum out-of-pocket fare willingness to pay
  - "Attributed costs" associated with path quality, fare restrictions, trip re-planning
- **Maximum willingness to pay (WTP) and attributed costs modeled as Gaussian distributions:**
  - Means and variances (k-factors) specified as inputs
- **Booking curves by passenger type over 16 booking periods before departure.**

# Booking Curves by Passenger Type



## *Business vs. Leisure Passengers*

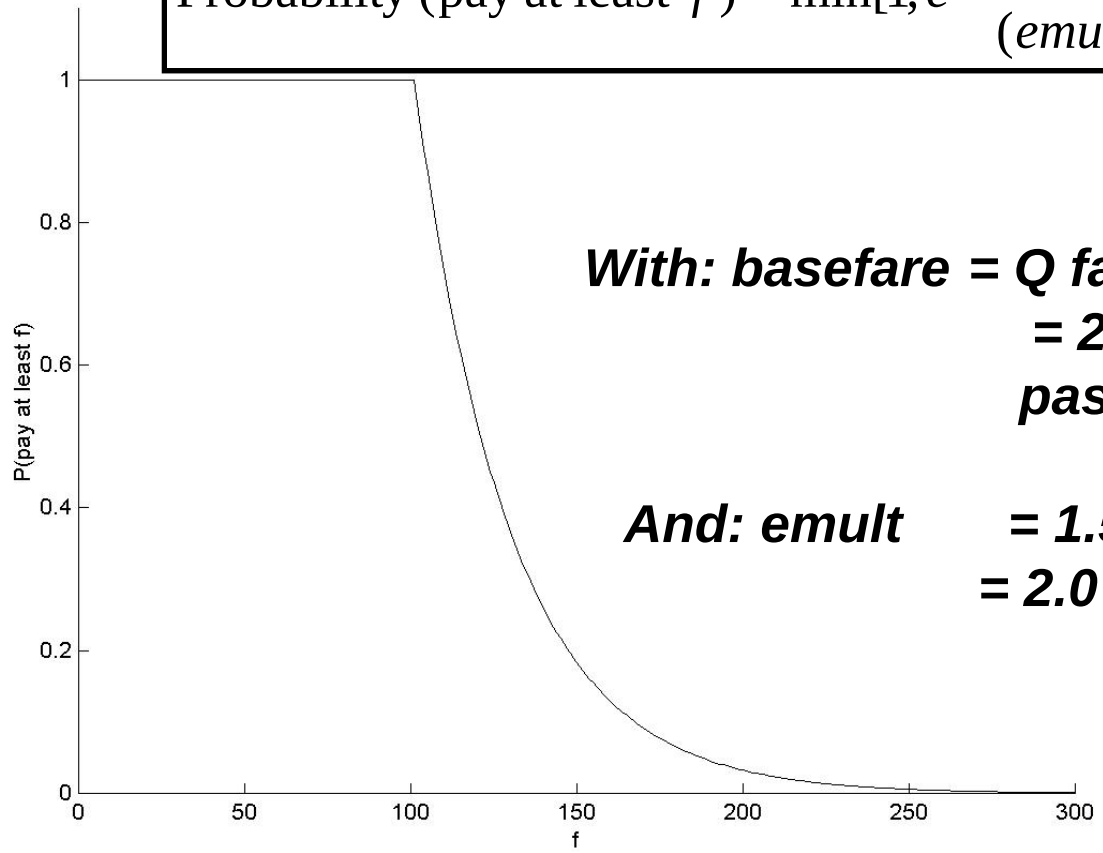
- **Two passenger types defined by:**
  - Time of day demand and schedule tolerance
  - Maximum out-of-pocket fare willingness to pay
  - “Attributed costs” associated with path quality, fare restrictions, trip re-planning

- **Maximum willingness to pay (WTP) and attributed costs modeled as Gaussian distributions:**
  - Means and variances (k-factors) specified as inputs
  - Each simulated passenger has randomly drawn value from each distribution

# Example of WTP Formulation

***In the passenger choice model used in PODS, a passenger's willingness-to-pay (WTP) is set according to:***

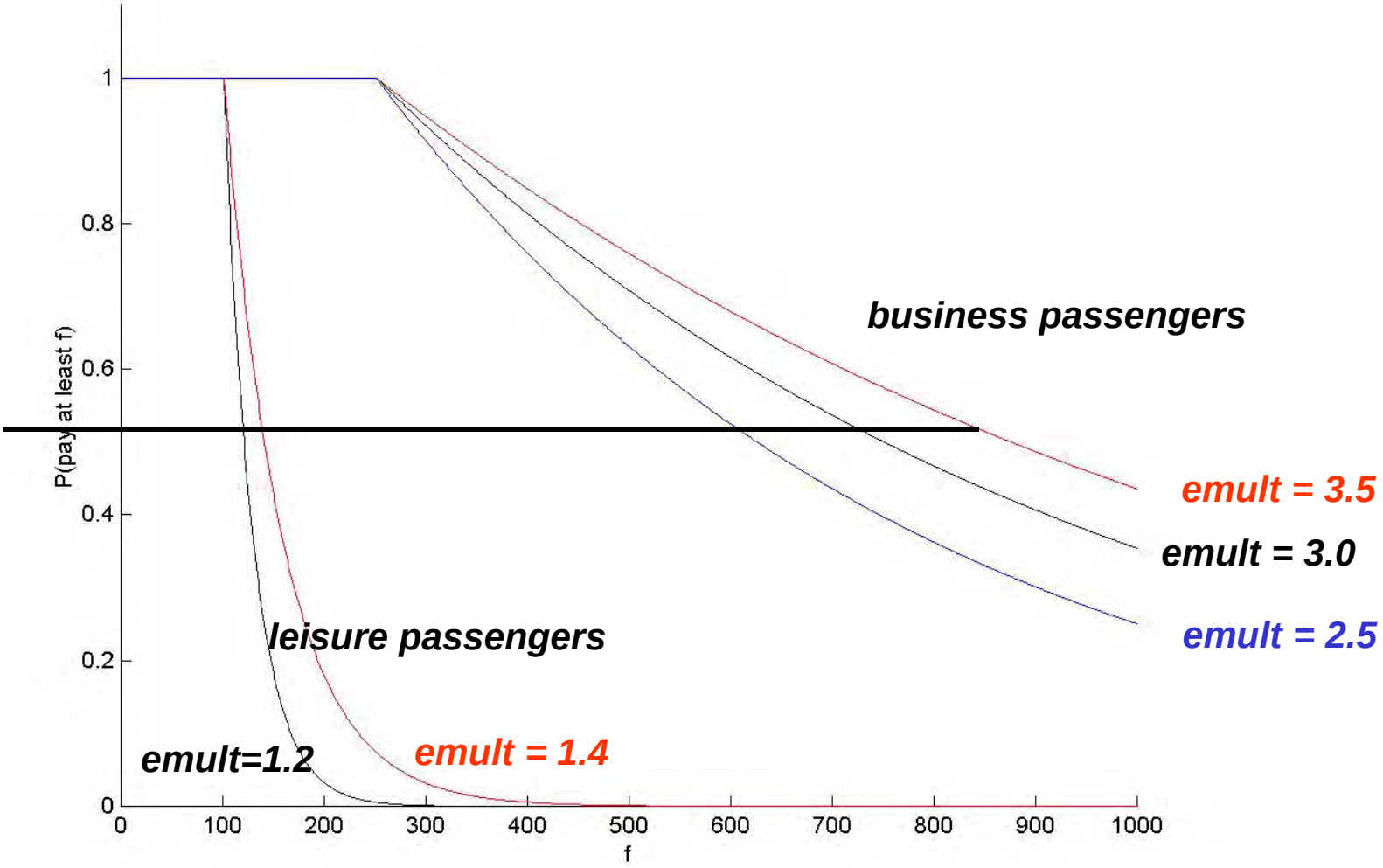
$$\text{Probability (pay at least } f) = \min[1, e^{\frac{-\log(2) * (f - basefare)}{(emult - 1) * basefare}}]$$




***With: basefare = Q fare for leisure passengers***
***= 2.5 * Q fare for business passengers***

***And: emult = 1.5 for leisure passengers***
***= 2.0 for business passengers***

# Different WTP Curves



# *Modeling Passenger Path Choice*

- **Define each passenger's "decision window":**
  - Earliest departure and latest arrival time
  - Market time-of-day demand profile
- **Eliminate paths with lowest available fare greater than passenger's maximum willingness to pay**
- **Pick best path from remainder, trading off:**
  - Fare levels and restrictions
  - Path quality (number of stops/connects)
  - Other disutility parameters

## *Choice of Path/Fare Combination*

- **Given passenger type, randomly pick for each passenger generated:**
  - Maximum “out-of-pocket” willingness to pay
  - Disutility costs of fare restrictions
  - Additional disutility costs associated with “re-planning” and path quality (stop/connect) costs

- **Screen out paths with fares greater than this passenger’s WTP.**

- **Assign passenger to feasible (remaining) path/fare with lowest total cost.**

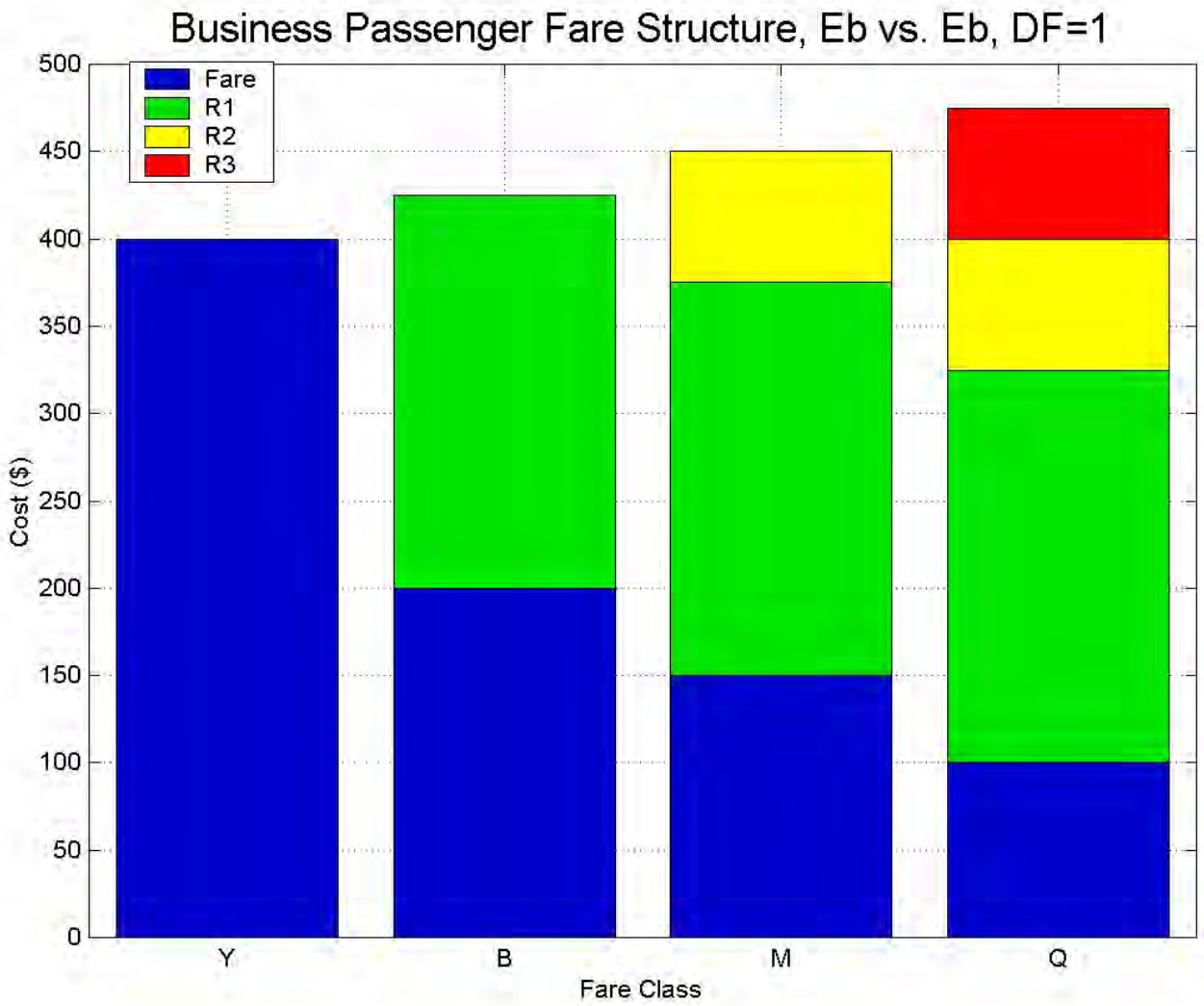
## *Fare Class Restriction Disutilities*

- **Disutility costs associated with the restrictions of each fare class:**
  - added to the fare value to determine the choice sequence of a given passenger among the classes with fare values less than his/her WTP.
- **The "traditional" restrictions are:**
  - R1: Saturday night stay (for B, M and Q classes),
  - R2: cancellation/change penalty (for M and Q classes),
  - R3: non-refundability (for Q class).

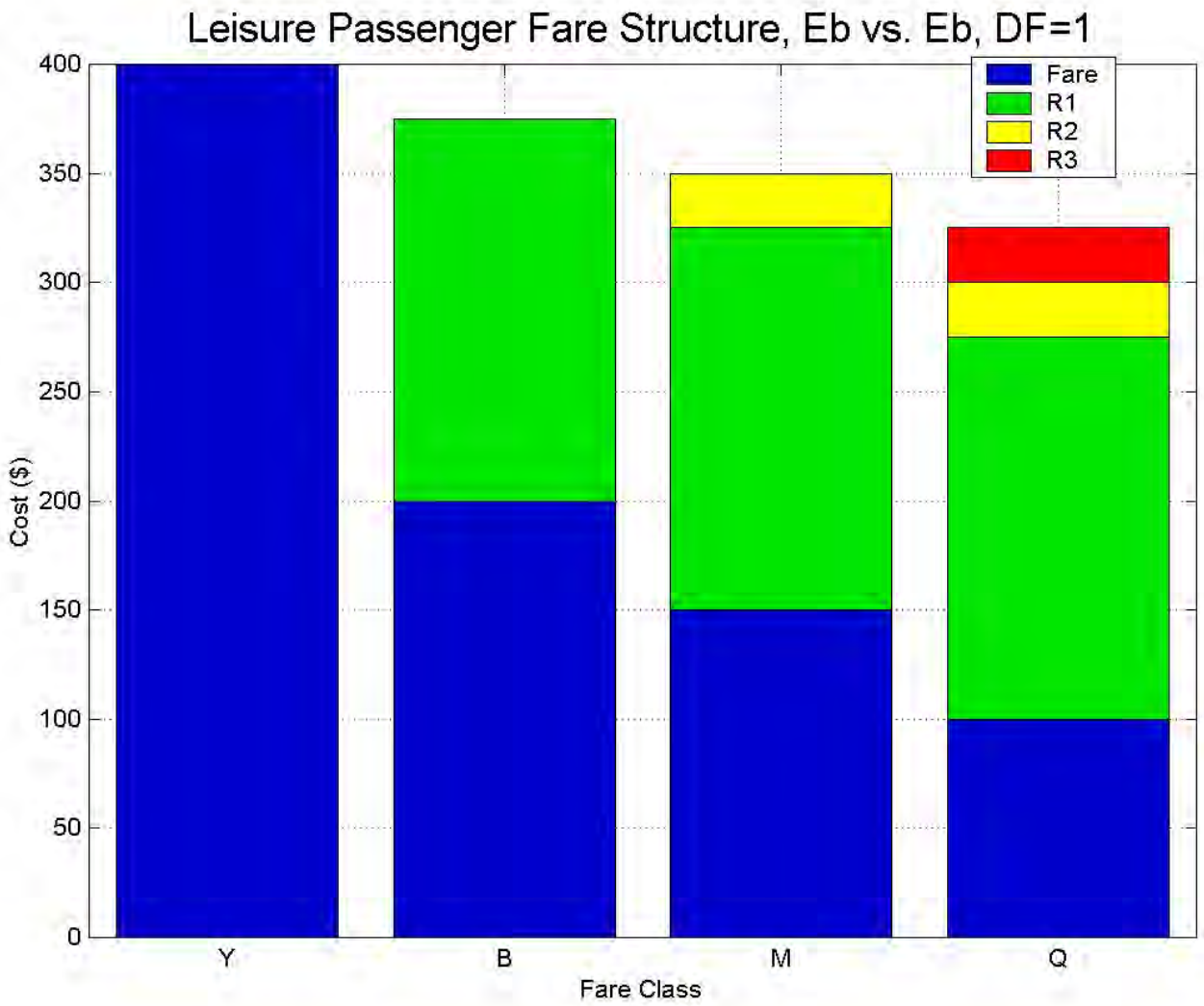
## *EXAMPLE: Fare Structure*

| Fare Code | Price Level | Advance Purchase | Sat. Night Min. Stay | Non-Refundable | Change Fee |
|---|---|---|---|---|---|
| Y | $400 | -- | -- | -- | -- |
| B | $200 | 7 day | Yes | -- | -- |
| M | $150 | 14 day | Yes | Yes | -- |
| Q | $100 | 21 day | Yes | Yes | Yes |

# *Total Generalized Cost of Fare Options*



# *Total Generalized Cost of Fare Options*



# *Other Disutility Costs*

- **PQI disutility cost**
  - Unit PQI disutility cost determined as function of market base fares
  - PQI: 1 for nonstop path, 3 for connecting path
  - PQI disutility cost = Unit PQI disutility cost*PQI

- **Replanning disutility cost**
  - Applies when a given path is outside of passenger's decision window
  - Function of market base fares

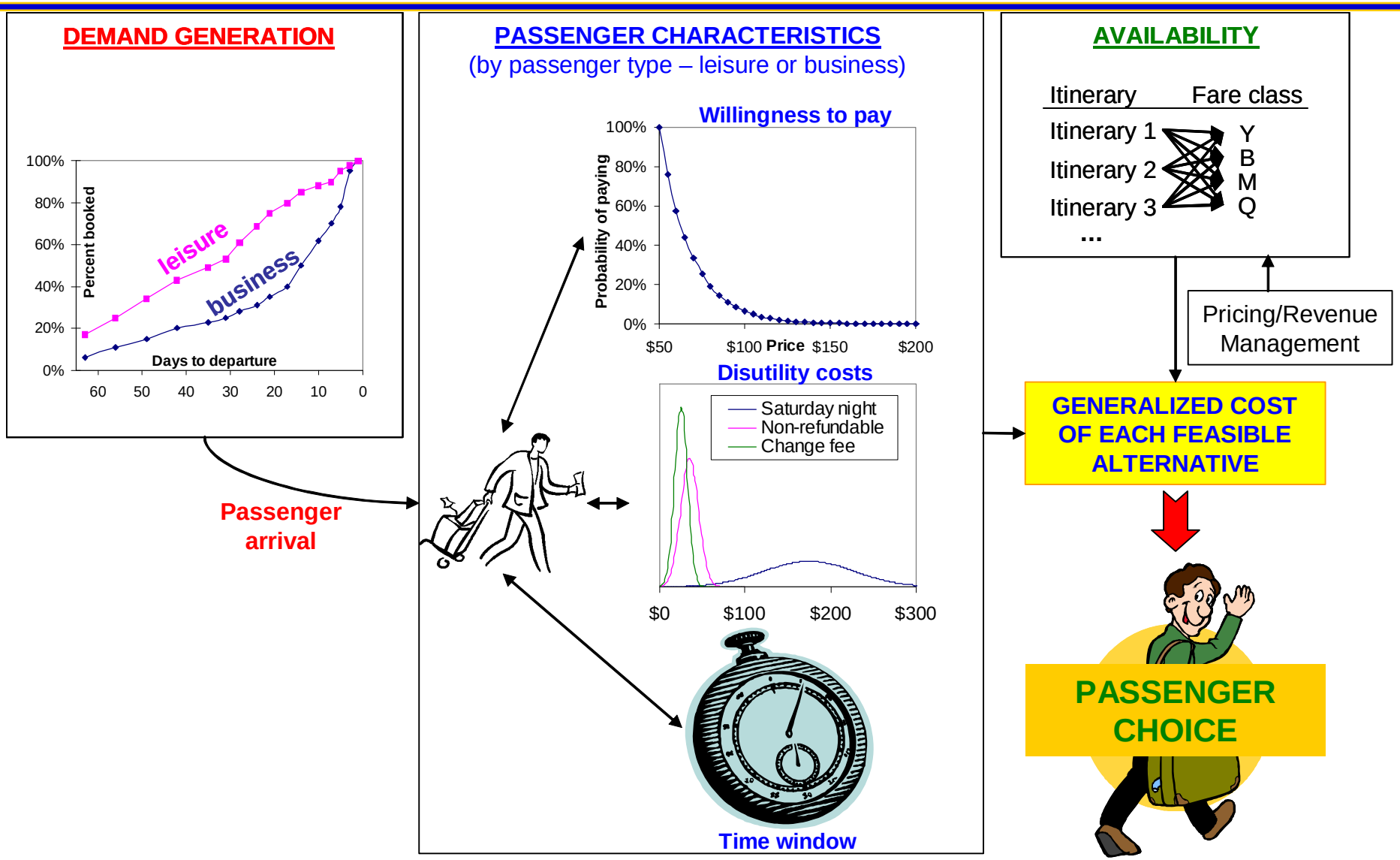
- **Unfavorite airline disutility cost**
  - Applies when a given path is not a favorite airline
  - Function of market base fares

# *Total Disutility Costs*

- **Passenger path choice criteria: Least total cost**
  - Total cost = Fare + Restriction disutility + PQI disutility + Replanning disutility + Unfavorite airline disutility

- **Impact of passenger disutilities**
  - With passenger disutility costs included in PODS simulations, passengers are able to differentiate the “attractiveness” of each path/fare combination, resulting in higher preference for “favorable” paths

# *Summary of Passenger Choice Model*




*Courtesy T. Gorin*