



Evidence for the Safety-Capacity Trade-Off in the Air Transportation System

G. L. Donohue

R. C. Haynie

D. Wang

J. F. Shortle

Dept. of Systems Engineering & Operations Research

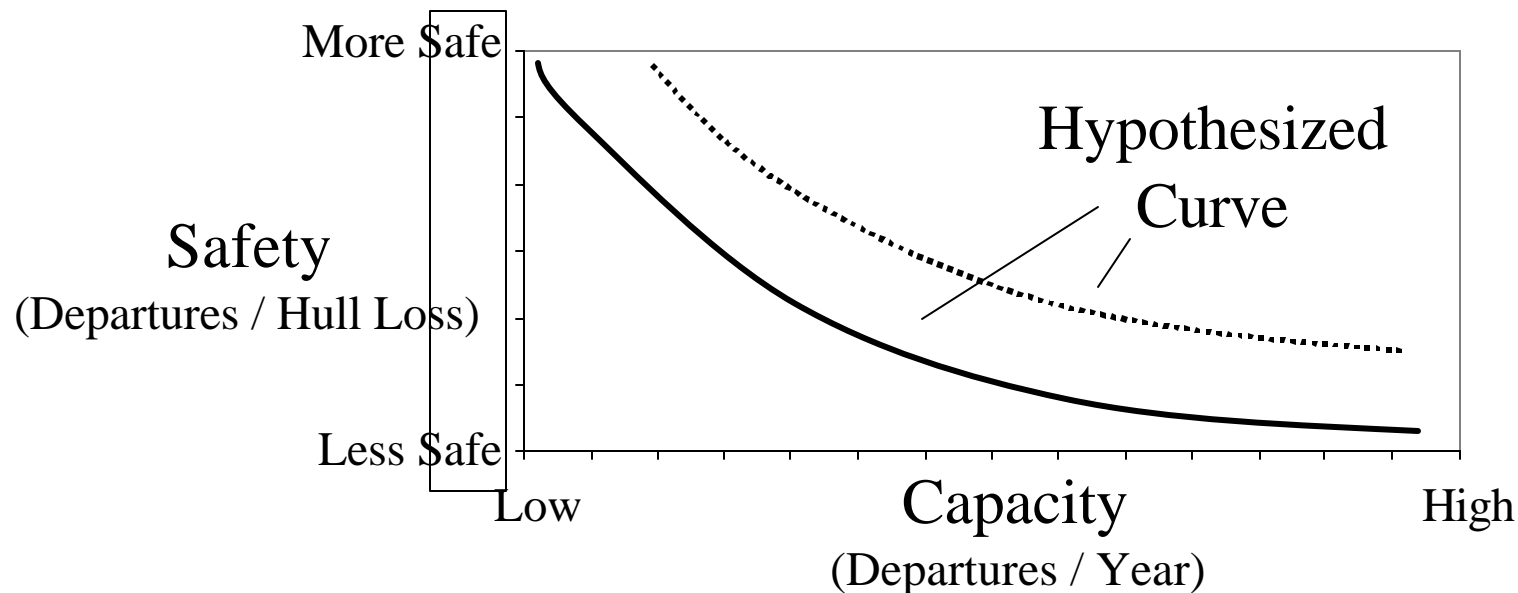
George Mason University

Fairfax, VA



Research Questions

- **Is there a safety-capacity trade-off?**
- **What happens to safety during periods of high utilization?**



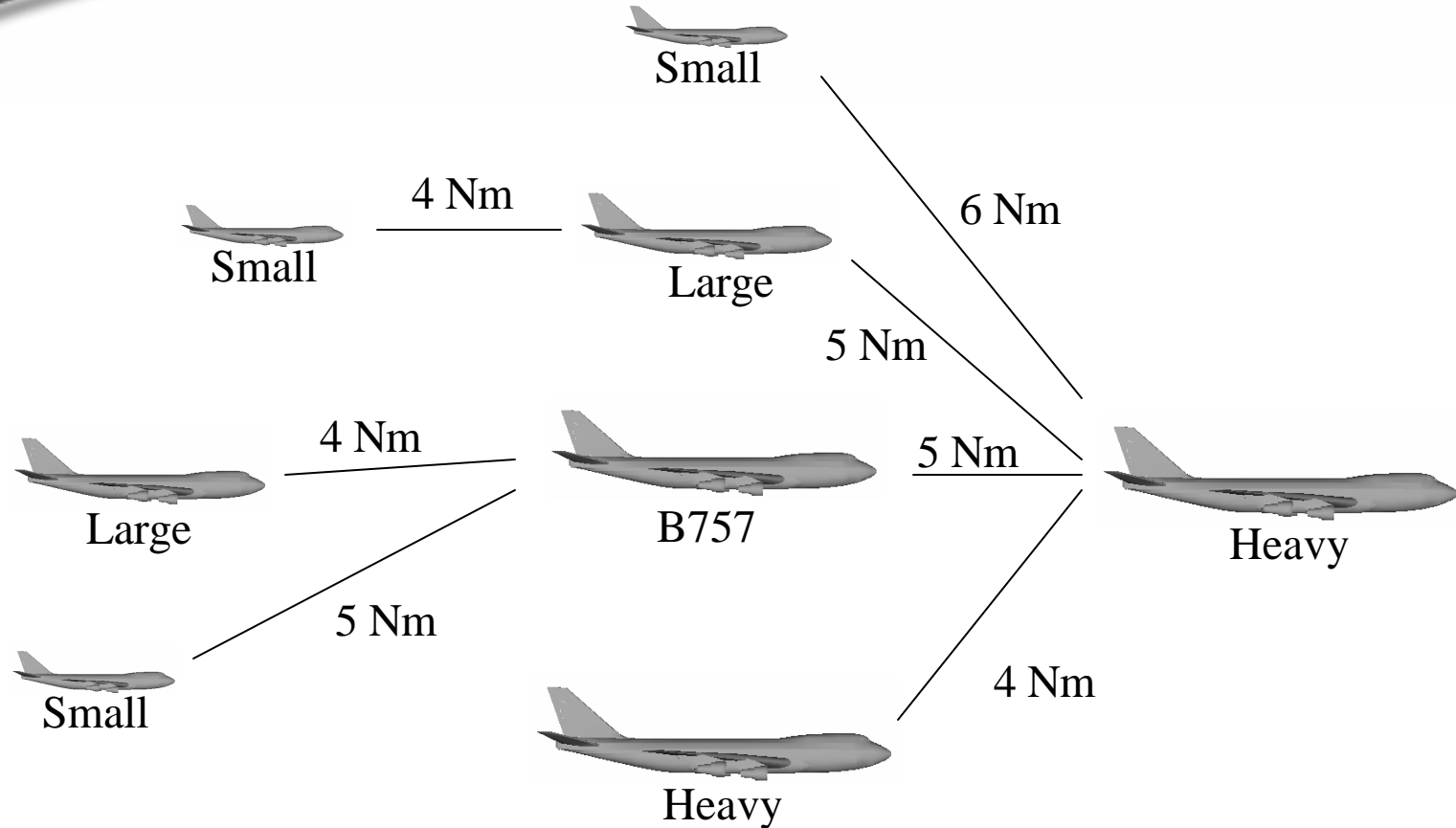


Outline

- **Data collection process**
- **Results from data collection**
- **Further analysis**
- **Conclusions**



Wake Vortex Separation Standards

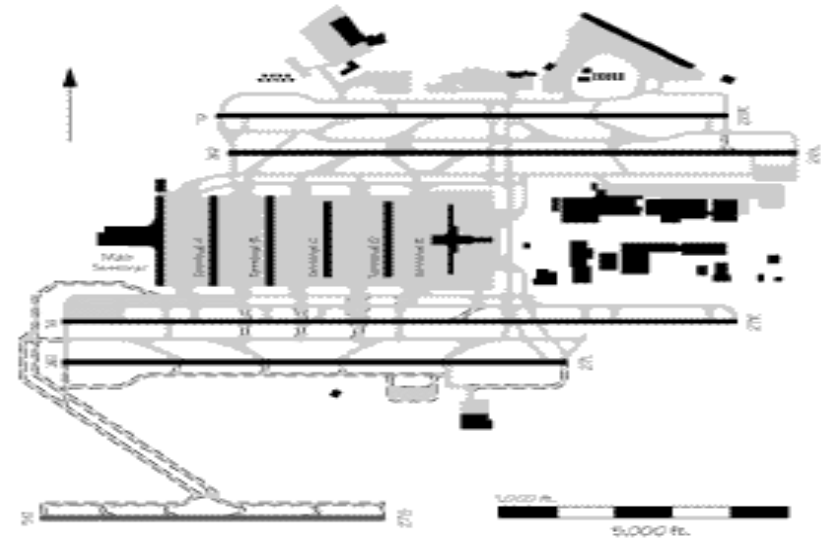


Heavy > 255,000 lbs
Large 41,000 lbs to 255,000 lbs
Small < 41,000 lbs

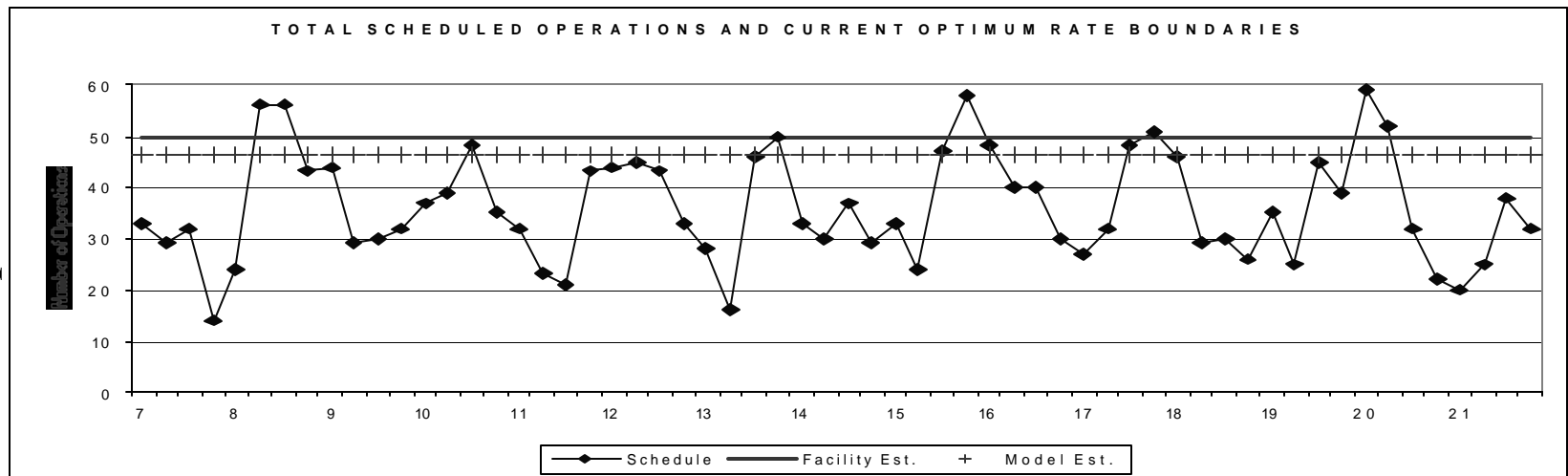


Atlanta Airport

- **2 Runways – Arrivals**
- **2 Runways – Departures**
- **50 Arrivals / Hr / RW – Max**
- **72 Seconds between Arrivals**
- **3.1% – Operations Delayed (> 15 min)**

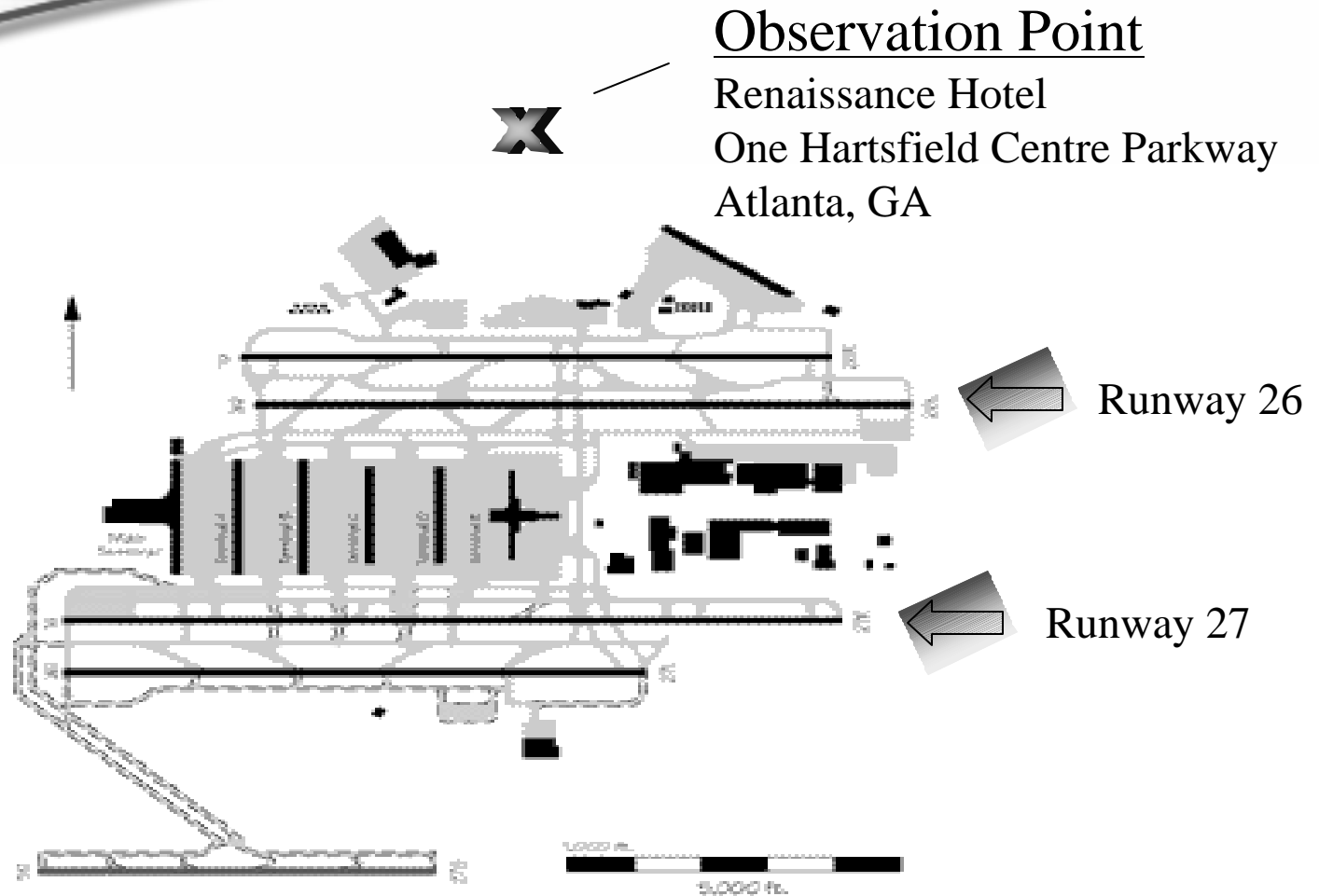


Total Operations,
VMC, (per 15 min)





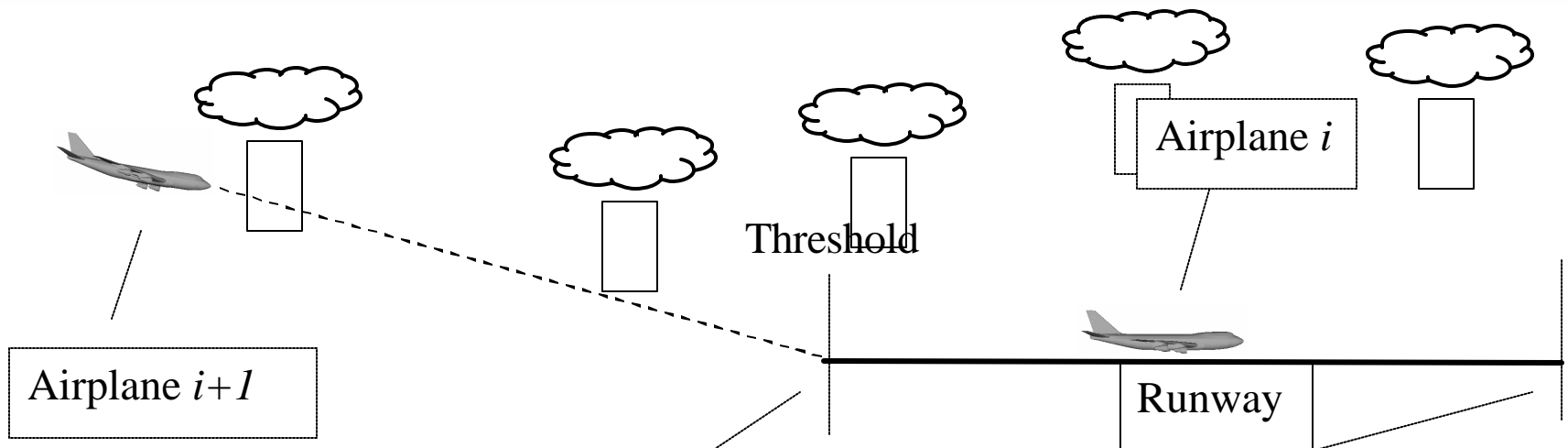
Data Collection, Atlanta



ATL Airport



Data Collection Process



Aircraft Type	Threshold	Leave Runway
Heavy	10:23:14	10:24:04
Large	10:24:28	10:25:13
Large	10:26:16	10:27:12
Small	10:28:32	10:29:28

⋮

⋮

⋮



Data Manipulation

*Runway Occupancy
Time (RTI)* 45 sec

Aircraft Type	Threshold	Leave Runway
Heavy	10:23:14	10:24:04
Large	10:24:28	10:25:13
Large	10:26:16	10:27:12
Small	10:28:32	10:29:28

$$108 \text{ sec} - 77 \text{ sec} = +31 \text{ sec} \quad \textit{Relative Inter-Arrival Time}$$

Inter-Arrival
Time

Wake Vortex Separation Standard
Large following Large (3 Nm)
(3 Nm / (140 knots / 3600 sec/hr))



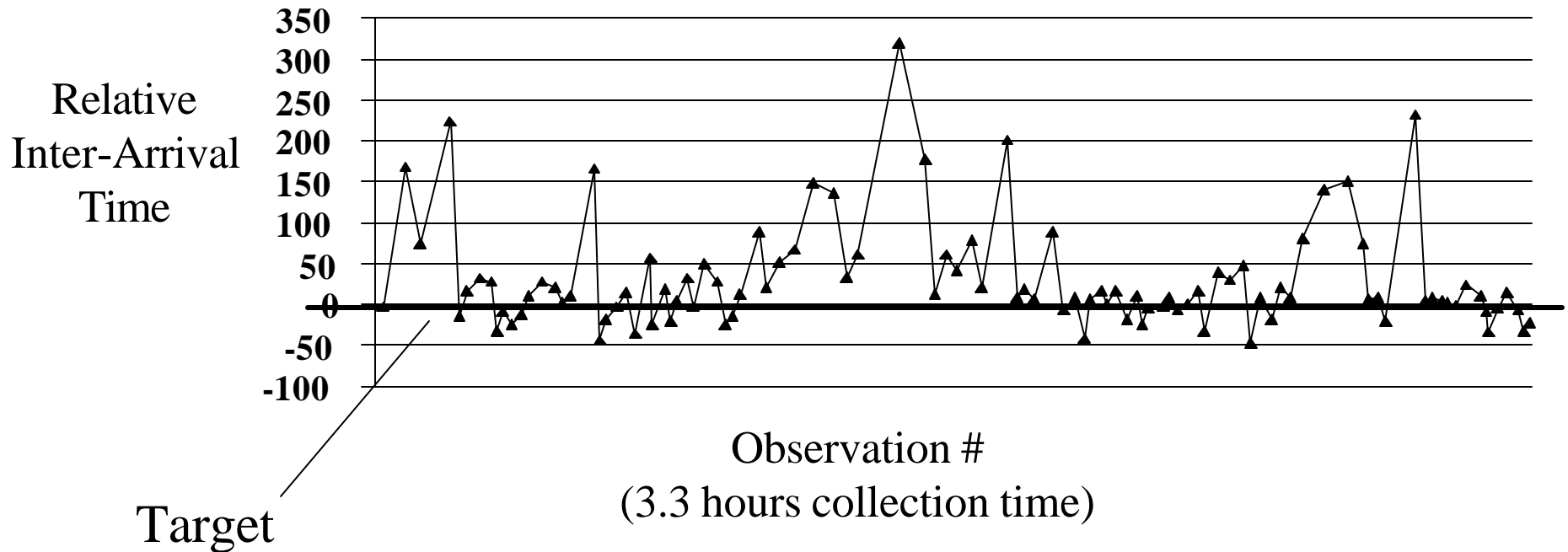
Data Collection Summary

Airport	Days	Observations	Weather
Atlanta (ATL)	3	765	VMC
LaGuardia (LGA)	3	584	VMC / IMC
Baltimore (BWI)	2	135	IMC



Atlanta Runway 27

Collection Day #1, VMC



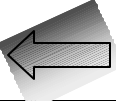
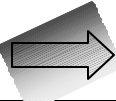
Total Observations: 103

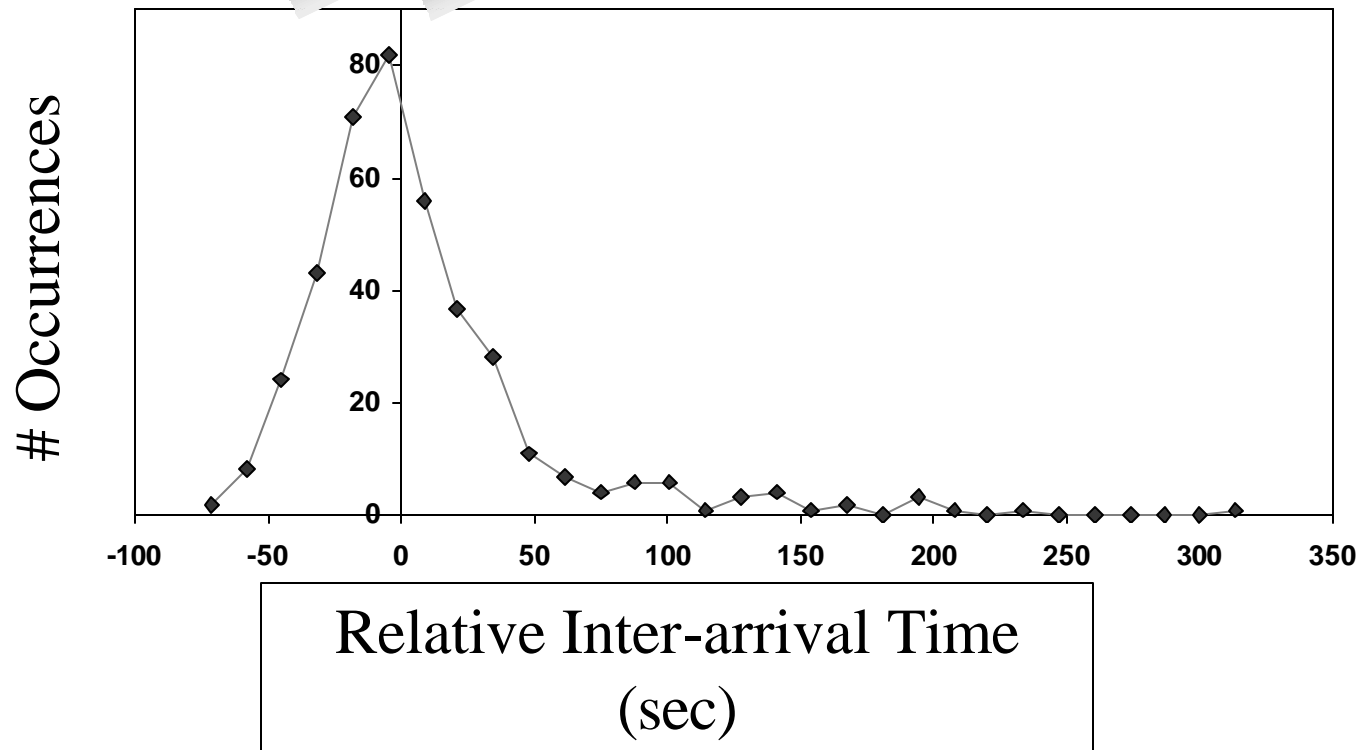
Arrivals / Hr: 31



Atlanta Runway 27

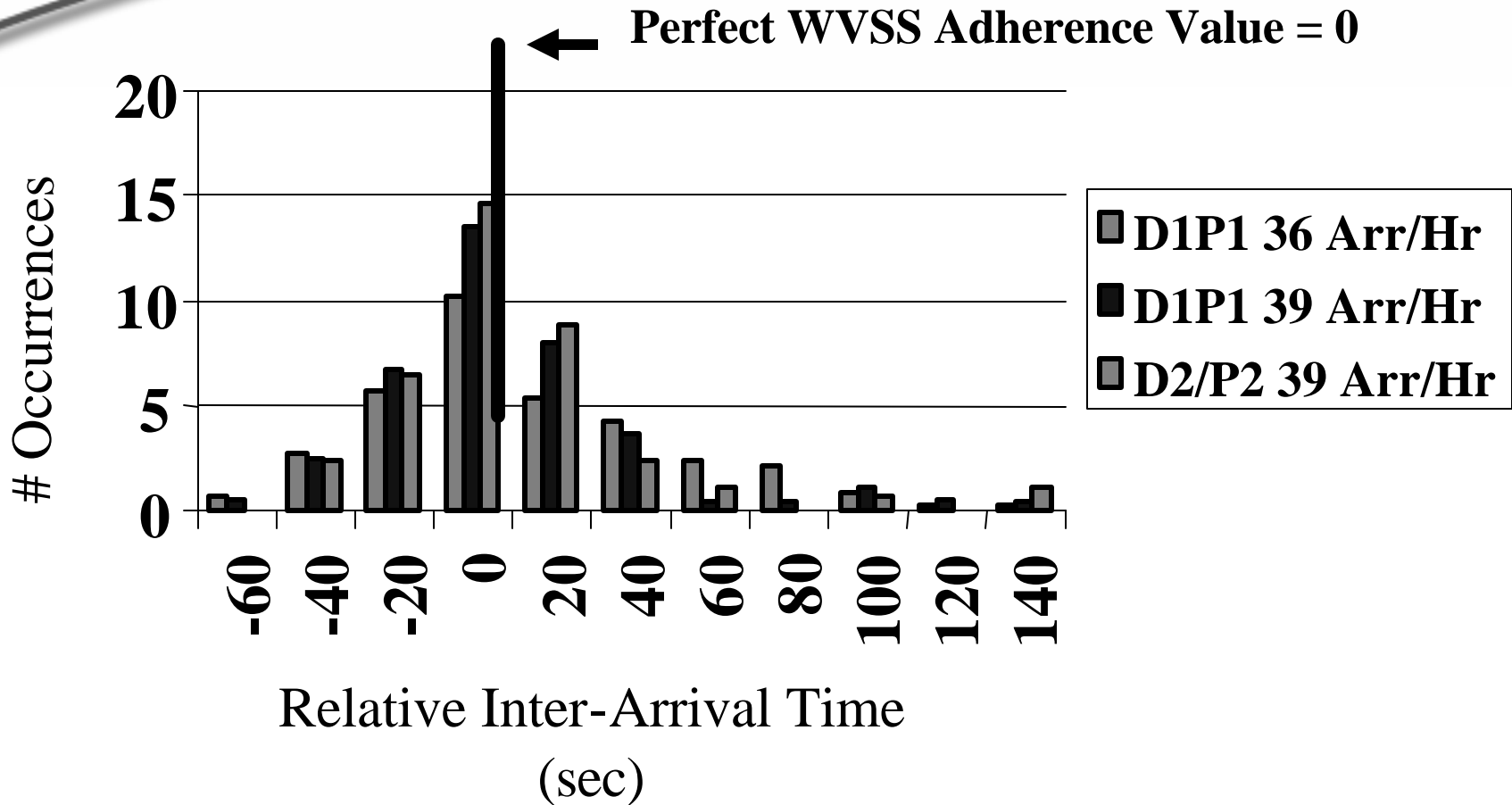
All Collection Days, VMC

Lost Safety   Lost Capacity





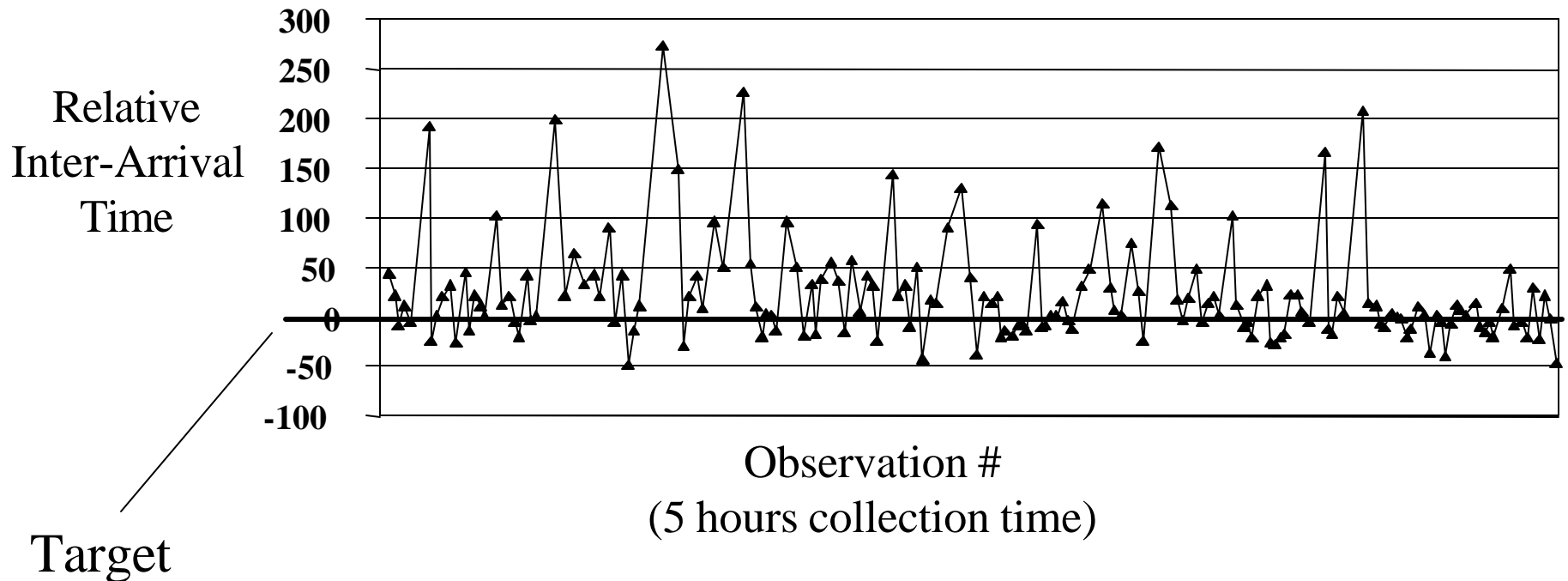
ATL Summary





LaGuardia

Collection Day #2, VMC

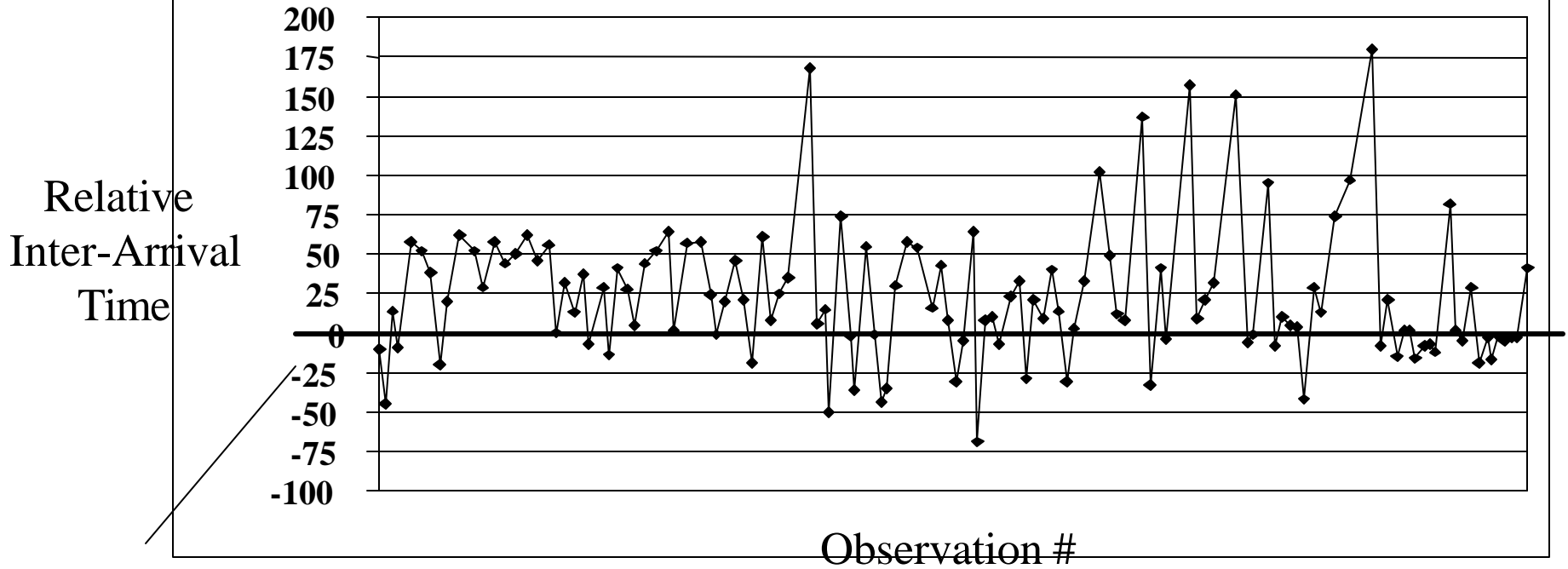


Total Observations: 169
Arrivals / Hr: 33.8



Results

LaGuardia Collection Day #3, IMC



Target

(3.7 hours collection time)

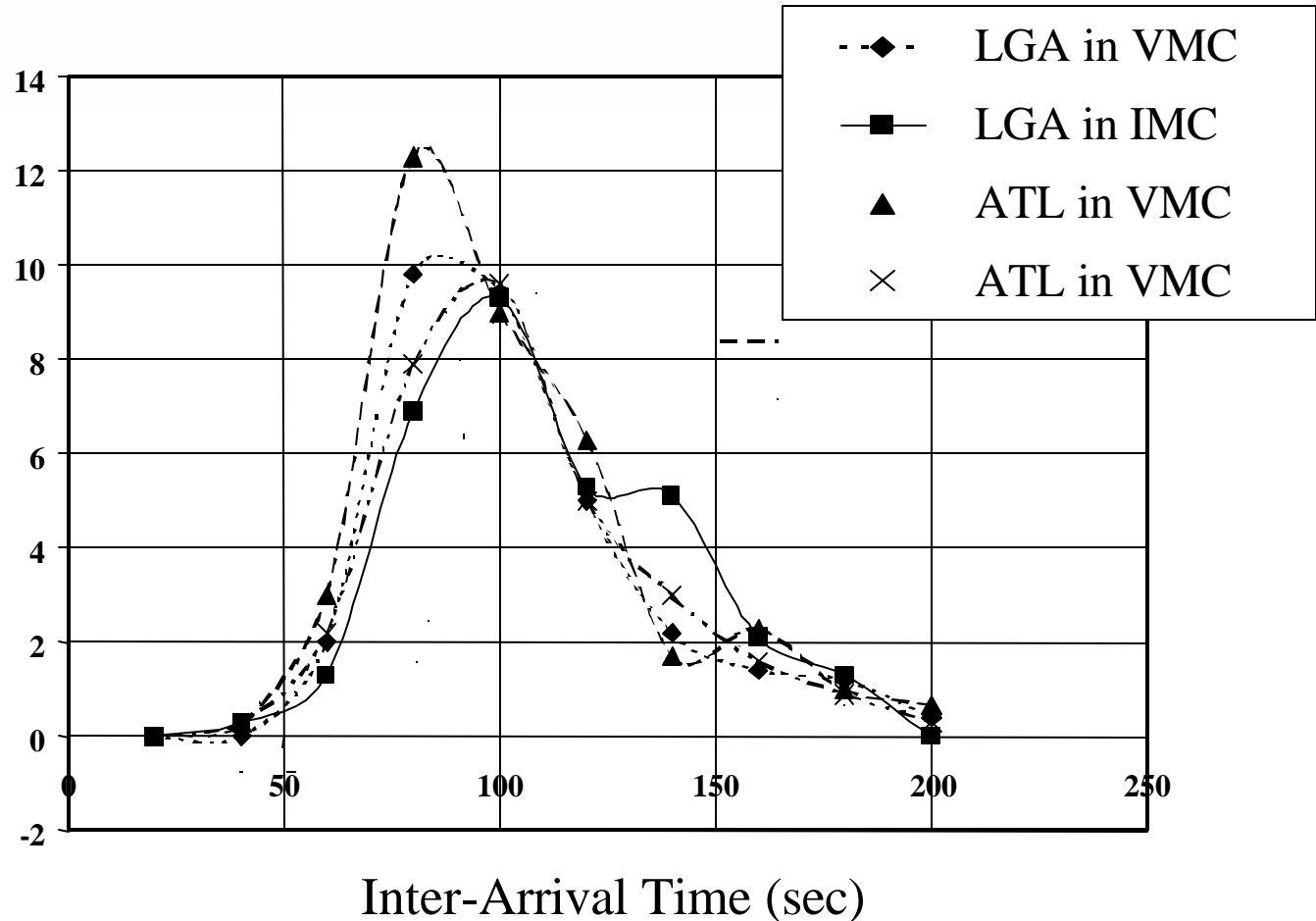
Total Observations: 126

Arrivals / Hr: 34



Comparison of Airports

Aircraft
Per Runway
Per Hour



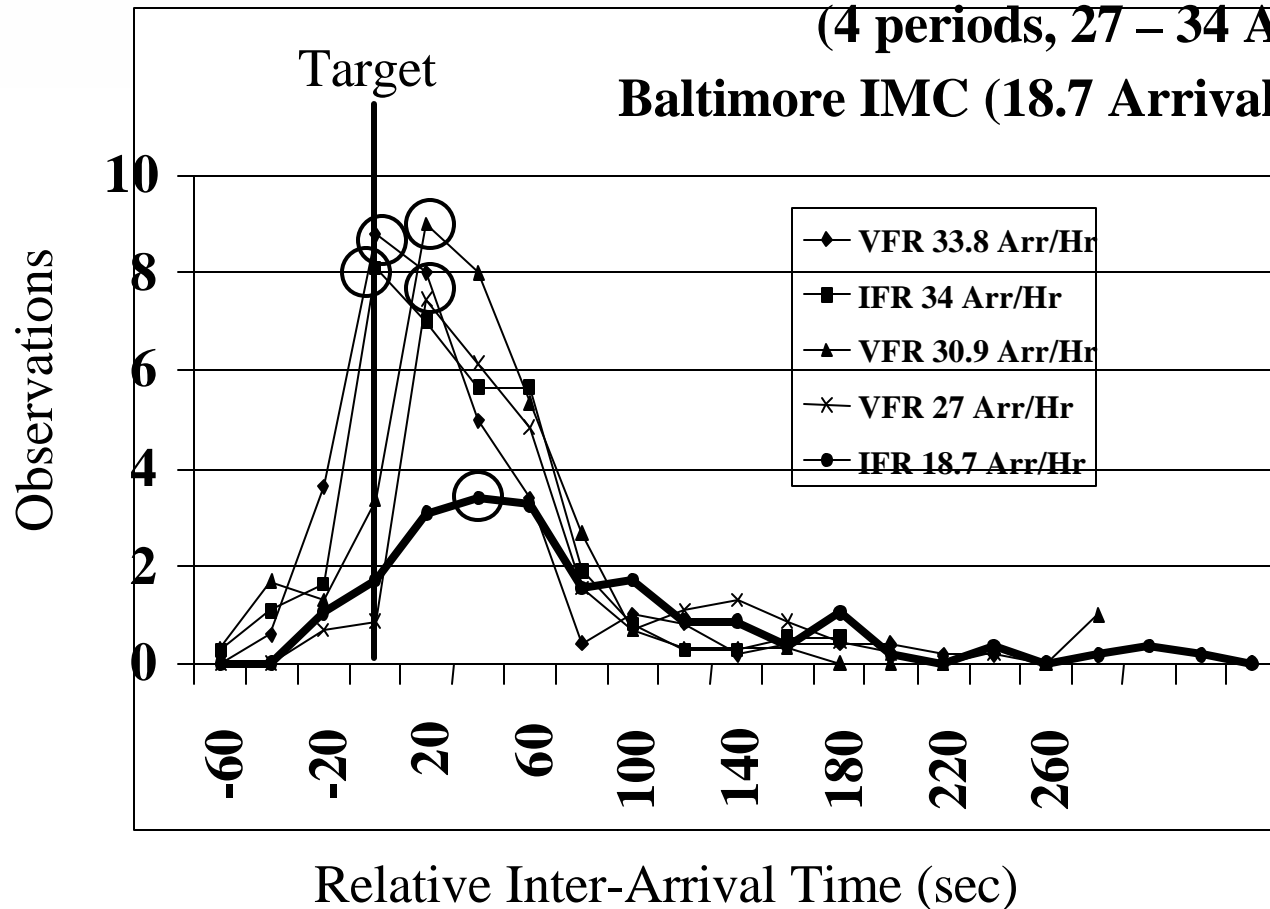


LGA & BWI Comparison

LaGuardia VMC / IMC

(4 periods, 27 – 34 Arrivals / Hr)

Baltimore IMC (18.7 Arrivals / Hr)



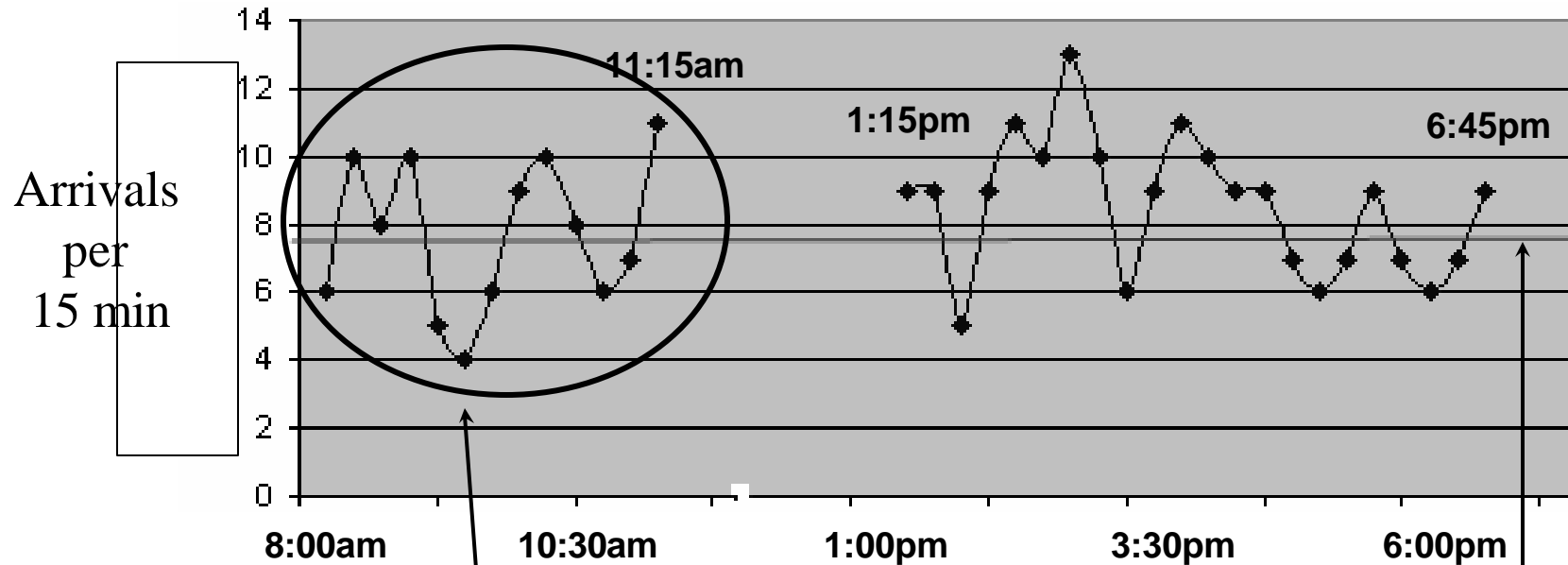


15 Min Arrival Rates

Atlanta Airport

Collection Day #1, VMC

15 min averages



Arrivals
per
15 min

11:15am

1:15pm

6:45pm

8:00am

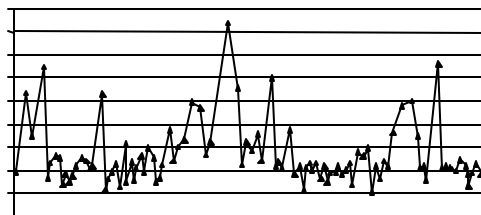
10:30am

1:00pm

3:30pm

6:00pm

Individual
Flight Data

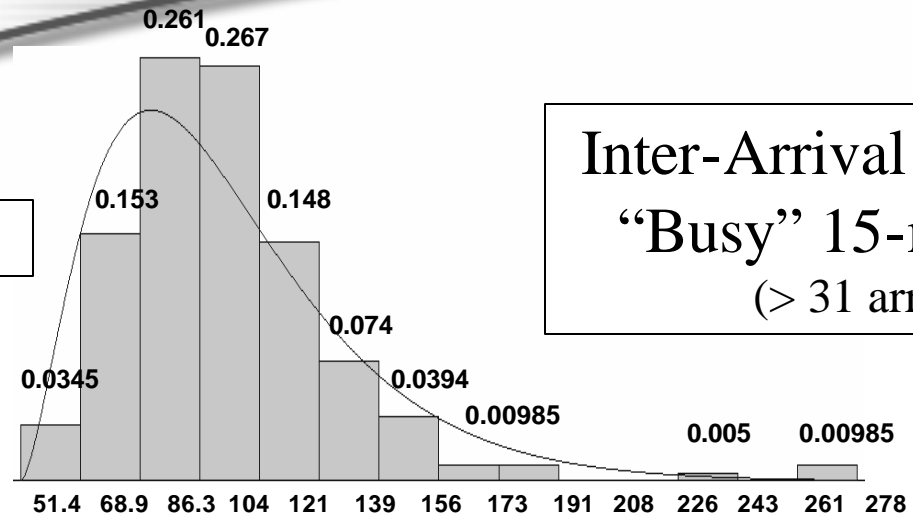


Average: 31 / hr



Arrival Rates

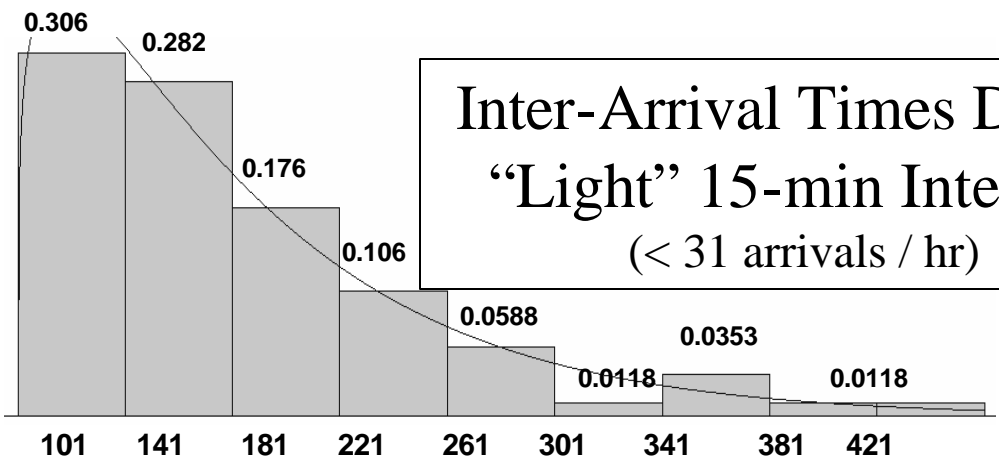
Frequency



Inter-Arrival Times During
“Busy” 15-min Intervals
(> 31 arrivals / hr)

Inter-Arrival Time (sec)

Frequency



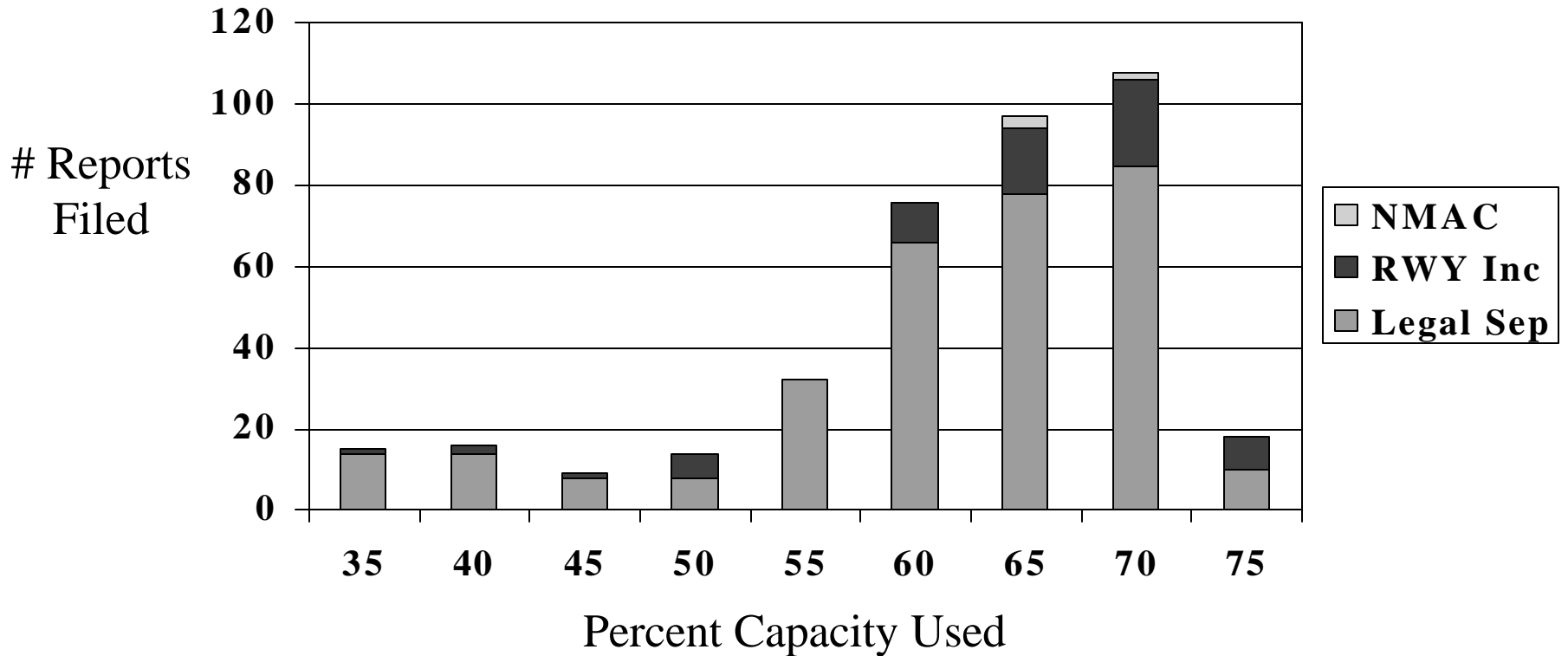
Inter-Arrival Times During
“Light” 15-min Intervals
(< 31 arrivals / hr)

Inter-Arrival Time (sec)



Safety / Capacity Relationship

ATL, DCA, LGA Historical Reports 1988-2001





Summary

- **Inter-arrival times indicate frequent loss of WV separation**
- **Shape of inter-arrival distributions similar**
 - For different airports
 - For IMC / VMC
- **Some evidence for decline in safety for higher arrival rates**
- **Small data set (~ 1,500 points) – more needed**
- **Data can be used as input to more sophisticated safety models (TOPAZ)**



Backup Slides

Backup Slides

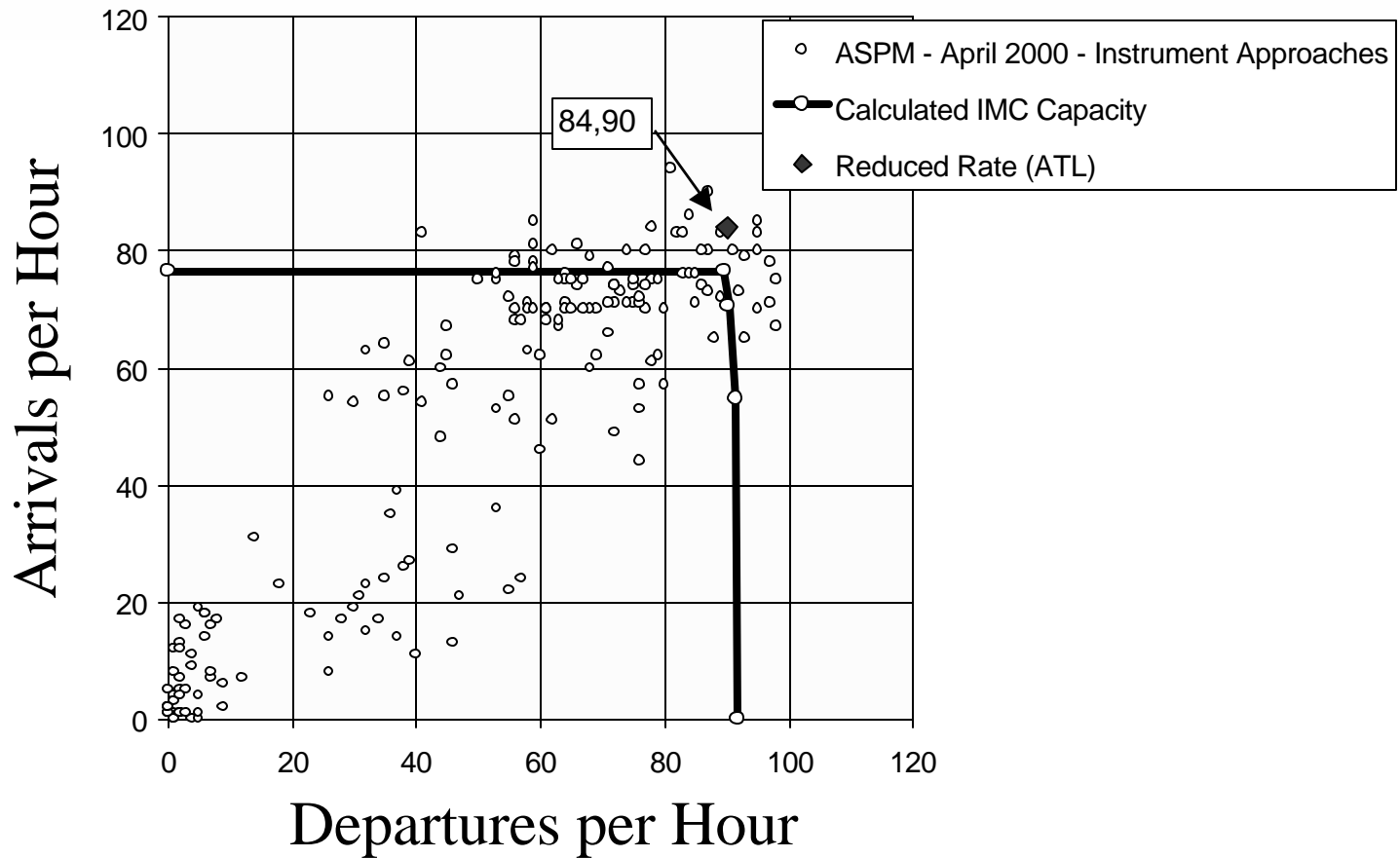


Average Approach Speeds

Aircraft Type	Avg. Approach Speed
Small	130 knots
Large	140 knots
B757	140 knots
Heavy	145 knots



ATL Arrival - Departure IMC

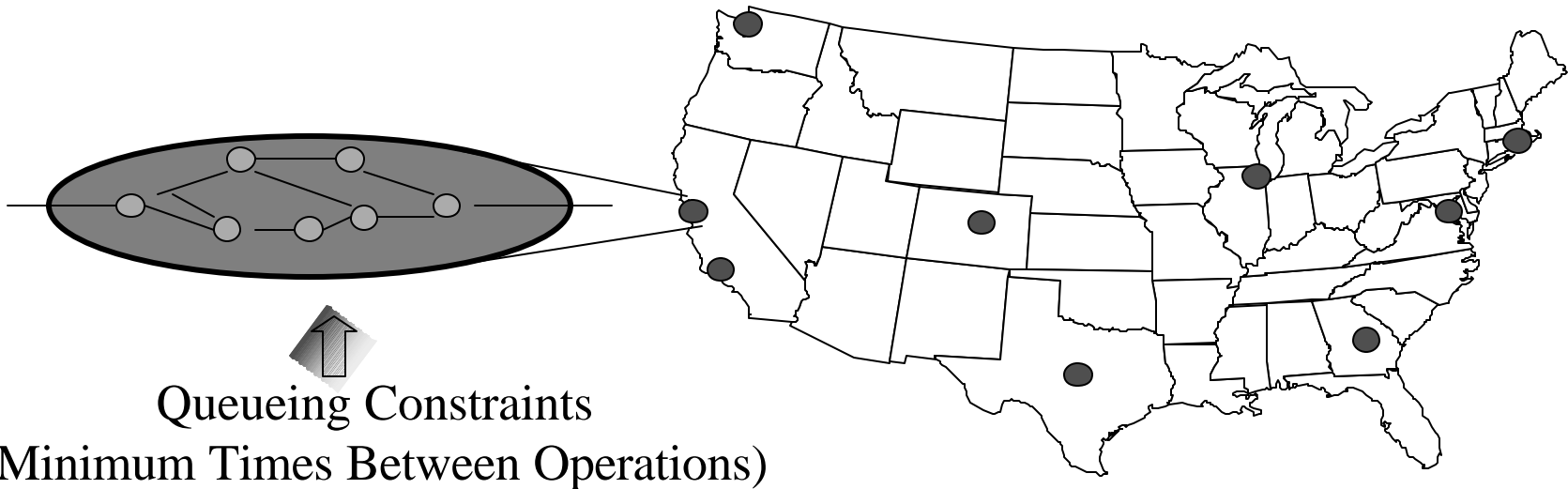




Modeling Implications

- **Typical Modeling Approach**

- Safety is a *constraint* (Maximum rate through node in network)
- Capacity is metric of interest



- **New Approach**

- Safety is a function of capacity / demand