Air Traffic Flow Management
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Air Transportation Management

M.Sc. Program

**Air Transportation Systems and Infrastructure**

Strategic Planning

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Air Traffic Flow Management (ATFM or TFM)

- **Most (if not all) elements of the air transportation system are subject to capacity constraints (airport runways, sectors, terminal-areas, etc.)**

- **Congestion occurs when there is an imbalance between the capacity and the demand, that is, when the demand for operations exceeds the available capacity**

  - Congestion leads to delays
  - Especially an issue during peak demand times (when demand is increased) and during weather/other disruptions (when capacity is decreased)
  - TFM attempts to correct this imbalance by strategically adjusting the aggregate flow rates into constrained resources

Air Traffic Management system functional structure

[Adapted from A. Haraldsdottir (Boeing), 1998]   3
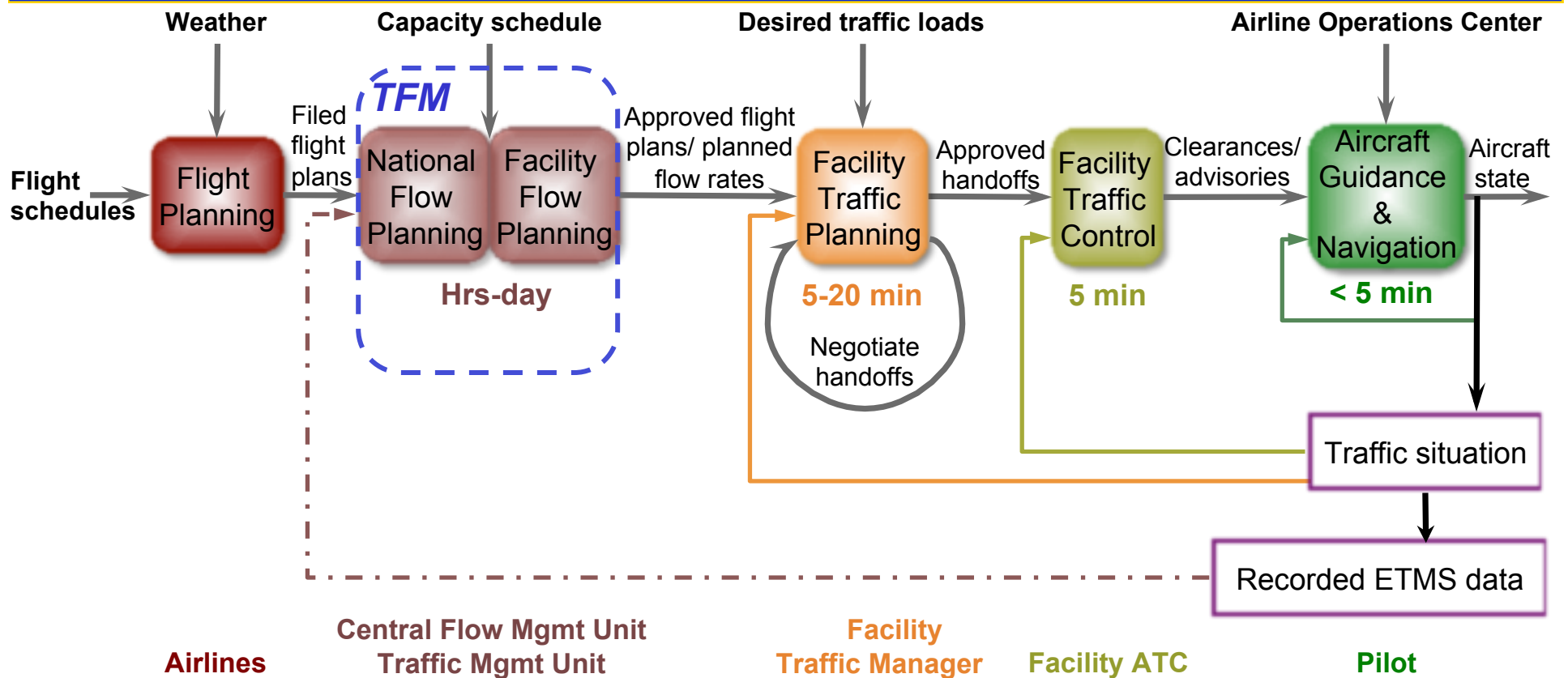
Capacity constraints

- ## Airports
  - ▪ Airport Arrival Rate (AAR)
  - ▪ Airport Departure Rate (ADR)

Approximate capacities (ops/hr)		
Airport	**Optimum**	**Reduced**
ATL	185−200	167−174
BOS	118−126	78−88
JFK	88−98	71
LGA	80−81	62−64
ORD	200−202	157−160
SFO	95−99	67−72

- ## Airspace
  - ❑ Sector capacity
  - ❑ Monitor Alert Parameter (MAP)

| Average sector flight time	MAP value*
3 min	5
4 min	7
5 min	8
6 min	10
7 min	12
8 min	13
9 min	15
10 min	17
11 min	18
12 min and higher	18

*Representative values. Actual values are sector-specific

http://www.faa.gov/airports_airtraffic/air_traffic/publications/ATpubs/FAC/Ch17/s1707.html

Airport capacity

- ## Tradeoff between arrival and departure throughputs

  - Capacity envelopes
  - Depends on operating conditions: Visibility, wind speed/direction, etc.
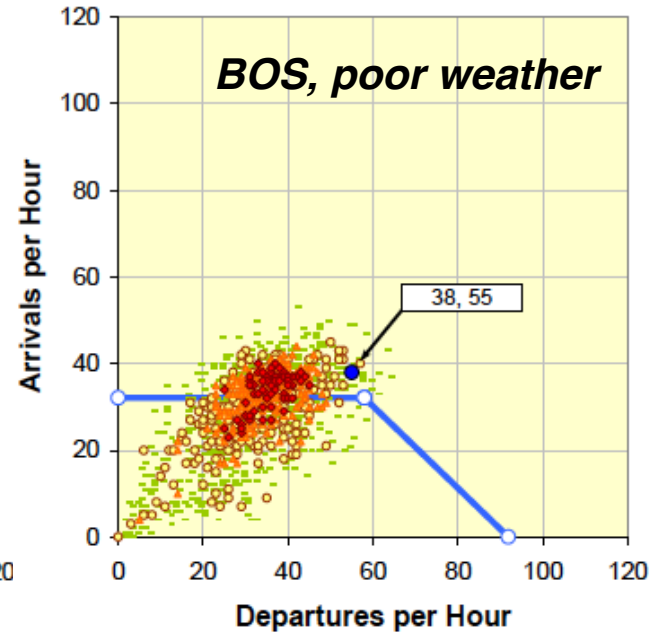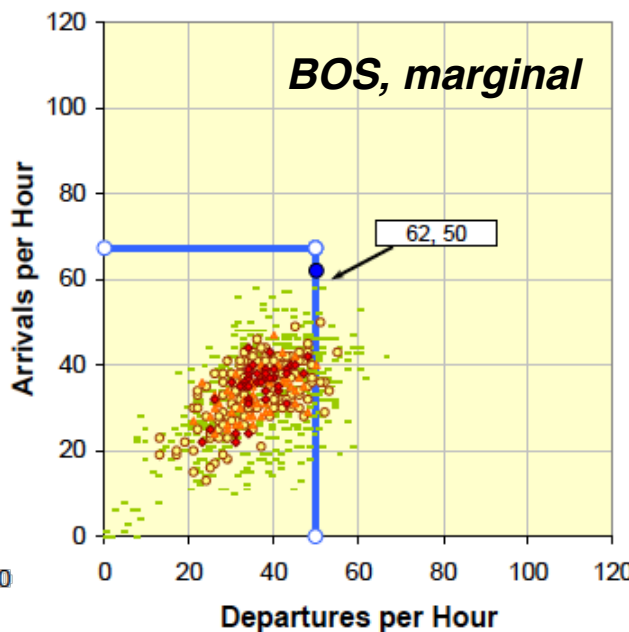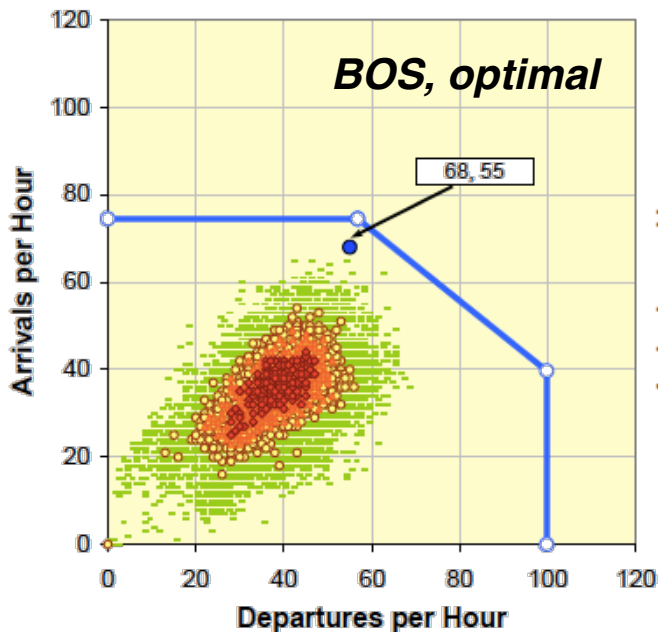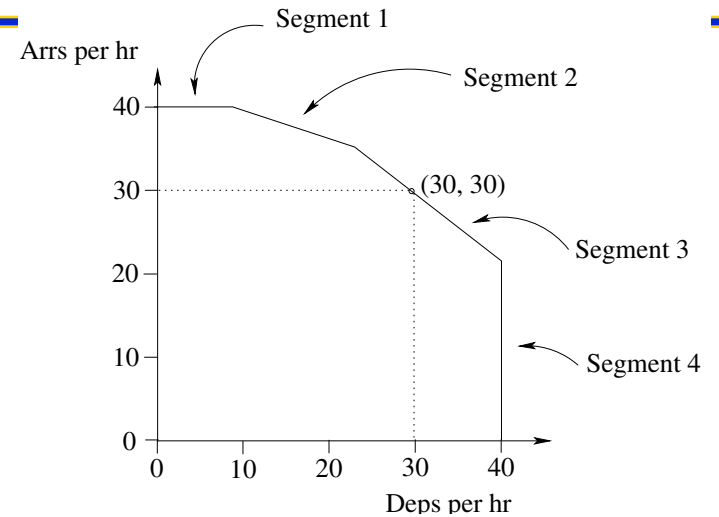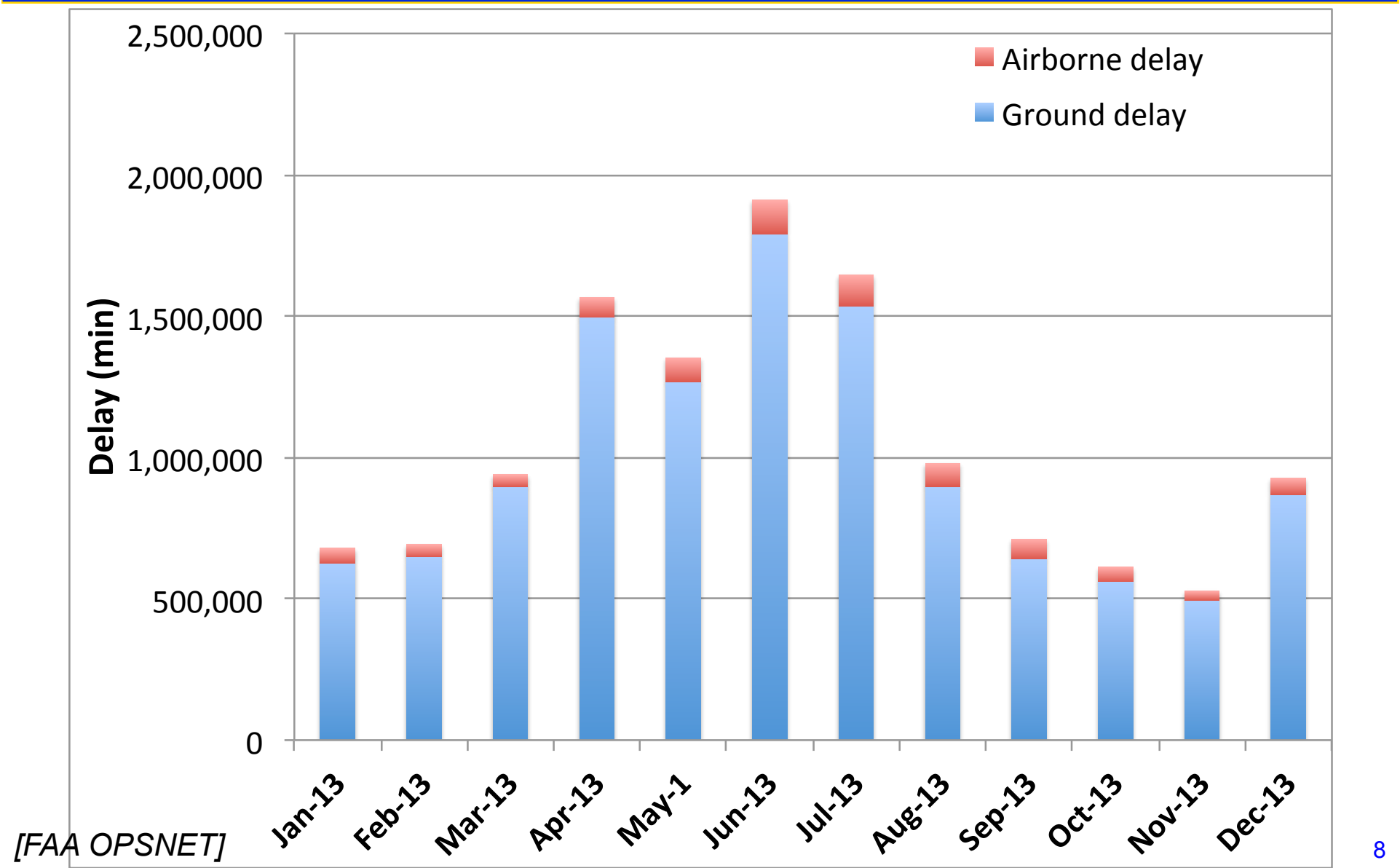
Traffic Flow Management strategies

- **Need to correct capacity-demand imbalance**

- **Two primary options**
  - Ground-holding (delay at origin airport)
    - Also known as gate-holding
    - Rationale is that ground delays are safer and less costly than airborne delays

  - Redistribute flows in the air (reroute, slow down, put in a holding stack, essentially assign airborne delay)
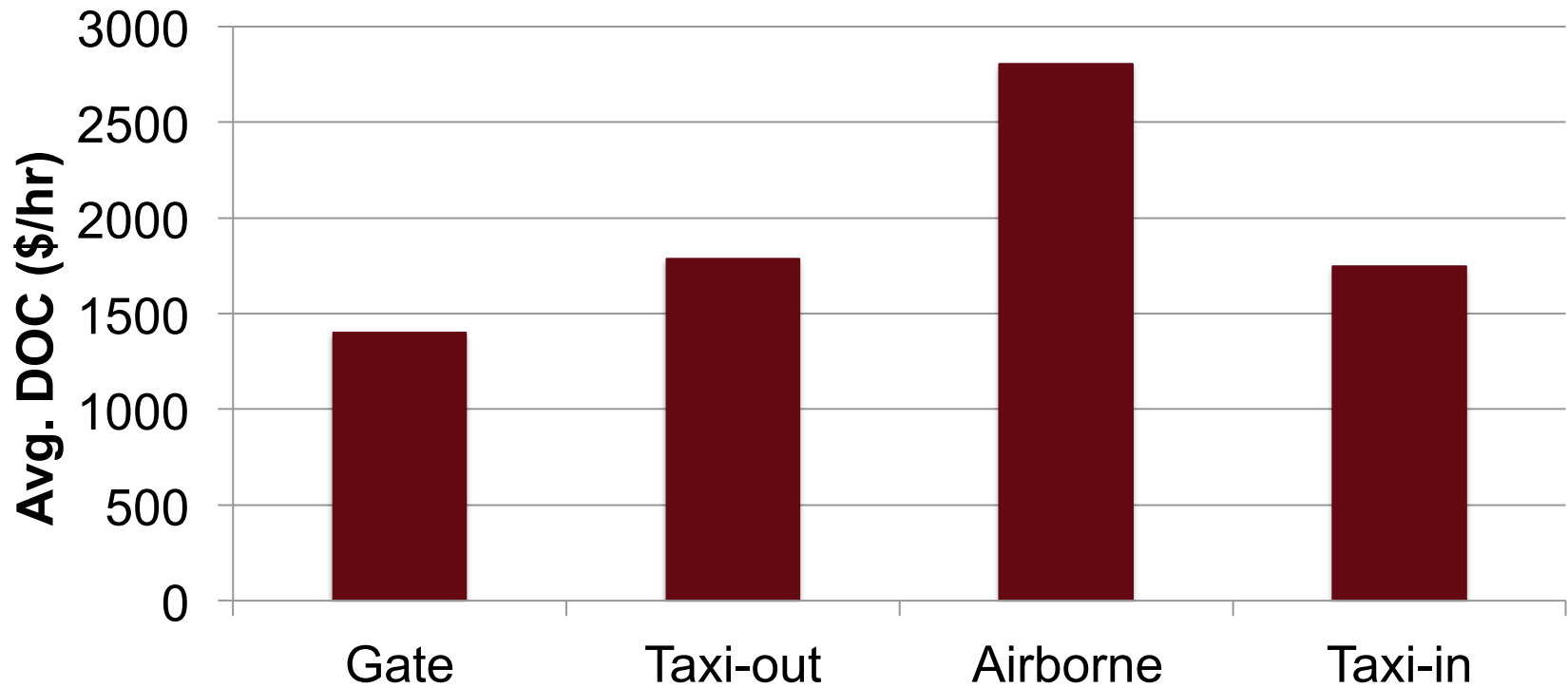
Ground delays are quite common in today's system

Ground Delay Programs in 2013
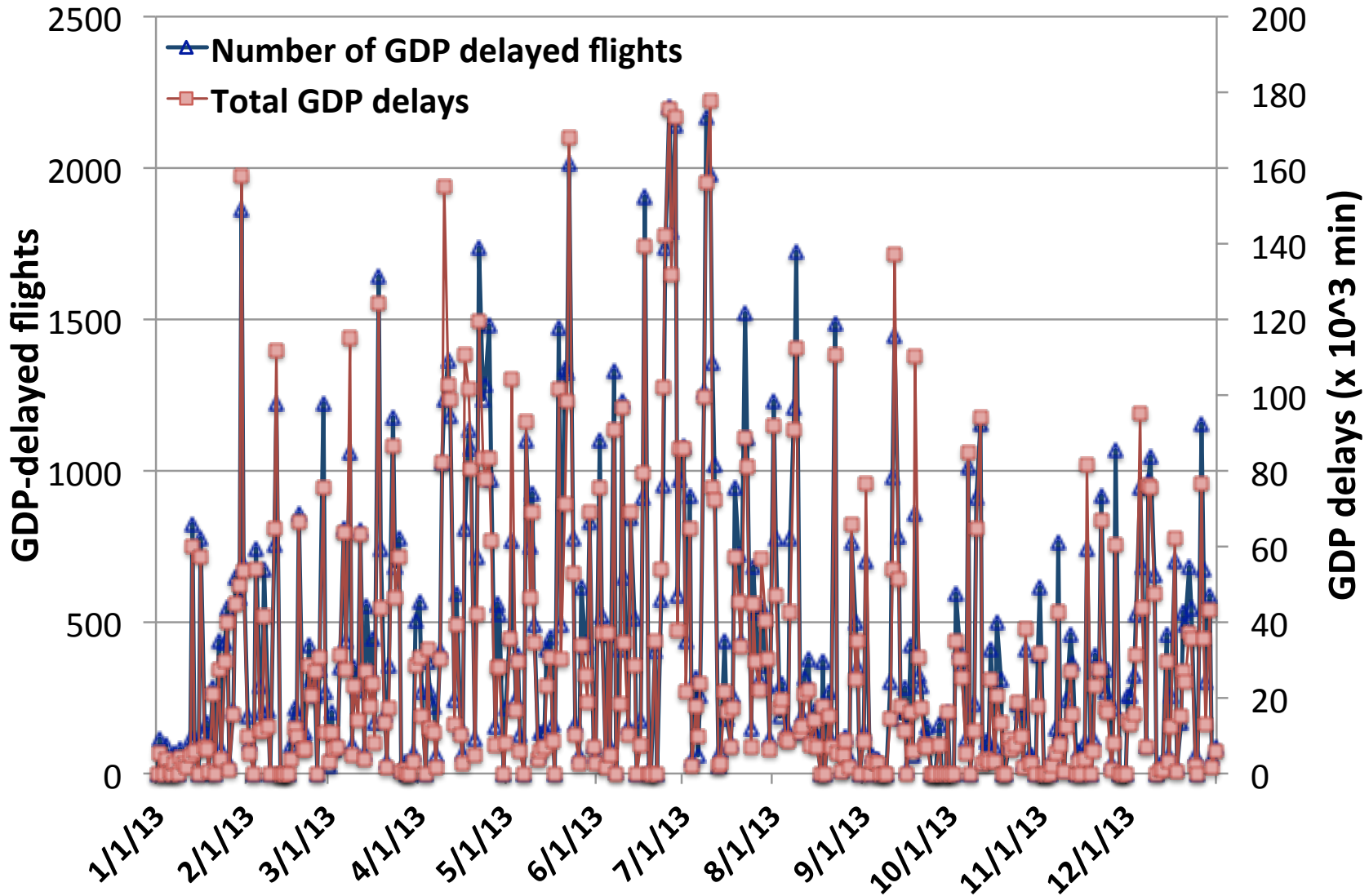
[FAA OPSNET] 7

Ground delays are more prevalent than airborne delays

[FAA OPSNET]

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Estimated ground and airborne average Direct Operating Costs

"Facts & Figures of the U.S. Scheduled Airlines", an Air Transport Association Publication, Volume One, Issue Two, January 2000
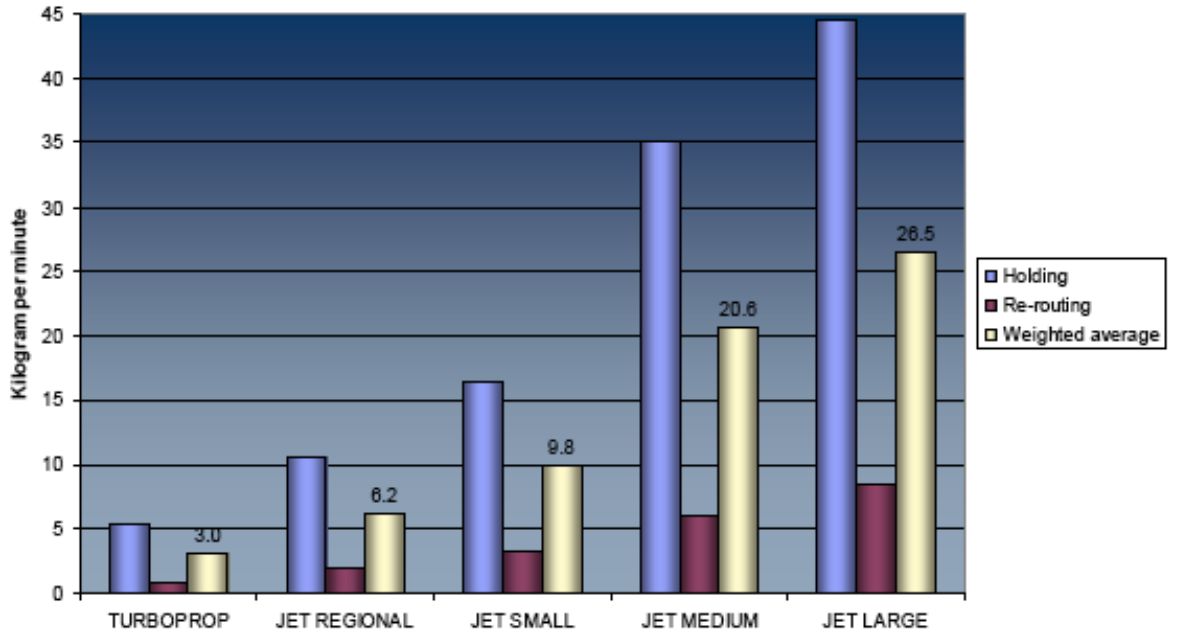
Estimated fuel burn of ground vs. airborne delays
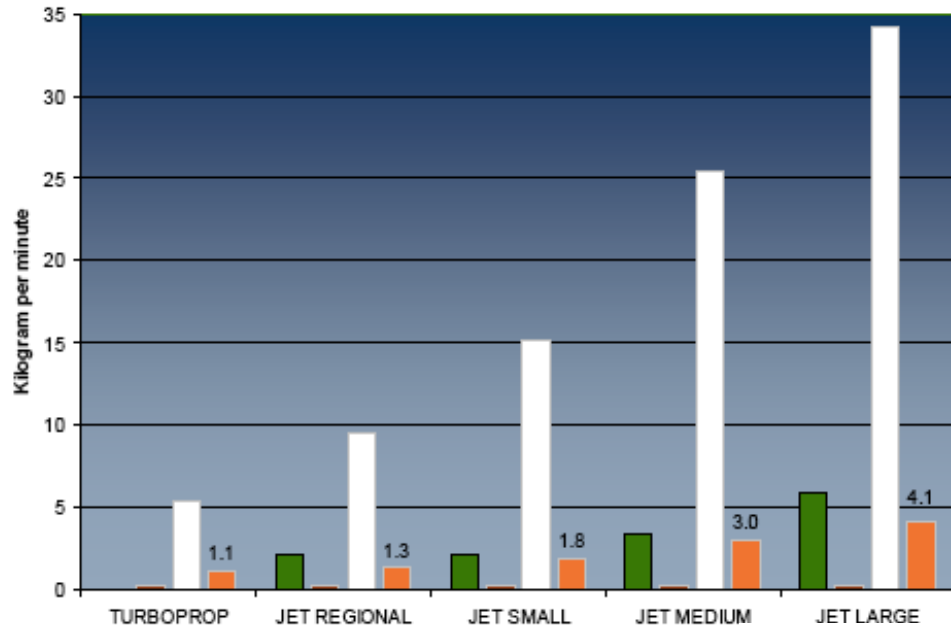
Ground delay weighting:
81% GPU + 9% APU + 10% Aircraft engines

Airborne delay weighting:
50% holding + 50% rerouting

Carlier, Hustache, Jelenik. Environmental Impact of Delay, Project GAES. Eurocontrol Experimental Centre, EEC/SEE/2006/006

Optimization approaches

- **Mathematical formulations to determine schedules of flights in order to meet (forecast) capacity constraints**
  - Single-airport Ground Holding Problem
    - One destination airport impacted by capacity constraints/ reduction
    - Stochastic capacity forecasts
  - Multi-airport Ground Holding Problem
    - Multiple destination airports impacted by capacity constraints
  - Traffic Flow Management Problem
    - Multiple capacitated origin and destination airports, as well as airspace capacity constraints

Capacity forecasts are uncertain

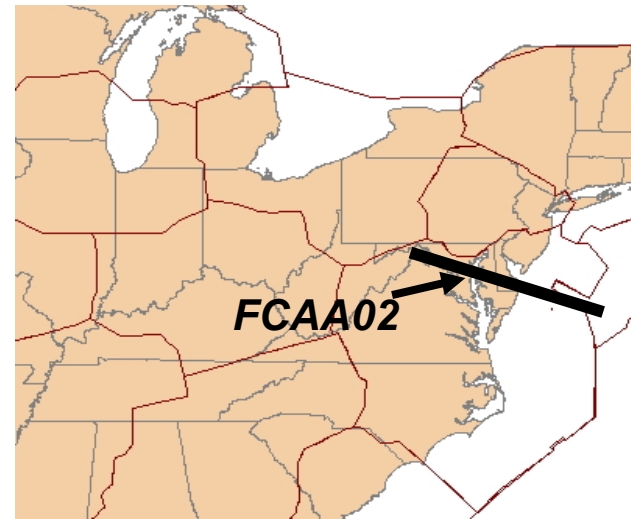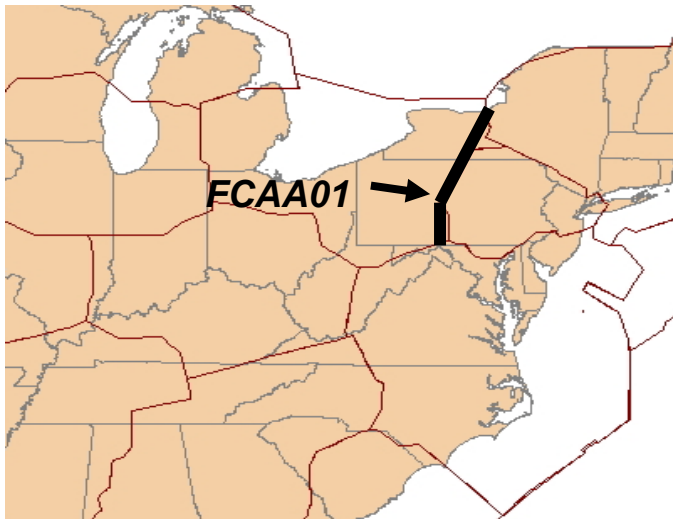- **In practice, capacity forecasts get updated as time progresses and new weather forecasts are obtained**
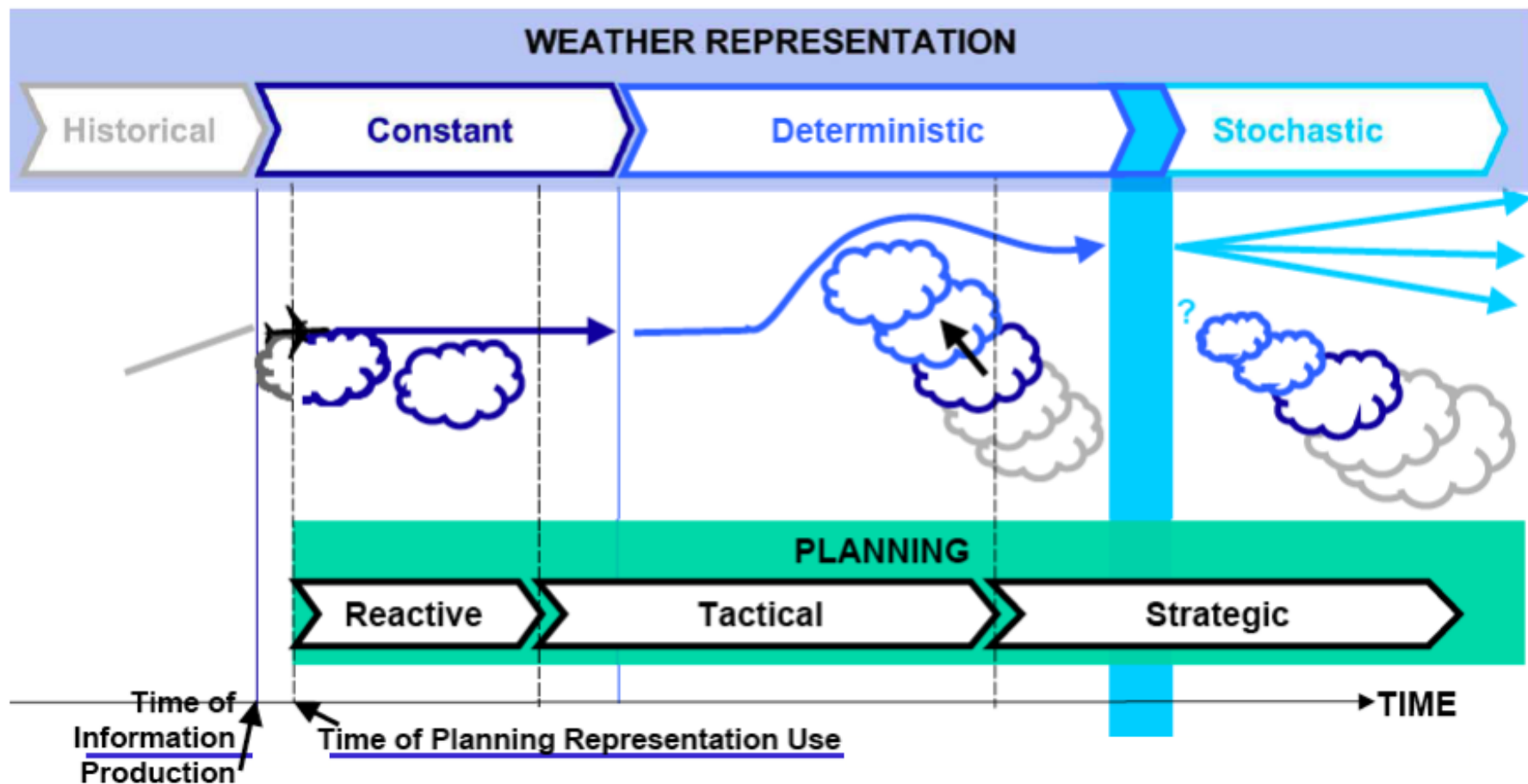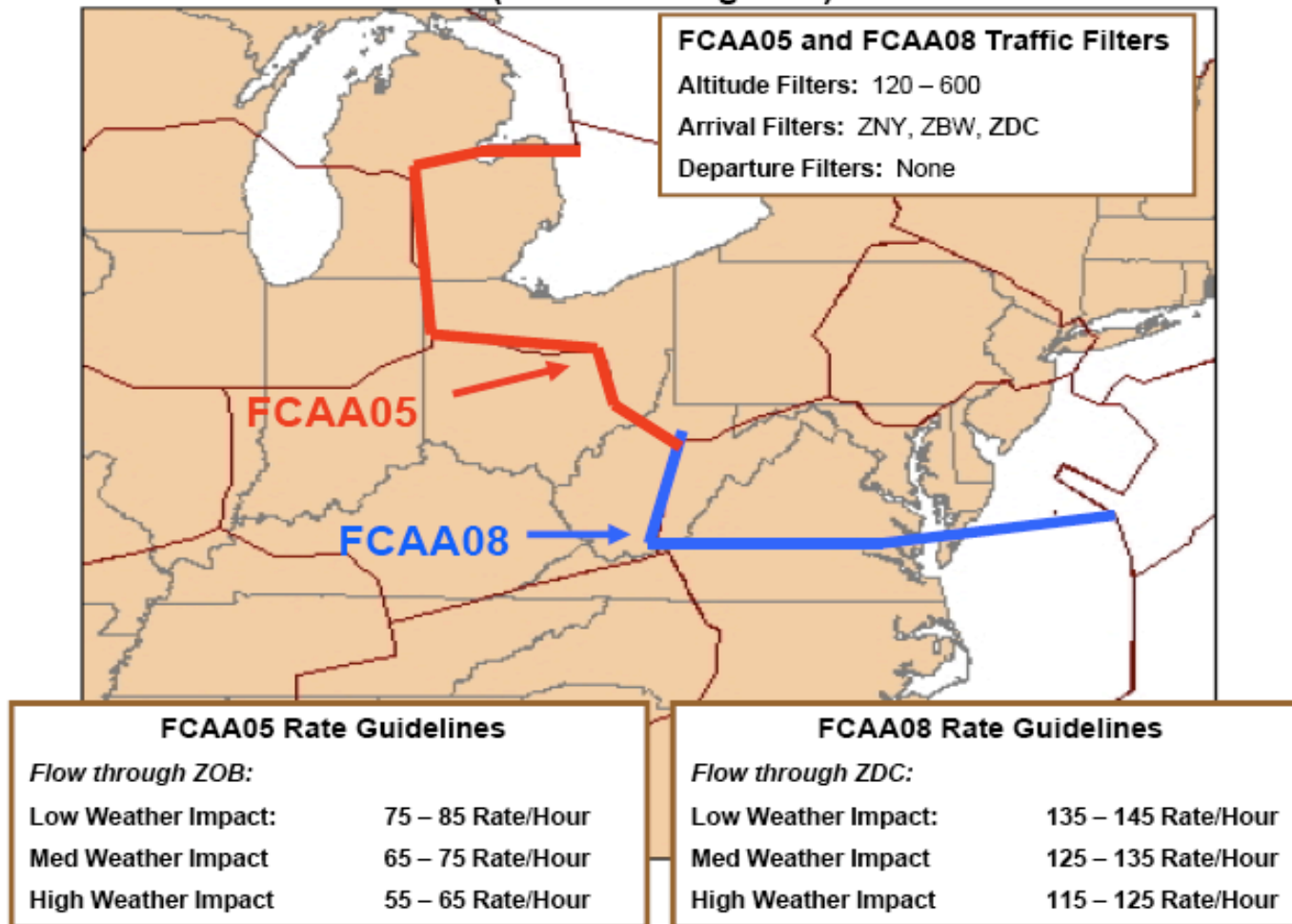

[Langlois and Hansman, 2000] 12

Airspace Flow Programs

- **Similar to GDPs, except for capacity-constrained airspace resources**

```
FOR FCAA02
ATCSCC EDCT FLOW CONTROL DEPARTURE TIME
ACID      ASLOT            DEP  ARR  CTD     CTA     TYPE EX CX SH EENTRY   IGTD
ABC1234  FCAA02.260400A  DCA  LGA  260300  260400  AFP  -  -  -  260400  260245
ABC5678  FCAA02.260500A  IAD  BOS  260400  260500  AFP  -  -  -  260300  260145
ABC3601  FCAA02.260323A  BOS  LGA  260206  260323  AFP  Y  -  -  260319  260150
ABC3522  FCAA02.260311A  DCA  BOS  260215  260311  AFP  -  -  -  260311  260145
ABC3994  FCAA02.260353A  ROC  LGA  260246  260353  AFP  -  Y  -  260355  260235
```


FCAA01

FCAA02

Airspace Flow Program examples

Most Frequently used AFP: AO5 and AO8
(often used together)

FCAA05 and FCAA08 Traffic Filters

Altitude Filters: 120 – 600

Arrival Filters: ZNY, ZBW, ZDC

Departure Filters: None

FCAA05

FCAA08

FCAA05 Rate Guidelines	
Flow through ZOB:	
Low Weather Impact:	75 – 85 Rate/Hour
Med Weather Impact:	65 – 75 Rate/Hour
High Weather Impact	55 – 65 Rate/Hour

| FCAA08 Rate Guidelines	
Flow through ZDC:	
Low Weather Impact:	135 – 145 Rate/Hour
Med Weather Impact:	125 – 135 Rate/Hour
High Weather Impact	115 – 125 Rate/Hour

Pop-up flights

- **A pop-up is a flight that is planned to arrive during the time period of a Ground Delay Program or Airspace Flow Program, but which did not exist when the program was issued**

- **How do we decide on their delay?**

Flight connectivity can pose a challenge

- **Only 6% of aircraft fly just one flight a day in domestic US operations**
  - Results in delay propagation
  - Short-term decisions can become very suboptimal
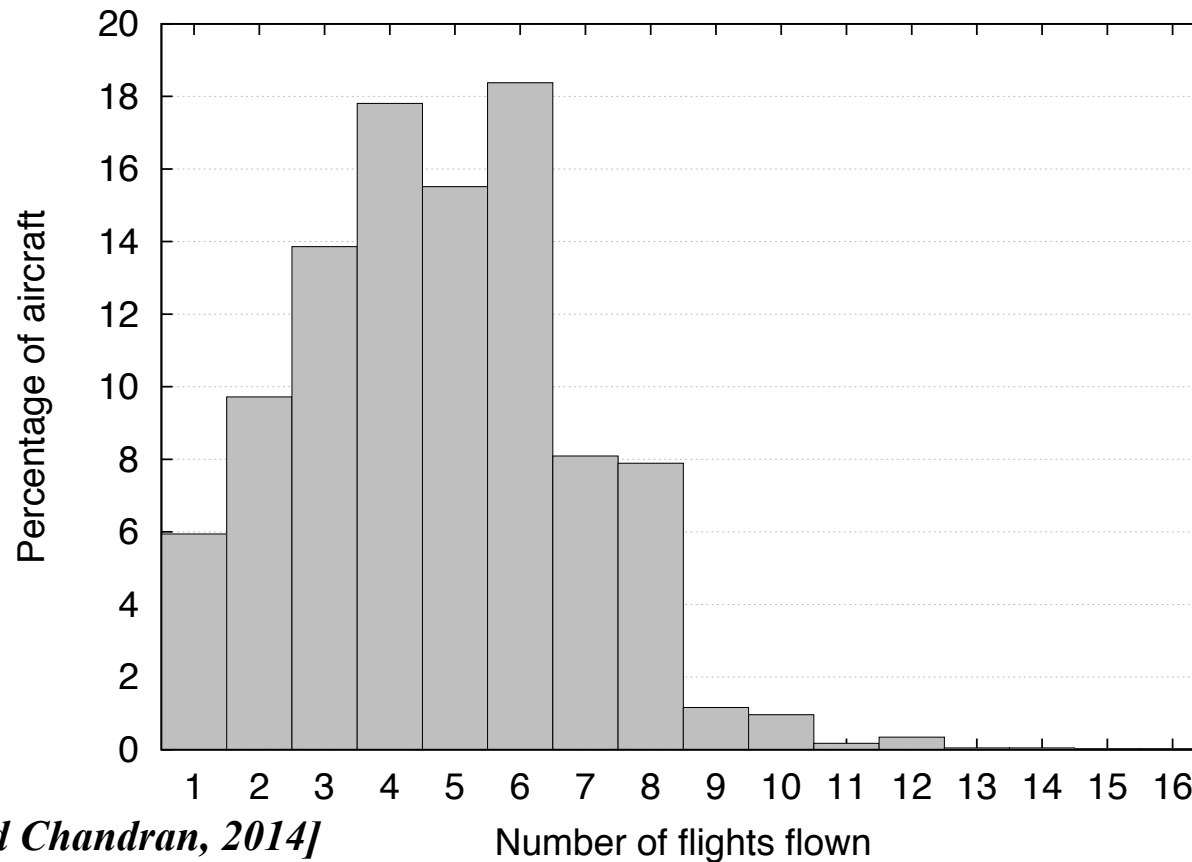
[Balakrishnan and Chandran, 2014]

Summary

- **Air Traffic Flow Management aims to address predicted imbalances between capacity and demand at airports and in the airspace**

- **Flight connectivity can pose a challenge**

- **Efficient use of resources require**
  - Reliable capacity/weather forecasts
  - Information sharing and cooperation of air carriers (**Collaborative Decision Making**)

- **Tradeoffs between "optimality" and delay distribution ("equity")**