An Evaluation of US and European Airspace Capacity

Airline and National Strategies for Dealing with Airport and Airspace Congestion March 15-16, 2001

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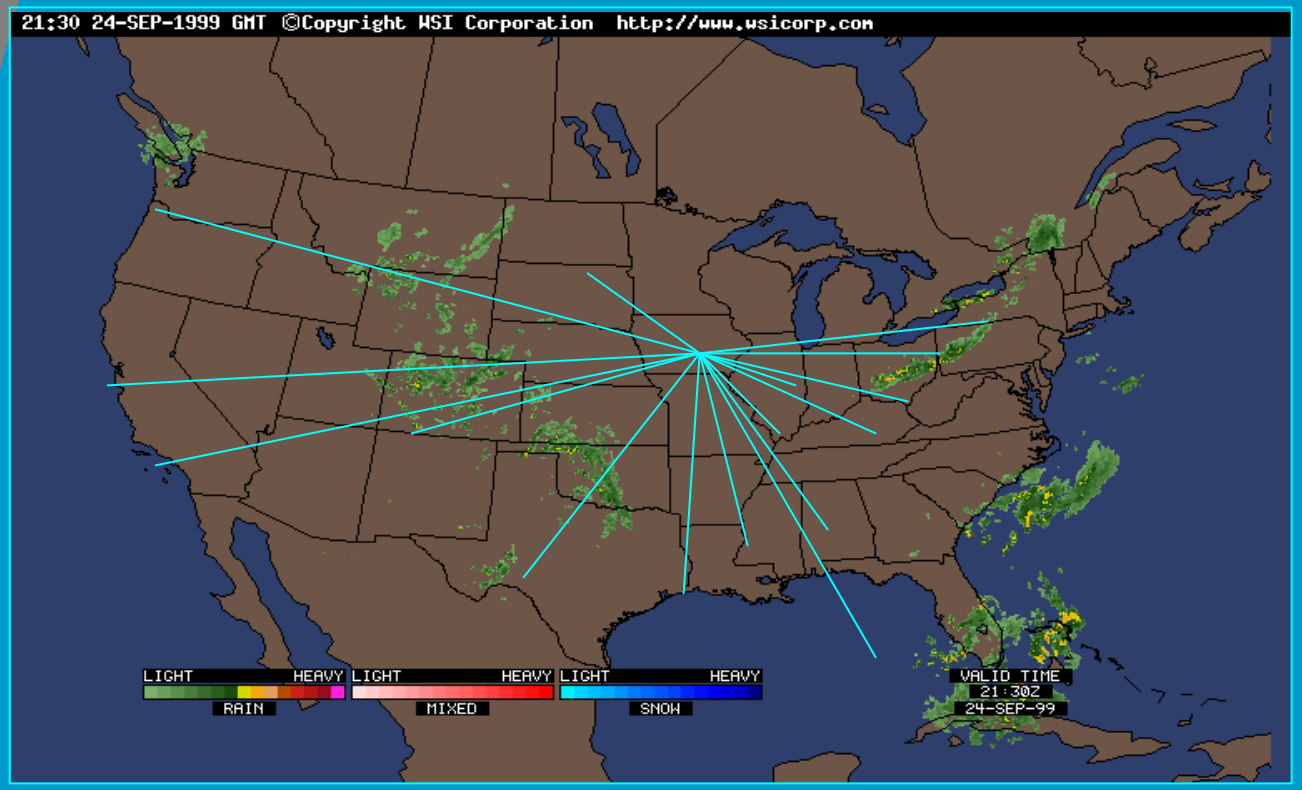
Problem

- > 11 % of US Disposable Personal Income (DPI) goes to Transportation
  - Transportation has moved to 3rd Place in DPI
- Highways and Airways are Approaching Gridlock and Hub-lock
  - DoT has National Policy Jurisdiction for Both
- FAA does not see itself as a Transportation Agency
  - Aircraft Safety Certification (Design & Maintenance)
  - Aircraft Separation for Safety
  - Funding of Runway construction and Navigation/Landing Aids
- NAS Architecture 4.0 is not a Blue Print for Capacity or Safety increase
  - Fiscally Constrained Govt./Union/Industry Consensus
- DoD also has a Major Stake in the development of the Future Aeronautical Telecommunications System

Outline

- Aircraft Separation
  - Capacity
  - Safety
- ATM Control Loop Feedback Time Constants
  - ATC vs. Aircraft Self Separation
  - Weather and Central Flow Control Stability
- Hub Airport Diseconomies of Scale
- Conclusions

Hub and Spoke Network



Completely Connected Network = 2(N-1) Flights
(eg., 50 Airports, 98 Flights)
Ref: J. Hansman, MIT

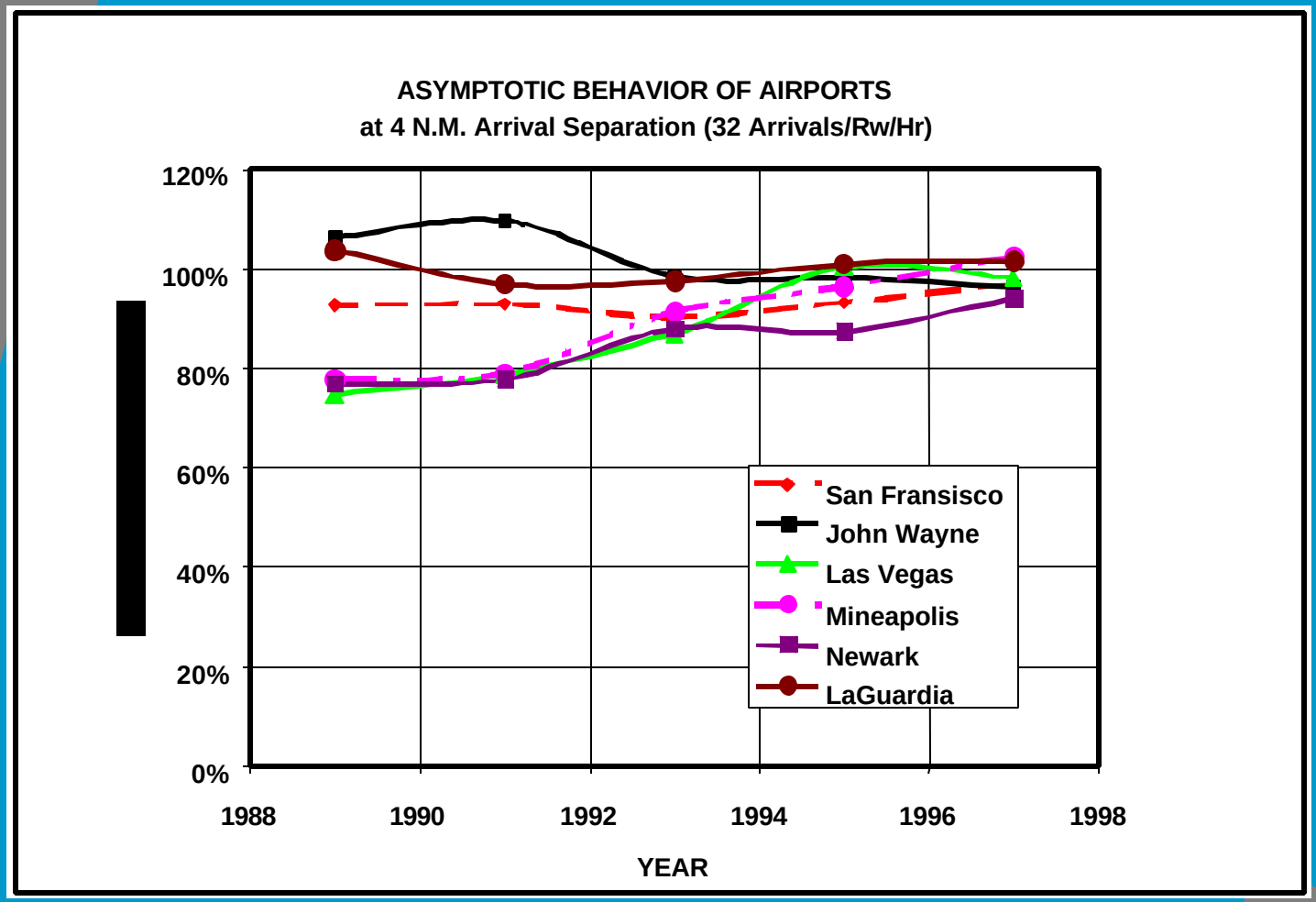
GMU Macro Capacity Model

- $C_{max} = 2 \times C_{AR\ MAX}\ S\ S_i\ (XGR)_i - C_{AS\ MAX}\ S_K\ A_K$.

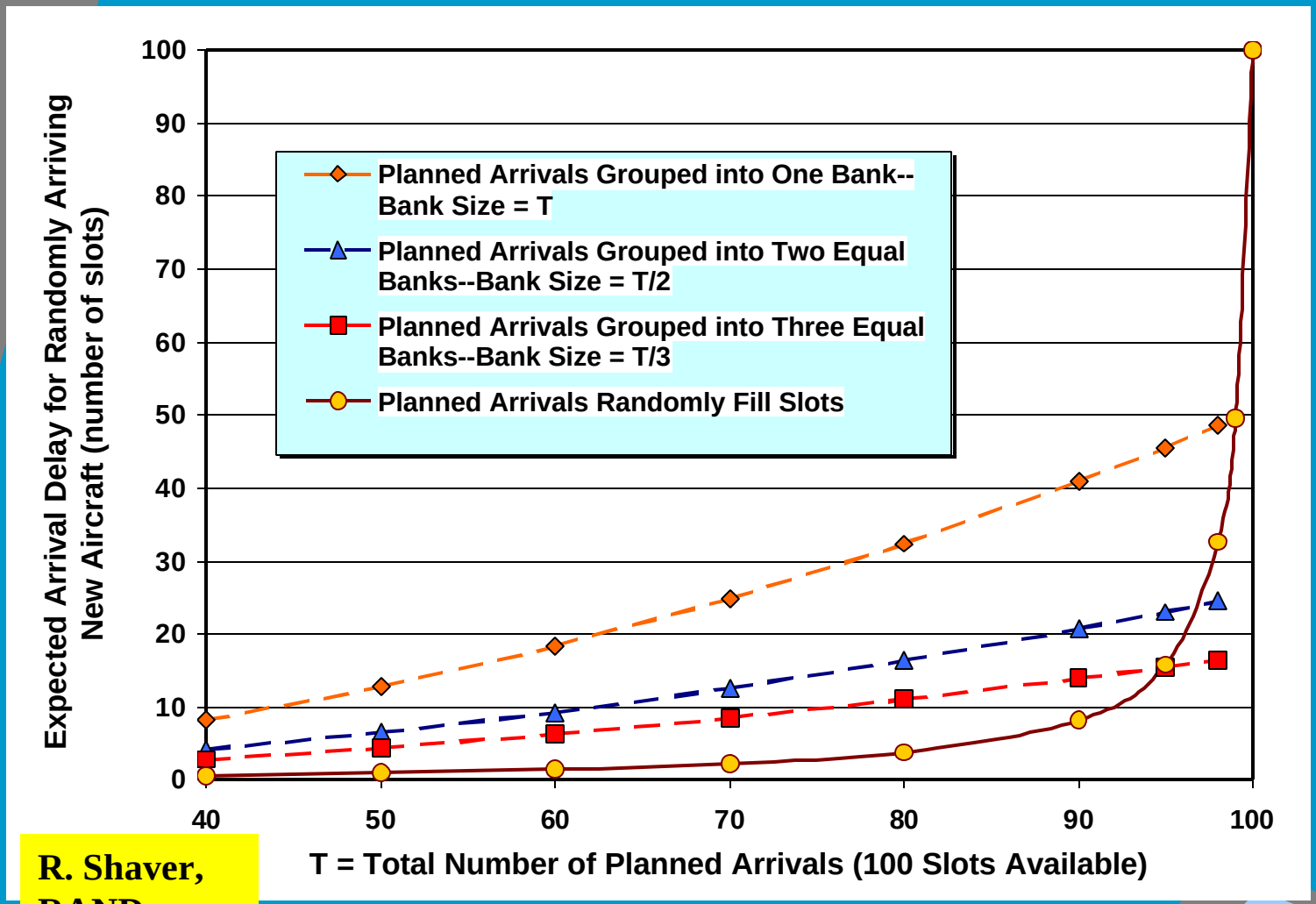
- $A_K = (A/C_{REQUEST} - A/C_{ACCEPT}) / C_{AS\ MAX}$
- S= f (Procedures,Technology,Safety)

- $C_{AR\ MAX}$ = 64 Arrivals/Hour
- $C_{AS\ MAX}$ = 120 Aircraft/Sector/Hour

Hub Airports Becoming Saturated

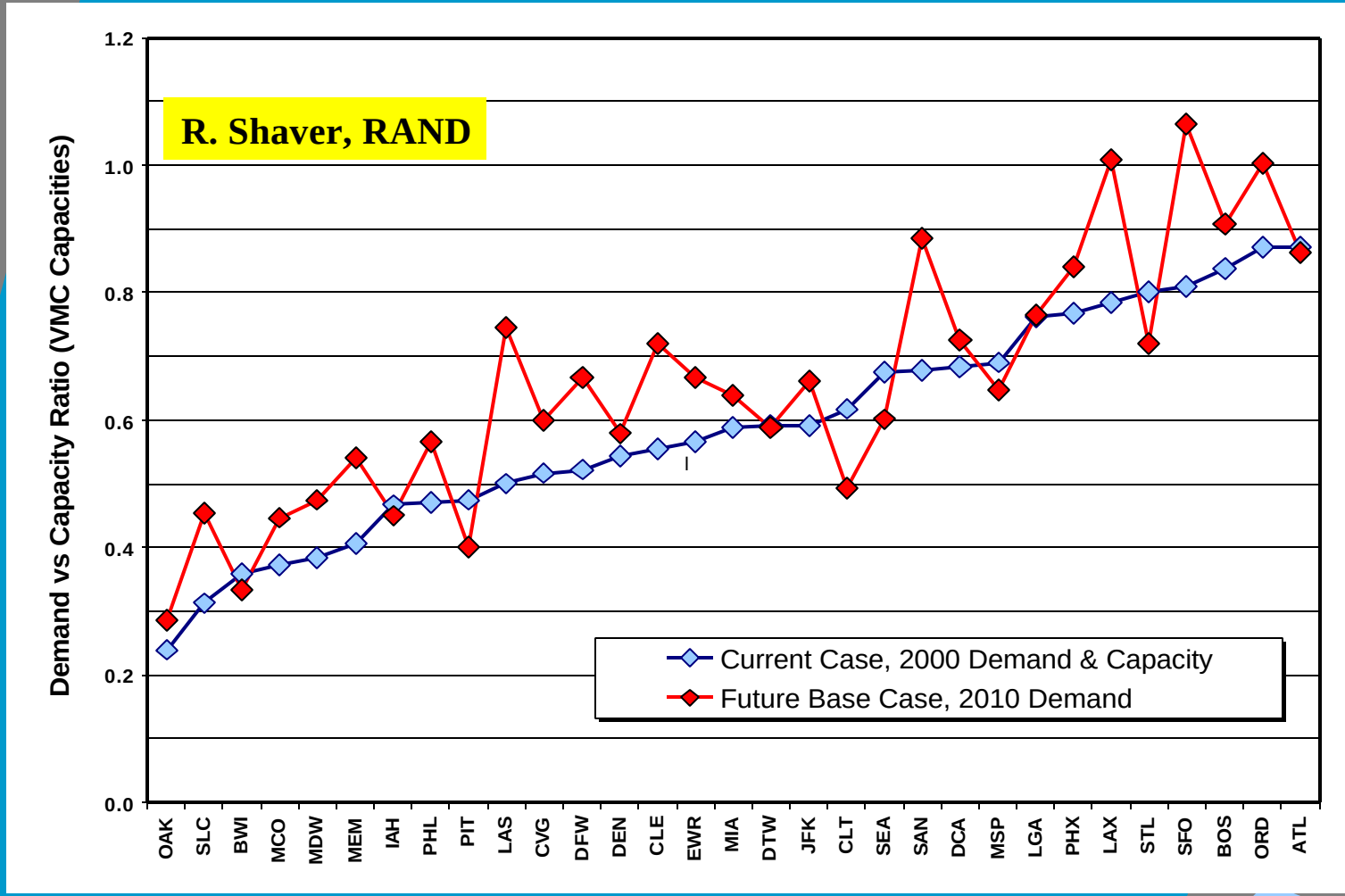


Delays at a Notional Airport: Random Unscheduled Arrivals (with and without banks)



R. Shaver, RAND

Demand/Capacity Ratios: 31 Large Hub Airports (VMC, airport enhancements only)



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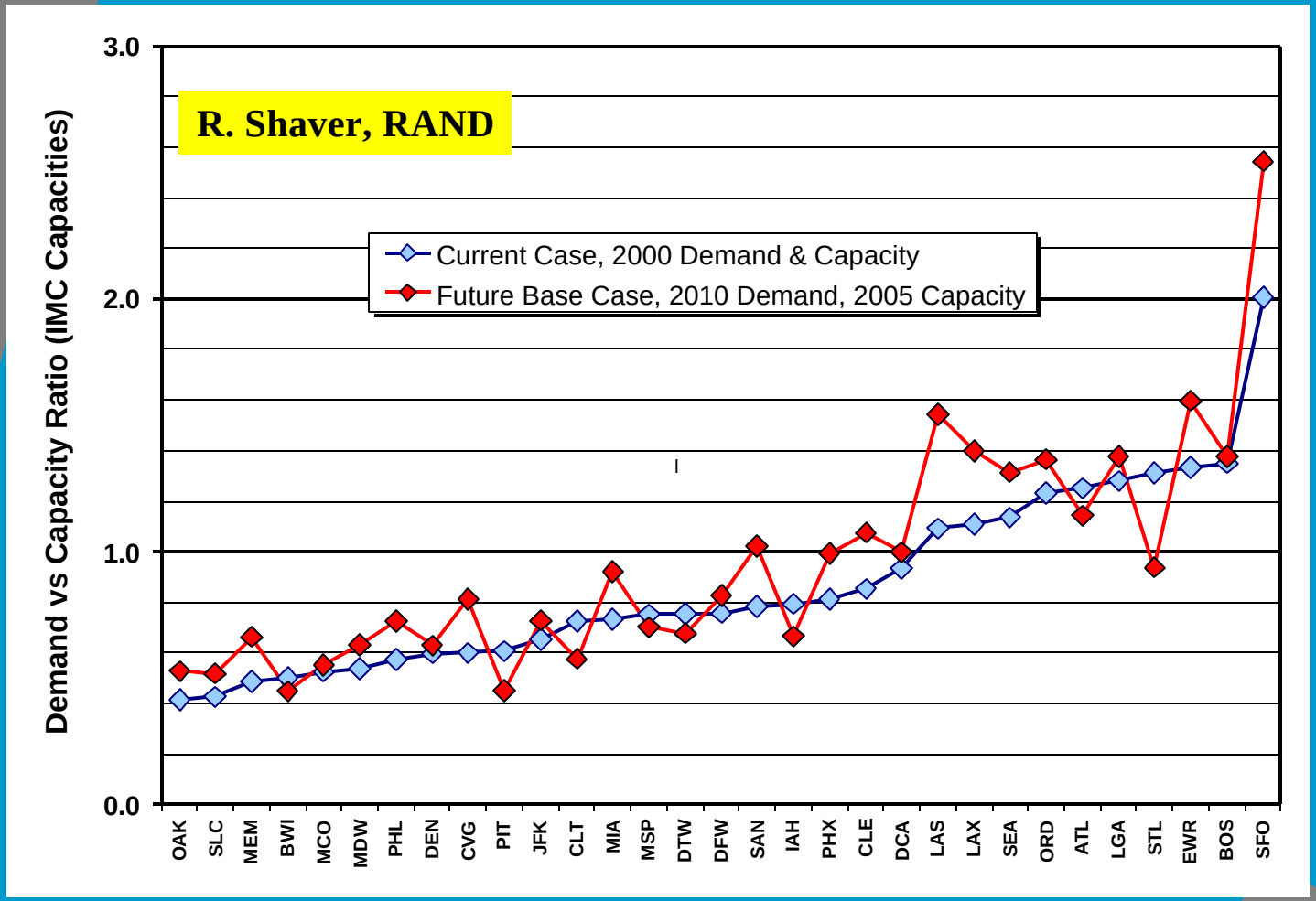
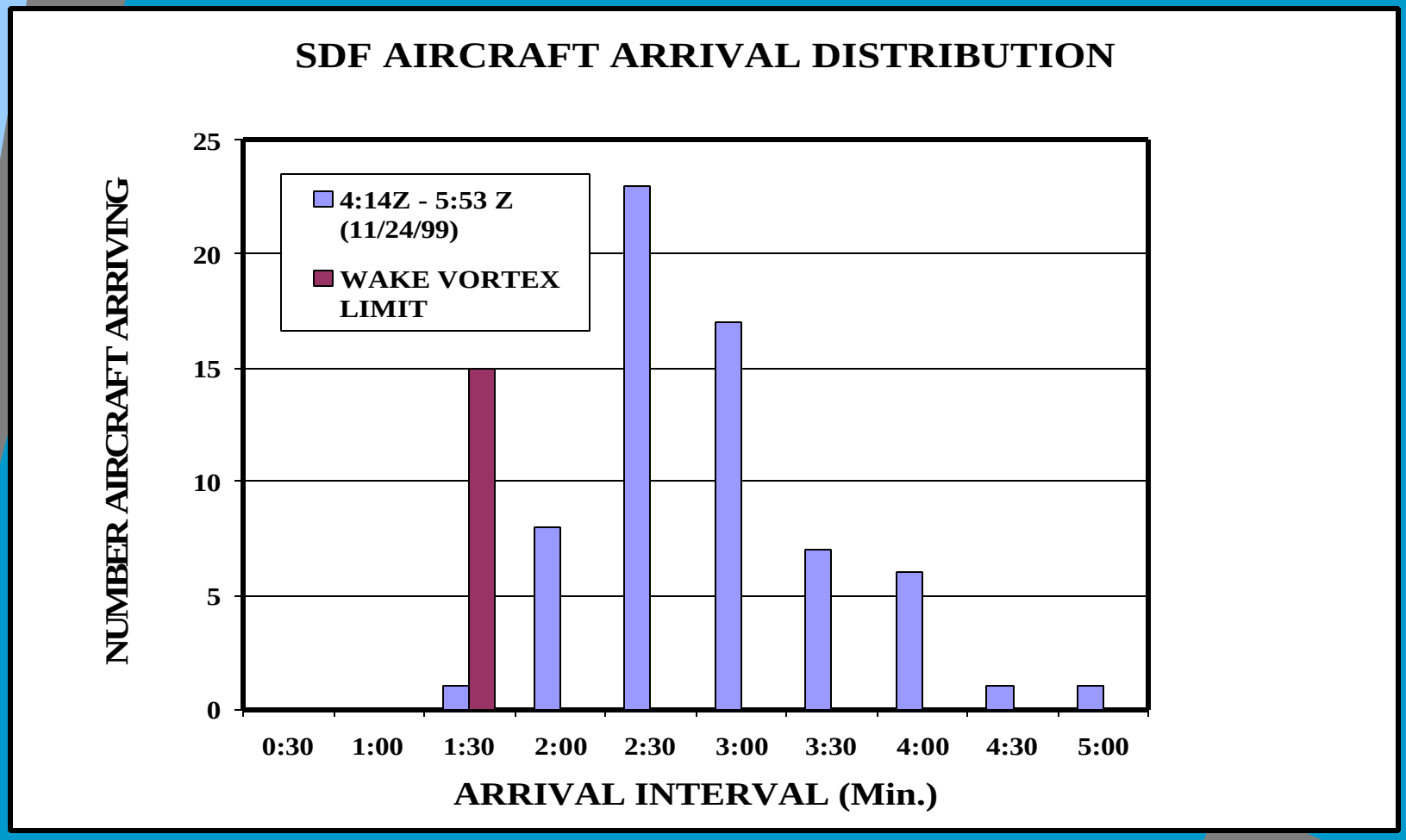


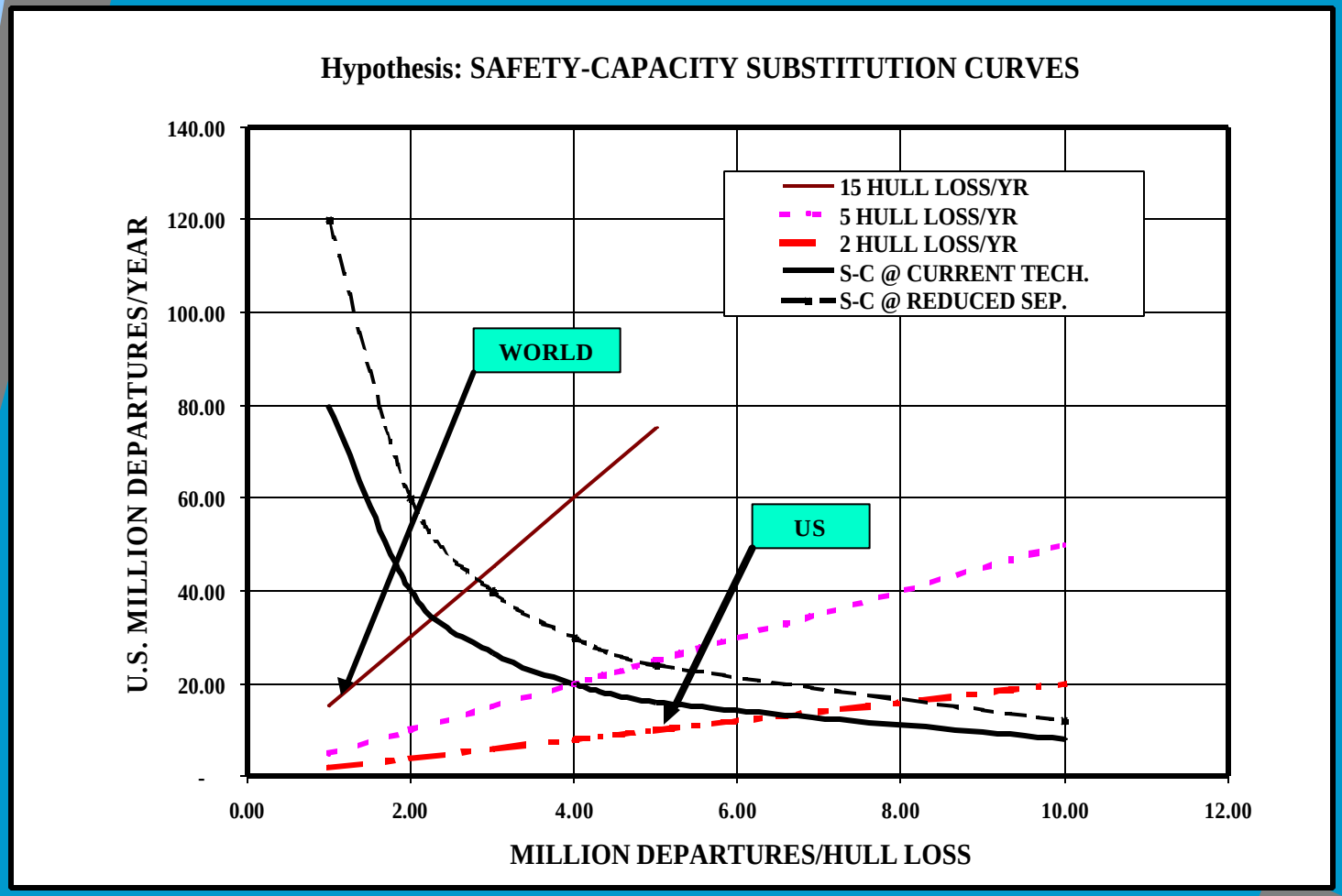
Arrival Spacing is Critical to Capacity and Safety



Aircraft Position Precision is Key to Capacity Increase & Collision Prevention

- Current Ground Radar, Controller-in-the-Loop, Push-to-Talk DSB AM radio controls aircraft position to about +/- 1 nmi.
- An average approach spacing of 2.5 minutes (~4 nmi.) Allows a Current Safety Metric of about 3 +/- 2 million Departures per Hull Loss
- GPS based ADS-B with aircraft Separation authority could lead to 1 minute (~2.5 nmi.) Separation at comparable levels of Collision Safety
- Internationally Approved Spectrum and Data Link Standards Required

Relationship Between Safety and Capacity: ATM Technology Effect (Hypothesis)



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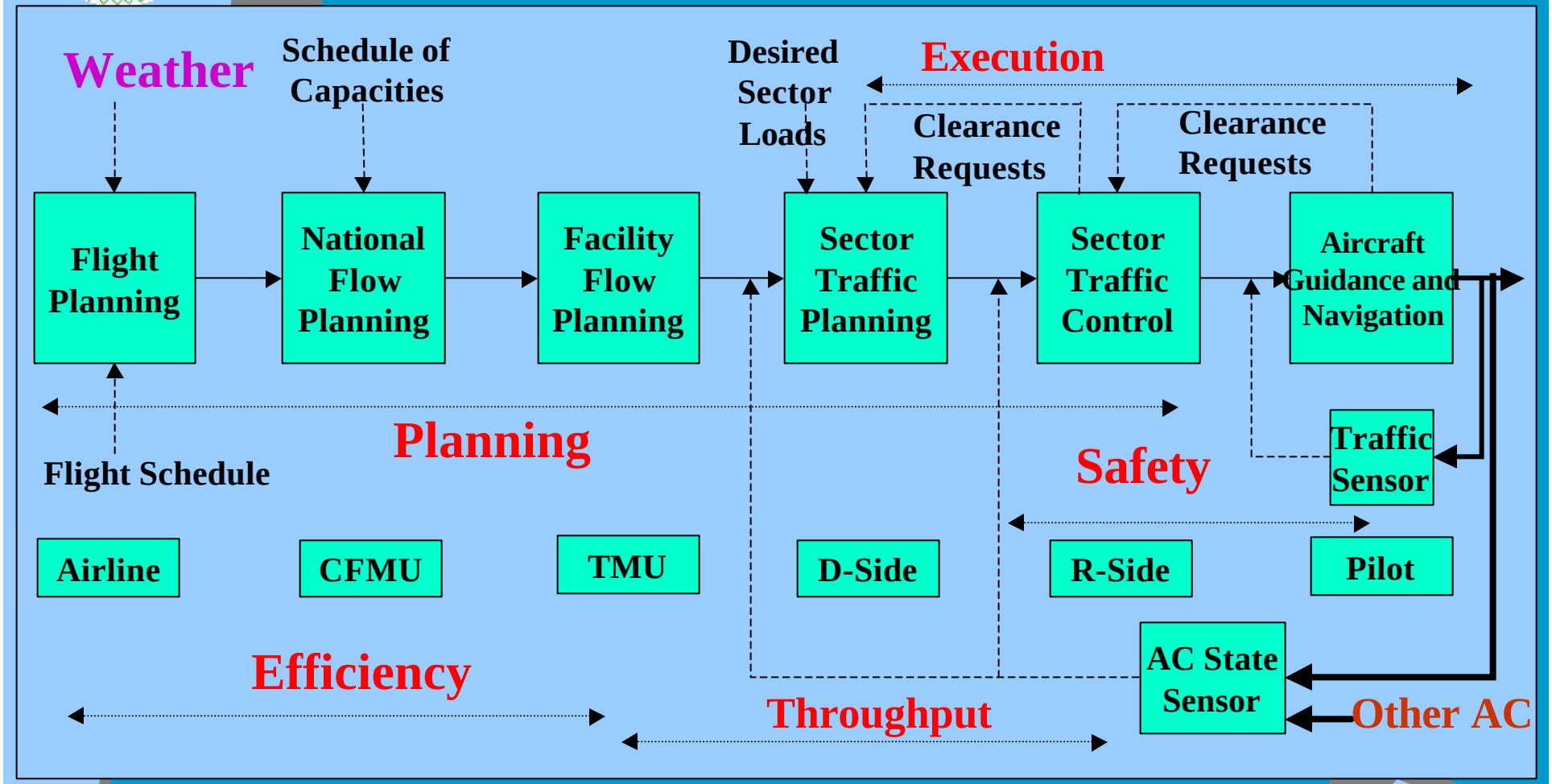
ATM System Functional Structure (Boeing Model)



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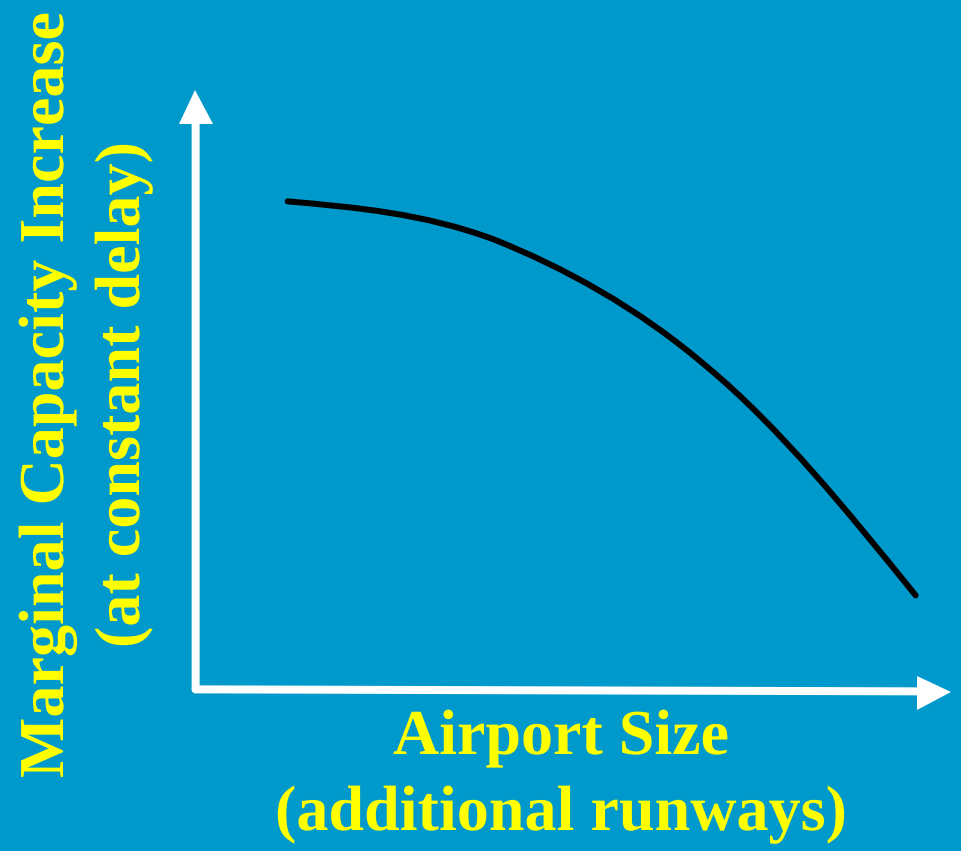
Marginal Capacity vs. Airport Size

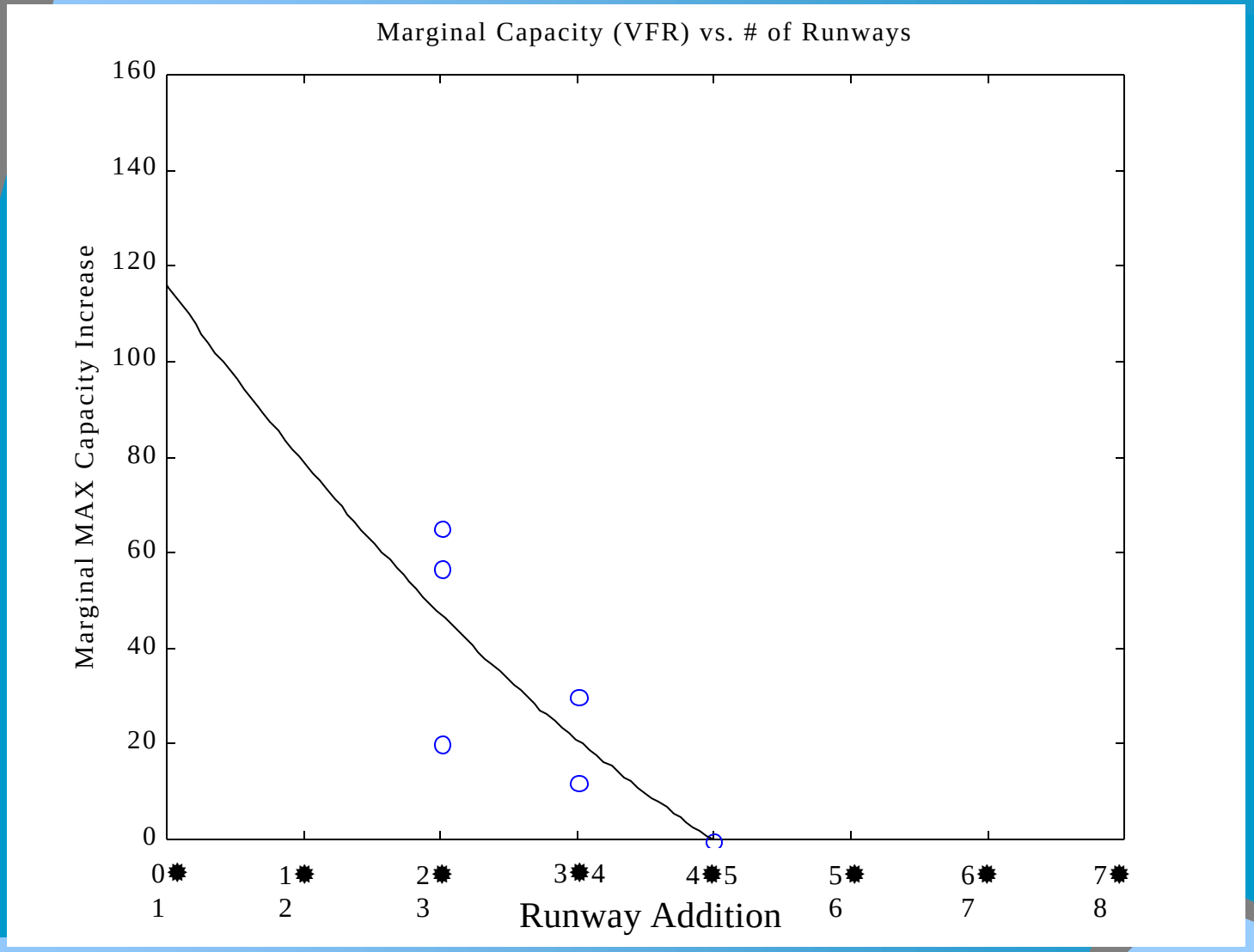


5 Airport Case Studies
ACE Data (1999)

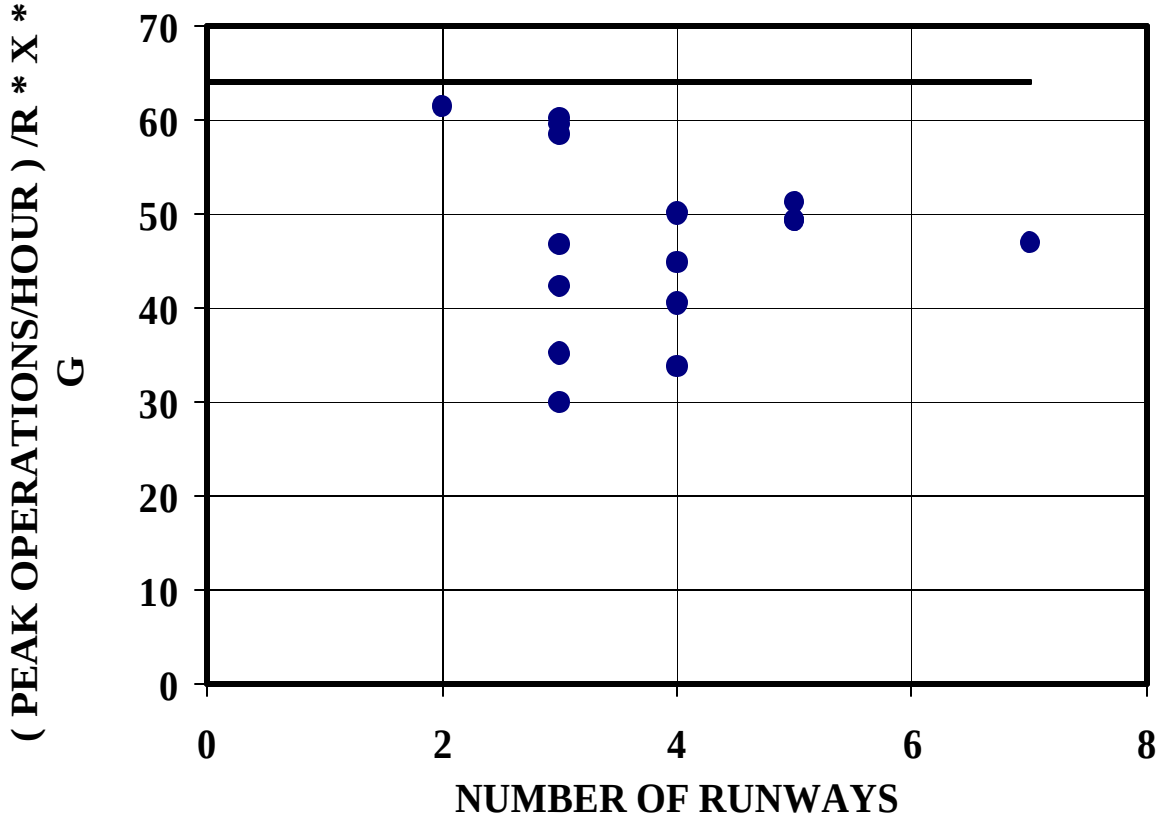
Airport & Current #Rwy	Condition	Current MAX Capacity	One Additional Runway	Two Additional Runways
Albuquerque (4)	VFR	125	125	
	IFR	45	80	
Port Columbus (2)	VFR	130	150	
	IFR	80	140	
Dulles (3)	VFR	179	191	
	IFR	159	172	
Raleigh Durham (2)	VFR	118	175	205
	IFR	90	95	95
Salt Lake City (2)	VFR	125	190	

Calculated with 50/50 mix of arrivals and departures

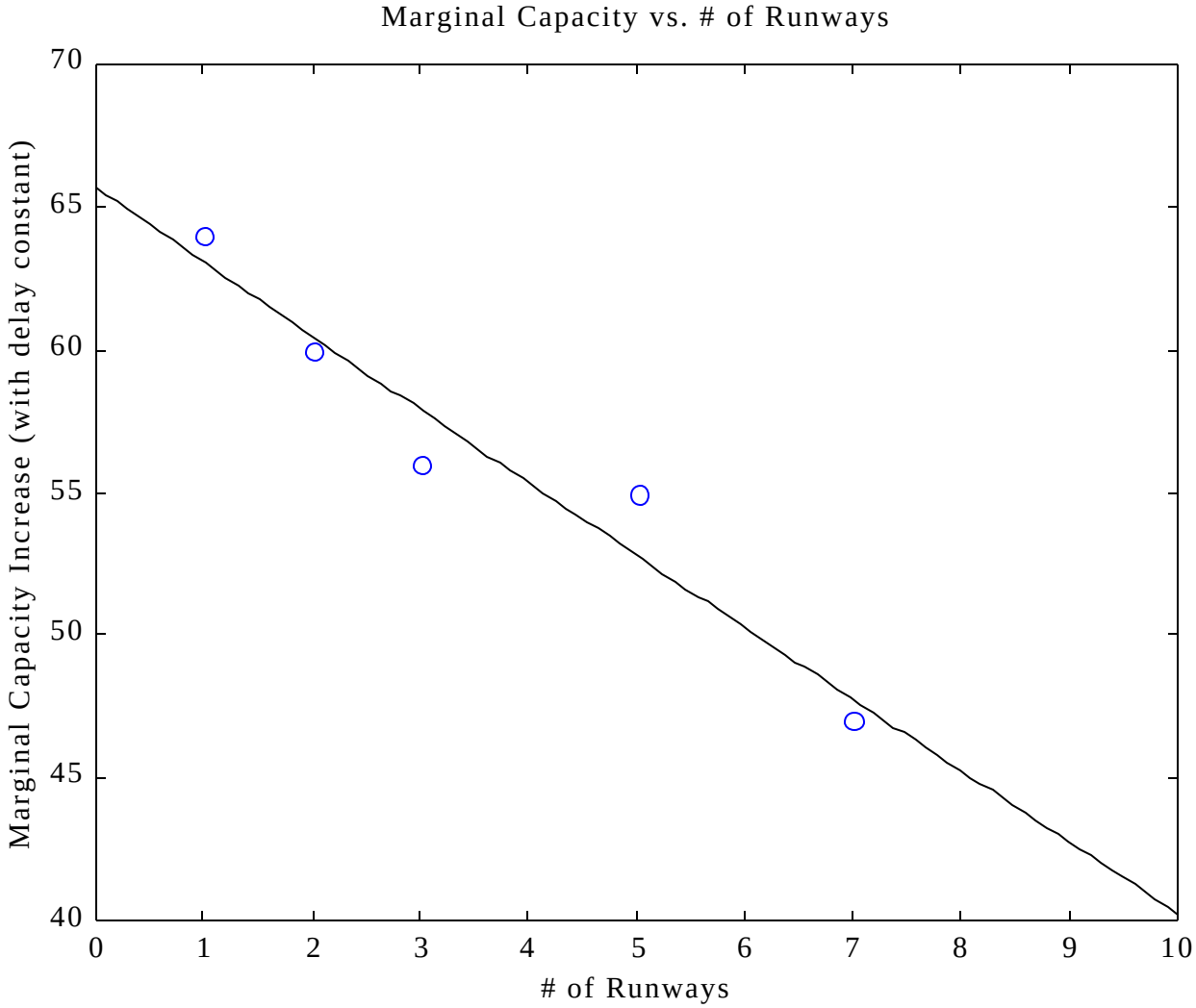
Additional Runway vs. Marginal MAX Capacity Increase (VFR)



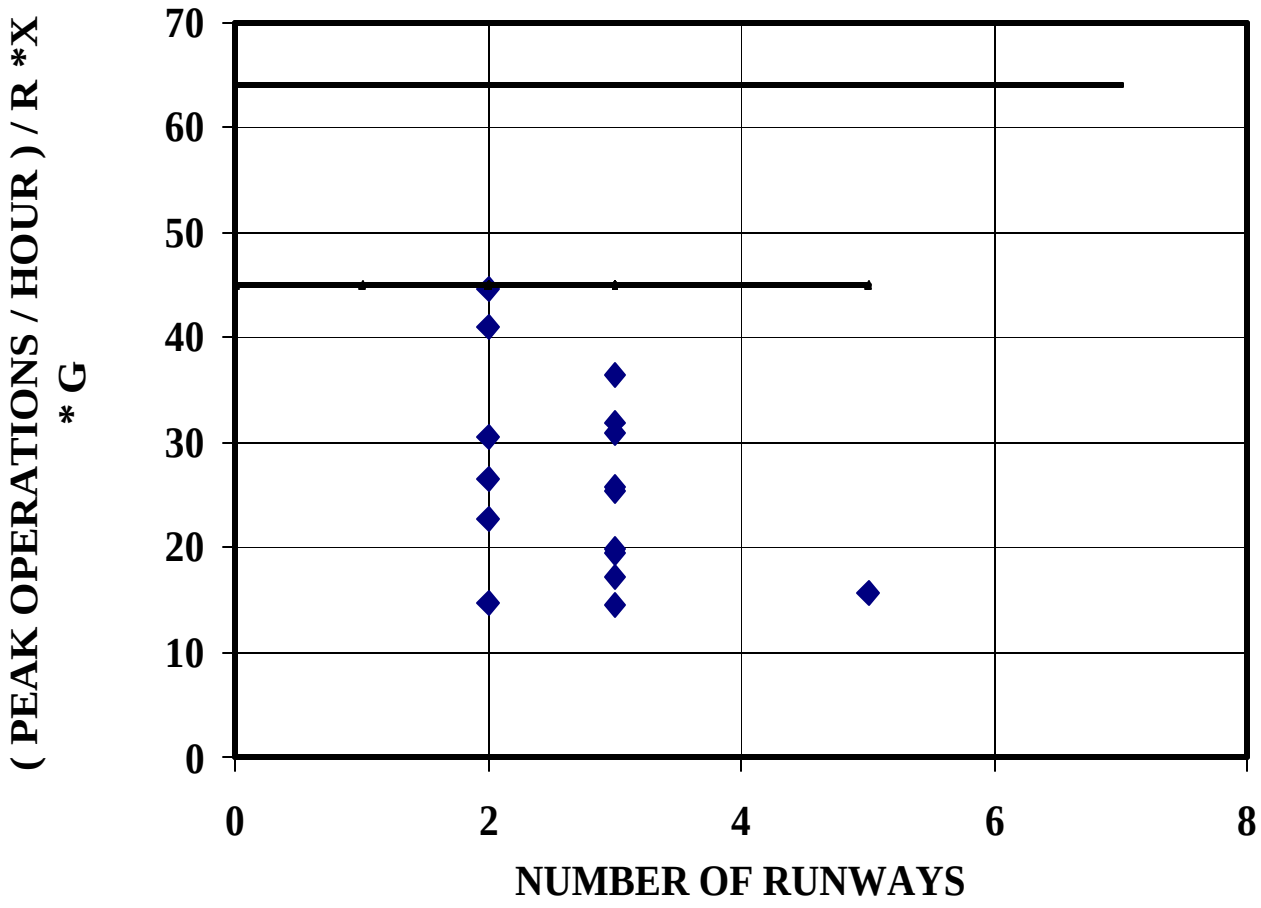
US Airport Runway Utilization
16 Airports in NE Triangle



Results from MCM



European Airport Utilization
16 Airports



Observations on Relative Capacity

USA	EUROPE
OPS/YR 7.6 (10^6)	OPS/YR 4.3 (10^6)
G/RW 26:1	G/RW 42:1
X=0.52	X=0.73
OPS/HR/RW < 64	OPS/HR/RW < 40

Conclusions

- Reduced aircraft spacing at an increased level of safety must be achieved in order to increase Hub and Spoke system capacity.
- Aircraft separation authority and responsibility must be transferred from ground ATC to the aircraft flight deck to decrease ATC feedback time constant.
- ADS-B requires DoD and Internationally Accepted Data Link Standards
- Adding more Runways to Large Hub Airports (>4) produces diminishing Capacity returns