Network Revenue Management: O&D Control

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Network, Fleet and Schedule
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Module 23 : 4 April 2015

Background: Fare Class Control

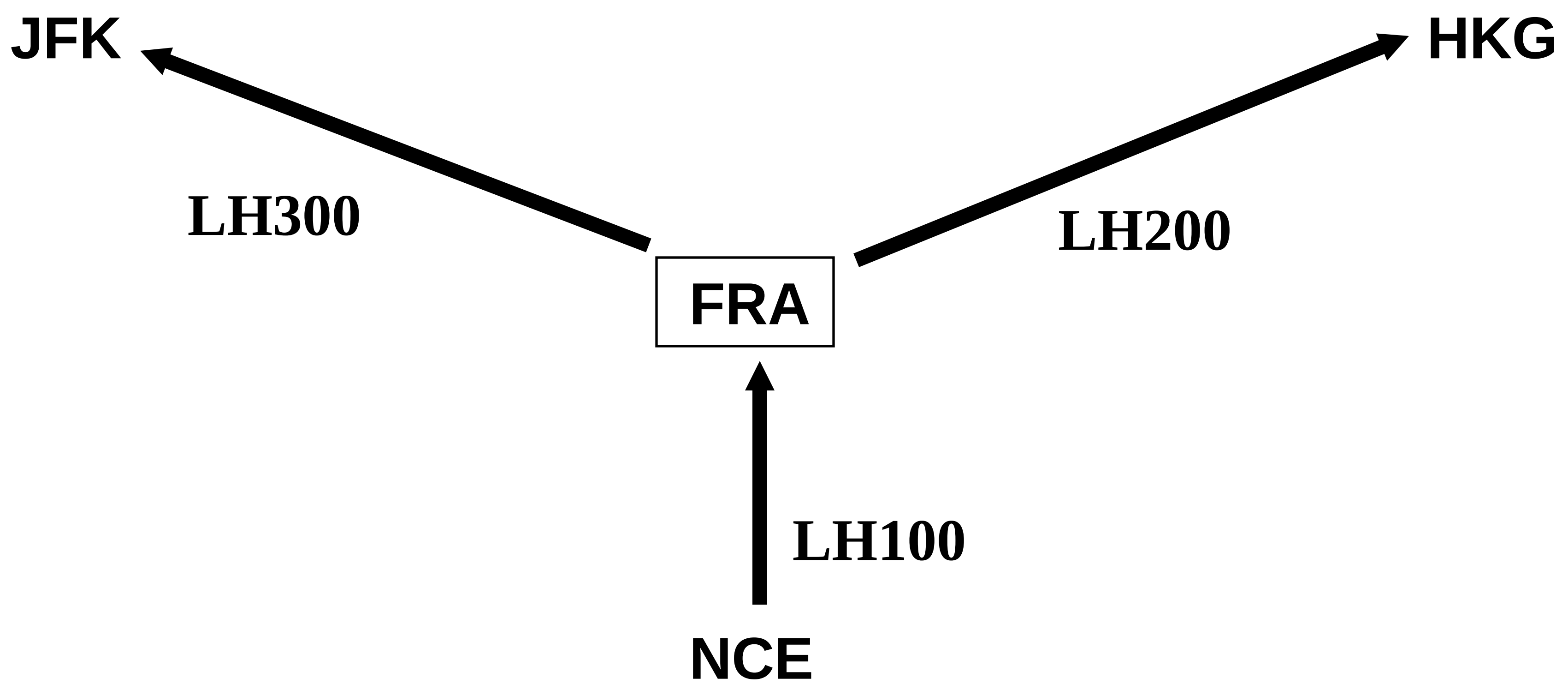
- **Majority of world airlines still practice "fare class control":**
  - High-yield ("full") fare types in top booking classes
  - Lower yield ("discount") fares in lower classes
  - Designed to maximize yields, not total revenues

- **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

O-D Control Example: Hub Network



Leg-Based Class Availability

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	

Leg Class Control Does Not Maximize Total Network Revenues

(A) SEAT AVAILABILITY: **SHORT HAUL BLOCKS LONG HAUL**

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

(B) SEAT AVAILABILITY: **LOCAL VS. CONNECTING PASSENGERS**

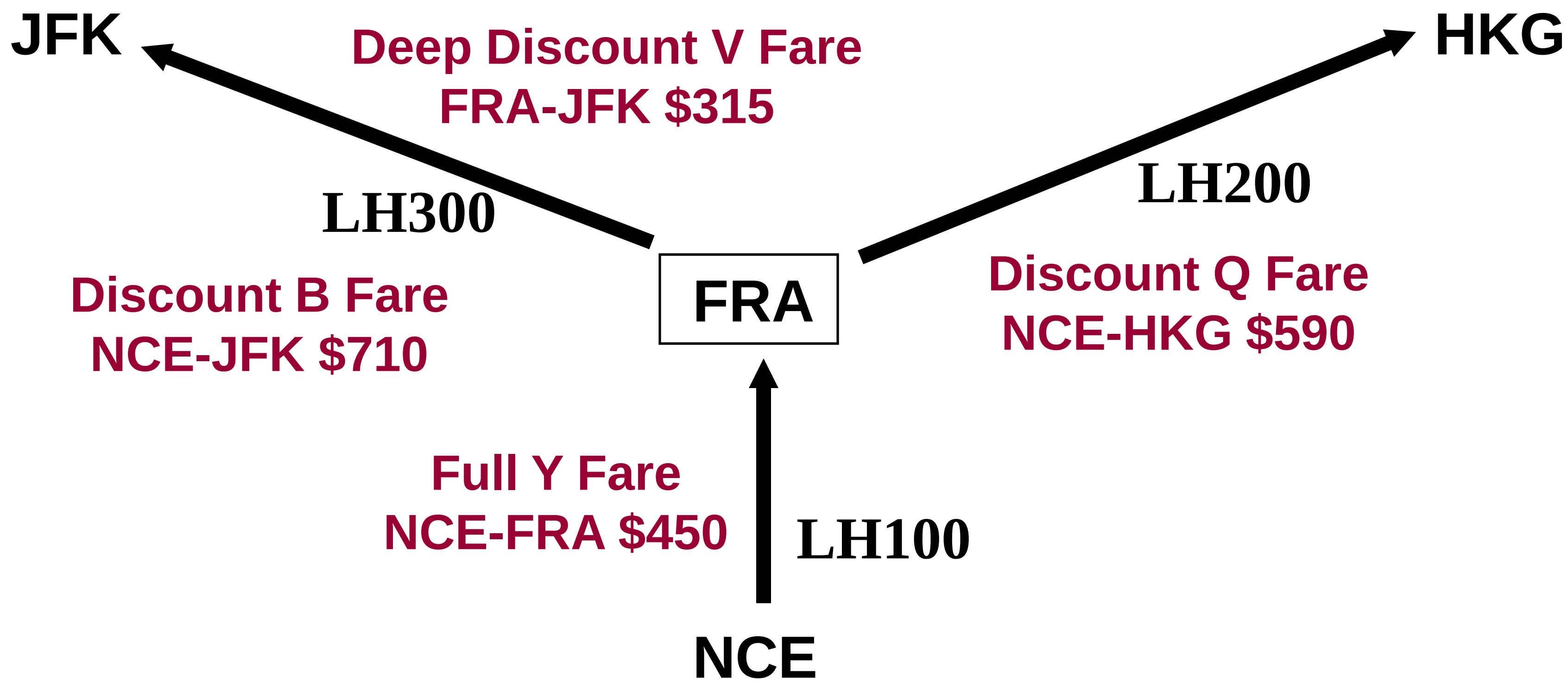
NCE/FRA	
CLASS	FARE (OW)
Y	$450
B	$380
M	$225
Q	$165
V	$135

FRA/JFK	
CLASS	FARE (OW)
Y	$920
B	$670
M	$515
Q	$385
V	$315

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

O-D Control Optimization Quiz

QUESTION: With 1 seat available on each flight leg, which of these 4 O-D requests should we accept to maximize network revenue?



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 (HBP)
  - Displacement adjusted virtual nesting (DAVN)
  - Network probabilistic bid price control (ProBP)

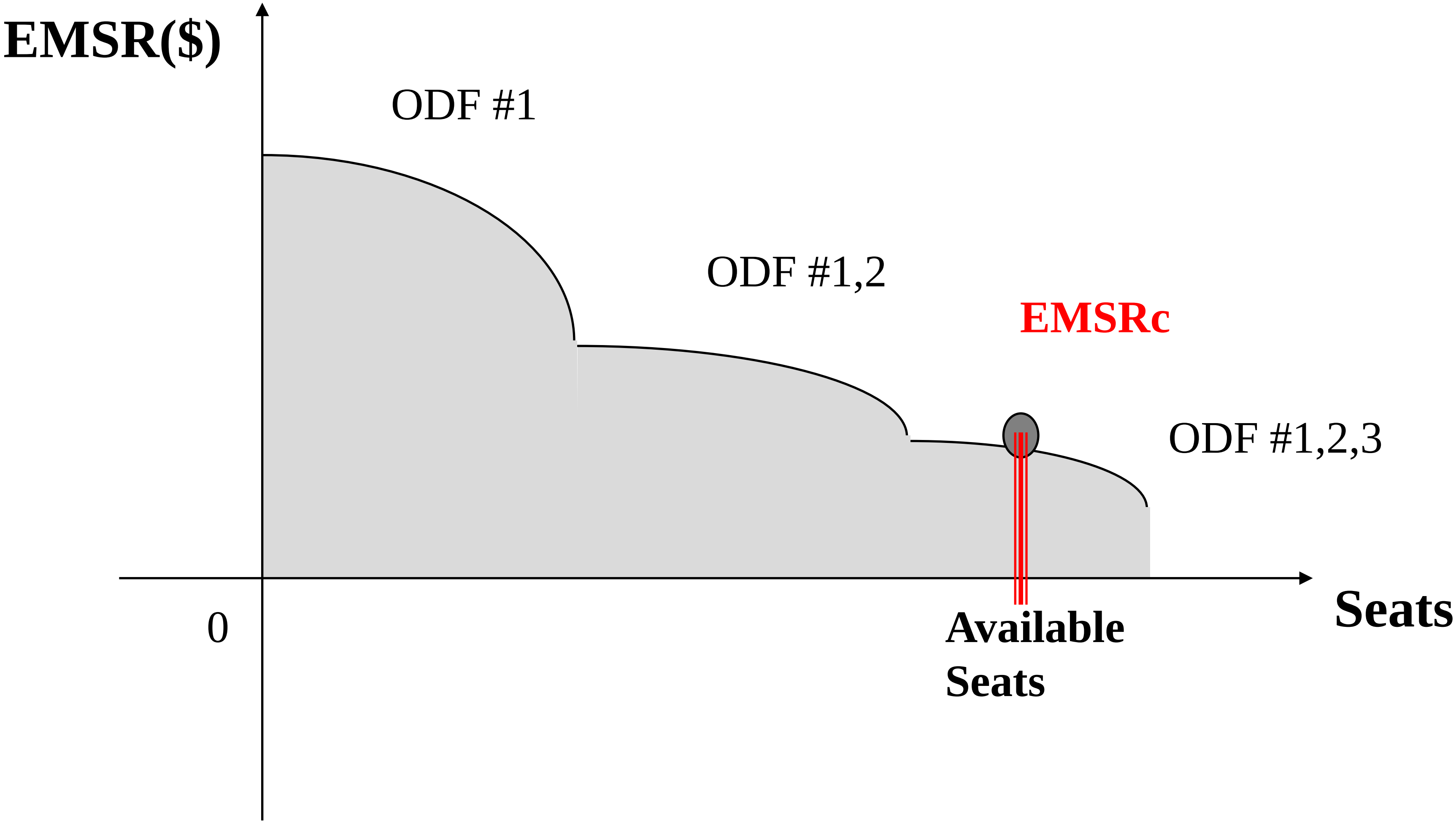
- **All of the above can increase revenues, but each one has implementation trade-offs.**

Marginal Value of Last Seat on a Leg

- **Marginal value concept is basis of leg RM:**
  - Accept booking in fare class if revenue value exceeds marginal value of last (lowest valued) remaining available seat on the flight leg

- **In network RM, need to estimate marginal network value of last seat on each leg:**
  - Can be used as “displacement cost” of a connecting vs. local passenger
  - Or, as a minimum acceptable “bid price” for the next booking on each leg

Marginal Network Value of Last Seat



Displacement Adjusted Network Value

- **Actual value of an ODIF 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
- **Given estimated down-line displacement, ODFs are ranked based on network value on each leg:**
  - Network value on Leg 1 = Total fare minus sum of down-line leg displacement costs
  - Under high demand, availability for connecting passengers is reduced, locals get more seats
- **Network optimization mathematics needed to estimate displacement costs for each flight leg**

O-D Optimization Concepts

- **Conceptual steps in O+D optimization process**
  - ODIFs are ranked according to their network revenue value, regardless of fare restrictions
  - Network revenue values account for displacement of passengers (and revenue) on connecting legs
  - Bid price calculated for each flight leg in network, reflecting marginal value of remaining seat(s)
  - Or, booking limits calculated to determine seat availability by revenue value virtual bucket

- **In the following FRA hub example, we focus on the NCE-FRA leg to illustrate this process**

Ranking by ODIF Revenue Value

RANKING ODIFs ON NCE-FRA LEG

RANK	FARE		ODIF DEMAND
1	$	1,415	Y NCEHKG
2	$	975	B NCEHKG
3	$	950	Y NCEJFK
4	$	770	M NCEHKG
5	$	710	B NCEJFK
6	$	590	Q NCEHKG
7	$	550	M NCEJFK
8	$	499	V NCEHKG
9	$	450	Y NCEFRA
10	$	425	Q NCEJFK
11	$	380	B NCEFRA
12	$	325	V NCE JFK
13	$	225	M NCEFRA
14	$	165	Q NCEFRA
15	$	135	V NCEFRA

Ranking with Displacement Adjustment

RANKING ODIFs ON NCE-FRA LEG

($500 DISPLACEMENT COST FRA-HKG)

RANK	FARE		ODIF DEMAND
1	$	950	Y NCEJFK
2	$	915	Y NCEHKG
3	$	710	B NCEJFK
4	$	550	M NCEJFK
5	$	475	B NCEHKG
6	$	450	Y NCEFRA
7	$	425	Q NCEJFK
8	$	380	B NCEFRA
9	$	325	V NCE JFK
10	$	270	M NCEHKG
11	$	225	M NCEFRA
12	$	165	Q NCEFRA
13	$	135	L NCEFRA
14	$	90	Q NCEHKG
15	$	(1)	V NCEHKG

Ranking with Displacement Adjustment

RANKING ODIFs ON NCE-FRA LEG
($500 DISPLACEMENT COST FRA-HKG)
($300 DISPLACEMENT COST FRA-JFK)

RANK	FARE		ODIF DEMAND
1	$	915	Y NCEHKG
2	$	650	Y NCEJFK
3	$	475	B NCEHKG
4	$	450	Y NCEFRA
5	$	410	B NCEJFK
6	$	380	B NCEFRA
7	$	270	M NCEHKG
8	$	250	M NCEJFK
9	$	225	M NCEFRA
10	$	165	Q NCEFRA
11	$	135	L NCEFRA
12	$	125	Q NCEJFK
13	$	90	Q NCEHKG
14	$	25	V NCE JFK
15	$	(1)	V NCEHKG

Ranking with Displacement Adjustment

RANKING ODIFs ON NCE-FRA LEG

($500 DISPLACEMENT COST FRA-HKG)

($300 DISPLACEMENT COST FRA-JFK)

RANK	FARE	ODIF DEMAND
1	$ 915	Y NCEHKG
2	$ 650	Y NCEJFK
3	$ 475	B NCEHKG
4	$ 450	Y NCEFRA
5	$ 410	B NCEJFK
6	$ 380	B NCEFRA
7	$ 270	M NCEHKG
8	$ 250	M NCEJFK
9	$ 225	M NCEFRA
10	$ 165	Q NCEFRA
11	$ 135	L NCEFRA
12	$ 125	Q NCEJFK
13	$ 90	Q NCEHKG
14	$ 25	V NCE JFK
15	$ (1)	V NCEHKG

NCE-FRA LEG BID PRICE = $200

ACCEPT

REJECT

Virtual Class Mapping with Displacement

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

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CLASS	FARE (OW)
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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	

Displacement Adjustment

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

- **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 request
  - Must revise bid prices frequently to prevent too many bookings of ODFs at current bid price

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

Example: Bid Price Control

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 Optimization Methods

- **Network optimization mathematics needed for both bid price and value bucket controls.**
- **Several optimization methods to consider:**
  - Deterministic Linear Programming
  - Nested Probabilistic Network Bid Price
  - Dynamic Programming (applied to each leg after displacement adjustment)
- **Simulated revenue gains are quite similar:**
  - ODF database, forecast accuracy and robustness under realistic conditions make a bigger difference

Network LP (Deterministic)

- **Maximize Total Revenue = Sum [Fare * Seats]**
  - Summed over all ODFs on network

  Subject to following constraints:

  Seats for each ODF <= Mean Forecast Demand

  Sum[Seats on Each Leg] <= Leg Capacity

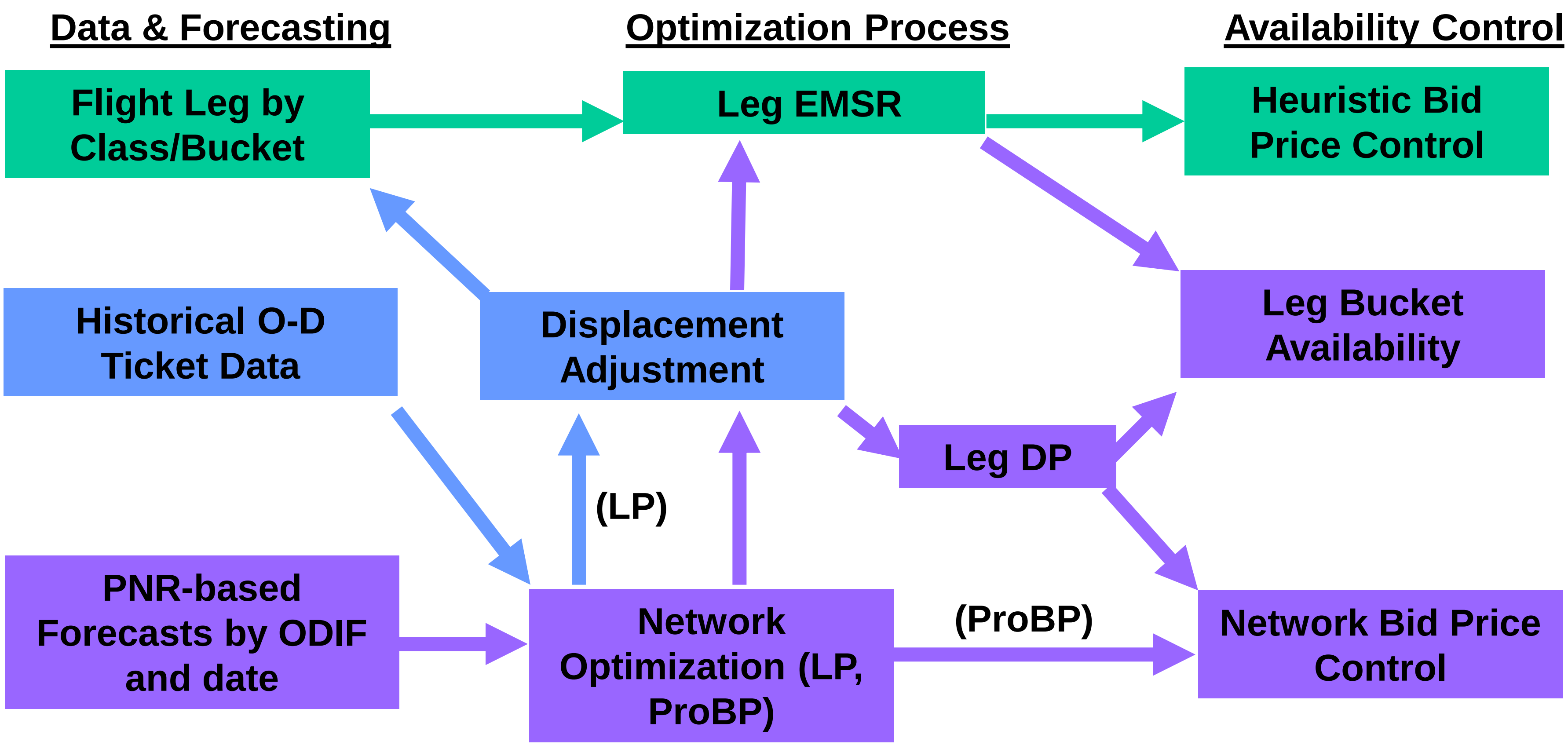
Outputs of LP solution:

- Seats allocated to each ODF (not useful)
- "Shadow price" on each leg (reflects network revenue value of last seat on each flight leg)
- Used as estimates of "displacement cost" for all connecting ODFs, for virtual nesting controls

O-D Control System Components

- **Much more than an optimization model:**
  - Database Requirements: Leg/bucket vs. ODF.
  - Forecasting Models: Level of detail to match data; detruncation and estimation methods.
  - Optimization Model: Leg-based or network tools; deterministic vs. probabilistic; dynamic programs
  - Control Mechanism: Booking classes vs. value buckets vs. bid price control.
- **Many effective combinations are possible:**
  - Revenue gain, not optimality, is the critical issue.

Overview of O-D System Alternatives



Potential for O-D Control

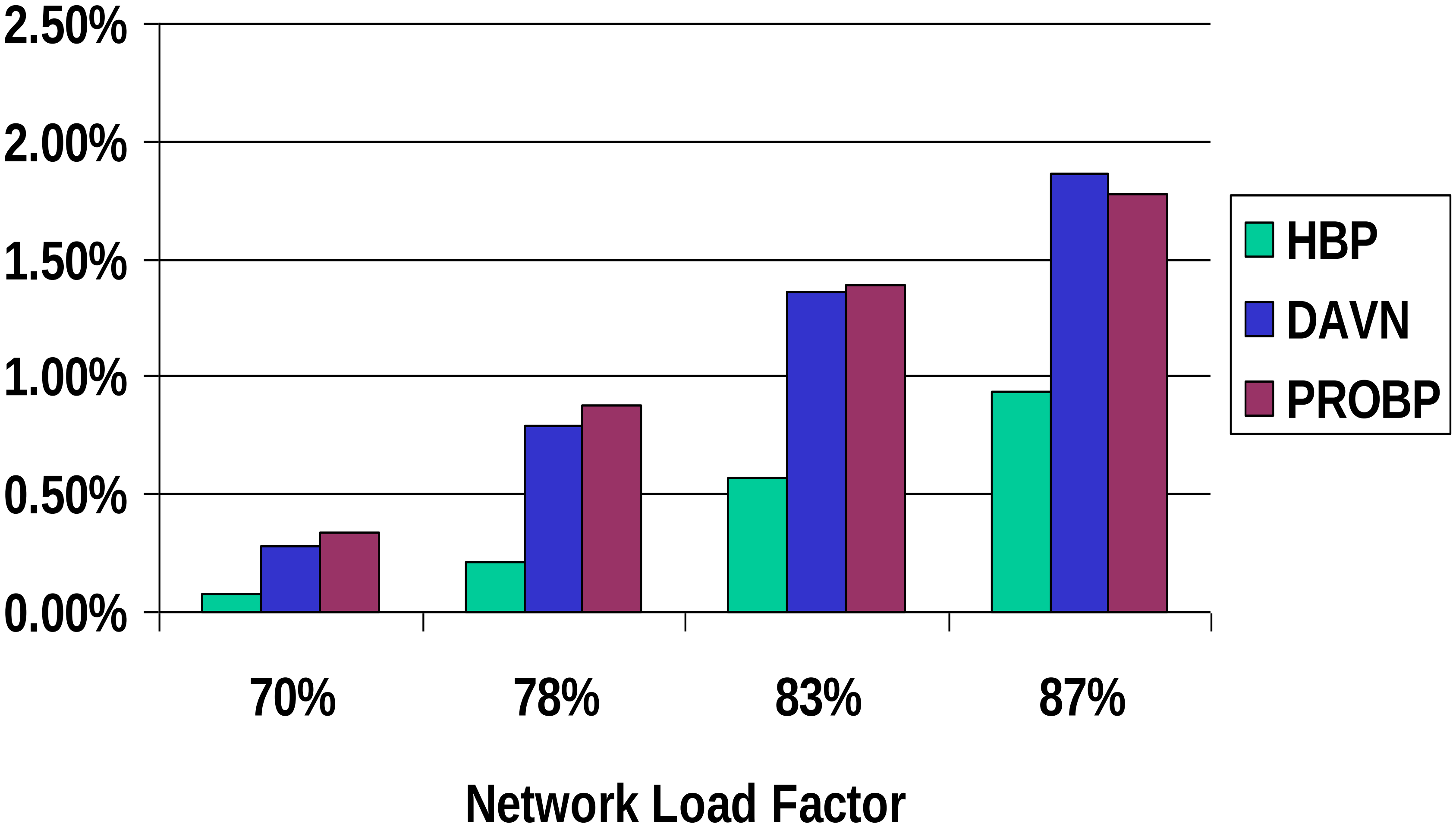
- **Simulations show potential O-D revenue gain:**
  - As much as 1-2% additional gain over leg/class control under ideal simulation conditions

- **Network characteristics affect O-D benefits:**
  - Substantial connecting traffic required
  - High demand factors on at least some feeder legs
  - Greater benefits with greater demand variability

- **CRS seamless availability links essential:**
  - Different responses to different ODF requests

Incremental Revenue Gains of 1-2%

O-D Control vs. Leg/Class RM



Additional Benefits of O-D Control

- **Simulation research and actual airline experience clearly demonstrate revenue gains of O-D control**
  - Return on investment huge; payback period short
  - Even 1% in additional revenue goes directly to bottom line

- **O-D control provides strategic and competitive benefits beyond network revenue gains**
  - Real possibility of revenue loss without O-D control
  - Improved protection against low-fare competitors
  - Enhanced capabilities for e-commerce and distribution
  - Ability to better coordinate RM with alliance partners

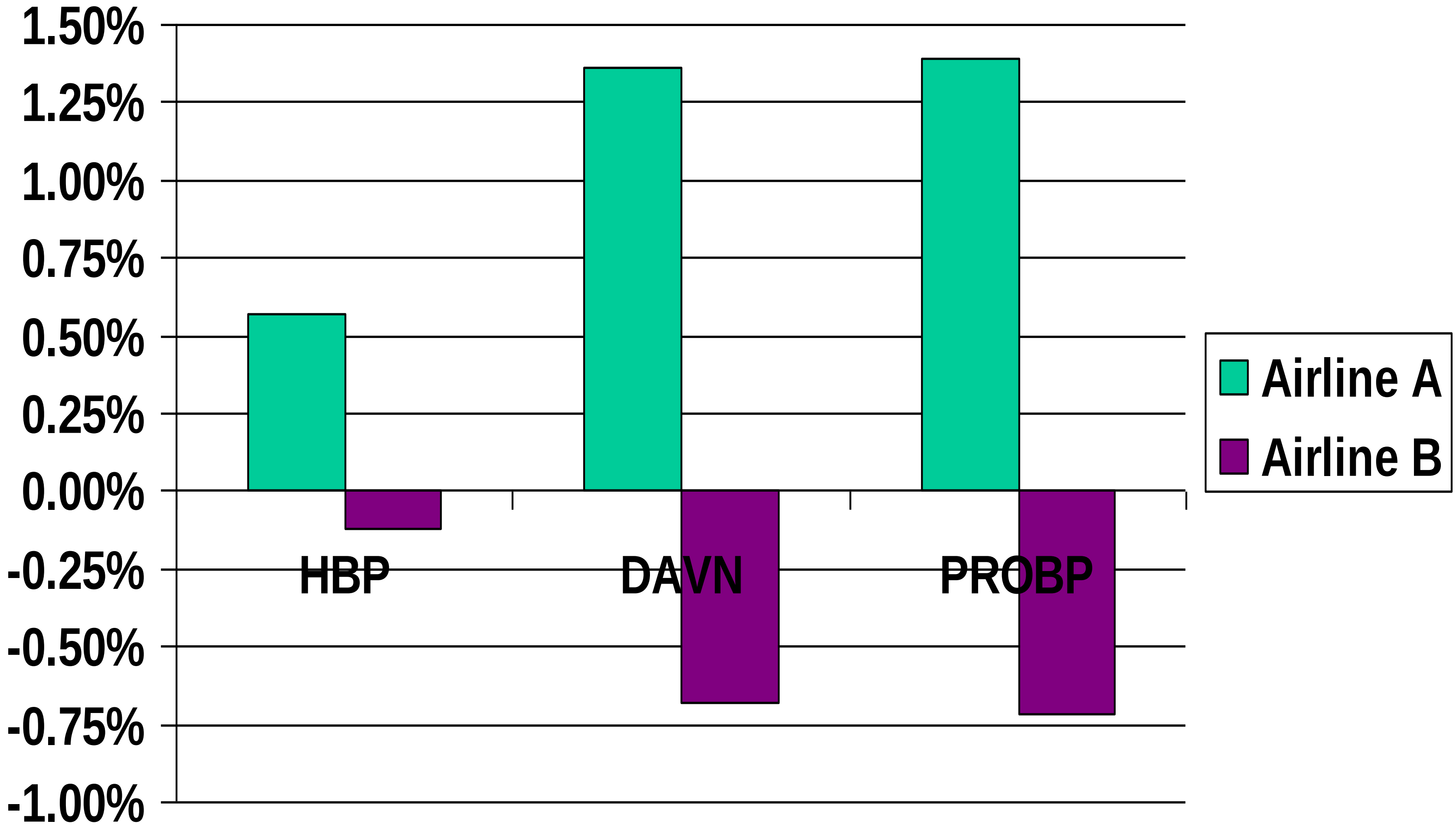
Competitive Impacts of O-D Methods

- **Implementation of O-D control can have negative revenue impacts on competitor:**
  - Continued use of basic FCYM by Airline B against O-D methods used by Airline A results in revenue losses for B
  - Not strictly a zero-sum game, as revenue gains of Airline A exceed revenue losses of Airline B
  - Other PODS simulation results show both airlines can benefit from using more sophisticated O-D control

- **Failure to implement network RM (O-D control) can actually lead to revenue losses against competitor!**

Competitive Impacts of O-D Control

Network ALF=83%, Airline B with Basic YM



Response to Low-Fare Competition

- **Under basic leg/fare class RM, no control over different O-D markets booking in each class**
  - With low-fare competitor, matching fares requires assignment to specific fare class
  - Fare class shared by all O-D itineraries using same flight leg and supply of seats

- **With O-D control, bookings are limited by network revenue value, not fare type or restrictions**
  - Low matching fares will still be available on empty flights
  - But will not displace higher revenue network passengers

Changing Distribution Channels

- **O-D control also allows for improved control of bookings by distribution channel**
  - Differential valuation of origin-destination-fare requests from a growing variety of alternative distribution options
  - Each new distribution channel represents an opportunity to increase revenues, but also a major risk of revenue dilution
  - Different costs and net revenue values to the airline

- **In e-commerce, RM fundamentals are unchanged**
  - Forecast and protect seats for high revenue ODF requests
  - Use O-D control to accept bookings only from channels and points of sale that will increase total network revenues

Summary: Airline O-D RM Systems

- **O-D control is the 4th generation of RM:**
  - Data collection, forecasting, optimization and control by origin-destination-fare type as well as distribution channel

- **Not just a revenue enhancement tool, a strategic and competitive necessity for airlines:**
  - Incremental network revenue gains of 1-2% over basic RM
  - Essential to protect against revenue loss to competitors
  - Increased control of valuable inventory in the face of pricing pressures, new distribution channels, and strategic alliances