Optimum Fleet Utilization under Congestion Management at NY LGA

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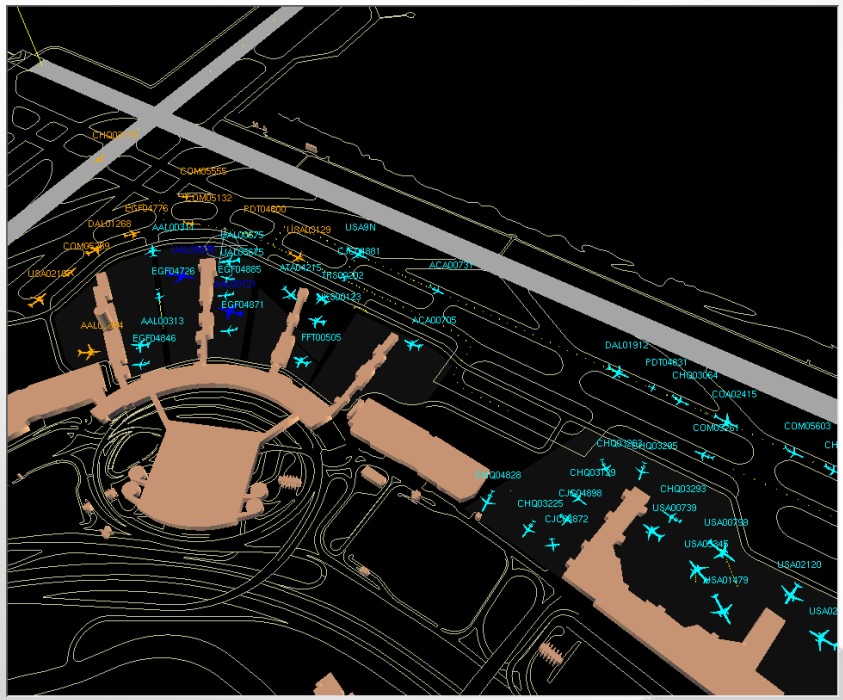
NEXTOR Wye River Conference June 7, 2007



CENTER FOR AIR TRANSPORTATION SYSTEMS RESEARCH

GEORGE MASON UNIVERSITY

Credits

Research team at GMU contributing to these insights:

- **Dr. Loan Le, Ph.D. (2006)**
- **Dr. Karla Hoffman, Prof. SEOR, CATSR**
- **Danyi Wang, Ph.D. Candidate**
- **Ning Xie, Ph.D. Candidate**
- **Dr. C.H. Chen, Prof. SEOR, CATSR**

RAND Corp.:

- **Dr. Russell Shaver, Senior Research Fellow**

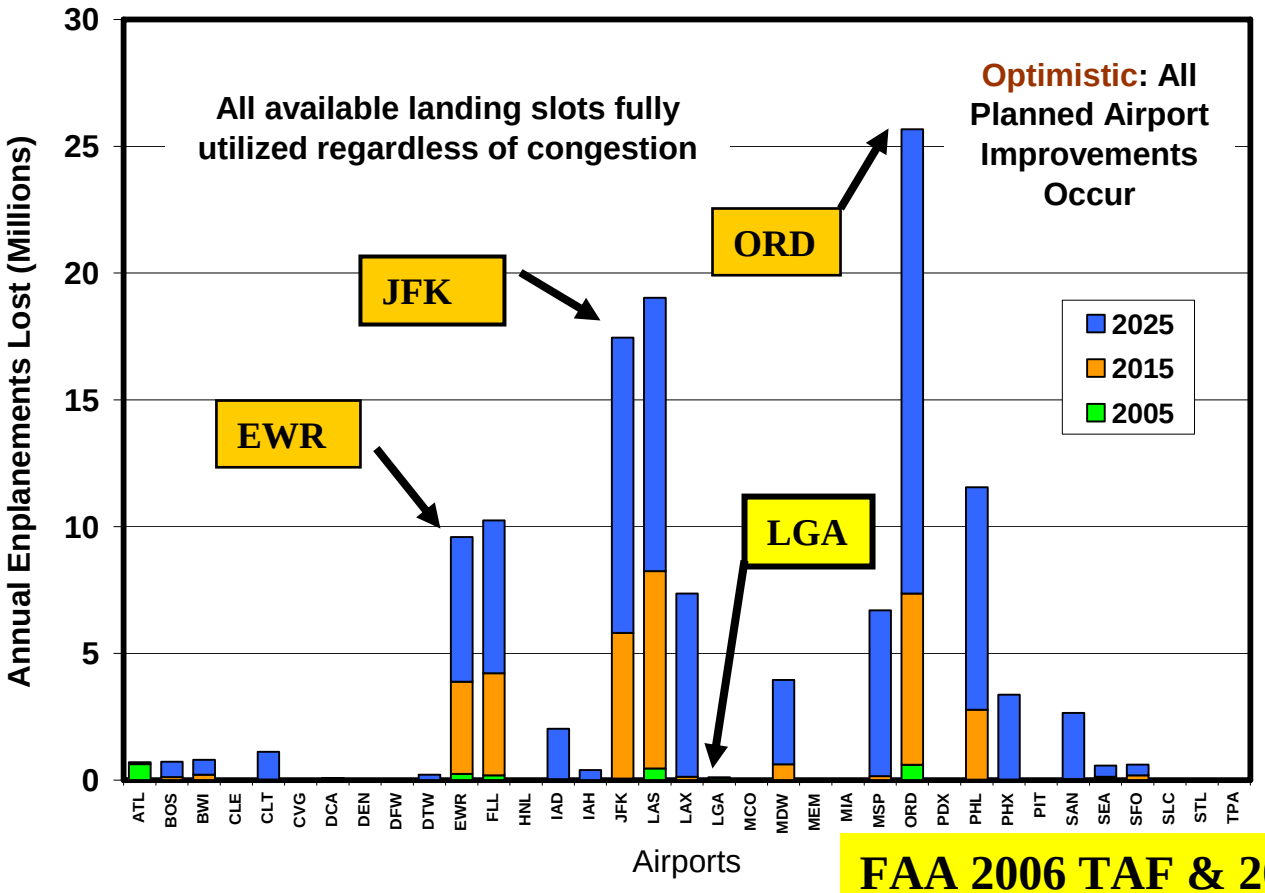
Outline

- **Motivation for the Study**
- **NY LaGuardia Data**
- **Approach**
- **Results from Schedule Optimization and Delay Simulation Study**

Annual Passenger Enplanements Predicted to be Lost: FAA Forecast to 2025

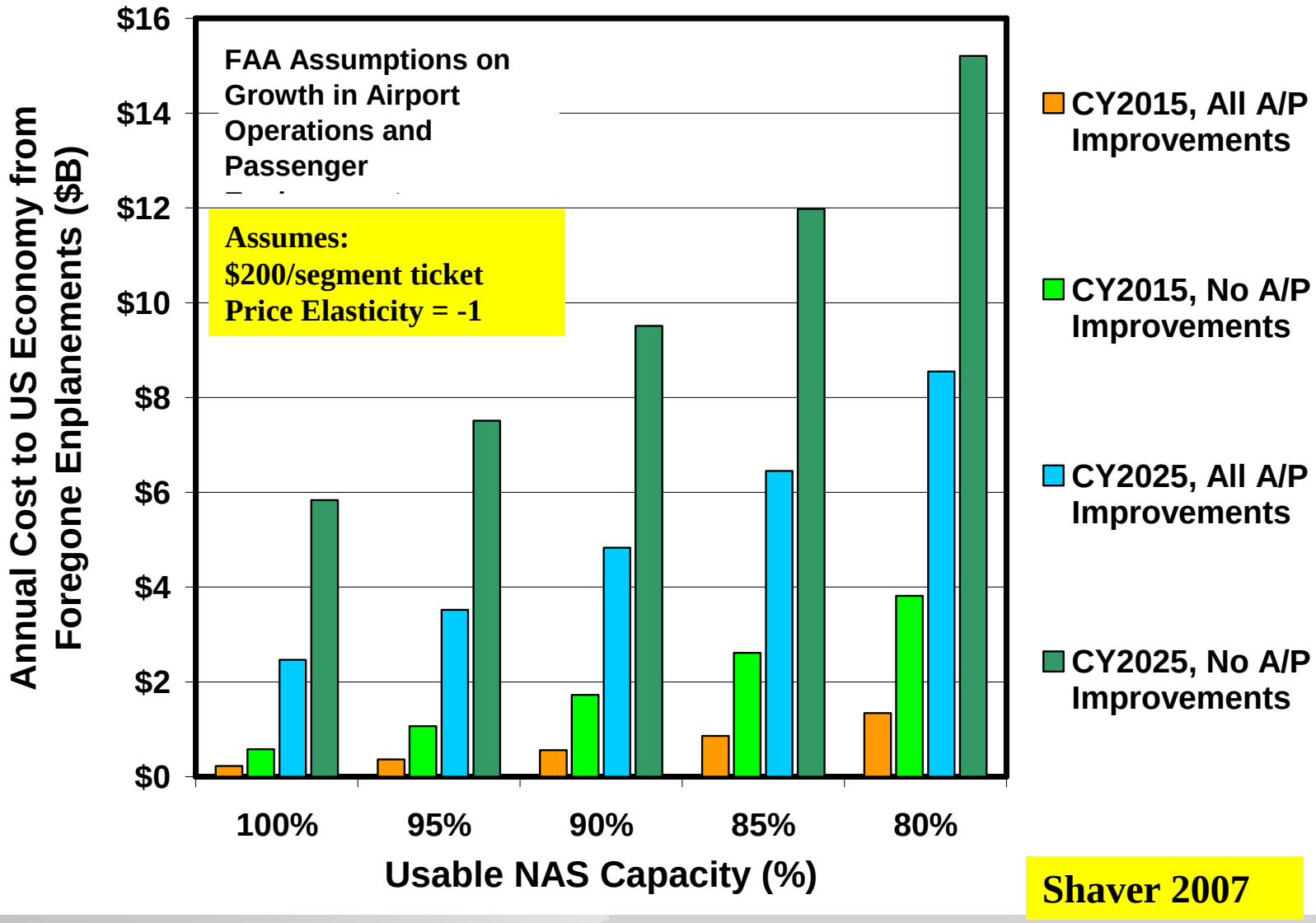
CATSR

Annual Projected Enplanements Foregone Because of Airport Capacity Constraints



FAA 2006 TAF & 2004 Benchmark

Estimated Annual Cost to US (Lost Consumer Surplus, 2005$) due to Expected Airport Capacity Limitations

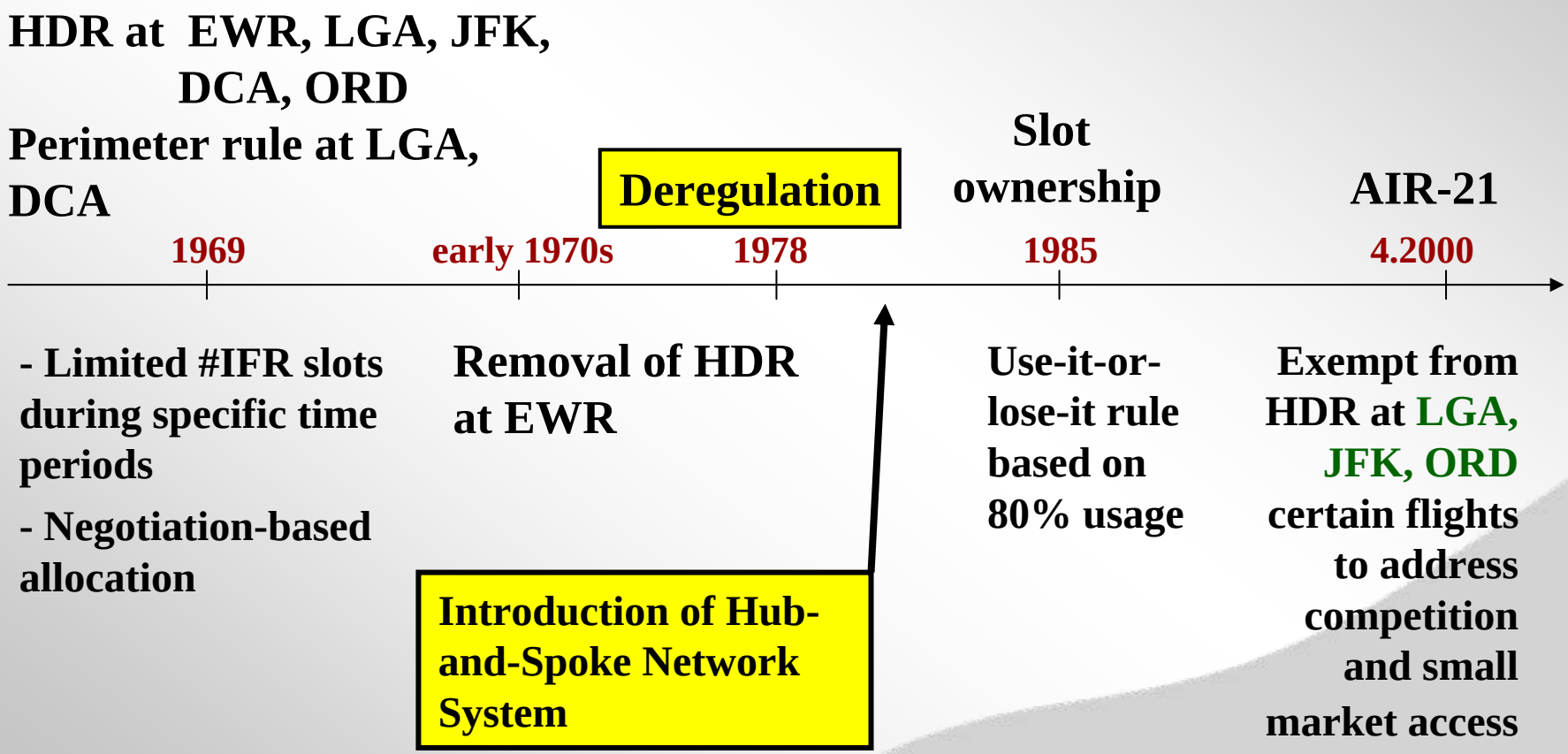


Shaver 2007

Severe Congestion at HDR Airports: A 40-year-old Reality

CATSR

Timeline recap of congestion management measures



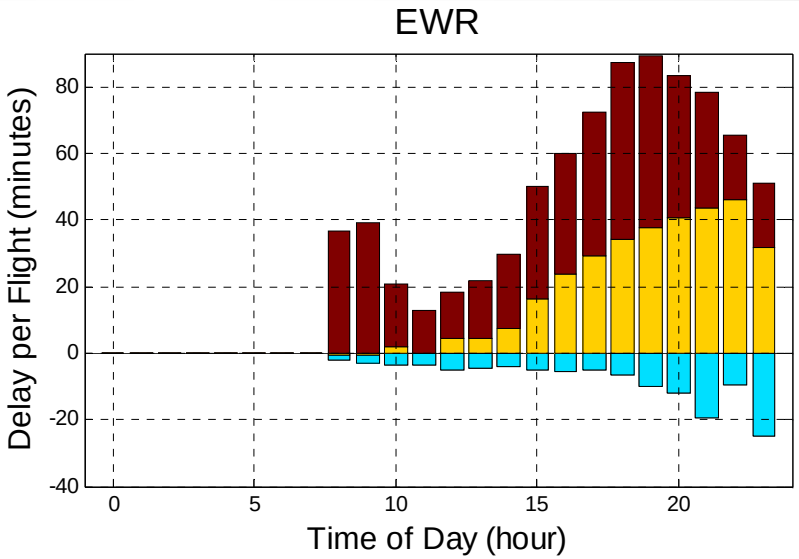
How is the Public Best Served?
Top 20 Worst Airports in the US (45-PTD)

CATSR

Year	2004		2005		2006		Average of 2004 to 2006	
Rank	Airports	Prob. Of PaxDelay >45 min	Airports	Prob. Of PaxDelay >45 min	Airports	Prob. Of PaxDelay >45 min	Airports	Prob. Of PaxDelay >45 min
1	ORD	14%	EWR	18%	ORD	17%	EWR	16%
2	EWR	14%	LGA	17%	EWR	16%	LGA	15%
3	LGA	13%	ATL	14%	LGA	15%	ORD	15%
4	PHL	12%	PHL	13%	PHL	15%	PHL	13%
5	ATL	11%	BOS	13%	JFK	14%	ATL	12%
6	MIA	9%	ORD	12%	IAD	12%	JFK	11%
7	FLL	9%	FLL	12%	MIA	12%	BOS	11%
8	MCO	9%	JFK	12%	ATL	12%	MIA	11%
9	DFW	9%	MIA	11%	MDW	12%	FLL	10%
10	LAS	9%	SFO	11%	DTW	12%	IAD	10%
11	BOS	9%	SEA	10%	DFW	12%	DFW	10%
12	SFO	9%	IAD	10%	BOS	11%	SFO	10%
13	IAD	9%	TPA	10%	DEN	11%	DTW	9%
14	JFK	9%	MCO	10%	CLT	10%	MCO	9%
15	CLE	9%	BWI	9%	IAH	10%	LAS	9%
16	SEA	8%	PIT	9%	CLE	10%	CLE	9%
17	TPA	8%	PDX	9%	PIT	10%	PIT	9%
18	STL	8%	DTW	9%	DCA	10%	SEA	9%
19	PDX	8%	LAS	9%	MEM	10%	MDW	9%
20	BWI	8%	DCA	9%	SFO	10%	DCA	9%

D. Wang, GMU PhD. In Progress

EWR a NYNJ Airport with No Slot Controls: Market Acceptable Transportation Predictability (2006)



airport-generated delay

In-bound delay

airport-absorbed delay

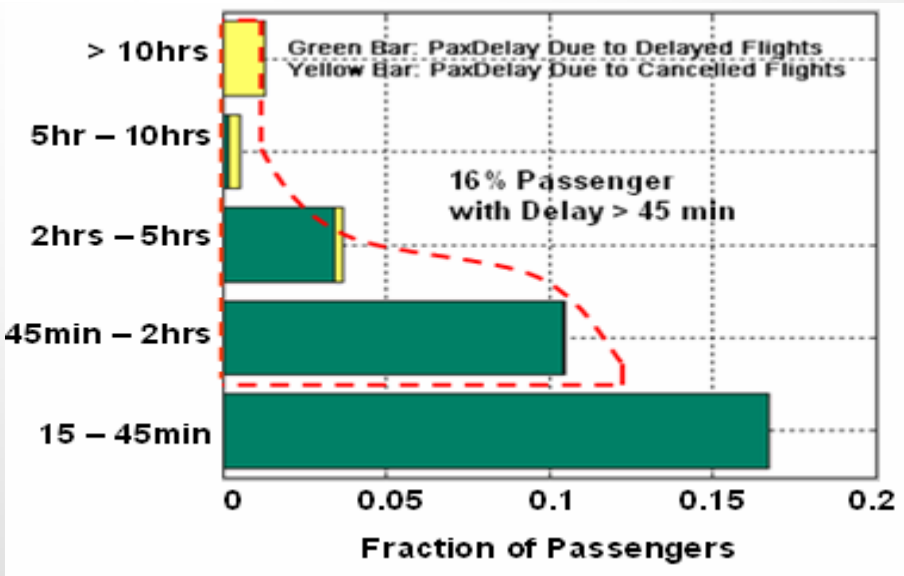
35 Airport BN Model

Summer 2006 Data

(N. Xie GMU 2007)

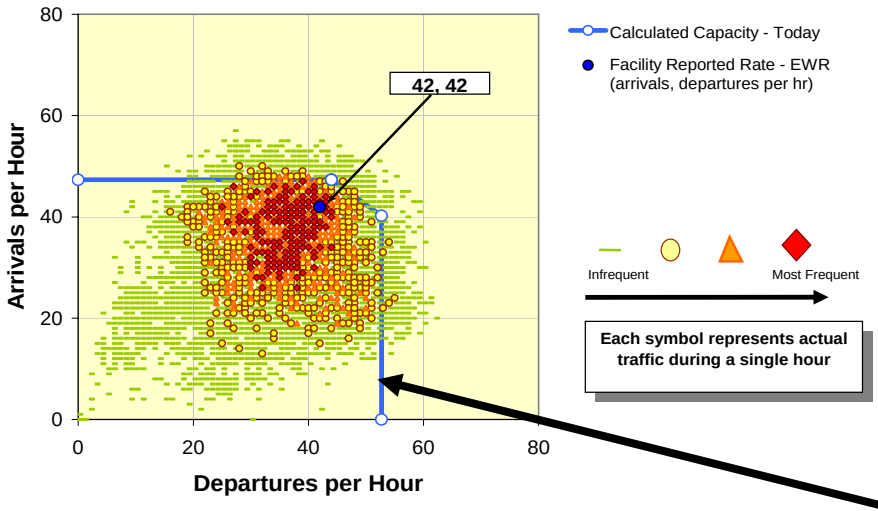
45 minute Passenger Trip Delay (45-PTD) Metric that Includes Flight Load Factors, Cancellations & Missed Connections

(D. Wang GMU 2007)



Calculated Capacity (Today) and Actual Throughput

Optimum Rate

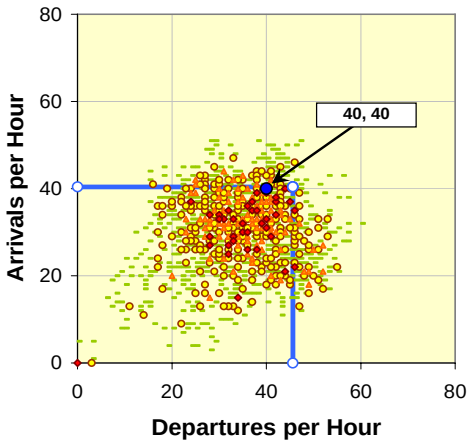


EWR :

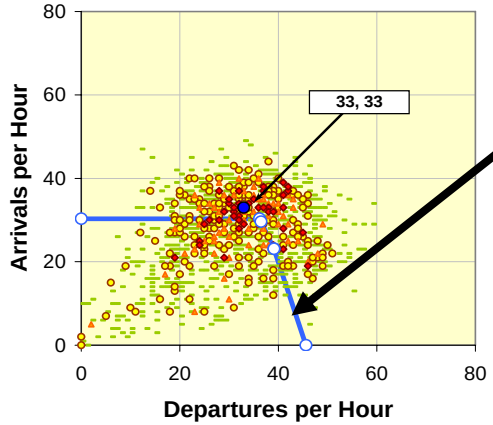
DoT/FAA

2004 Capacity Benchmark Report

Marginal Rate

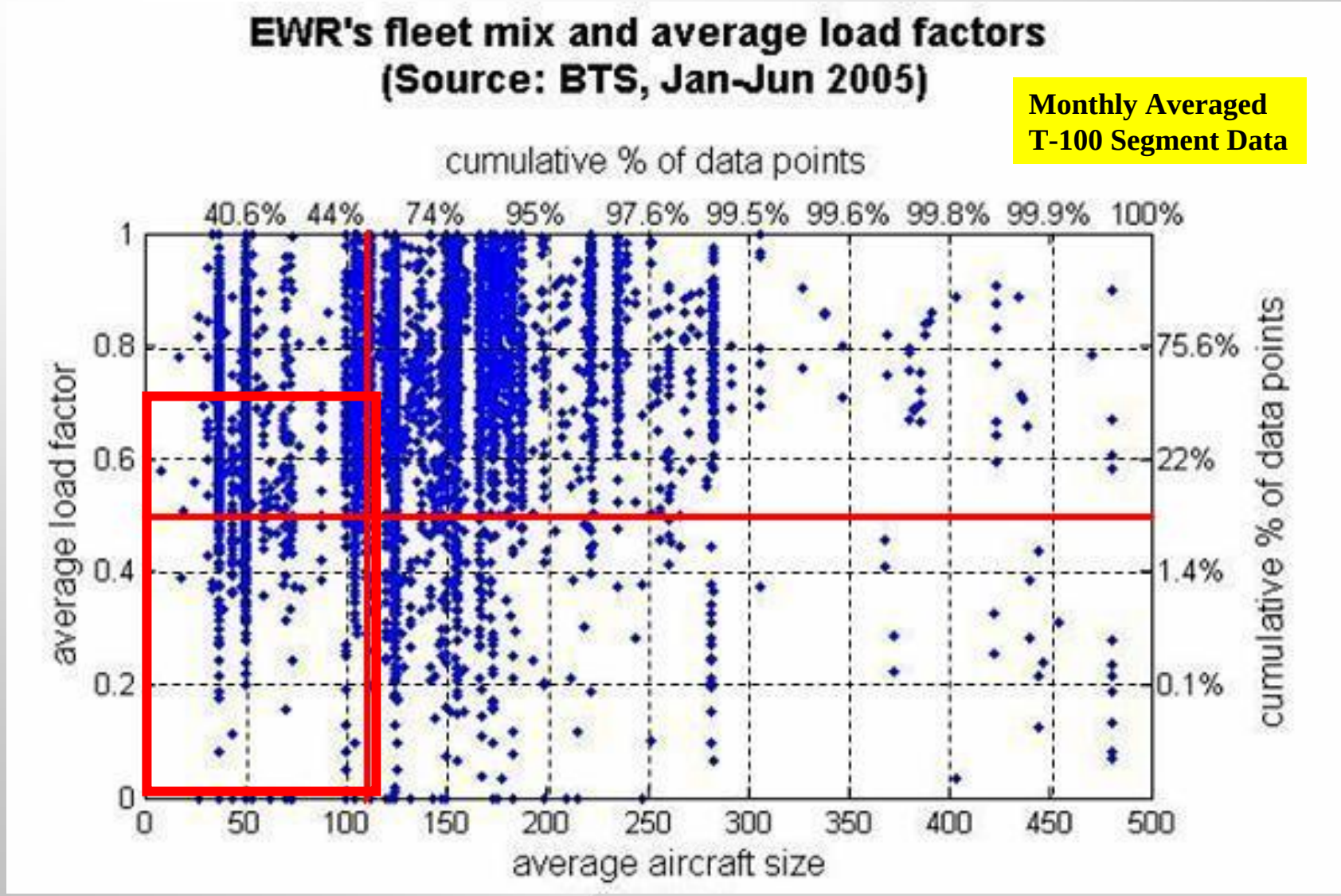


IFR Rate

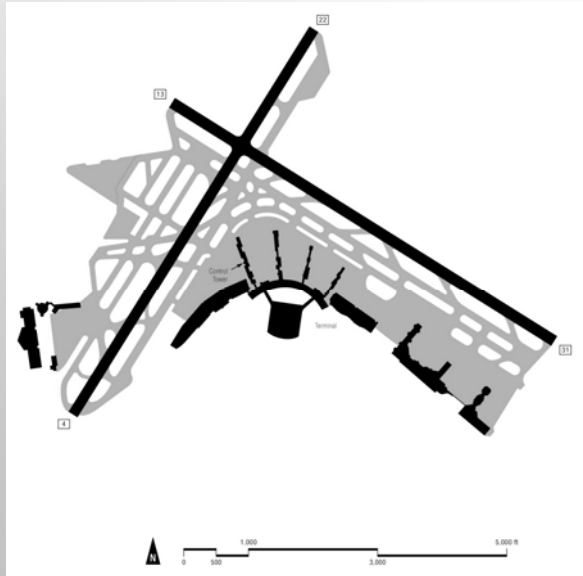


Operational Rates Inside this Envelope Satisfy FAA Safety Standards (i.e. establish Max. Number of Arrival and Departure Slots)

Are Airlines Making Optimal use of these Operations? EWR Fleet Mixture



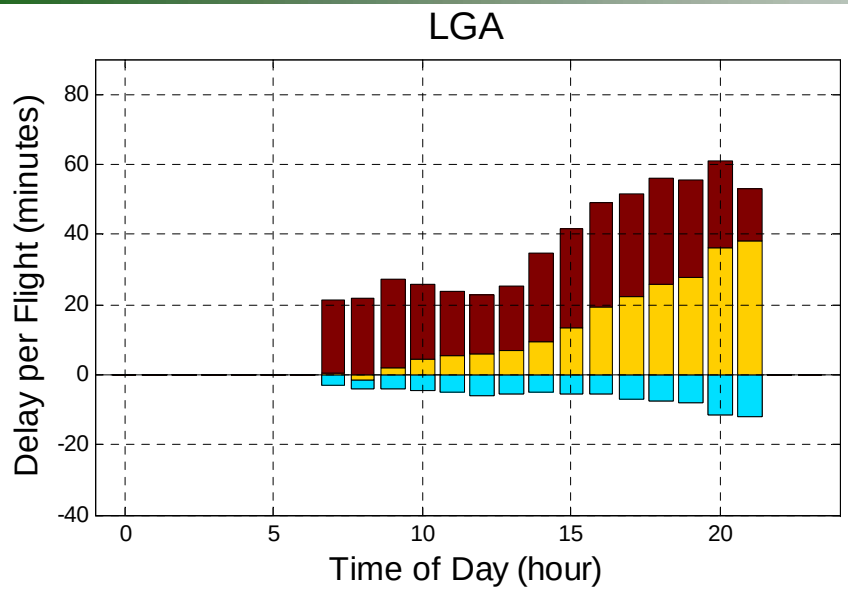
New York LaGuardia Airport: Case Study

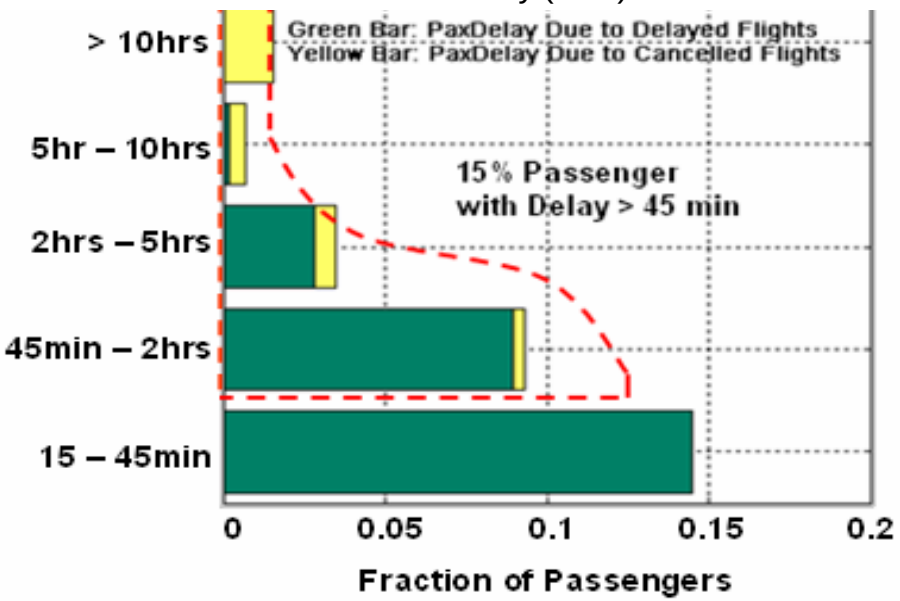


Data (2005):

- **Throughput:**
  404,853 flights/yr
- **Average flight delay:**
  38 min
- **Revenue passengers:**
  26,671,787
- **Average aircraft size:**
  96 passenger
- **Average inter-city fare:**
  $133

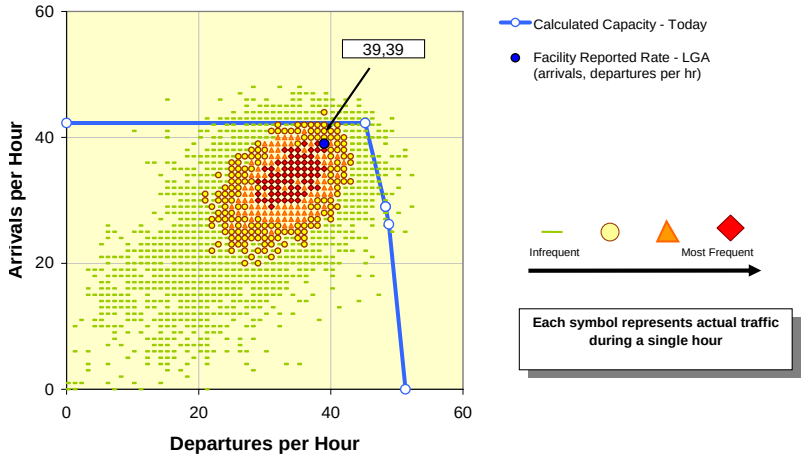
NYNJ Airport with Current Slot Controls: LGA 2004 - 2006



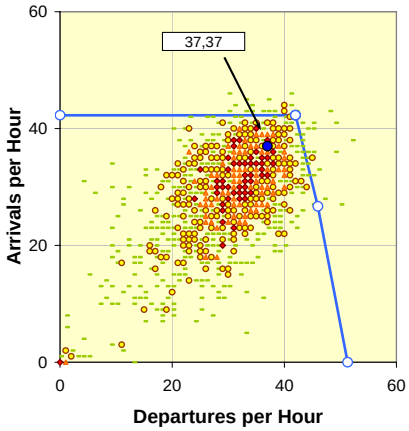


Calculated Capacity (Today) and Actual Throughput

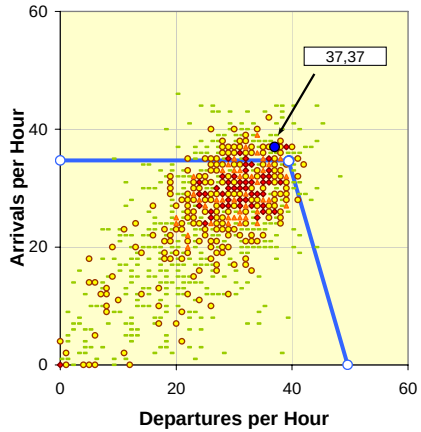
Optimum Rate



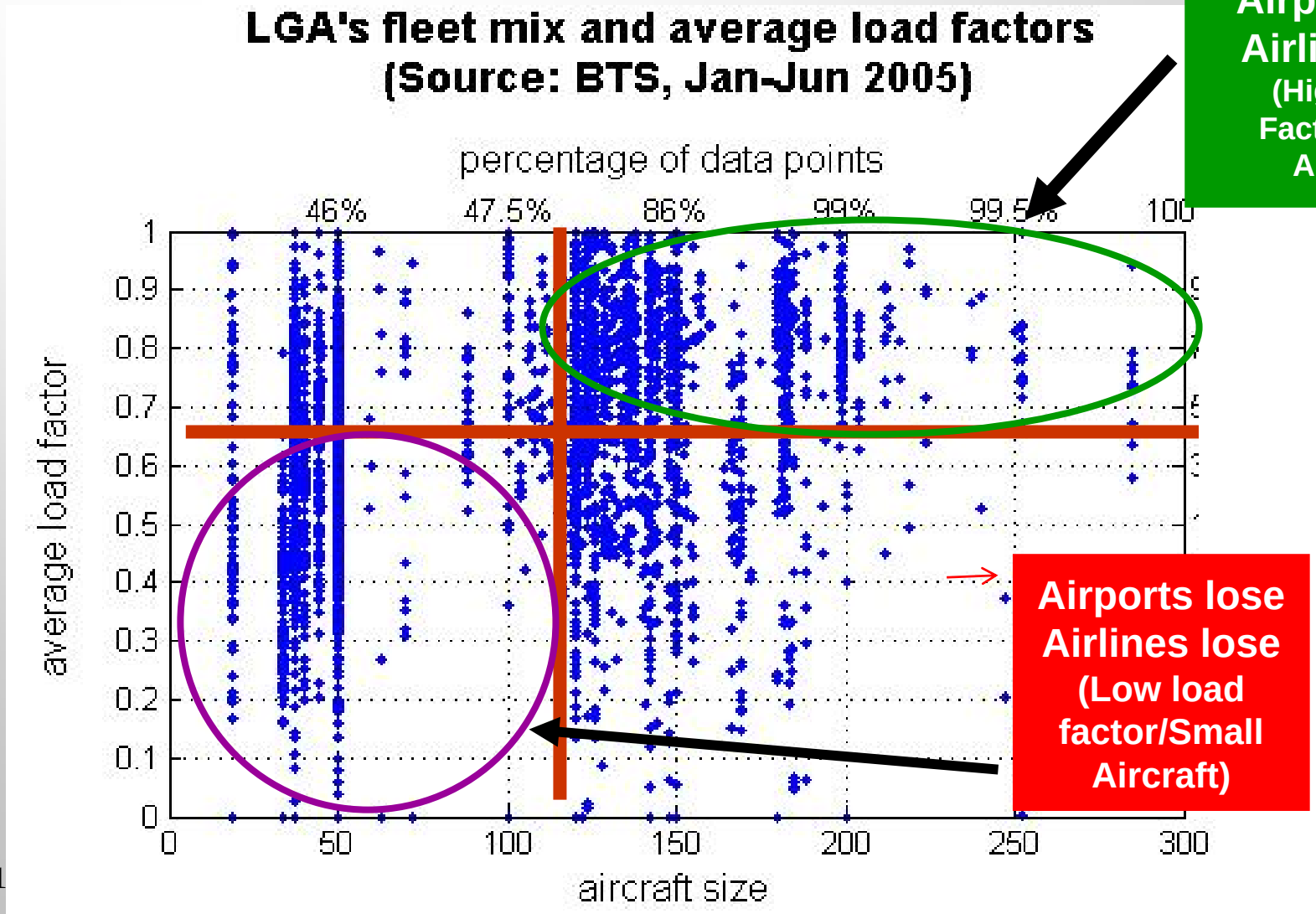
Marginal Rate



IFR Rate



Current Government Rules at LGA Also Lead to Poor Use of Runway Resources



Why do the Airlines Schedule beyond the Maximum Safe RW Capacity with Flights that Loose Revenue?

- There is no government regulation to Limit schedules for Safety or Compensate passengers for Excessive Delays and Volume related Flight Cancellations
  - These were errors in the 1978 Deregulation Act
  - Congress creates New Slots
- Passenger surveys indicate that Frequency and Price are the most (Only?) desirable characteristics of a flight
- Passengers are not Told of Consequences of published schedule to travel Predictability
- If any One airline decided to offer Feasible Schedules, their competition might offer more frequency to capture market share (No Good Deed goes Unpunished!)
  - Thus, still producing delays and cancellations for All
- In Game Theory, this is called the Prisoner's Dilemma

A Natural Question? Is There an Optimal Allocation of Scarce Runway Resources?

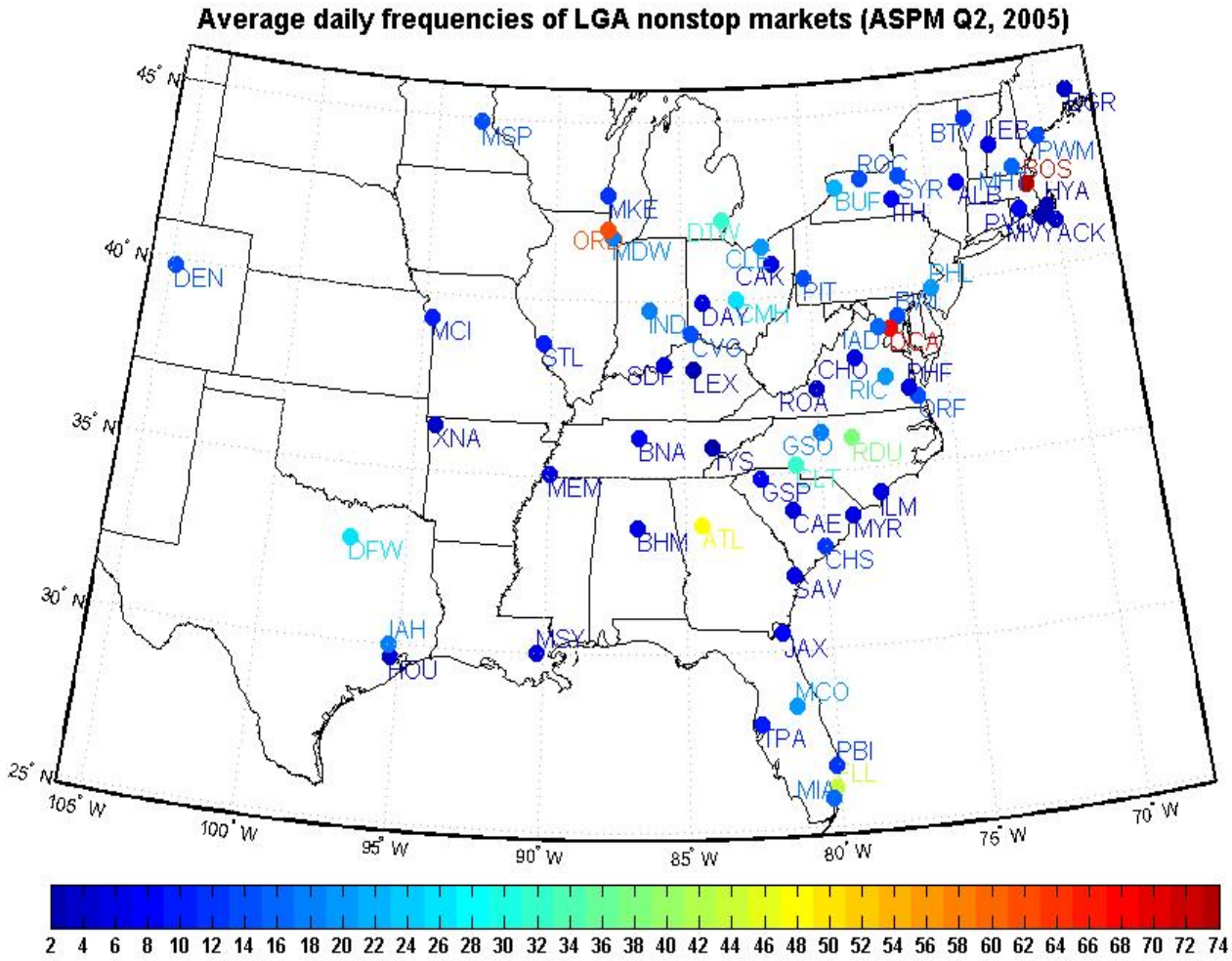
CATSR

- **What would happen if schedules at major airports were capped by predictable runway capacity and allocated by a market mechanism?**
  - **What markets would be served?**
  - **How would airline schedules change?**
    - **Frequency**
    - **Equipment (#seats per aircraft)**
  - **How would passenger demand change?**
    - **At airport**
    - **On routes**
  - **How would airfares change?**
    - **What would happen to airline profit margins?**
  - **How would airport and network delays be altered?**

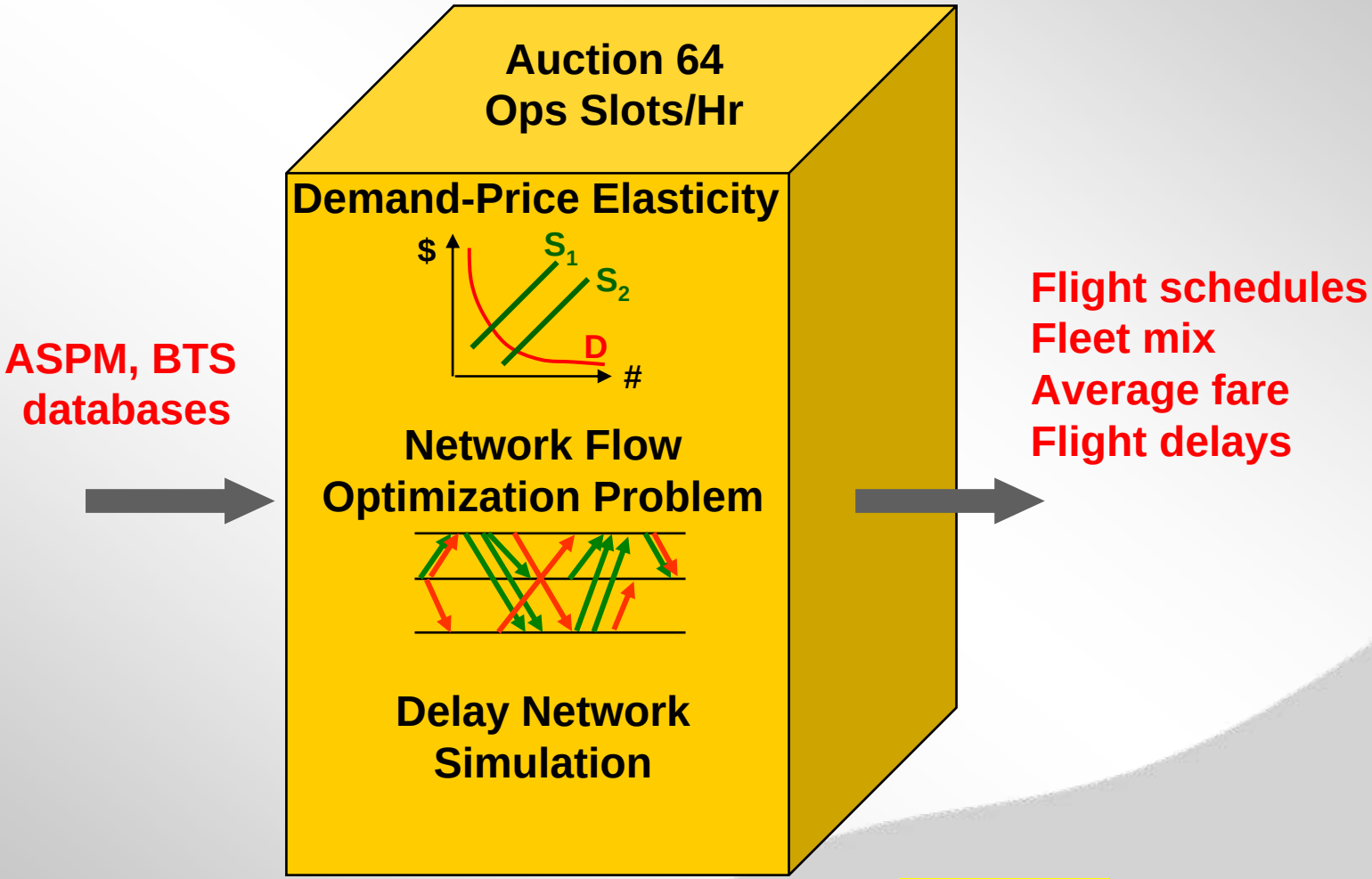
Modeling Approach and Assumptions

- **A Benevolent Monopolistic Airline (e.g. Port Authority of NY&NJ) has the ability to Determine and Set an Optimum Schedule to:**
  - **Operate at Competitive Profit Margins**
  - **Maximize Passenger Throughput**
  - **Ensure an Airline Operating Profit (Max, 90%,80%)**
- **All Current Domestic Origin and Destination Markets are Considered**
  - **67 Scheduled Daily Service Markets**
- **Current Market Price Elasticity Remains Constant**
  - **BTS T-100 segment data**

NY LGA Has 67 Daily Markets

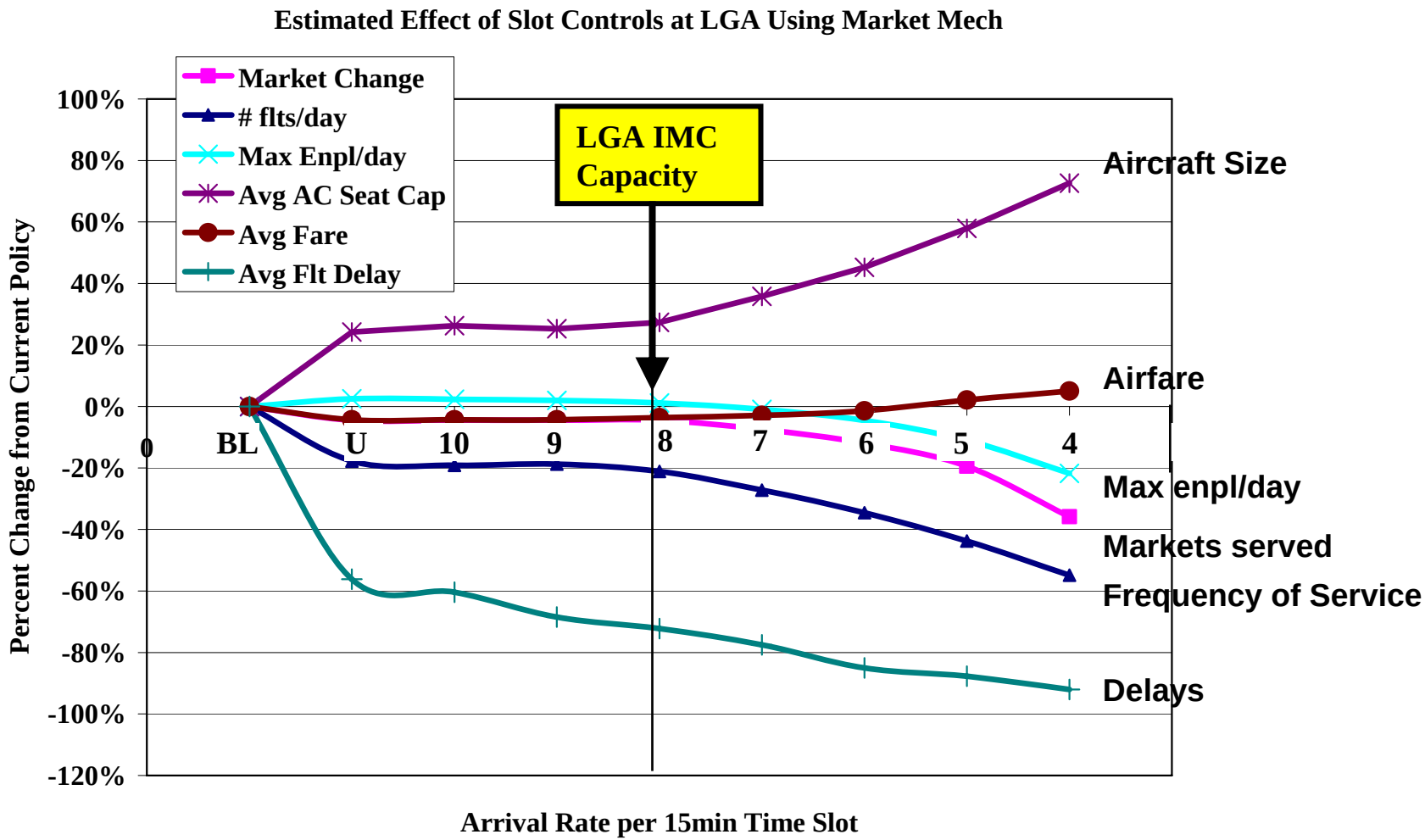


Airline Competitive Scheduling: Modeling Framework

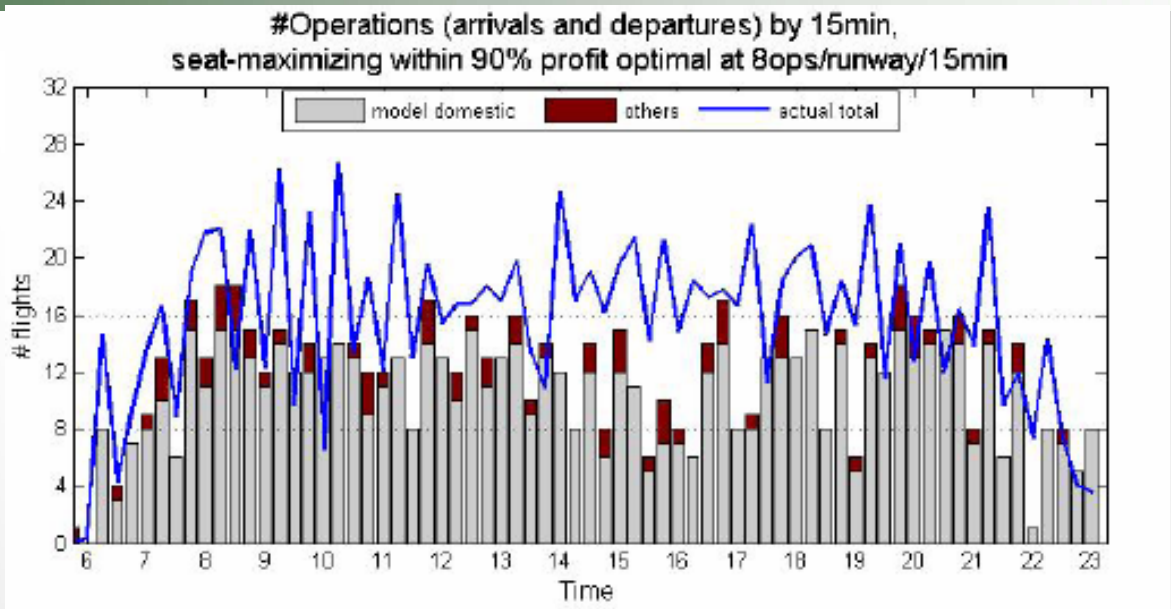


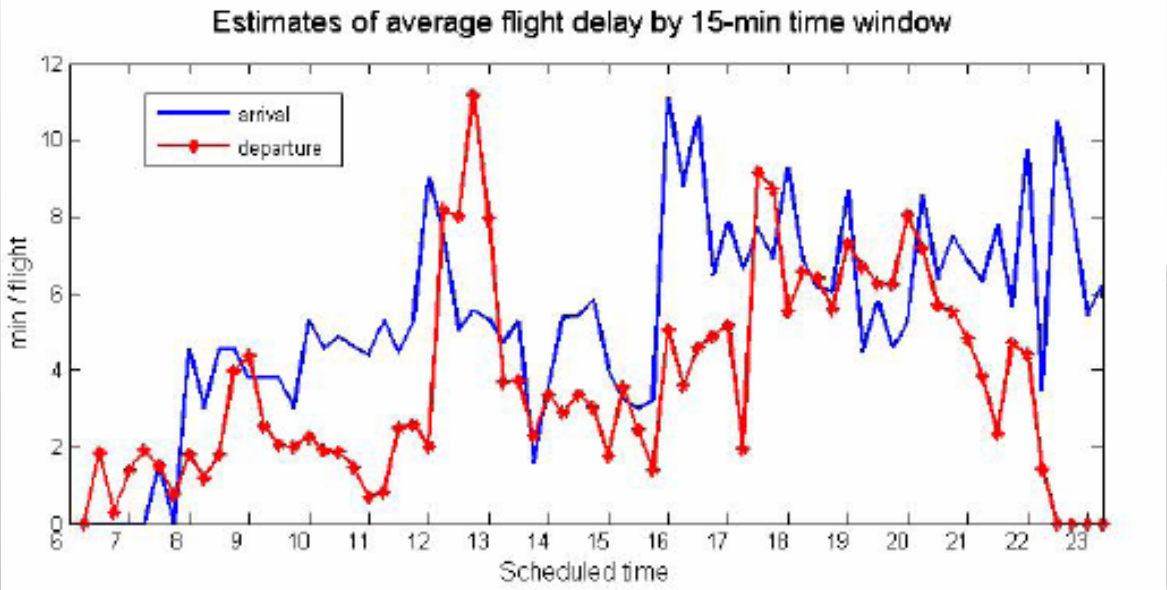
(Le, 2006)

Research Results:
Detailed Data at 90% of Profit Optimality

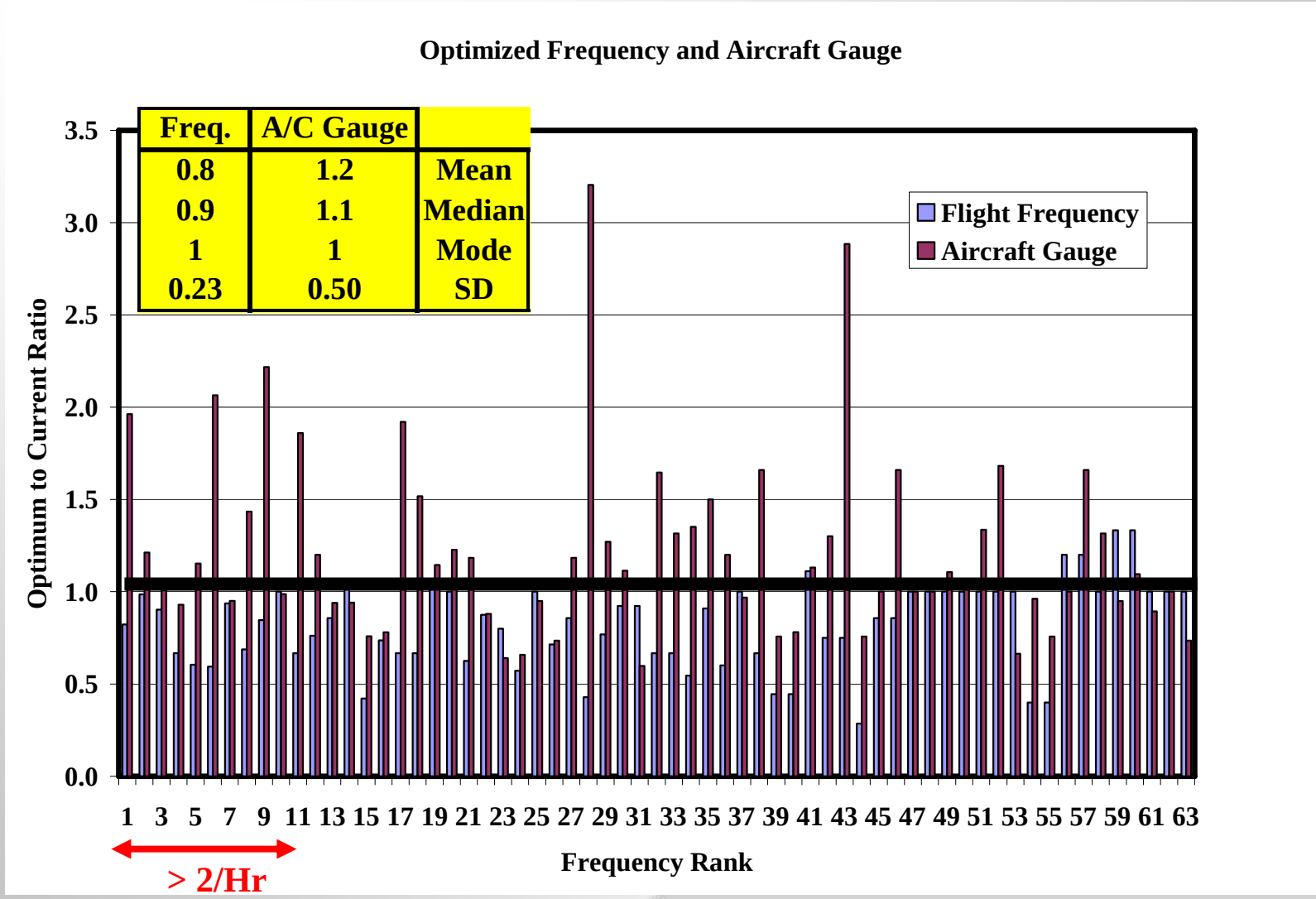


90% Profit Max - 64 Ops/Hr compromise: Frequency and Delay profile by time of day

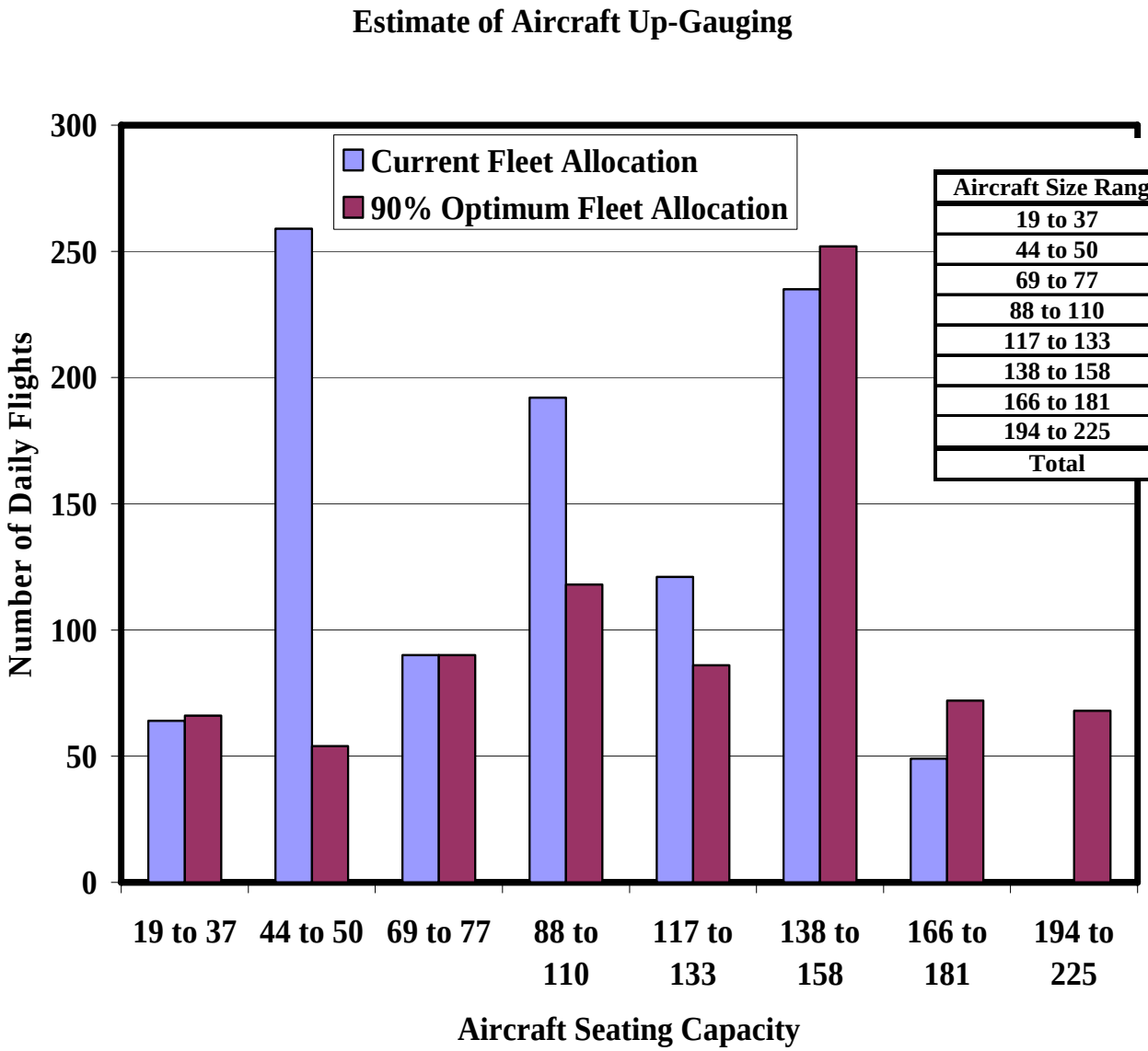




Optimized Schedule Frequency and Aircraft Gauge by Market (Opt/Current)



Model Estimate of Aircraft Gauge Change



Aircraft Size Range	Current # Flights	90% Opt # Flights	% Change
19 to 37	64	66	3%
44 to 50	259	54	-79%
69 to 77	90	90	0%
88 to 110	192	118	-39%
117 to 133	121	86	-29%
138 to 158	235	252	7%
166 to 181	49	72	47%
194 to 225	0	68	-
Total	1010	806	-20%

Unprofitable daily markets at LGA

- **Three markets (13 Flights) that are not profitable to operate on a daily basis are identified to be:**
  - **Lebanon-Hanover, NH (LEB),**
  - **Roanoke Municipal, VA (ROA),**
  - **Knoxville, TN (TYS).**

Runway Cap.	Market	seats/AC	Fare	Passengers	RPM Yield	Flights/day
unconstrained	LEB	19	$153	50	$0.72	6
10,9,8,7	ROA	37	$186	77	$0.46	5
6,5,4	TYS	50	$125	85	$0.19	2

Research Results – Win Win

Airlines adapt with aircraft size and frequency to congestion constraint:
Positive impacts on passengers, airports, airlines, and ATC

- **Airlines**
  - Reduced frequency with larger aircraft
  - Most Markets Retained
  - More Profitable (90% of Optimum)
- **Airports**
  - Increased passenger throughput
  - Reduced delays (70%)
- **Passengers**
  - Markets served: Little change
  - Airfares no change
  - Improved Predictability
- **Air Traffic Control**
  - Reduced delays
    - Demand within capacity
    - Reduced Prob. SRO

Conclusions and Recommendations

- **Airport Congestion Management will be Required to Accommodate Projected passenger growth rates**
- **Market Based Approaches May be able to Approximate Optimum Allocation of Scarce Runway Availability Resources**
- **Metropolitan "Metroplex Operation" should be Investigated to Better Understand Airport Synchronization Possibilities under Congestion Management Measures**

Opinion

- **FAA Owns slots Because:**
  - **FAA computes Max Number of Safe Arrival and Departure Combinations as a Function of:**
    - **Airport Runway Configuration,**
    - **Separation Technology**
    - **Designated Level of Safety**
  - **Daily GDP control (and Acceptance by Airlines) is an implicit exercise of this ownership**
- **Slot Exemptions (or total lack of control) are an implicit reduction of the FAA's stated safety standards**
  - **Standards should be either changed or enforced**

Center for Air Transportation System Research Publications and Information

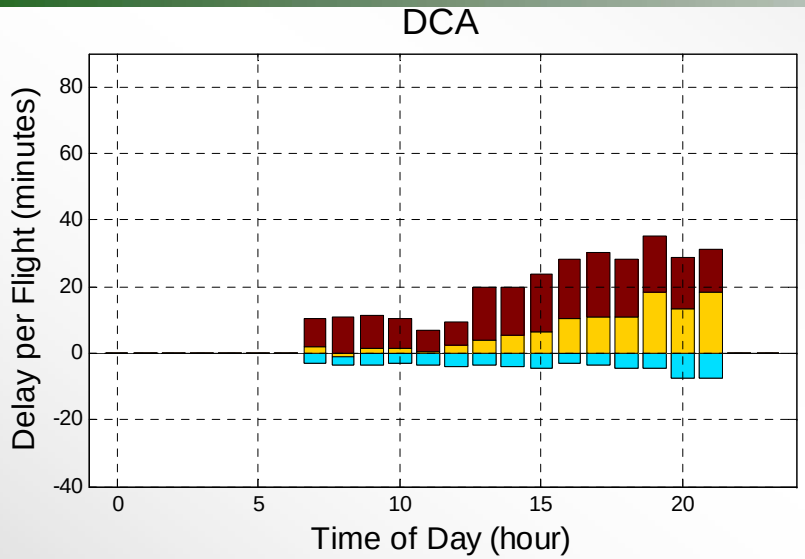
- **Loan Thanh Le, "Demand Management at Congested Airports: How far are we from Utopia?", Ph. D. dissertation August 2006.**
- **http://catsr.ite.gmu.edu**

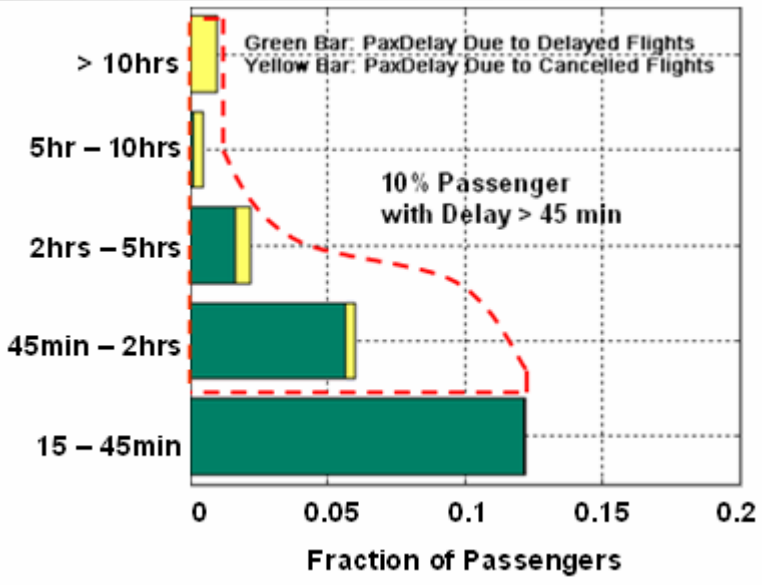
  – **Other Useful Web Sites**

- **http://mytravelrights.com**
- **http://gao.gov**
- **http://www.airconsumer.ost.dot.gov**

BACKUP Material

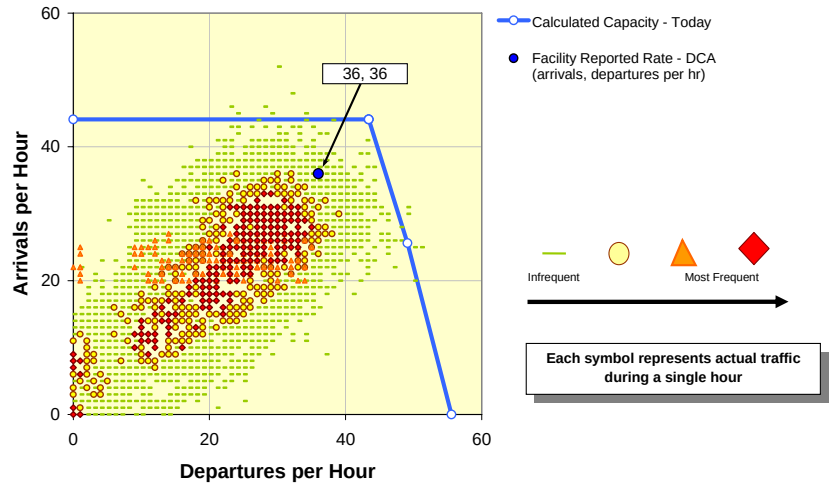
DCA a Conservatively Scheduled High Demand Slot Controlled Airport



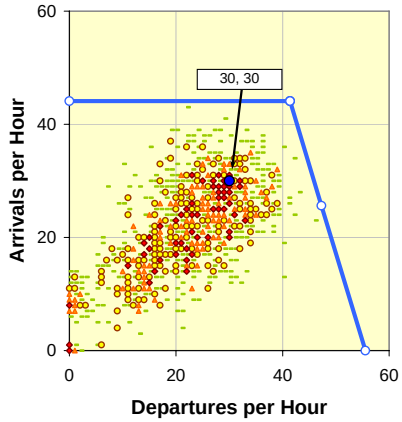


Calculated Capacity (Today) and Actual Throughput

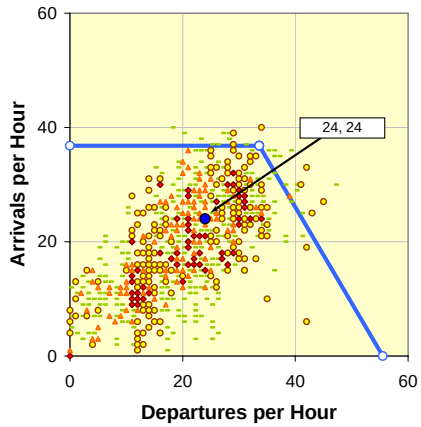
Optimum Rate



Marginal Rate



IFR Rate



Congestion Management could Shift Hubbing Passengers to other Large Airports

Airport	Connecting Passengers %
Chicago O'Hare	59
Newark NJ	32
NY LaGuardia	8
NY JFK	40
Philadelphia	38
Atlanta	66
Boston	15
Miami	55
Washington Dulles	53
Dallas/Fort Worth	60

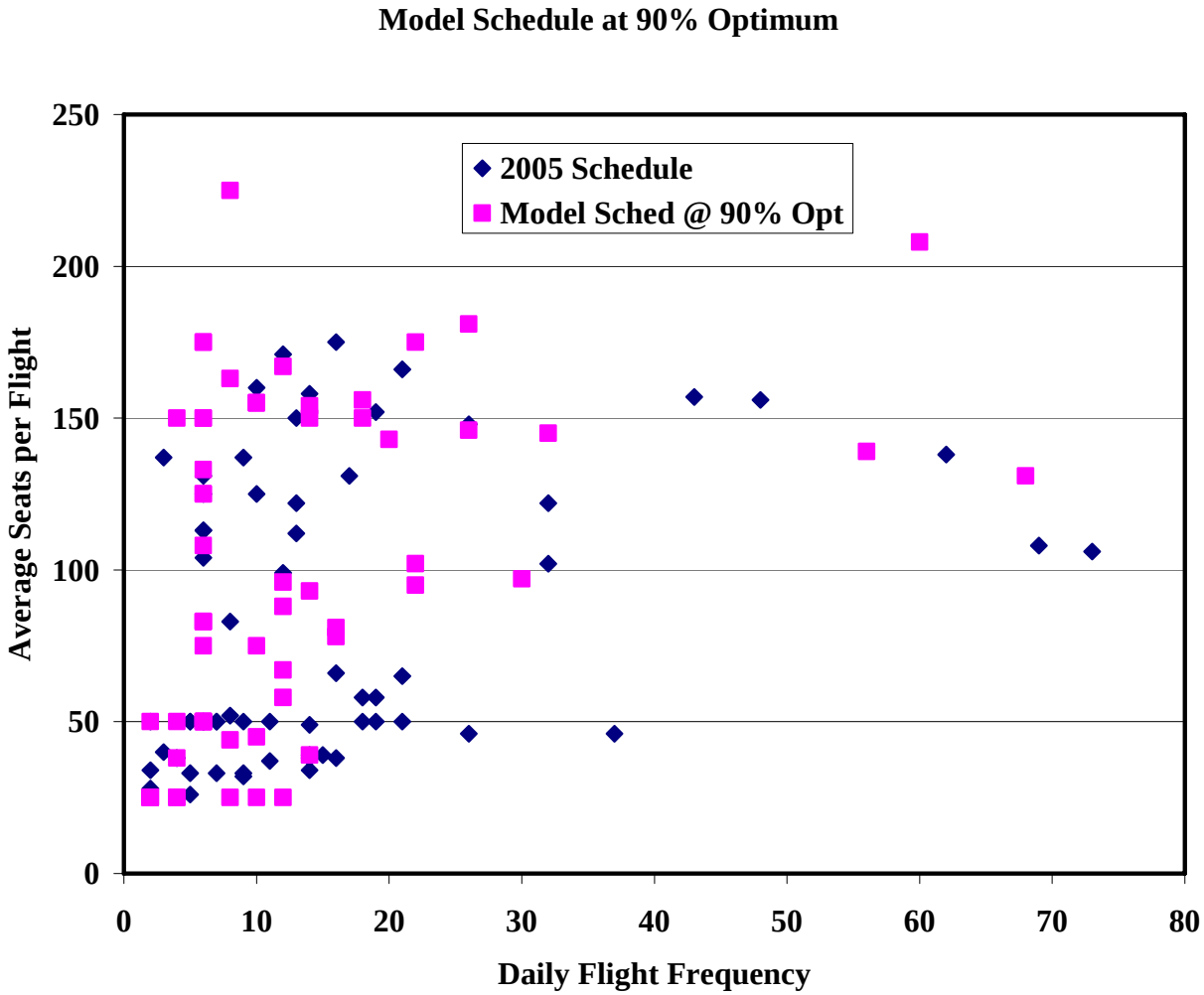
FAA 2006 NPIAS

LGA High Frequency Flights: Current and 90% of Optimum

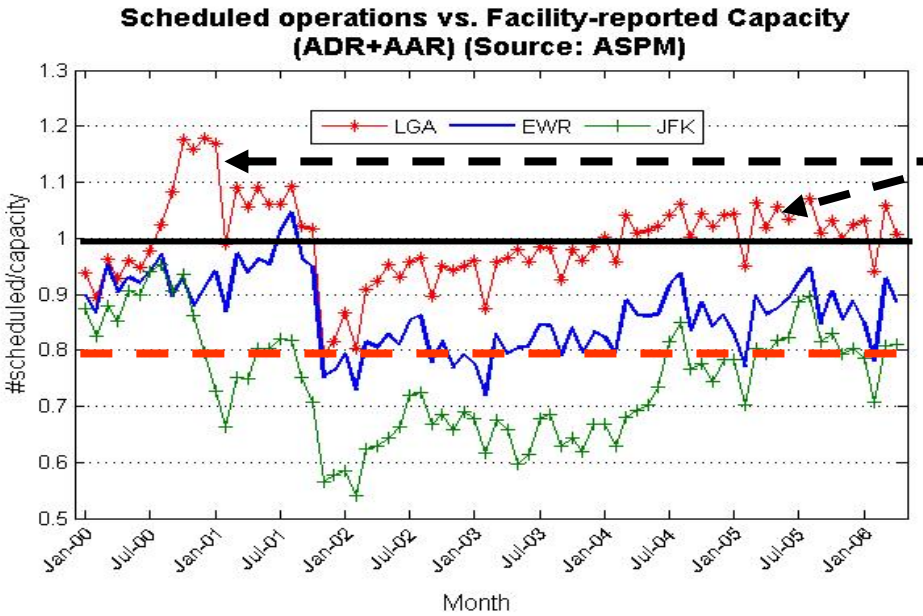
CATSR

	Market	Daily Freq	A/C seats	Model Freq	Model seats	Normalized		Rank
						Freq	Seats	
Boston Logan	BOS	73	106	60	208	0.8	2.0	1
Washington DC Reagen Nat	DCA	69	108	68	131	1.0	1.2	2
Chicago O'Hare	ORD	62	138	56	139	0.9	1.0	3
Atlanta Hartsfield	ATL	48	156	32	145	0.7	0.9	4
Fort Lauderdale Fl	FLL	43	157	26	181	0.6	1.2	5
Raueigh/Durham NC	RDU	37	46	22	95	0.6	2.1	6
Detroit Mi	DTW	32	122	22	175	0.7	1.4	7
Charlotte NC	CLT	32	102	30	97	0.9	1.0	8
Columbus OH	CMH	26	46	22	102	0.8	2.2	9
Dallas Ft Worth	DFW	26	148	26	146	1.0	1.0	10

Model preserves Heterogeneous Aircraft Mix: But Reduces Frequency and Up-Gauges some Markets



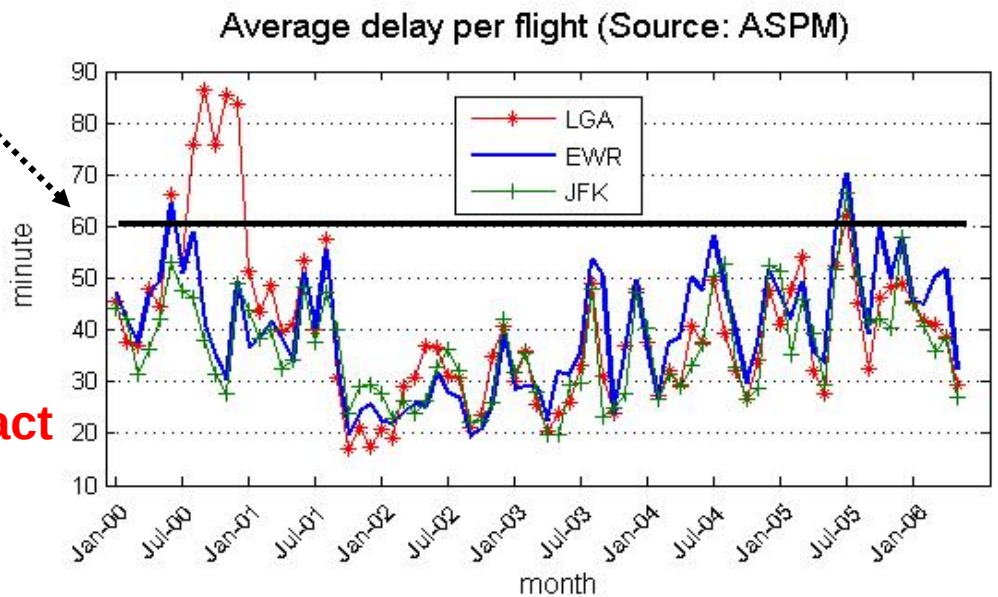
Network Delays Driven by Uncoordinated and Over-Scheduled Flights: e.g. LGA, EWR, JFK



Airline Demand Driven by Market Access/Competition/Profitability Concerns

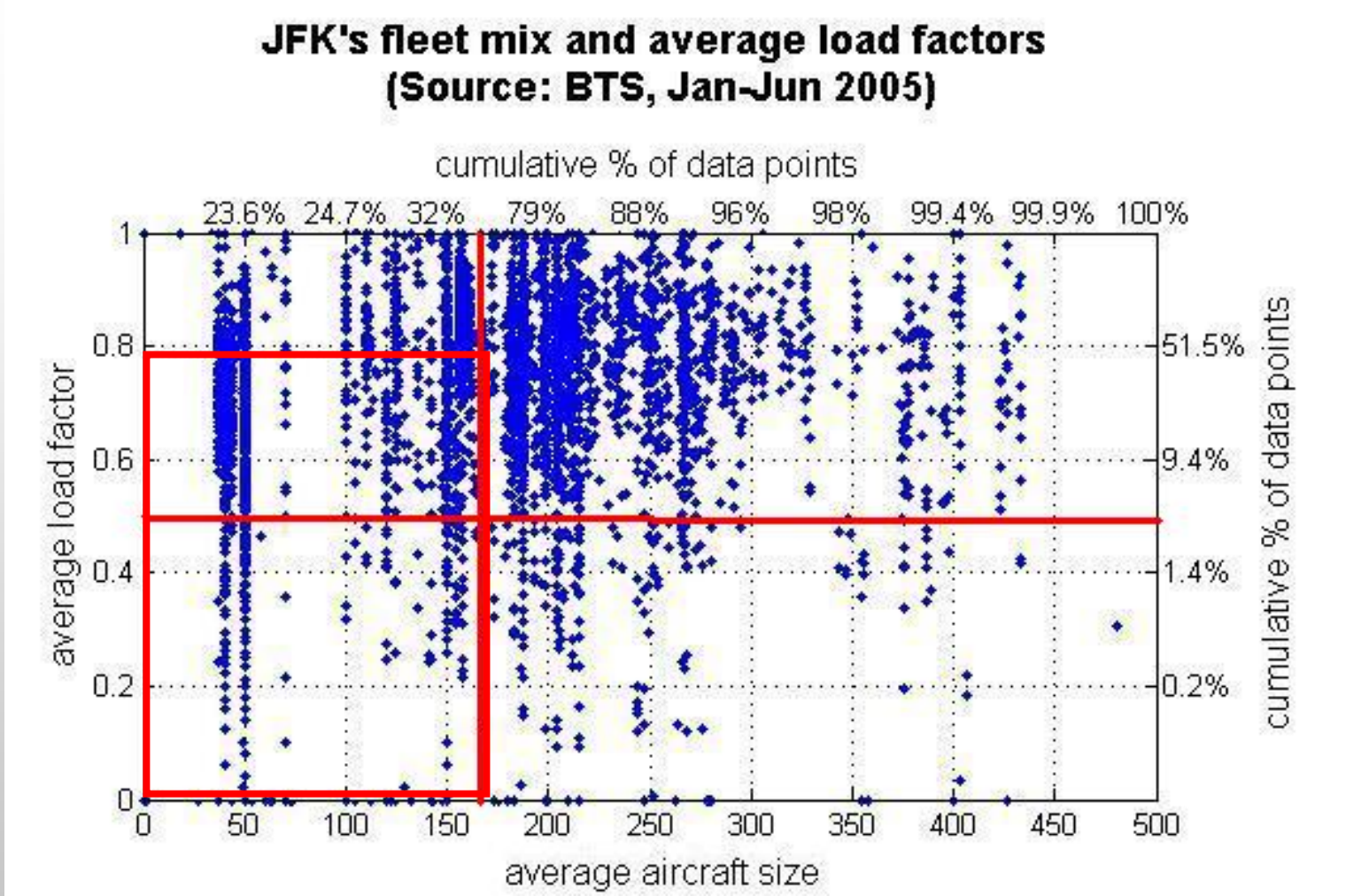
Runway Capacity is Set by Aircraft Safety Separation Standards

1 Hr



- **High utilization rates (>80%) increase delays exponentially**
- **Delays at major airports Impact the Entire Air Transportation Network**

JFK Fleet Mixture



Sub-problem: Modeling a single market

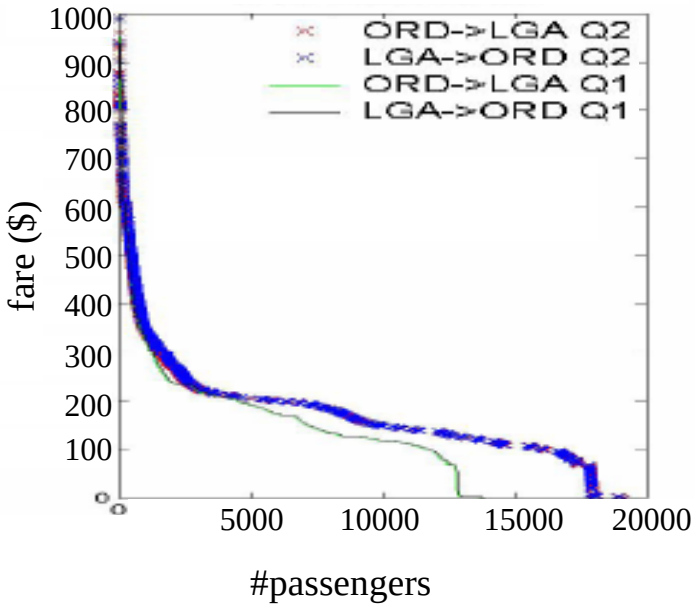
Build timeline network: complete schedule of all possible flights, fleets

Estimate arc costs

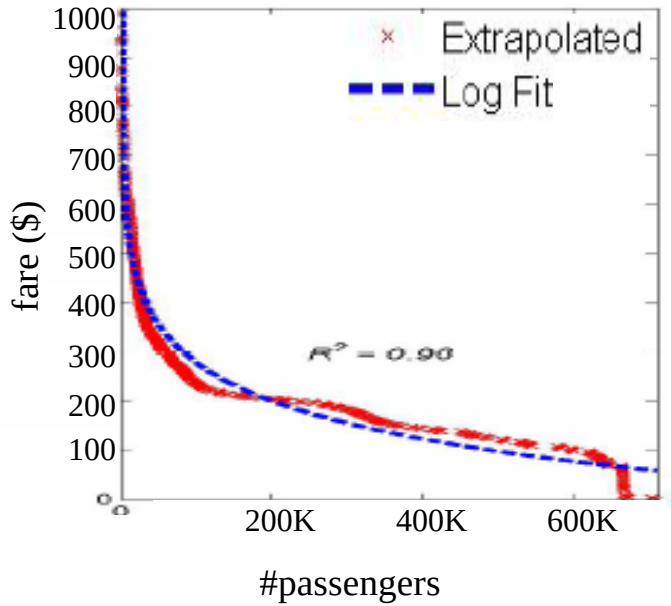
Estimate node revenues: for each 15-min arrival time window

Available data: 10% ticket price sample by quarter

ORD-LGA segment, 10%



ORD→LGA segment, 100%



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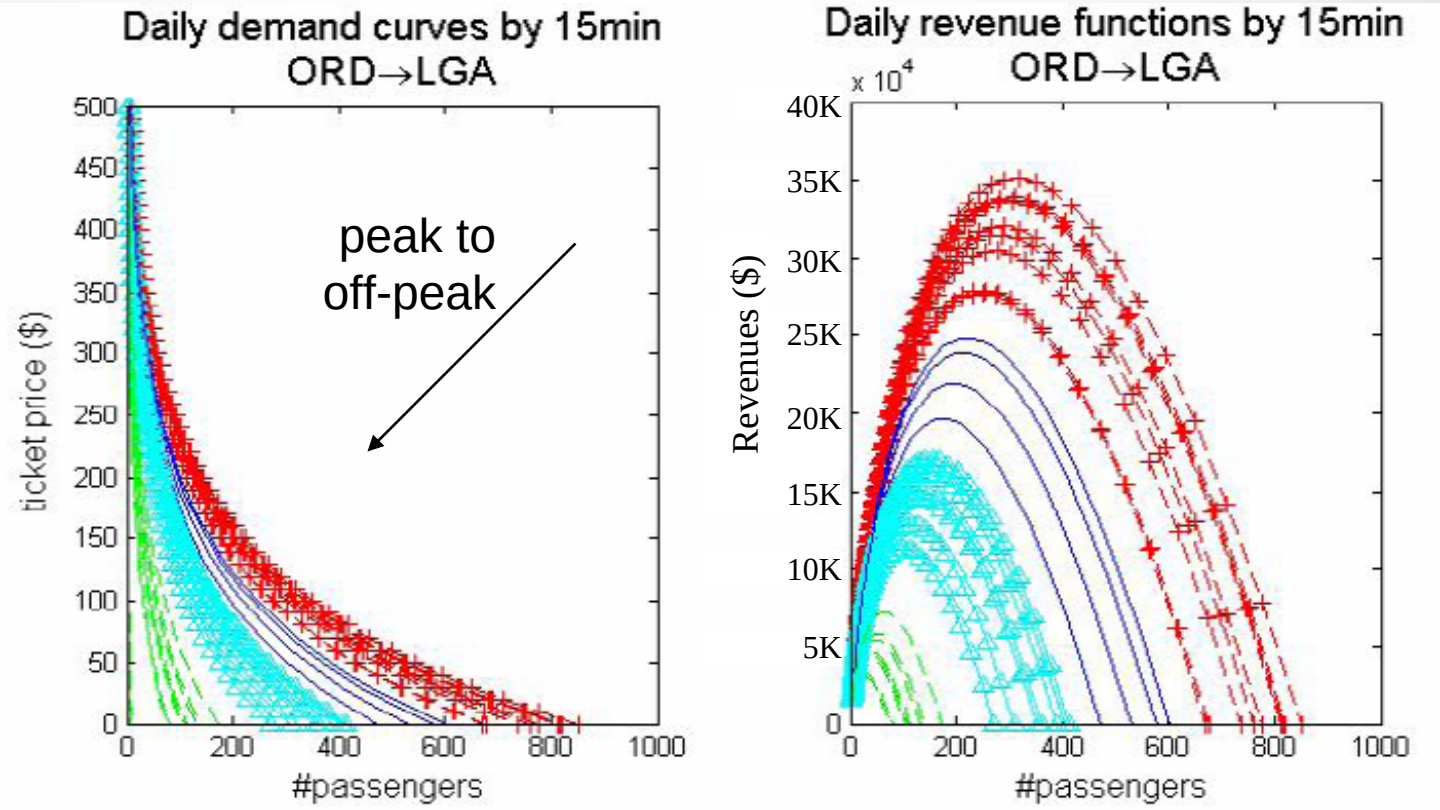
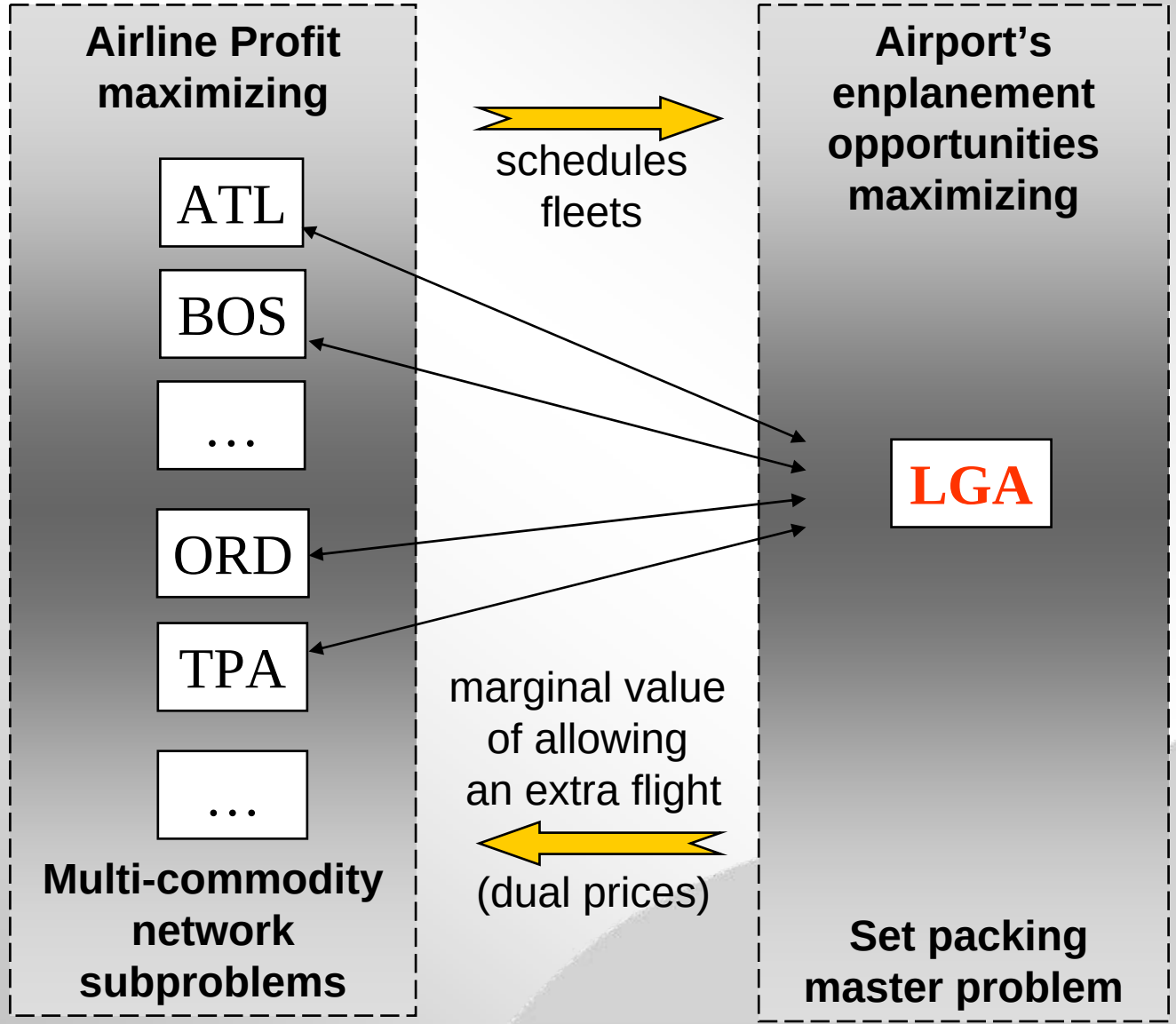
From demand curves to revenue curves



General solution approach

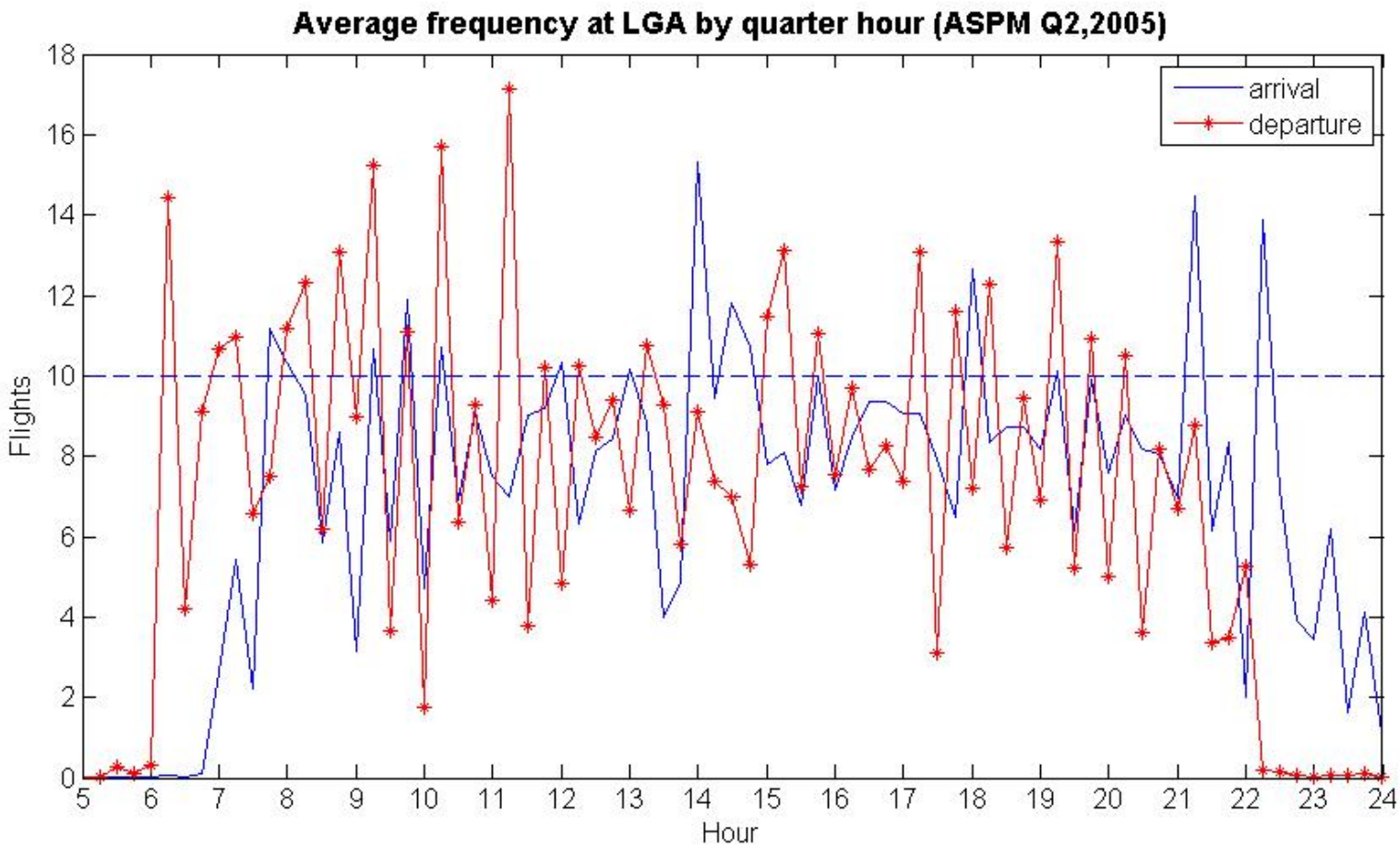


67 nonstop daily domestic markets

Congestion management by better scheduling

CATSR

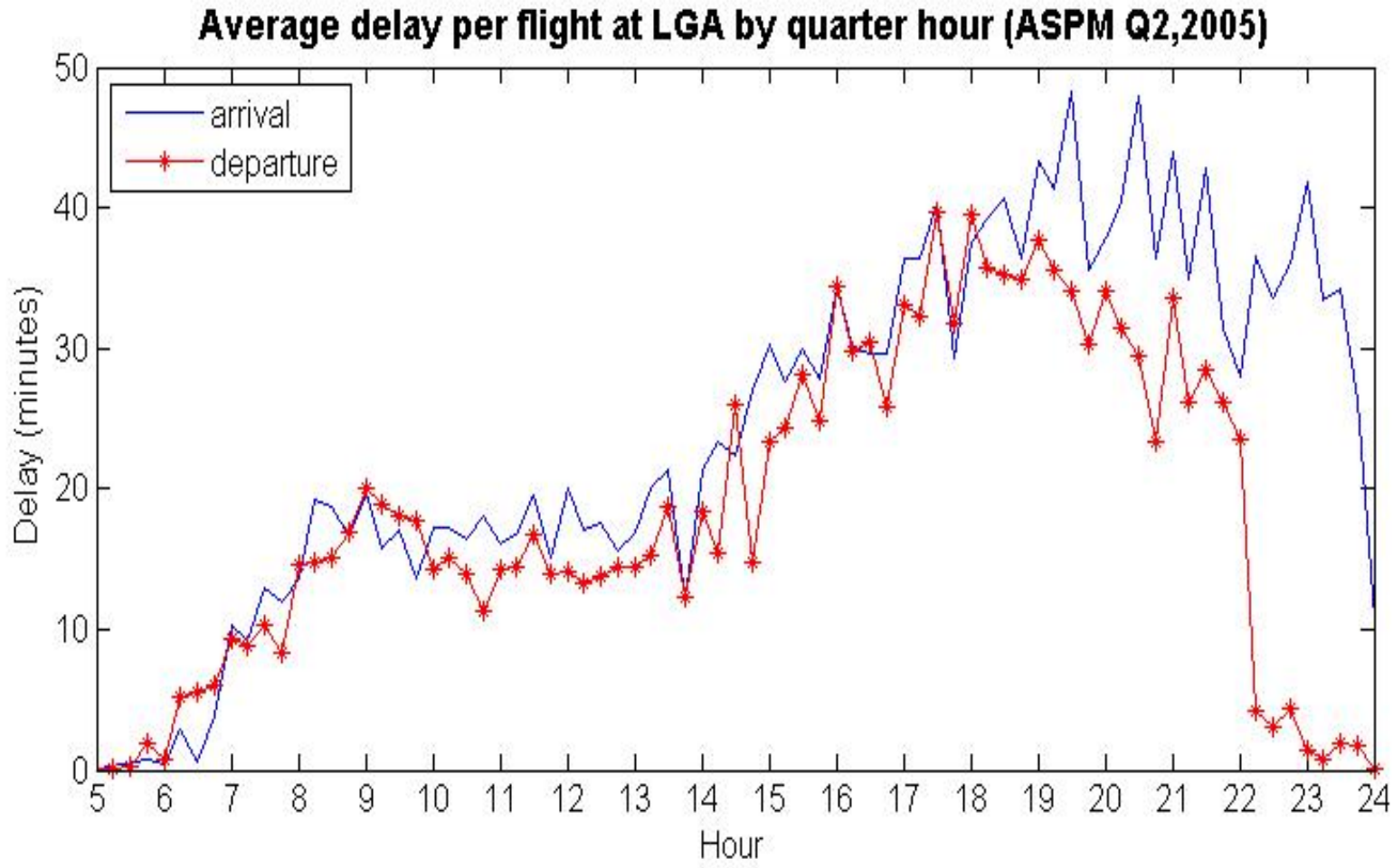
Schedules exceeding airport optimum rates…



Congestion management by better scheduling

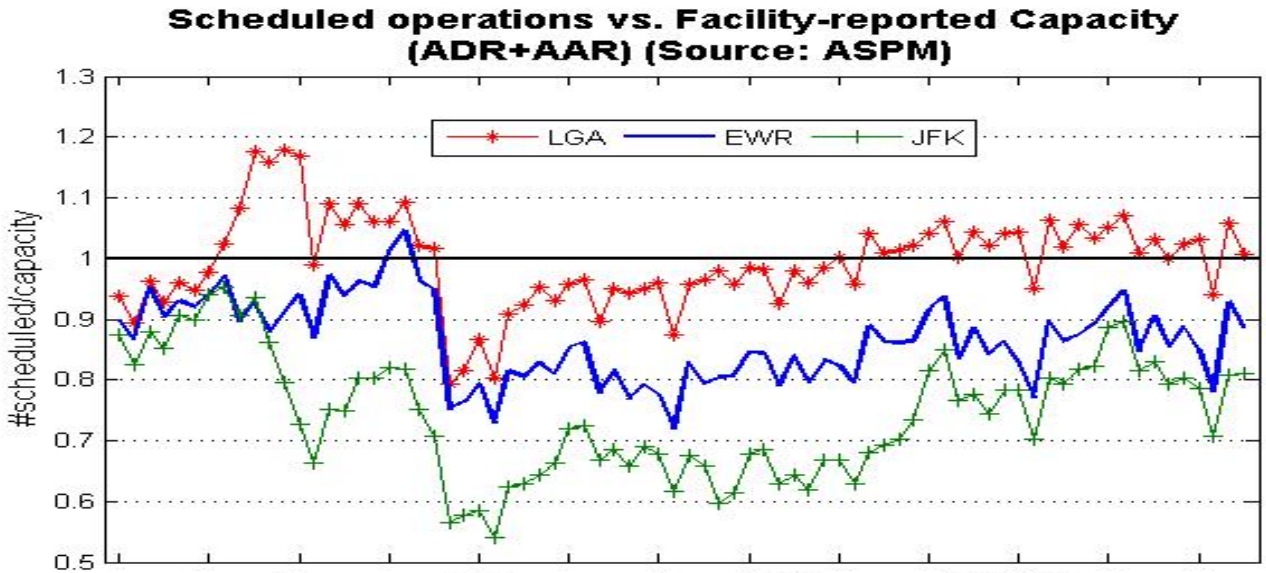
CATSR

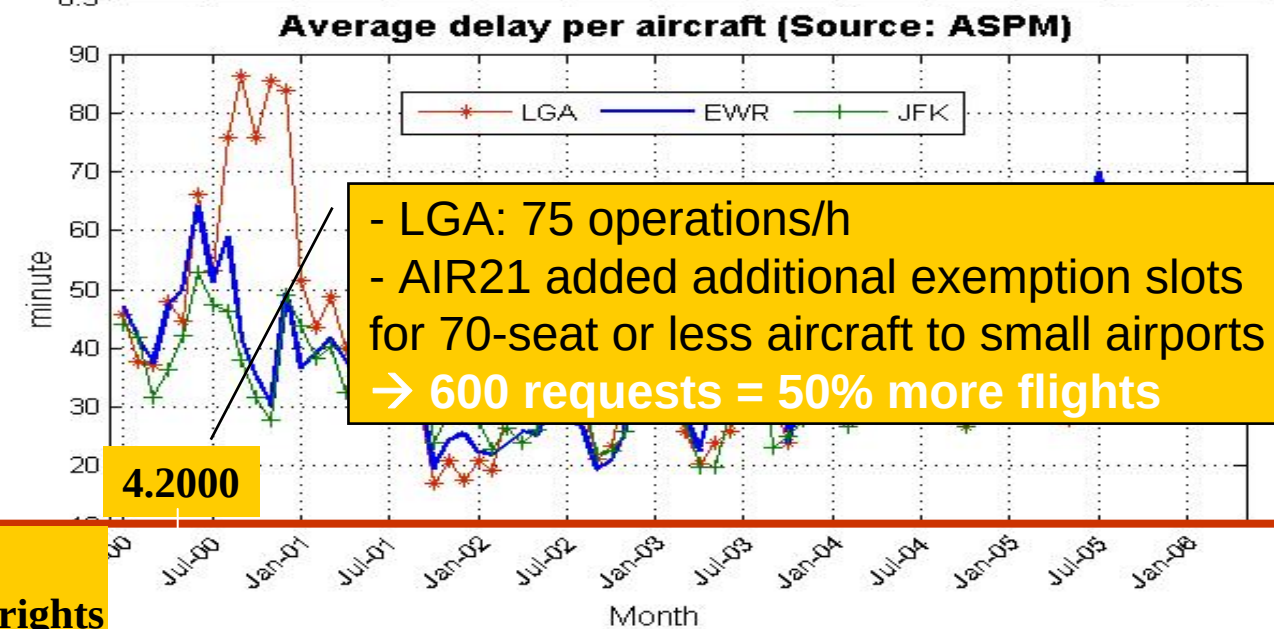
…lead to excessive queuing delay



Excess of demand and severe congestion at NY area airports: a 40-year old reality

CATSR





- LGA: 75 operations/h
- AIR21 added additional exemption slots for 70-seat or less aircraft to small airports
- → **600 requests = 50% more flights**

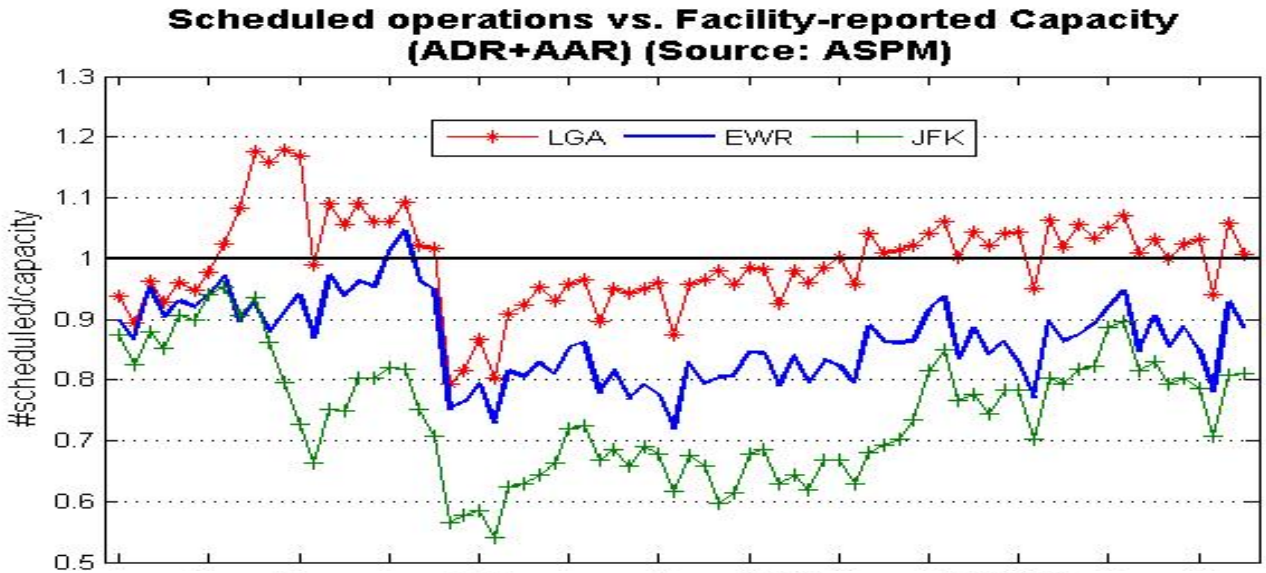
HDR 1969

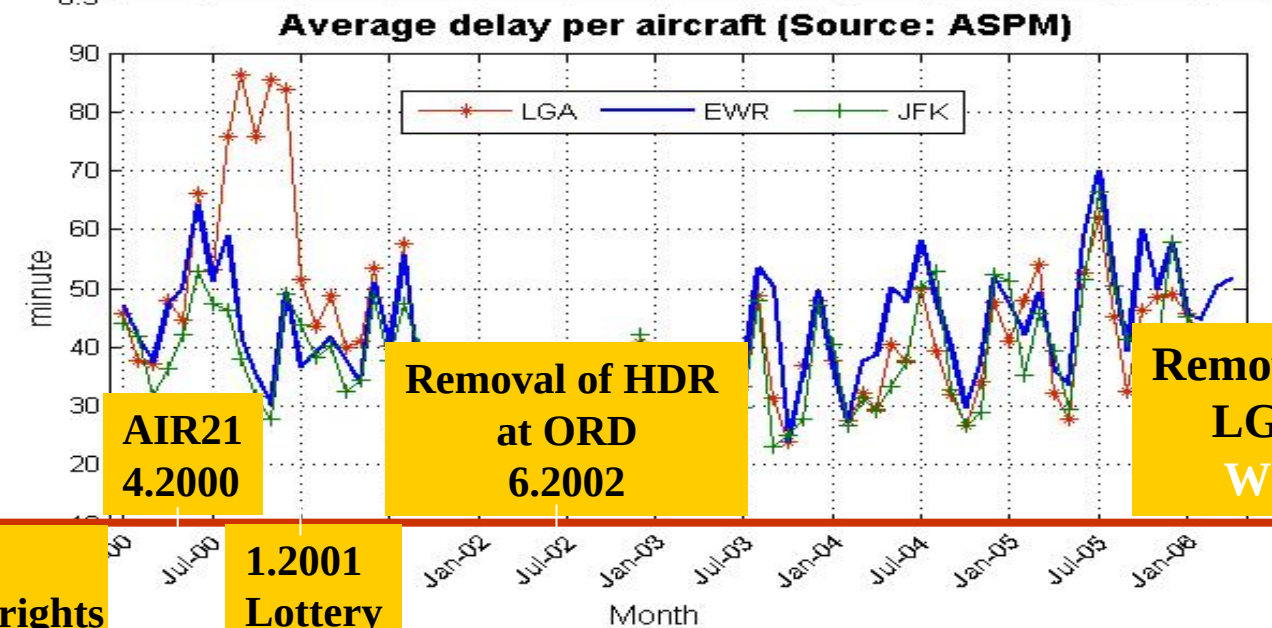
4.2000

1985 Grandfather rights

Excess of demand and severe congestion at NY area airports: a 40-year old reality

CATSR





HDR 1969

1985 Grandfather rights

AIR21 4.2000

1.2001 Lottery

Removal of HDR at ORD 6.2002

Removal of HDR at LGA and JFK

What's next?

1.2007

Summary of European Passenger Bill of Rights - http://news.bbc.co.uk/1/hi/business/4267095.stm

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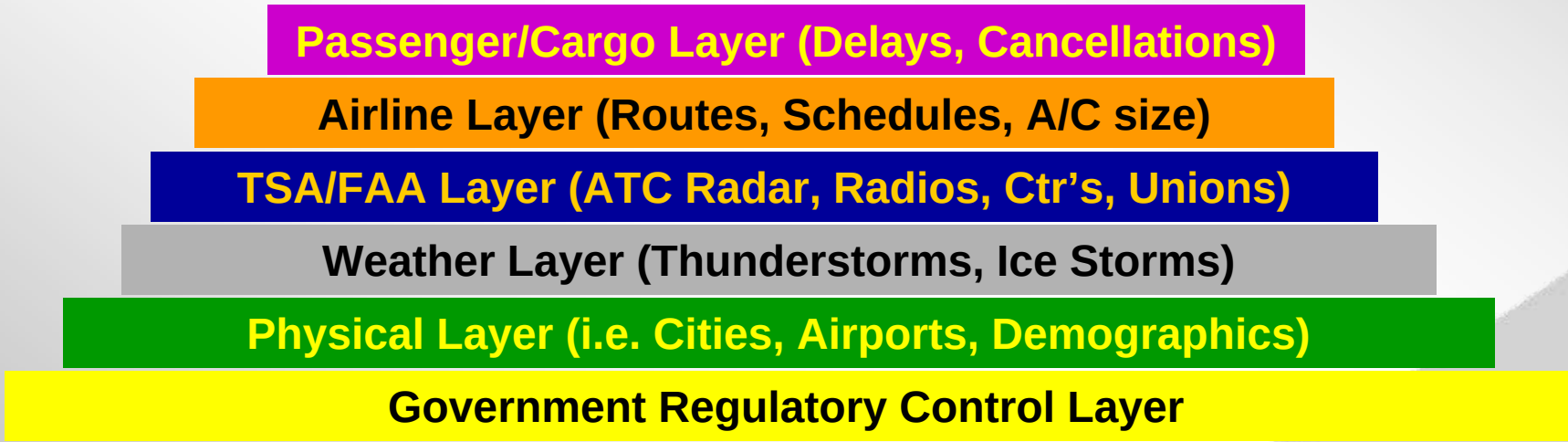
- **Overbooked Flights**
  - **Passengers can now get roughly double the existing compensation if they are bumped off a flight.**
    - **Compensation must be paid immediately.**
    - **These passengers must also be offered the choice of a refund, a flight back to their original point of departure, or an alternative flight to continue their journey.**
  - **May also have rights to meals, refreshments, hotel accommodation if necessary even free e-mails, faxes or telephone calls.**
- **Cancelled Flights**
  - **Offered a refund of your ticket, along with a free flight back to your initial point of departure, when relevant. Or, alternative transport to your final destination.**
  - **Rights to meals, refreshments, hotel accommodation if necessary, even free e-mails or telephone calls.**
    - **Airlines can only offer you a refund in the form of travel vouchers if you agree in writing**
  - **Refunds may also be paid in cash, by bank transfer or cheque**
  - **If the reason for your flight's cancellation is "within the airline's control", it must pay compensation.**
  - **Compensation for cancellations must be paid within seven days.**
- **Delayed Flights**
  - **Airline may be obliged to supply meals and refreshments, along with accommodation if an overnight stay is required.**
  - **If the delay is for five hours or more, passengers are also entitled to a refund of their ticket with a free flight back to your initial point of departure if this is relevant.**

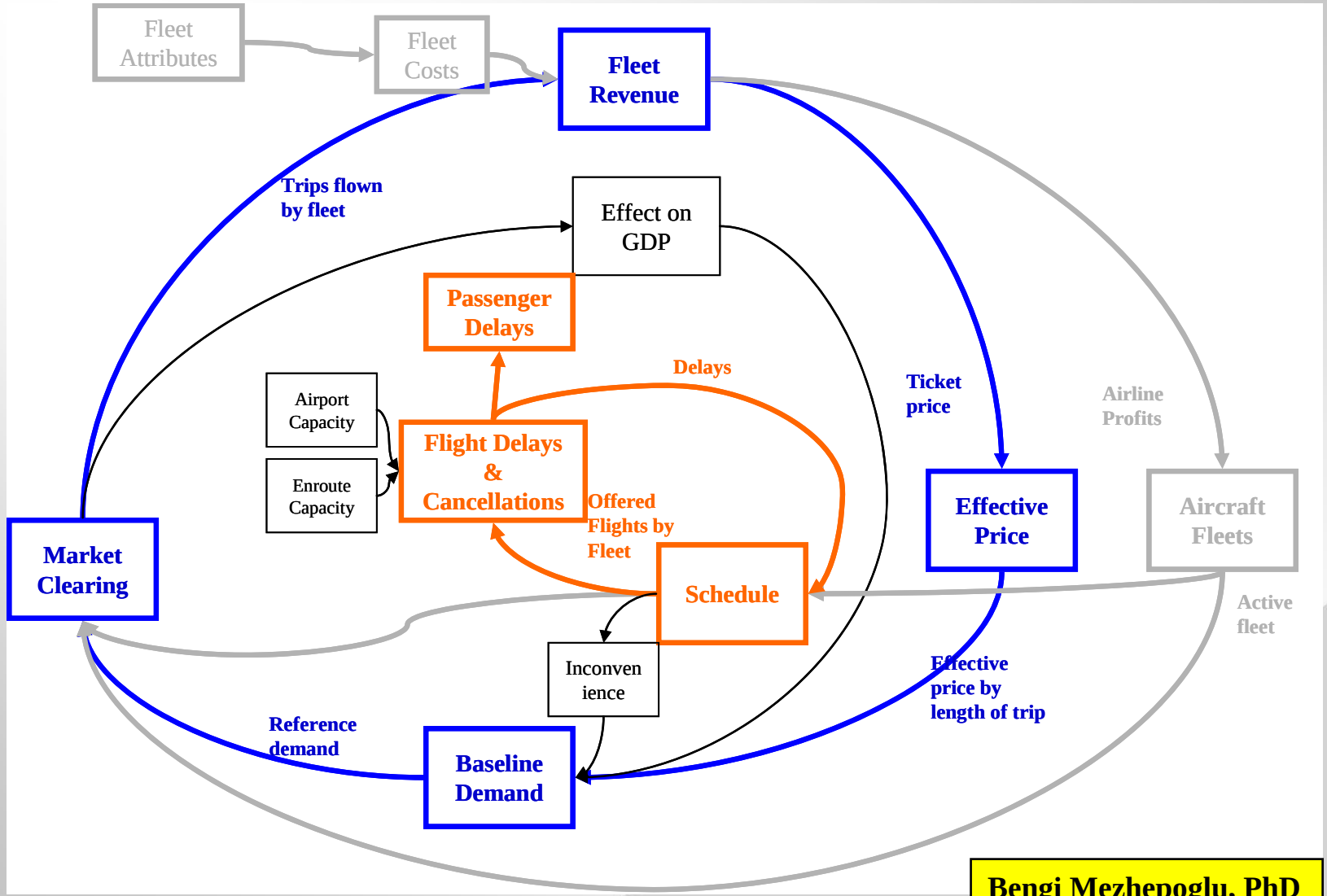
Air Transportation System (ATS) is a Network with 6 Interacting Layers

CATSR

- **The ATS is a Public - Private Partnership with conflicting objective functions:**
  - **Public – Commerce and safety; interest groups**
  - **Private – Profit maximization**



Air Transportation is Characterized as a Complex Adaptive System (CAS)



Bengi Mezhepoglu, PhD in progress

Research problems and findings

Research problem 1:

Are current rules of slot allocation the main causes of the congestion problem?

Answer:

Yes, grand-father rights, weight-based landing fees, slot exemptions

Research problem 2:

Impacts on congestion, enplanement opportunities, markets served, aircraft size, flight demands ?

Metric	Baseline	90% consolidation		80% consolidation	
#markets	67	64	(-4%)	64	(-4%)
#flights	1024	808	(-21%)	824	(-20%)
#seats	96997	98100	(1%)	100250	(3%)
aircraft size	95	121	(27%)	122	(28%)
average fare	139	134	(-4%)	131	(-6%)
flight delay*	18.7min	5.2min	(-72%)	6.4min	(-66%)

TABLE 3. Projected effects on daily operations at LGA that result from a market-based slot allocation at 8 ops/runway/15min (*queueing delay estimates do not include international, non-daily and non-schedule operations)

Airline response model

Model a single benevolent airline

Model the interaction of demand and supply through price

- **Price elasticity of demand determine demand at each price point**
- **Each supply curve corresponds to a fleet mix profile**
- **Different supply levels result in different equilibriums**