Airside and Landside Congestion

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Objective and Topics

- **Objective:**
  - To summarize fundamental concepts regarding delays and waiting times as they occur on airside and on landside
- **Topics:**
  - Delay/congestion on airside and its impacts on airlines and passengers
  - Delay/waiting times on landside
  - Aggregate and distributive measures of delay
  - Relationship between capacity, demand and delay
  - High sensitivity of delay to demand and capacity
  - On-time arrival statistics and why they can be deceptive
  - Measuring and attributing delays
  - Bad measures of delay

Outline

- Delay/congestion on airside and its impacts on airlines and passengers
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Delay / Congestion on Airside

- Delay is one of the two key measures of performance on airside; the other is environmental impact
- Delay affects airlines negatively in several major ways:
  - Direct costs: labor, fuel, maintenance, depreciation
  - Level of service perceived by passengers
  - Disruption of daily schedules
  - Need for additional resources (staff, aircraft, etc) to permit schedule recovery
  - Long-term loss of goodwill, loss of demand (diversion to other modes, alternatives to travel)
- Similar negative impacts on passengers:
  - Direct cost of lost time
  - High cost of trip disruptions
  - Change of travel strategies, more time spent traveling
- Negative impacts on environment and safety

Cost of Air Traffic Delays in US, 2007

Cost Component	**Cost (billion dollars)**
Cost to Airlines	8.3
Cost to Passengers	16.1
Cost of Lost Demand	7.9
Total Direct Cost	32.3
Indirect Impact on GDP	4.0
Total Cost Impact	36.3

Source: *Total Delay Impact Study: A Comprehensive Assessment of the Costs and Impacts of Flight Delay in the United States,* NEXTOR 2010

Passengers Experience More Delay than Flights

- Important observation (2005): In the US, the average passenger experiences much longer air traffic delay than the average flight
- This is also true throughout the world
- When a flight is late, the passengers on the flight experience the same delay as the flight itself
- But connecting passengers may also suffer additional delay due to missing their connecting flights
- Flight cancellations may also impose long delays on passengers
- Interesting note: As the load factors on flights increase, the average delay per passenger also increases. Why?
- **A very complex problem for the airlines!**

Delay / Congestion on Landside

- Delay (= waiting time for processing) is also one of the most important measures of performance on landside (terminal buildings)
- Different airports and airlines have different standards (and many have no standards at all)
- IATA/ACI have recently (2014) issued some guidelines as to what are considered "acceptable" and "non-acceptable" waiting times in terminal buildings [Prof. de Neufville's lecture]
- Perceptions play a very important role in the case of waiting times in terminal buildings: the same amount of waiting may be perceived as "very long" in some cases and "OK" in others

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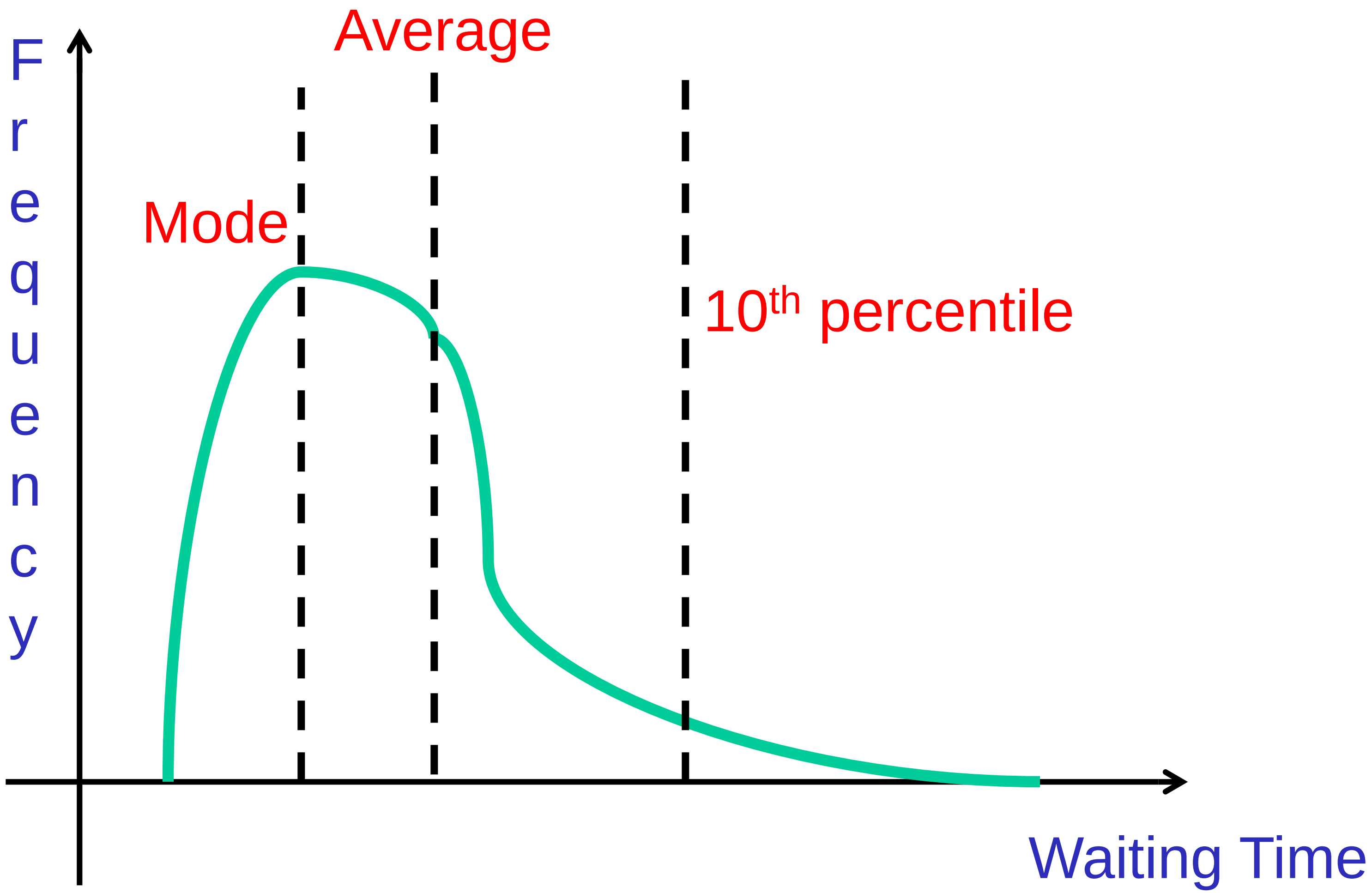
Measuring and Assessing Delay

- Delay-related performance at an airport must be assessed from several perspectives:
  - **"Average"** (expected value)
  - **"Spread" / "uncertainty"** (standard deviation)
  - **"Extreme cases" / "outliers"** (X-percentile of distribution, where X=10 or 5 or 1)
  - **"Most frequent"** (mode of distribution)
- Typically we are concerned about
  - Delay over the entire period under consideration, as well as
  - Delay during peak demand periods (peak hours, peak days, peak month, special days

Sketch of a Distribution of Waiting Times



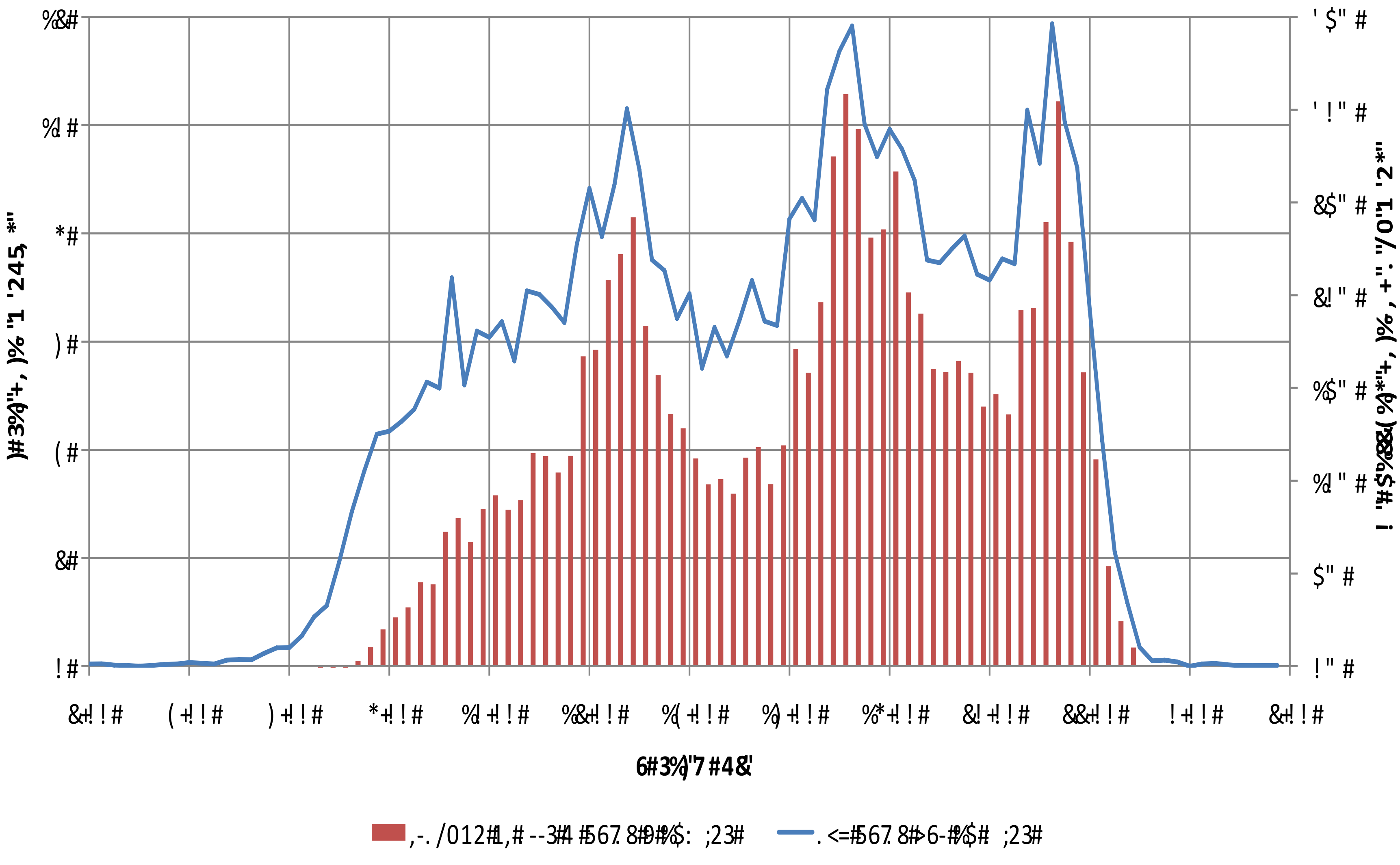
Two Common Measures of Airside Delay

- Average delay per arrival (or per departure or per airport movement).

- Percent (%) of arrivals which are more than 15 minutes late (or % of departures or % of all movements); “lateness” is measured relative to the scheduled arrival time.

- *Note:* This is the “On-Time Arrival” (OTA) statistic which is used widely around the world; it measures the probability that a flight will arrive more than 15 minutes late.

Runway Delay Statistics for a Typical Day at FRA



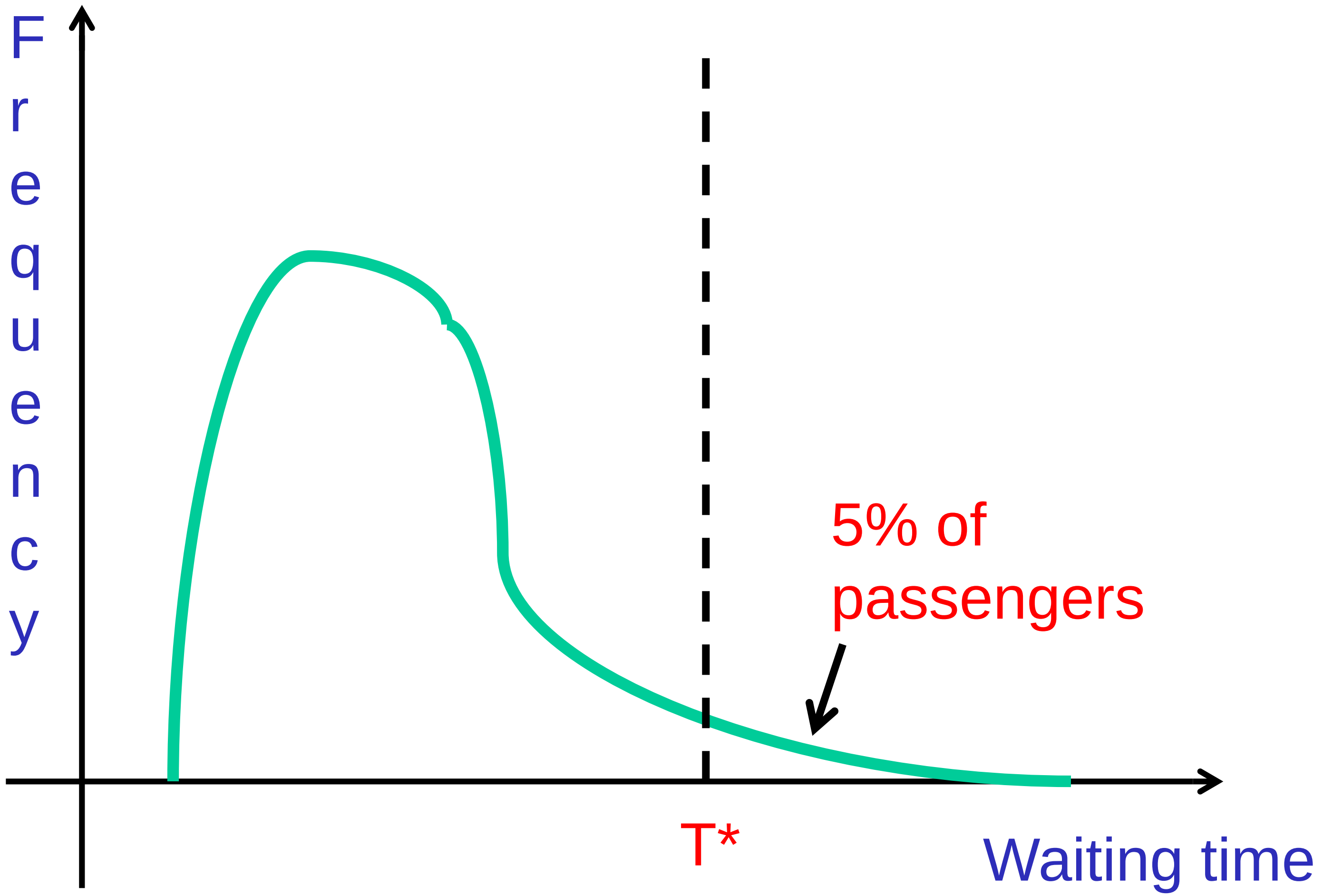
IATA-ACI Waiting Time Measure for Landside Services

- In their newest guidelines, issued in 2014, IATA and ACI have proposed that one of the two measures of the level of service provided in terminal buildings should be:

"The 95th percentile highest waiting time experienced by passengers at each facility and process in the terminal."

- For example: "95% of arriving passengers, experience a waiting time of 12 minutes or less for passport control"
- Airports are invited to set their Level-of-Service (LOS) standards by using this 95th percentile measure of waiting time.
- Example: Consider airport A and suppose that the LOS for waiting times for check-in has been set to 10 minutes

Example continued: Distribution of Waiting Time for Check-In



- Collect data to measure T*
- If T* < 10 min then the level of service is OK

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Behavior of Queuing Systems in the "Long Run"

- The "utilization ratio", ρ, measures the intensity of use of a queuing system:

$$r = \frac{average\ demand\ rate}{average\ service\ rate} = \frac{"demand"}{"capacity"} = \frac{l}{n}$$

- Even when the demand rate is smaller than the service rate (i.e., $\rho < 1$) delays/waiting will occcur because of:
  - – variability of demand and capacity over time
  - – probabilistic fluctuations of demand and capacity
- **These delays will become very large, if ρ gets close to 1**

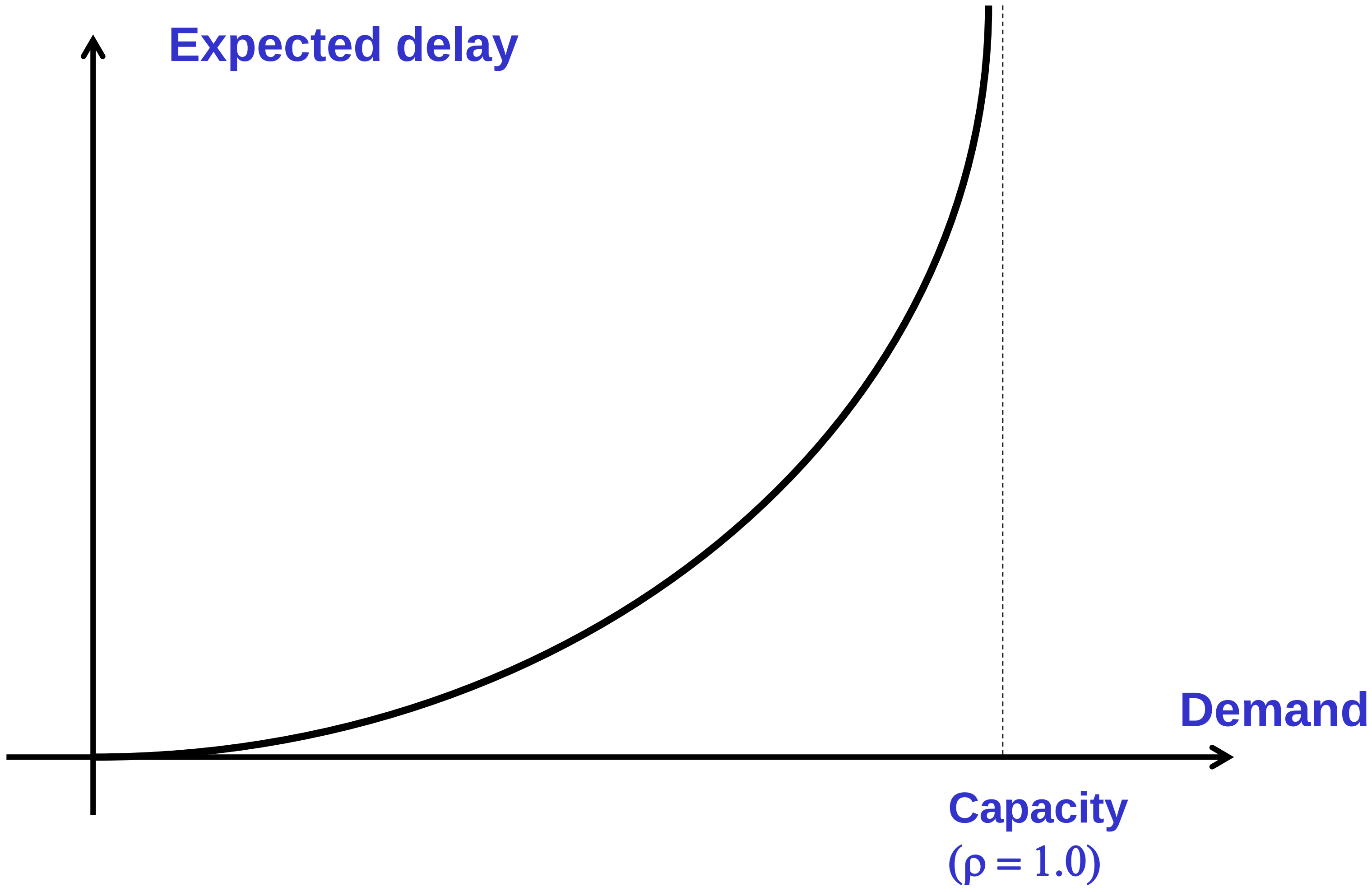
Behavior of Queuing Systems in the "Long Run"[2]

- In the "long run", the average queue length and average delay in a queuing system are proportional to:

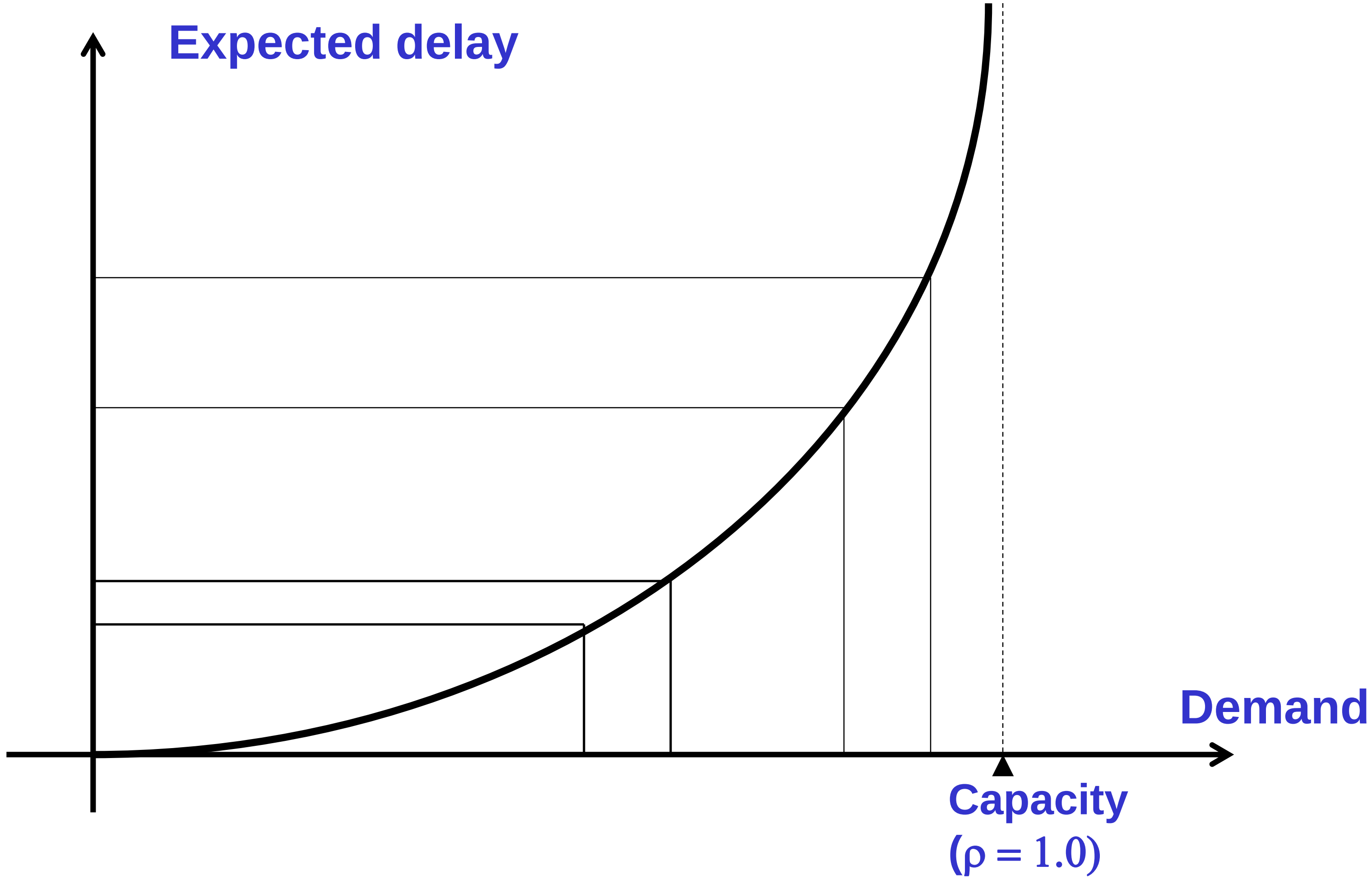
$$\frac{1}{1-\rho}$$

- Thus, as the demand rate approaches the service rate (or as $\rho \to 1$, or as "demand approaches capacity") the average queue length and average delay increase rapidly
- The "proportionality constant" increases with the variability of demand inter-arrival times and of service times

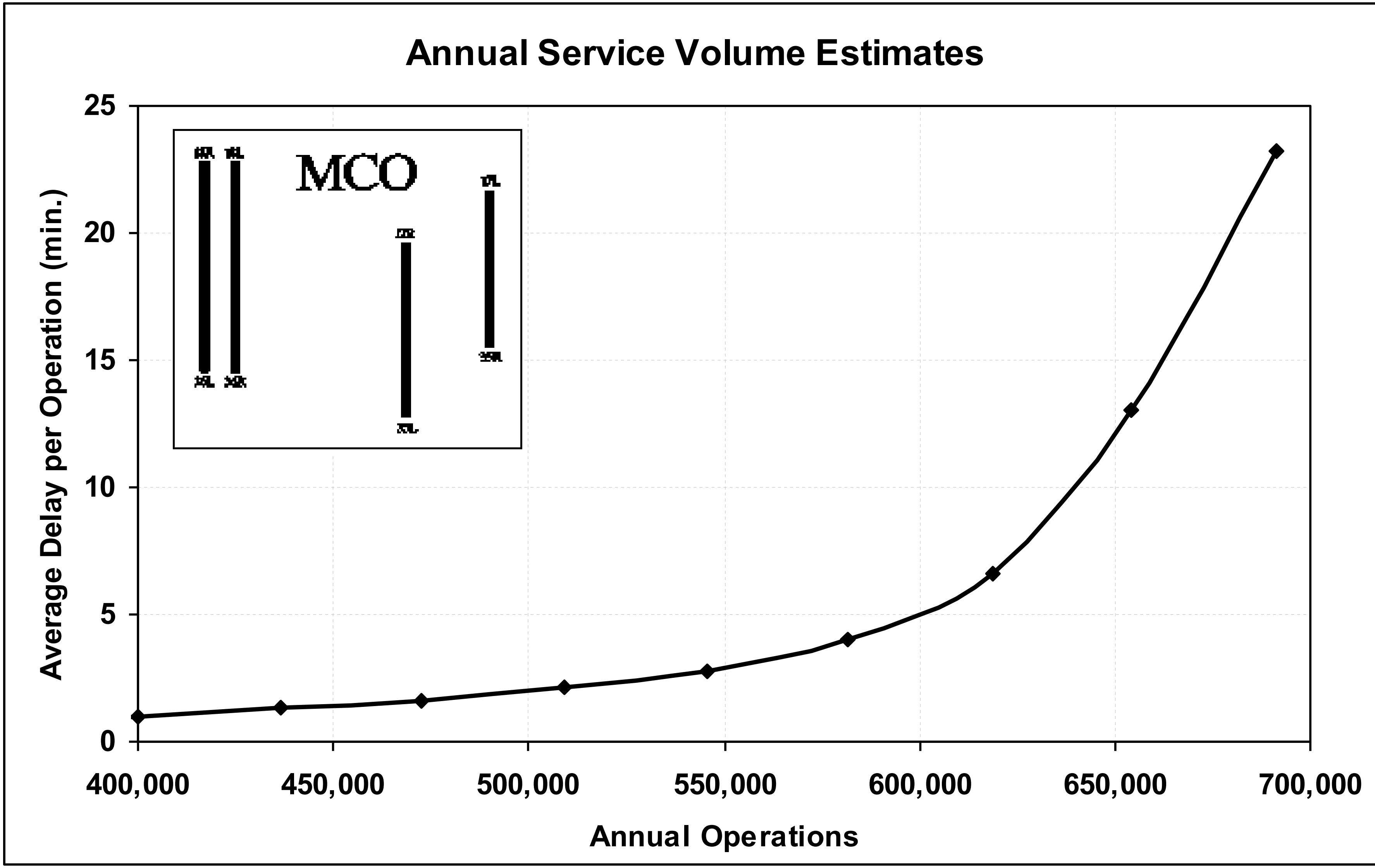
Delay vs. Demand and Capacity



High Sensitivity of Delay at High Levels of Utilization

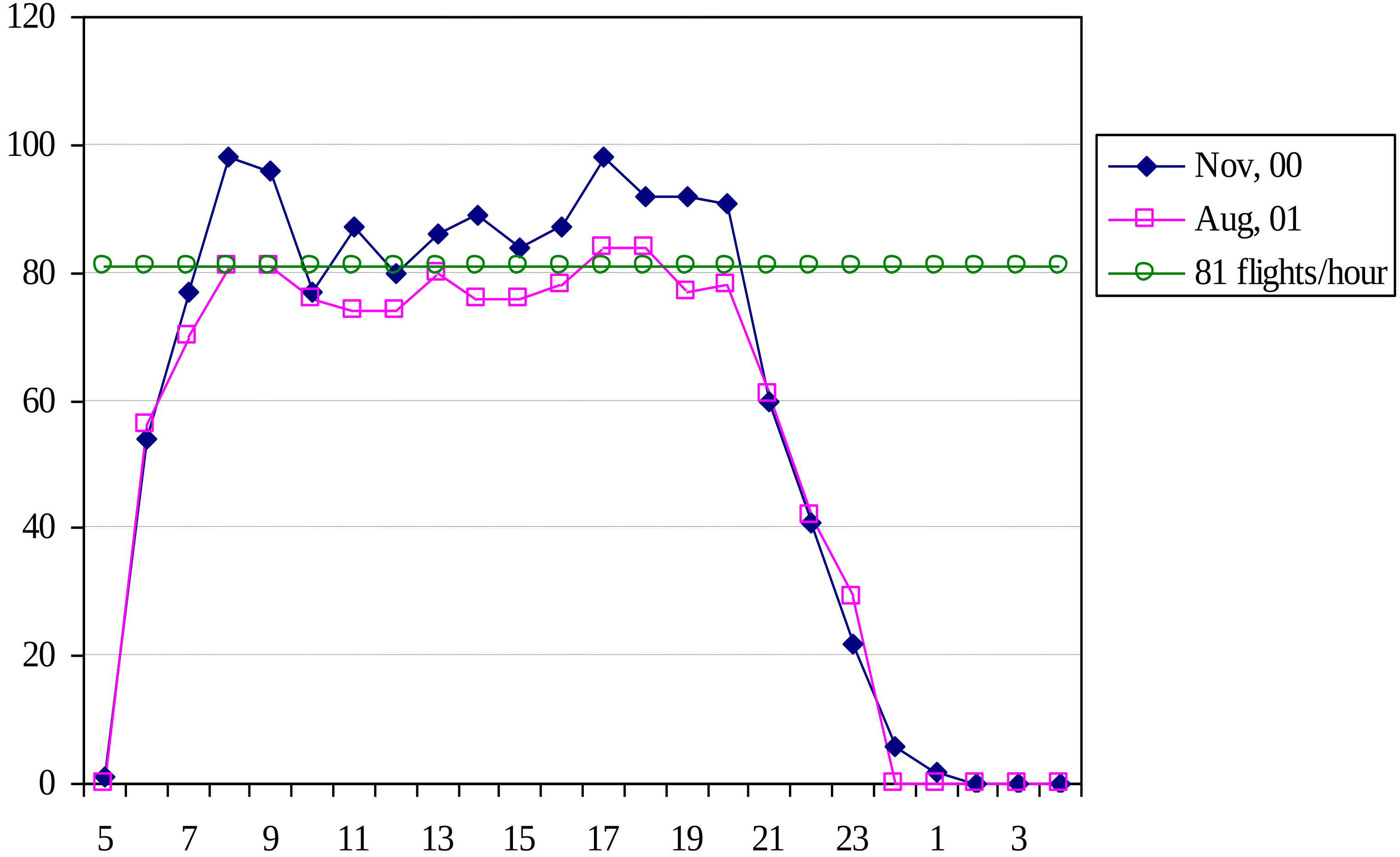


Delay vs. Annual Operations at Orlando Airport (MCO)



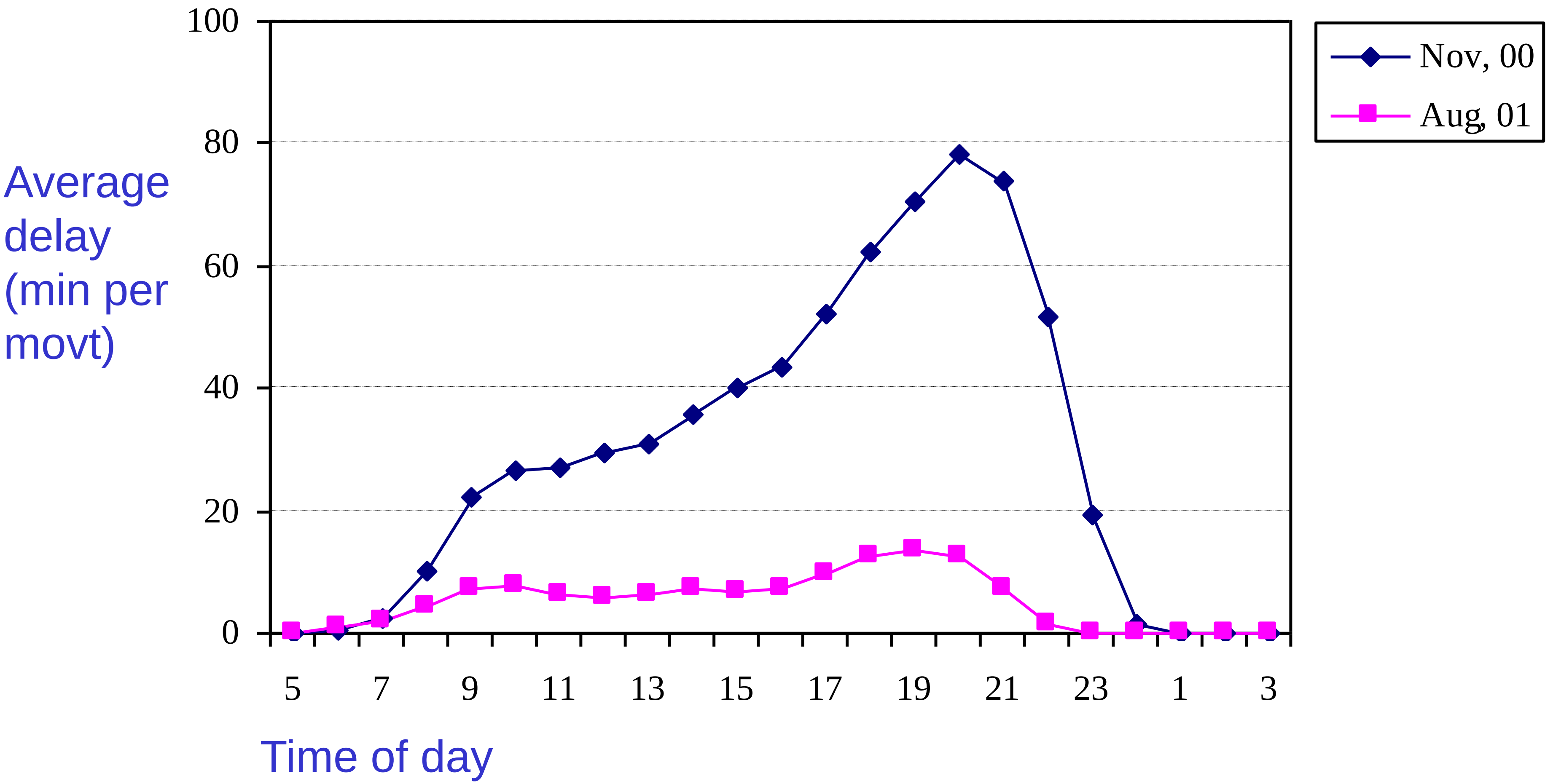
Scheduled aircraft movements at LGA before and after 2001 slot lottery

Scheduled movements per hour

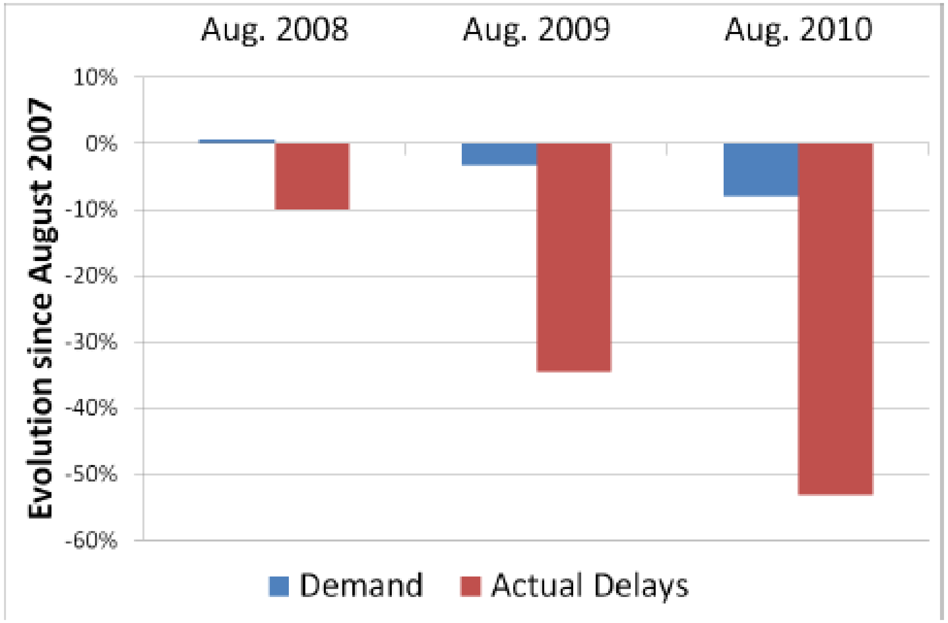


Time of day (e.g., 5 = 0500 – 0559)

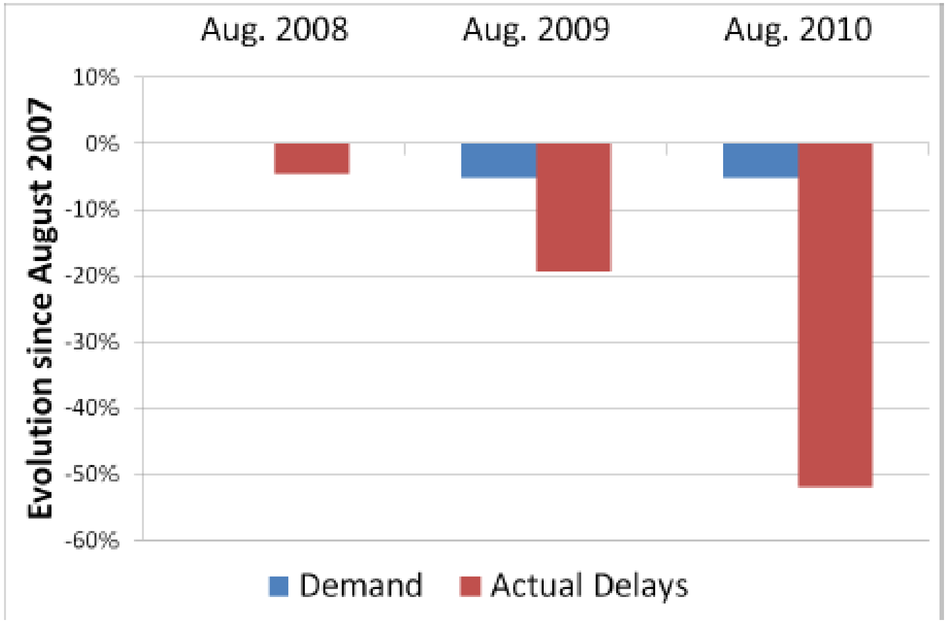
Estimated average delay at LGA before and after slot lottery in 2001



Evolution of NY Delays (2007 – 2010)



(a) JFK



(b) EWR

	JFK		EWR	
Month in 2010	**July**	**August**	**July**	**August**
Demand	-6.84%	-8.02%	-3.37%	-5.16%
Actual Delays	-46.90%	-53.15%	-32.93%	-52.02%
Model-Predicted Delays	-48.69%	-51.30%	-36.14%	-41.56%

Jacquillat, 2012

Variability of Queues

- The variability of delay also builds up rapidly as demand approaches capacity.
- In "steady state," the standard deviation --a measure of variability -- of delay and of queue length is also proportional to:

$$\frac{1}{1-\rho}$$

- A large standard deviation implies unpredictability of delays from day to day and low reliability of schedules

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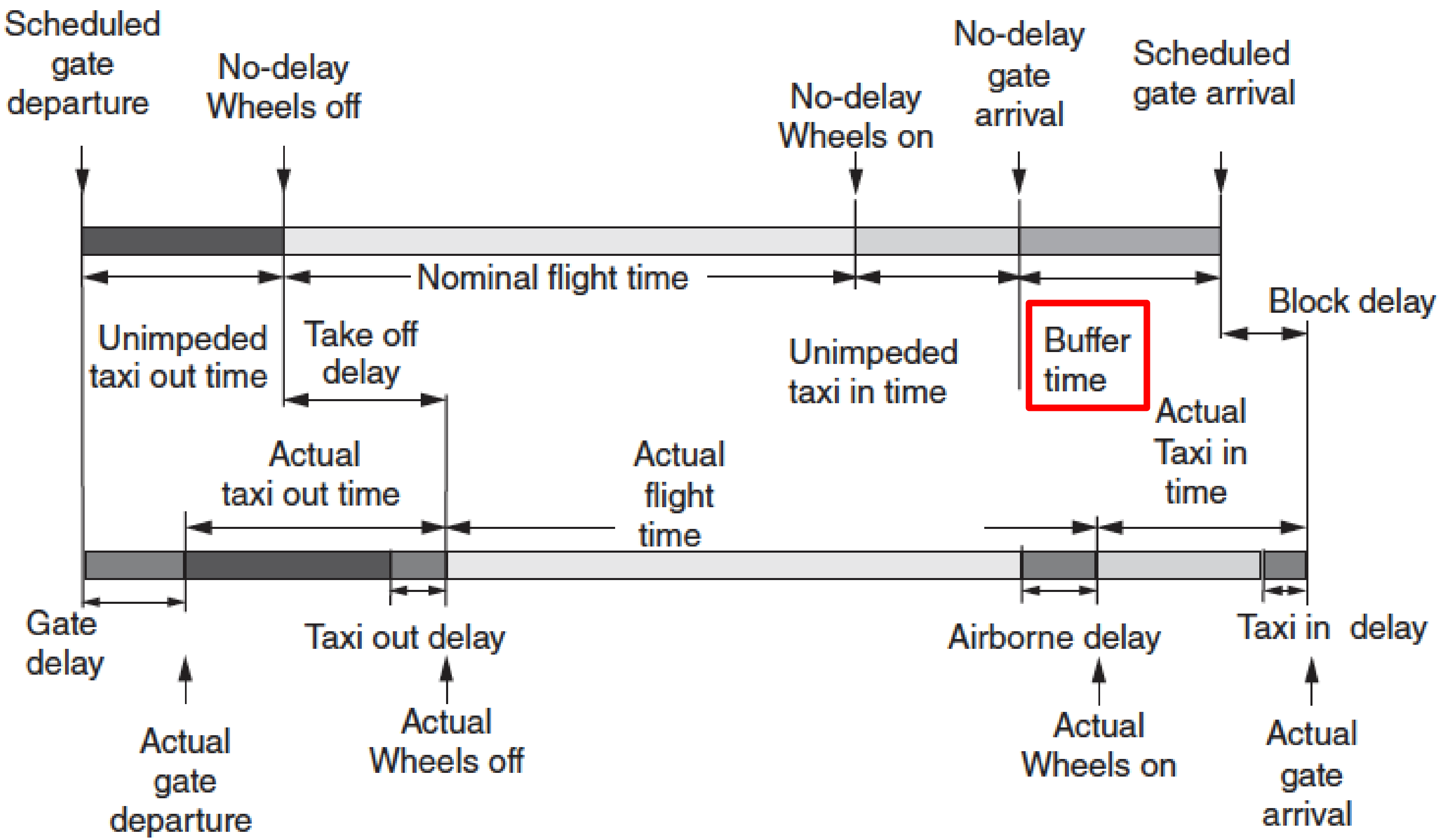
Two Types of Delay Measurement

- Two types of delay measures; cause of much confusion:
  - "True" delay: the difference between the actual time it took to complete a flight (or a flight segment) and an estimate of the time ("nominal time") that would be required in the absence of delay
  - Delay relative to schedule
- In much of the world, a flight is counted as "late" if it arrives or departs (at gate) more than 15 minutes later than scheduled [note this is delay relative to schedule]
- In recognition of habitual "true" delays, airlines have been lengthening ("padding") the scheduled duration of flights
    - improve "on-time arrival" statistics
    - improve reliability and realism of their schedules
- Thus, airline scheduled flight durations include a delay allowance: a flight that arrives on schedule may in truth have been significantly delayed!

Understanding the Measurement of a Flight's Delay



True Delay = Buffer Time + Block Delay

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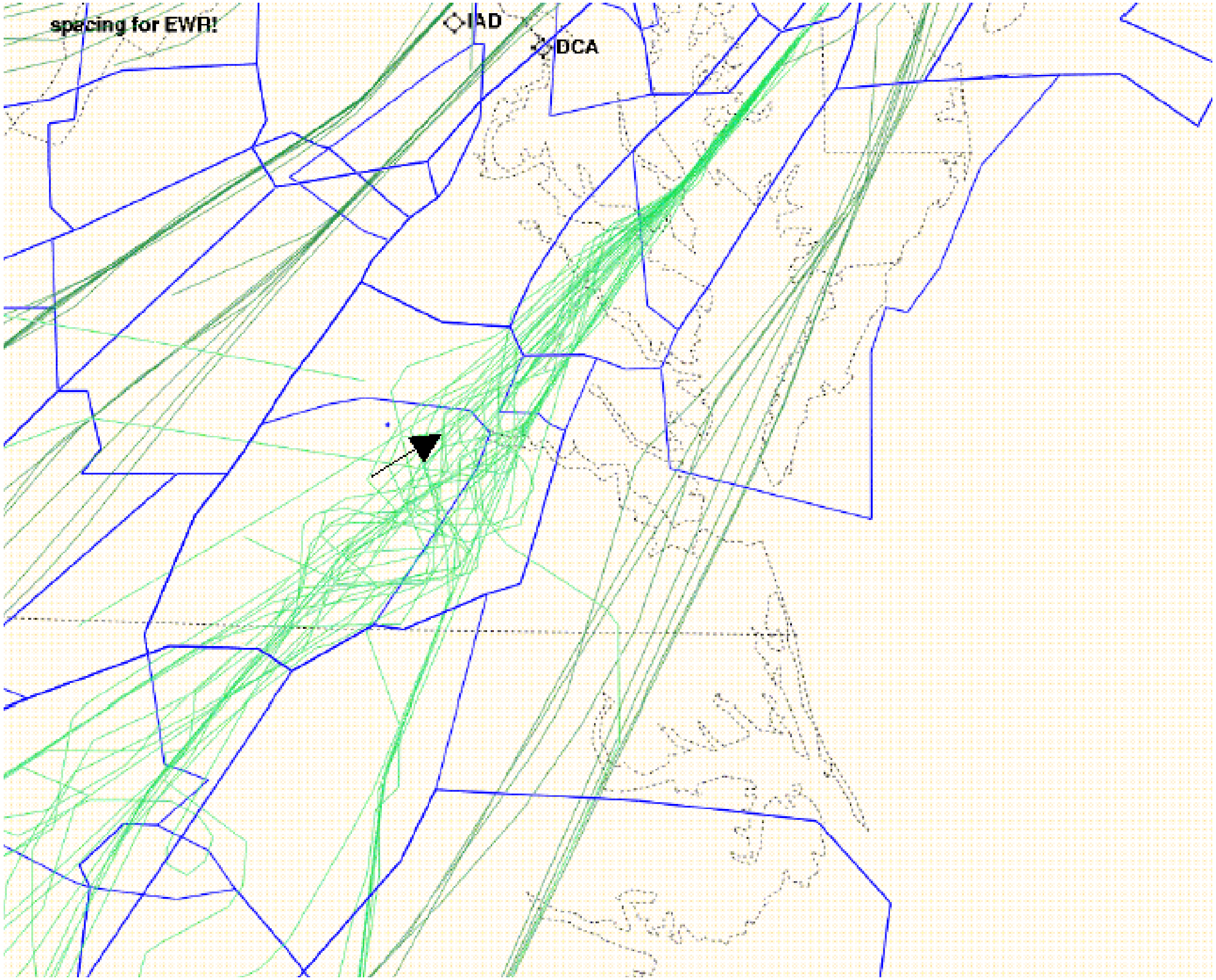
Measuring and Attributing Delay

- It is difficult to use field data to measure and attribute delay when congestion is severe
- Tightly inter-connected, complex system
- Users react dynamically to delays (feedback effects, flight cancellations)
- Geographical spreading (no single location for measurement), temporal propagation and secondary effects
- Delay-free, nominal travel times are not readily available
- Causality is unclear

Sequencing and Spacing of EWR Traffic

Source: FAA/Eurocontrol (2004)



A Poor Performance Measure

- Many airports and airlines specify quality-of-service requirements of the form:

  "Average time to complete service S equal to X minutes, maximum time equal to Y minutes"

  – Example: S=check-in, X=10, Y=20

- But, "maximum time" requirements make no sense; extreme cases should be quantified by means of probabilities (or "frequency of occurrence")

  – Example: 95% of passengers should be able to complete check-in in 20 minutes or less

- The length of queues should also be a concern and should be limited in a similar way

Example of Proper Measures and Targets

- London Heathrow, Terminal 5
- Central security queue: Measures of performance

1. Percent of time that queue requires less than 5 minutes
   - Target: 95%
   - Actual figure for January 2015: 96.54%
2. Percent of time that queue requires less than 10 minutes
   - Target: 99%
   - Actual figure for January 2015: 99.88%

Questions? Comments?