Congestion Management for Air Transportation: Trends in Research and Practice

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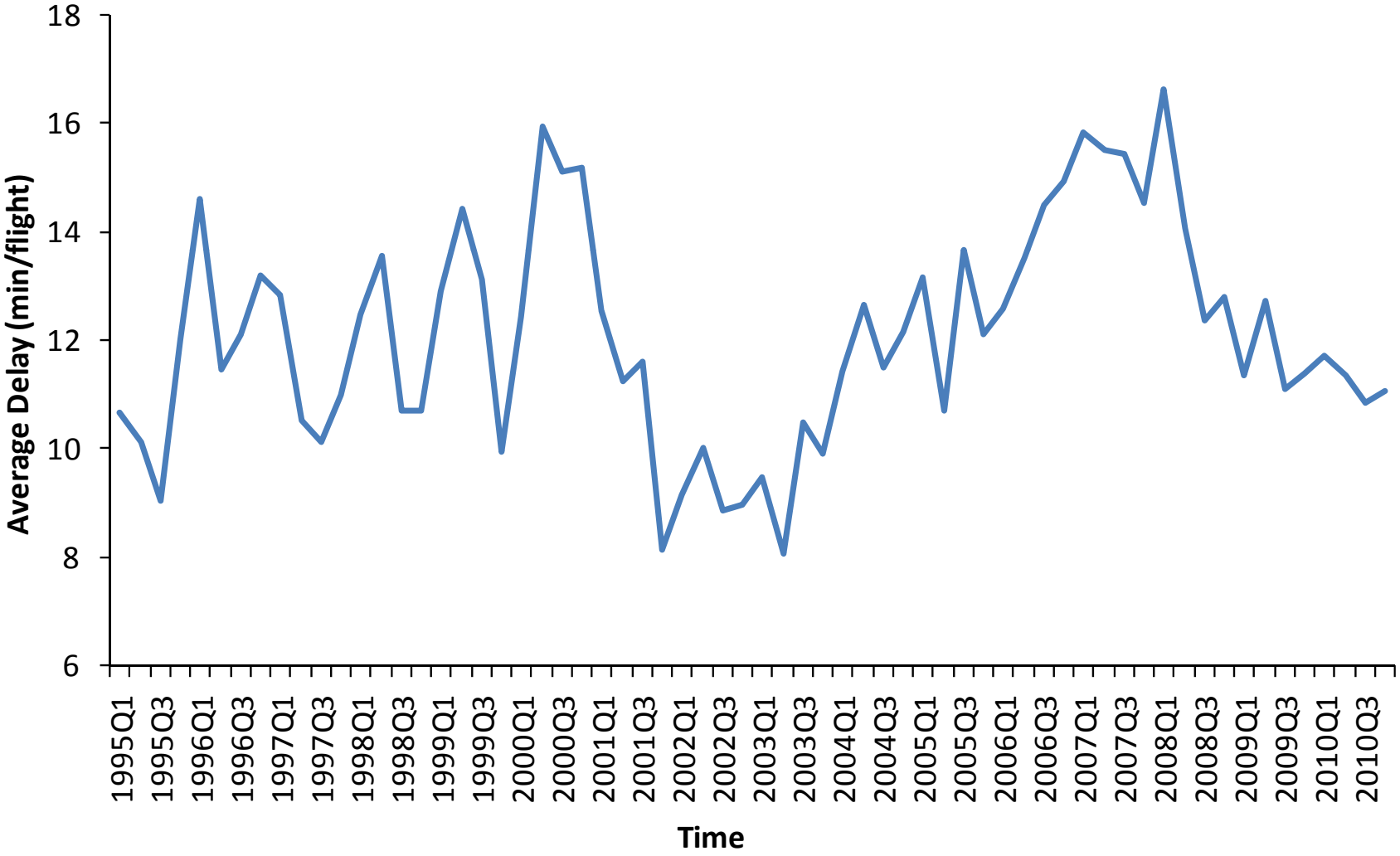
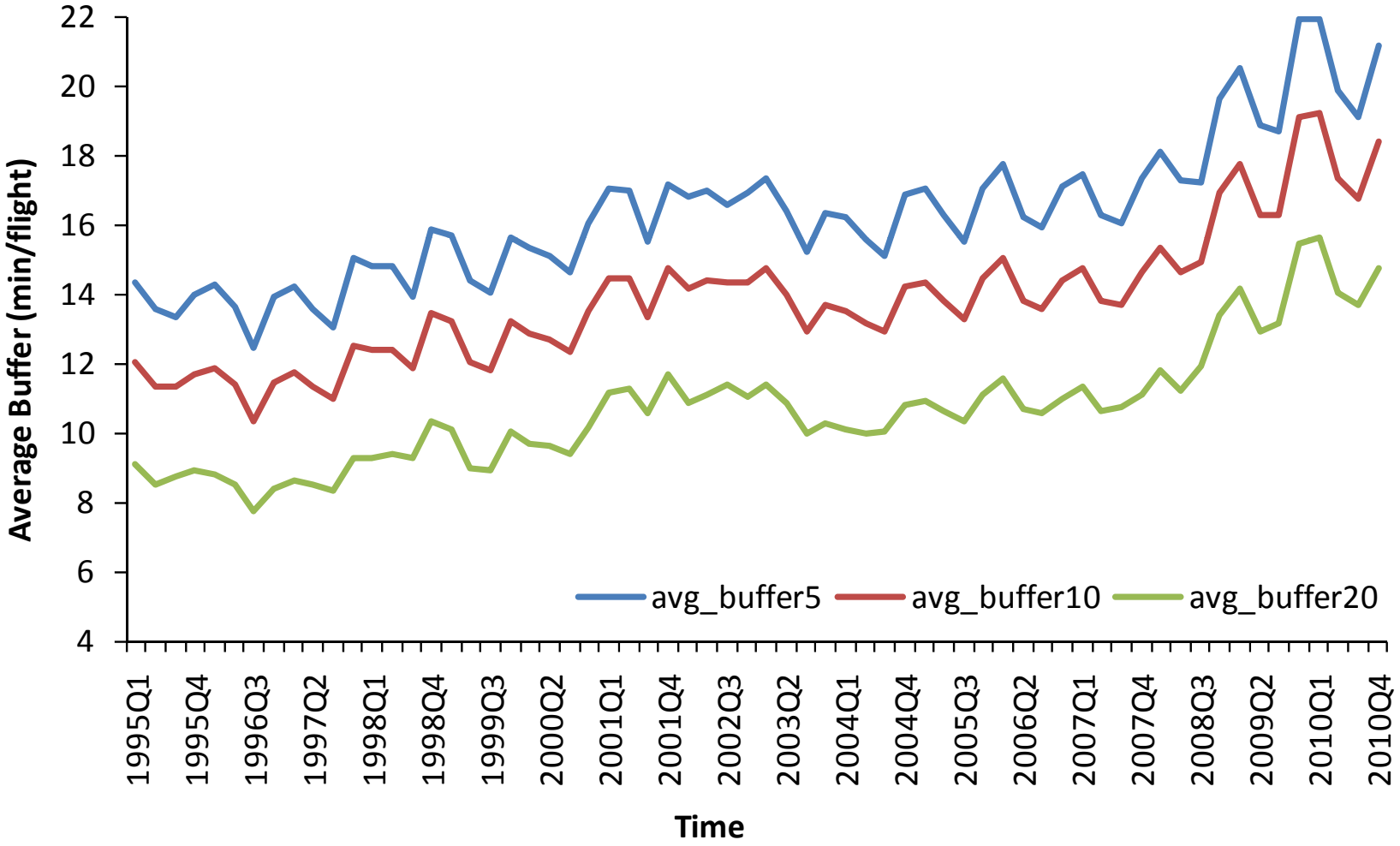
Air Transportation Delay in the U.S.: Aggregate Average Delay Evolution

(fr Zou and Hansen)



Aggregate buffer (schedule padding) over time

(fr Zou and Hansen)



Cost to Society of Air Transportation Delay in 2007

(ref: NEXTOR Total Delay Impact Study)

Cost Component	Cost (billion dollars)
Cost to Airlines	8.3
Costs to Passengers	16.7
Cost from Lost Demand	3.9
Total Direct Cost	28.9
Indirect Impact on GDP	4.0

Passenger Delay Costs

Delay Category	Delay Cost (billion dollars)
1. SB (schedule buffer)	6.0
2. PDS (passenger delay against schedule)	
2a. Delay due to delayed flights	4.7
2b. Delay due to flight cancellations	3.2
2c. Delay due to missed connections	1.5
Total estimated PDS (2a+2b+2c)	9.4
3. CSD (capacity induced schedule delay)	.7
4. VSA (voluntary early departure time adjustment)	.6
Total cost of passenger delay	16.7

Passenger delay modeling:

Sherry, The effect of airline networks and itineraries on passenger trip delays

Fearing,
Passenger travel and delays in the national air transportation system

Mitigating Delays

- **Capacity expansion:**
  - Infrastructure investment, e.g. new runways
  - New technology: the Next Generation Air Transportation System (NextGen)

  Zou, Assessing benefits from aviation capacity investment: an equilibrium approach
- **Air Traffic Flow Management (ATFM):** Daily operational strategies and controls that make the best use of available capacity on a given day
- **Demand management (aka – airport congestion management):** methods for restricting the demand placed on the system by flight operators, e.g. slot controls, congestion pricing.

NextGen

- Satellite-based navigation
- More information/control moves to cockpit
- Greater precision in all aspects of flight
- Trajectory-based operations
- Performance-based operations
- Dynamic capacity management
- ***Requires investment both in ground infrastructure (FAA) and in new aircraft avionics (flight operators)***

Churchill, Best equipped, best served: a new operational paradigm?

Air Traffic Flow Management

- Forecasting capacity levels (usually reductions due to weather), demand and capacity-demand imbalances
- Planning and controlling traffic management initiatives, e.g. ground delay programs, airspace flow programs,
- Collaborative air traffic flow management
- Research topics: dynamic, stochastic models; distributed decision-making, collaborative decision making.

ATFM Presentations

Marla, Integrated disruption management and flight planning to trade off delay and fuel burn

Kuhn, Multicriteria air traffic flow management

Hoffman, Development and evaluation of market-based traffic flow management concepts

Gupta, Addressing weather induced uncertainty in air traffic flow management: a robust and adaptive optimization approach

Kim, The effects of user competition in air traffic management initiatives

Need for Airport Congestion Mgmt

Motivation for limiting the number of scheduled operations at an airport:

- an airport's runway complex has a capacity, which may vary depending on weather
- as demand (scheduled ops) approaches capacity, queueing delays will increase at an exponential rate.

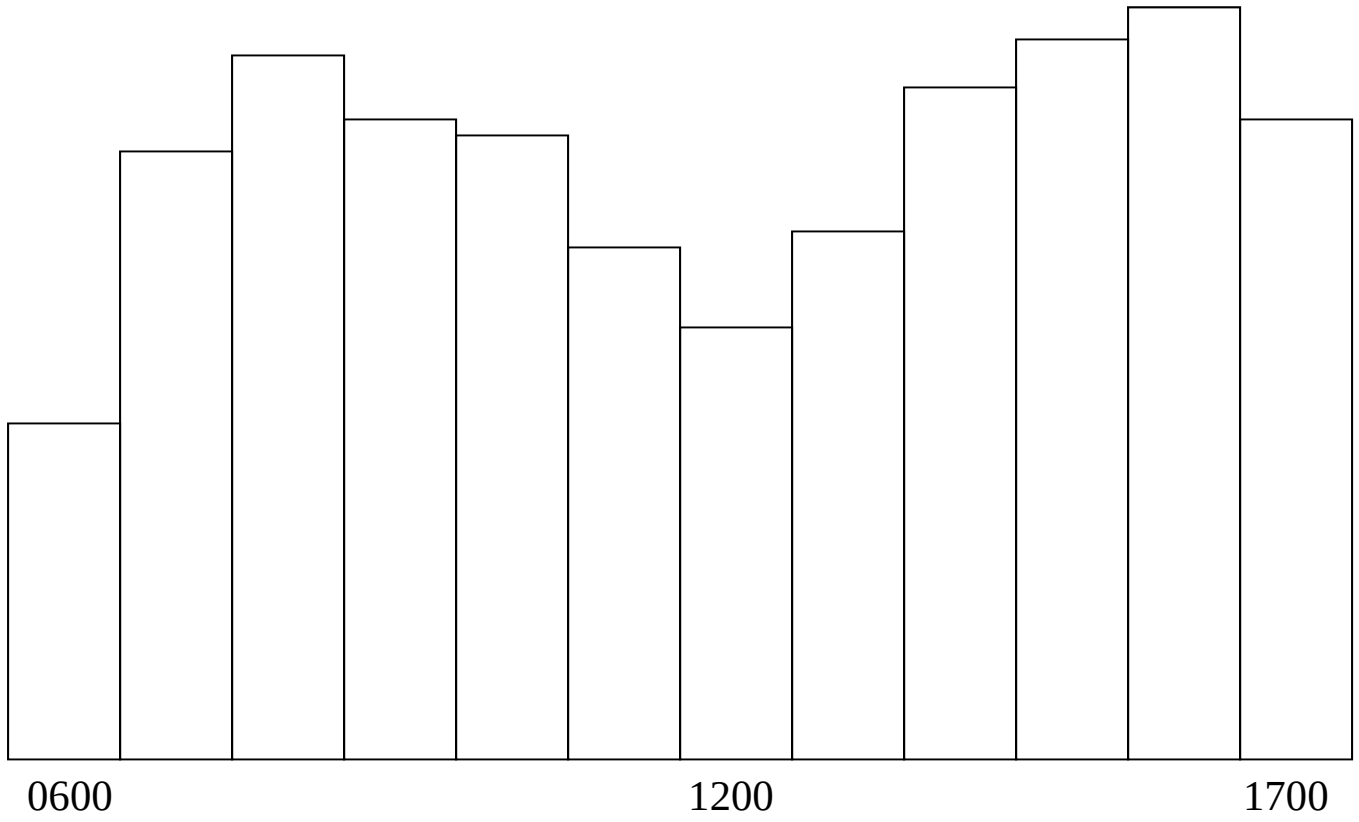
Inherent problem:

- ***multiple, competing airlines seek to use common airport capacity***
- ***the incremental addition of a flight may cause much more delay (to other flights), than the delay experienced by the added flight***

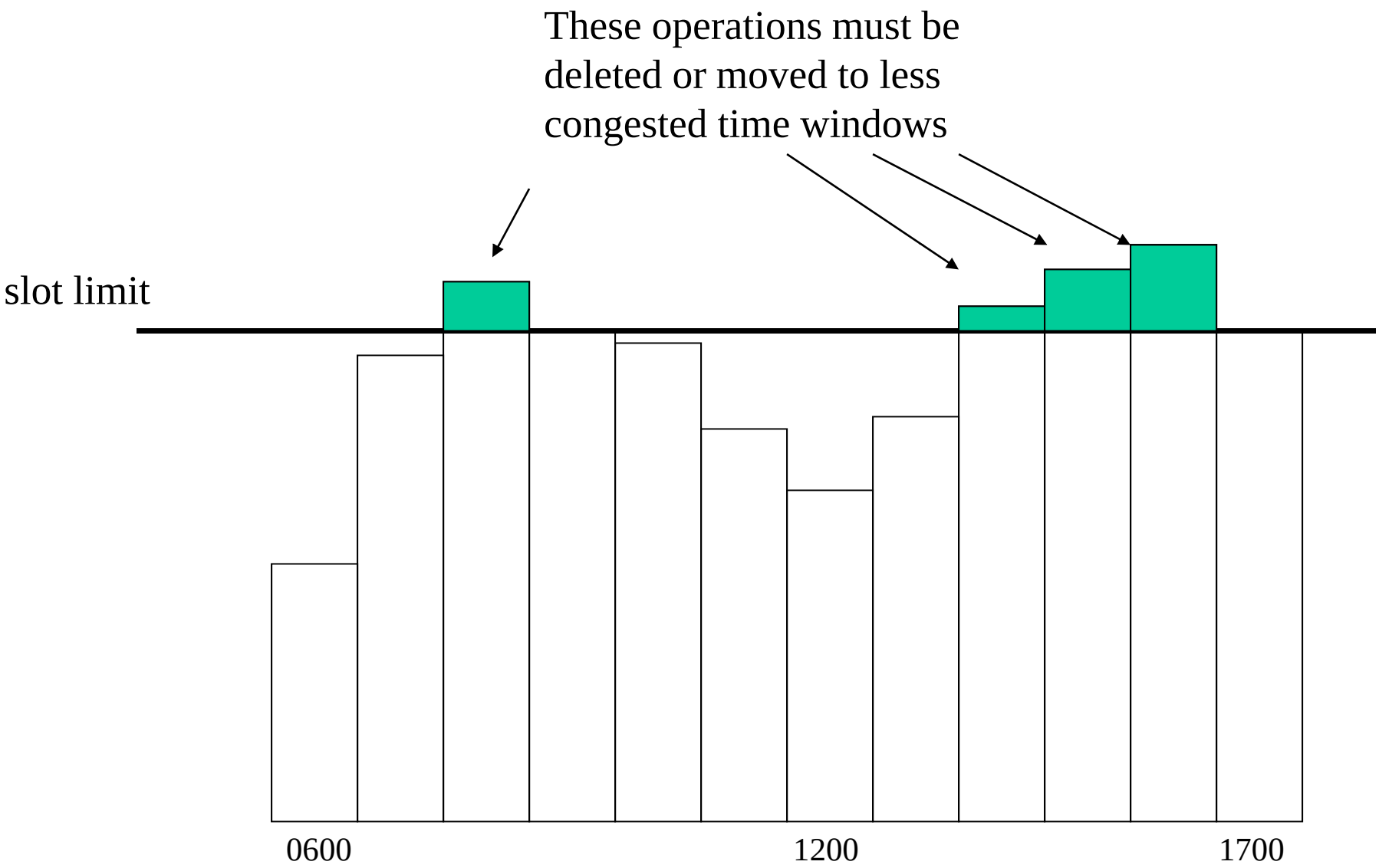
➔ ***without controls, an airport will naturally evolve to a highly congested state.***

Slot Controls

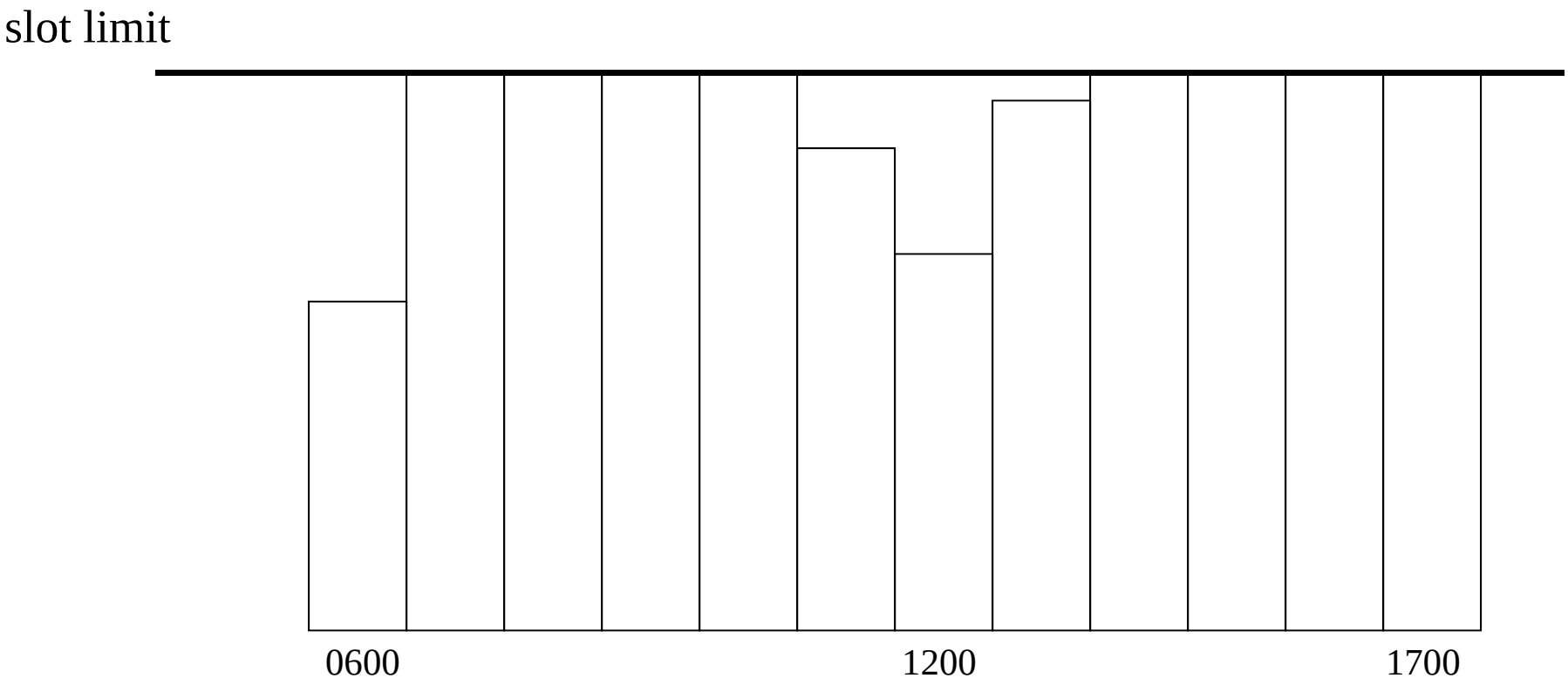
Slot controls place an upper limit on the number of operations (scheduled departures and arrivals) in a given time window.



Slot Controls



Slot Controls



Basic Options and Tradeoffs

Administrative measure vs market mechanism

Slots vs no slots

Market mechanism: auctions vs congestion pricing

Administrative measure ➔ slots

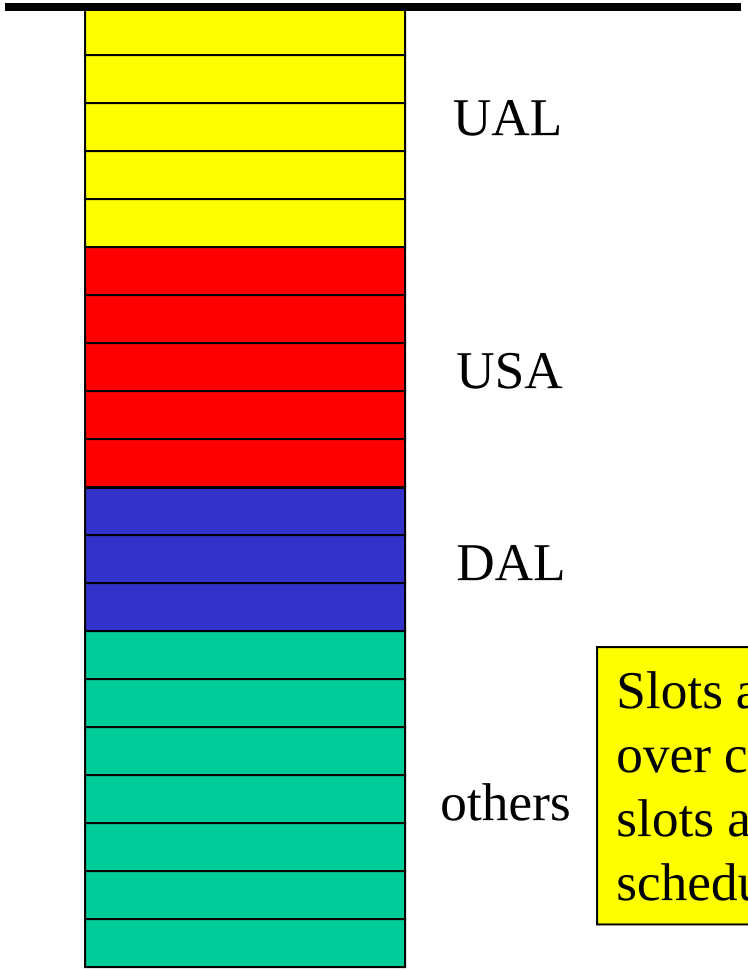
Slots + Market Mechanism ➔ Auctions

No Slots ➔ Congestion Pricing

Slots vs No Slots

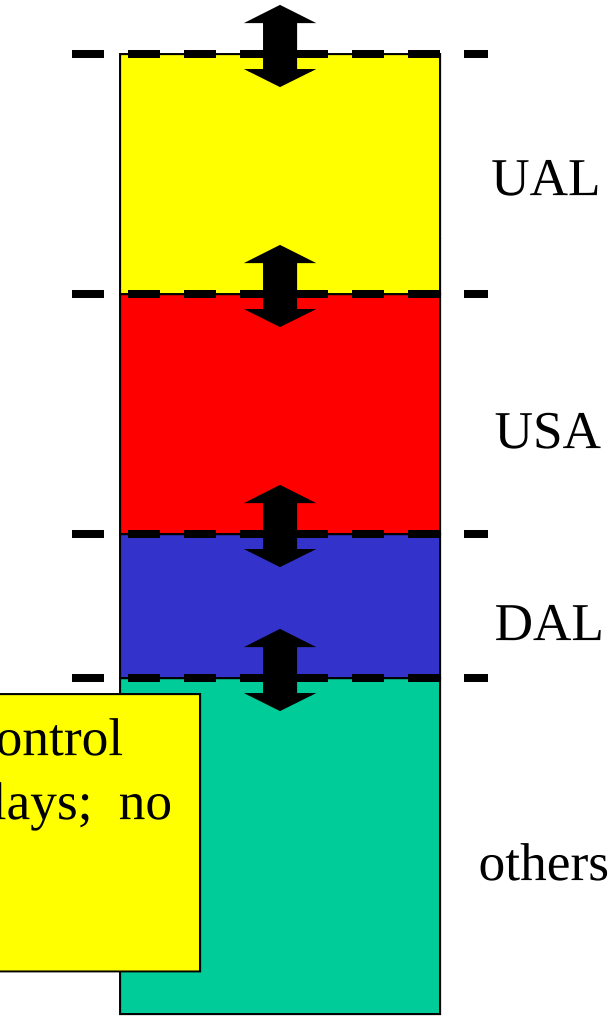
SLOTS

Fixed limit on number of operations



(Congestion) Prices provide "incentive" to limit operations

$$$$$$$ NO SLOTS



Slots allow for strong control over congestion and delays; no slots allow for carrier scheduling flexibility

Airport Congestion Management: US vs Europe

Europe:

- virtually all major European airports are slot controlled (based on EEC and IATA rules) ➔ "grandfather rights" and "use-it-or-lose-it" rules.

US:

- to a great extent a first-come-first- served system is operated; access is limited only by availability of terminal facilities
- Historical exceptions: in 1968 high density rule (HDR) established slot controls at five airports: Chicago O'Hare (ORD), Washington Reagan National (DCA) and three NY area airports: LaGuardia (LGA), Kennedy (JFK) and Newark Liberty (EWR); HDR policies very similar to IATA (but does include buy-sell provision)
- There has been significant government activity in this area in the past 6 years, including ***proposed*** slot auctions – currently DCA, EWR, LGA, JFK have some form of slot controls

Demand Management Presentations

Determining slot levels and slot allocation:

- **Pita, Optimization-based analysis of slot allocation strategies for European airports**
- **Lovell, Determining the number of airport slots**

Justification of market-based approaches:

- **Swaroop, Social welfare justification for market-based approaches to airport congestion management**
- **Vaze, Airport demand management under airline frequency competition**

Environmental benefits of demand management:

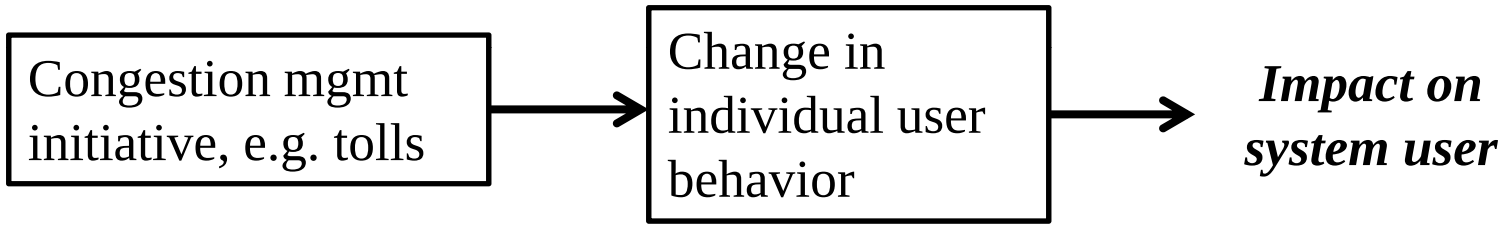
- **Ryerson, Demand management and fuel savings**

Air/road interactions:

Peeta (DeLaurentis), An integrated framework to analyze interactions between air and road modes in a regional transportation system

Perspectives on Congestion Management on the Ground vs in the Air

Road Transportation:



Perspectives on Congestion Management on the Ground vs in the Air

Road Transportation:

Air Transportation:

Perspectives on Congestion Management on the Ground vs in the Air

Road Transportation:

Air Transportation:

Congestion management research activities for ground and air transportation have largely proceeded independently ….

… we hope that this workshop will foster a cross fertilization of ideas and future research interactions.