



Do En Route Delays Matter? Some Preliminary Evidence

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Overview

- ❑ Assess the effect of en route delay on system delay
- ❑ Determine effect of en route delay to a particular flight on queuing delay at its destination airport
- ❑ Define and calculate a *delay multiplier* for flights delayed in ZID



Motivating Question (from Arnie Barnett)

TSA no longer requires passengers boarding flights to show ID. How much flight boarding delay does this save?



Answer to Motivating Question

~0. (The bottleneck is at the entrance to the plane.)

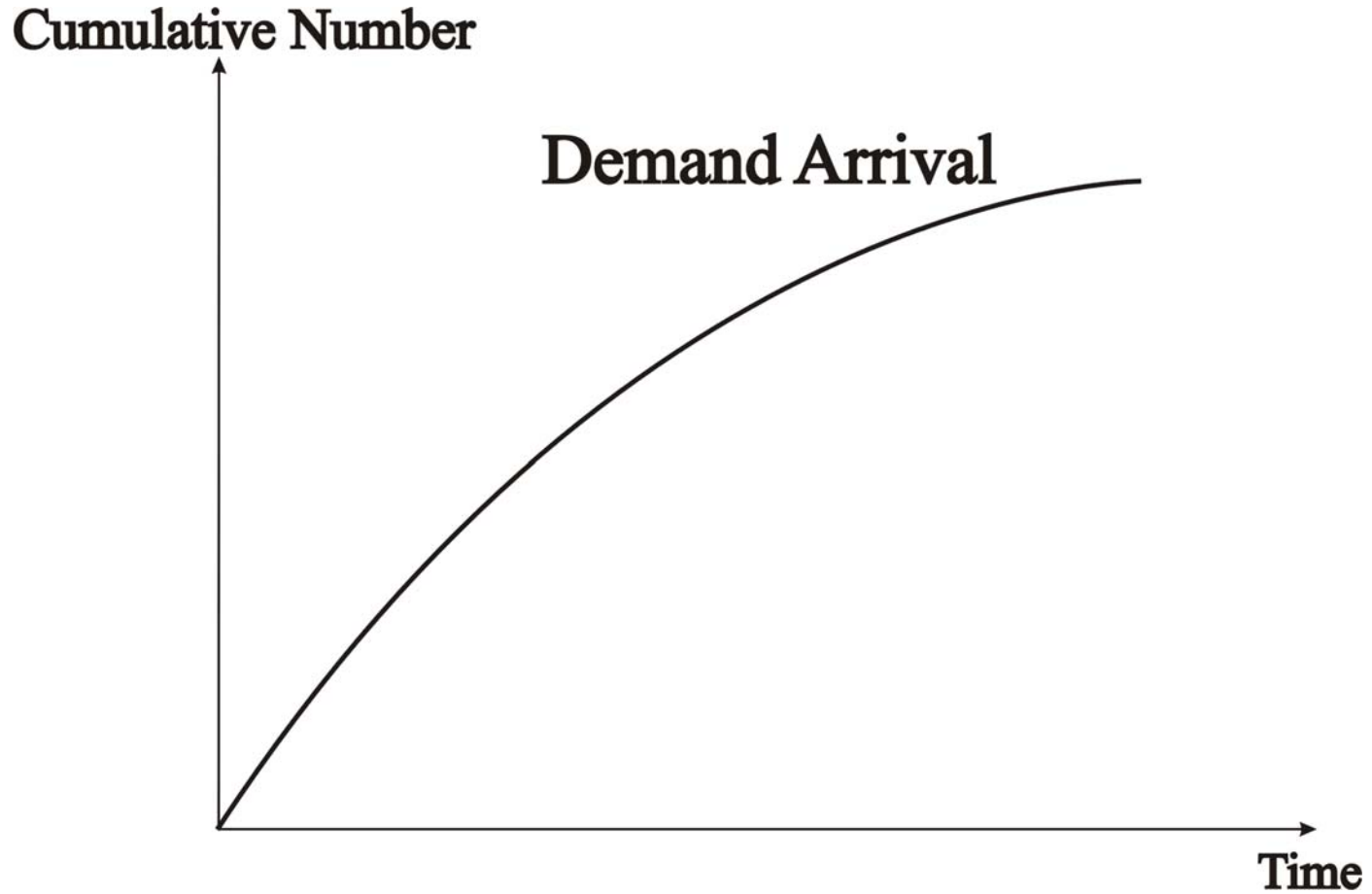


General Principle

- ❑ In a queuing situation the effect of an upstream delay on total delay is not obvious
- ❑ The effect may be
 - 0
 - A lot less than the upstream delay
 - About the same as the upstream delay
 - A lot more than the upstream delay

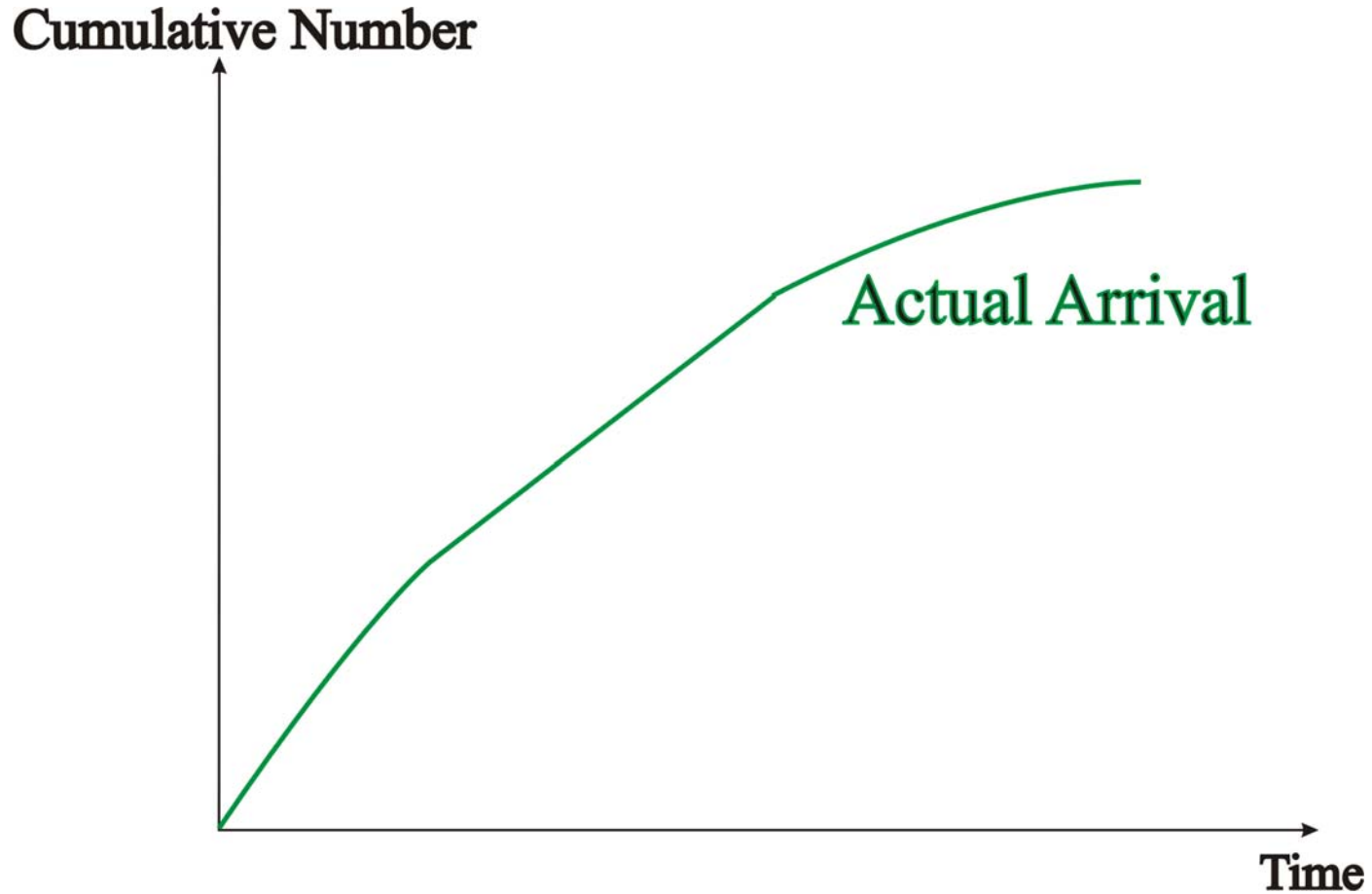


Queuing Diagram



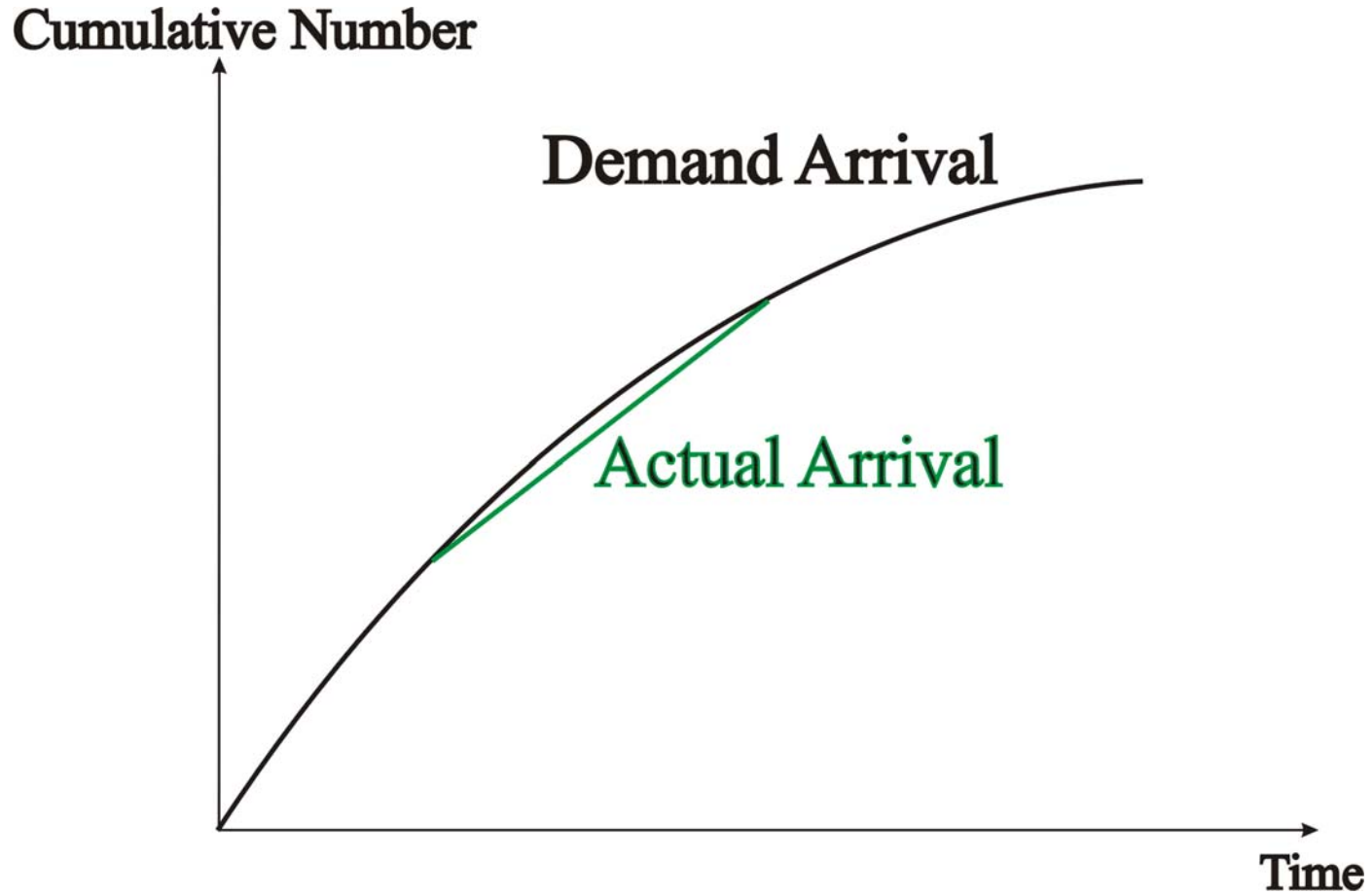


Queuing Diagram Cont.



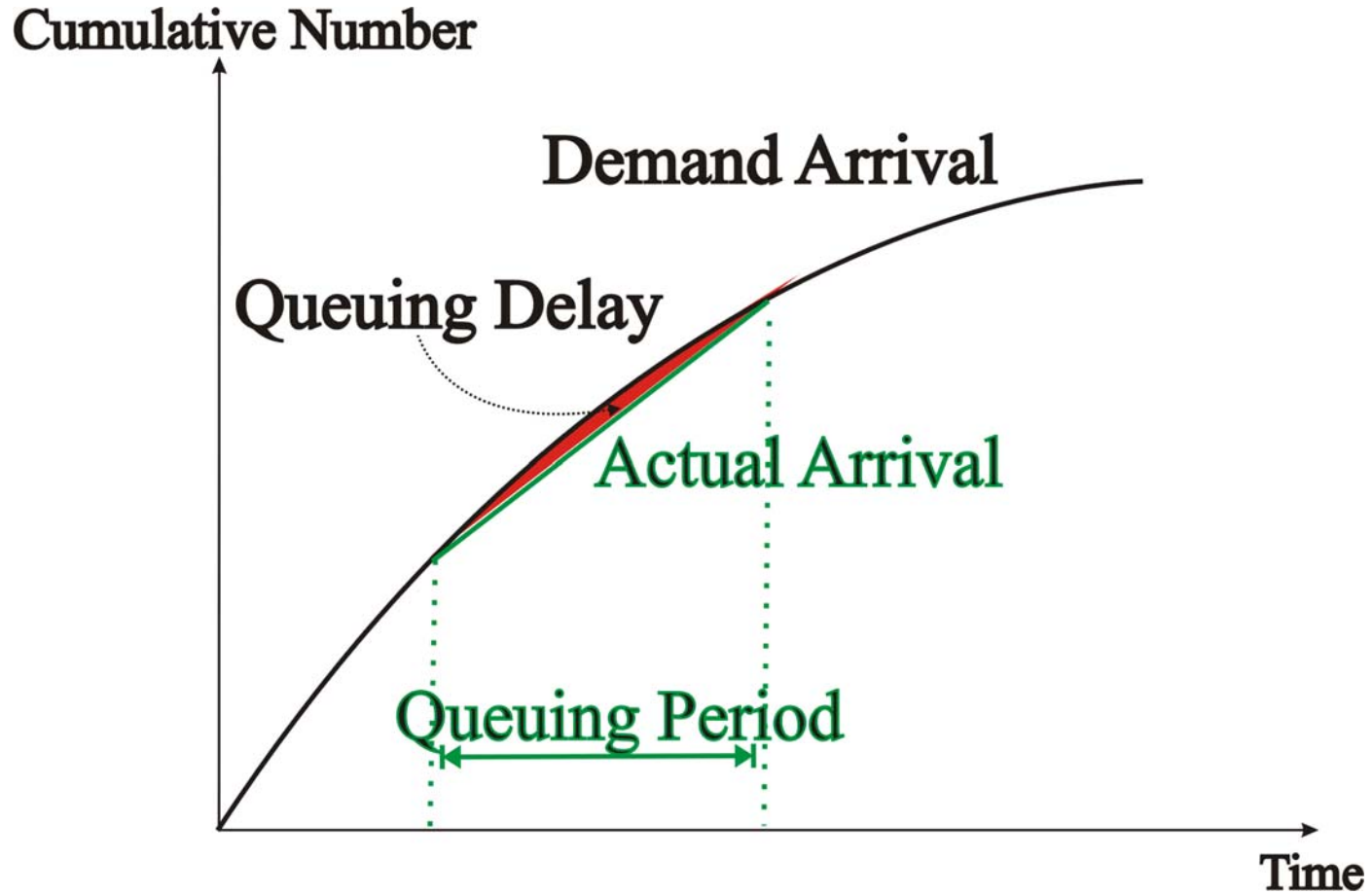


Queuing Diagram Cont.



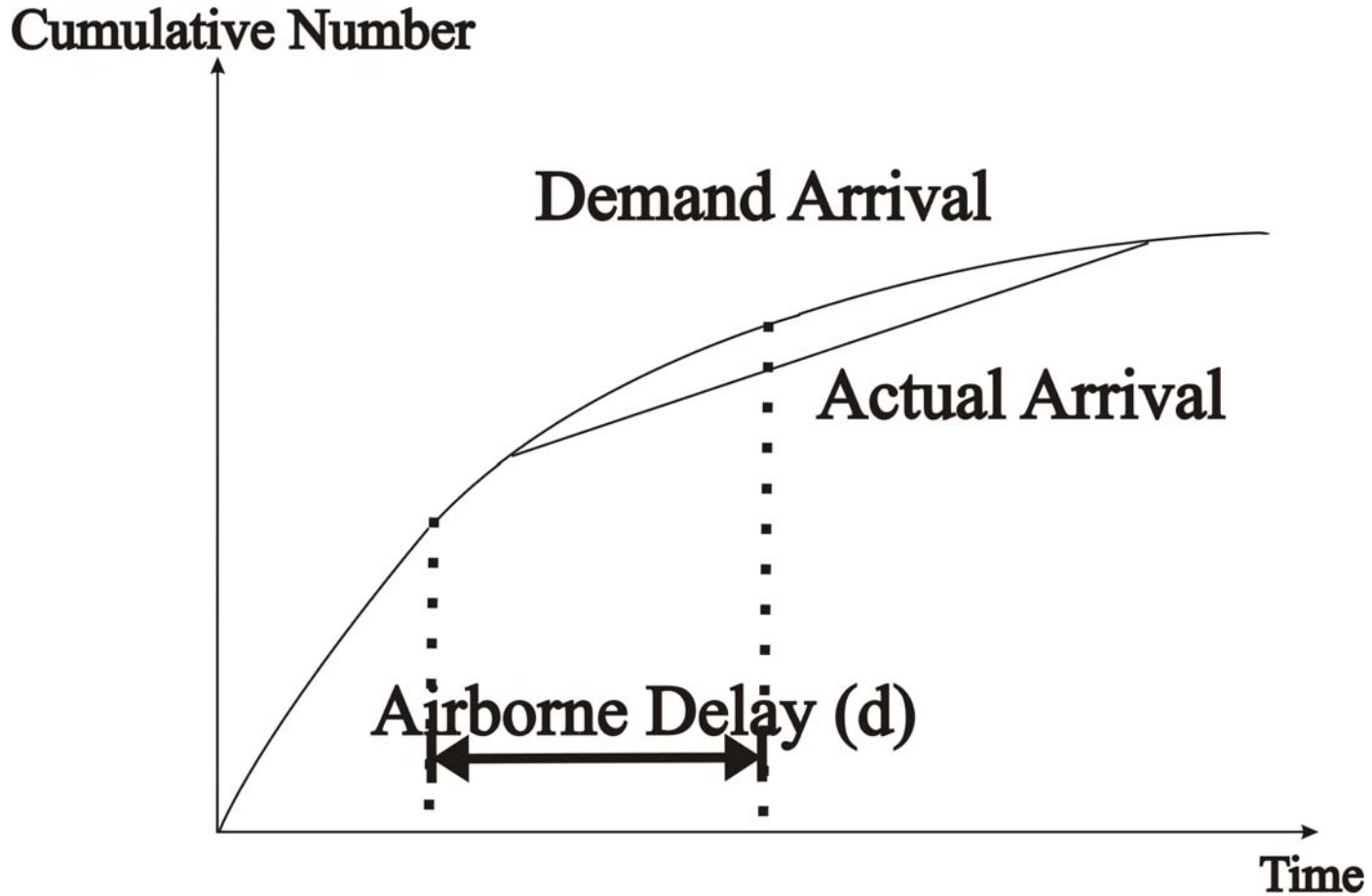


Queuing Diagram Cont.



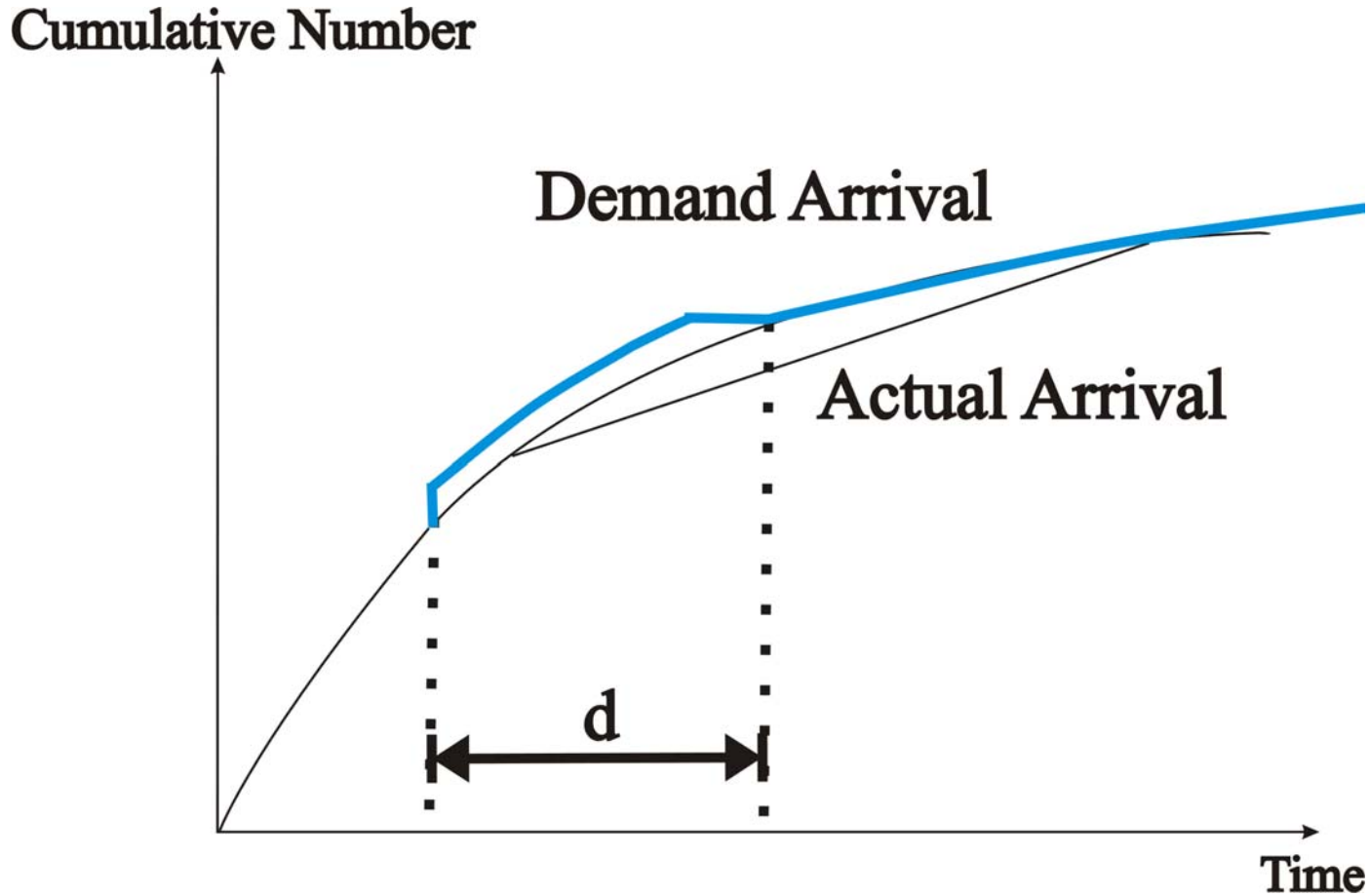


System Delay Impact of En Route Delay (example 1)



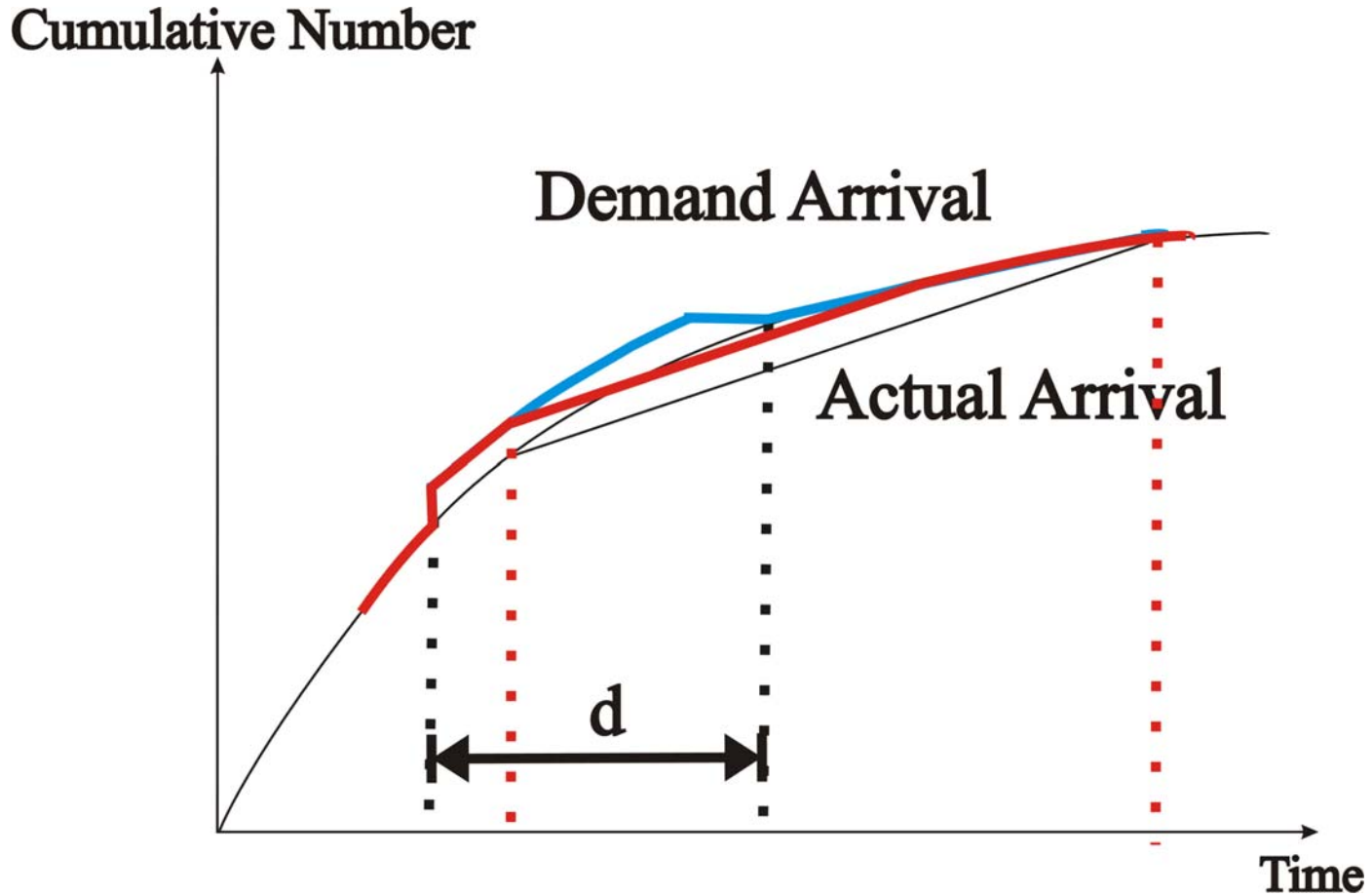


System Delay Impact of En Route Delay (example 1) Cont.



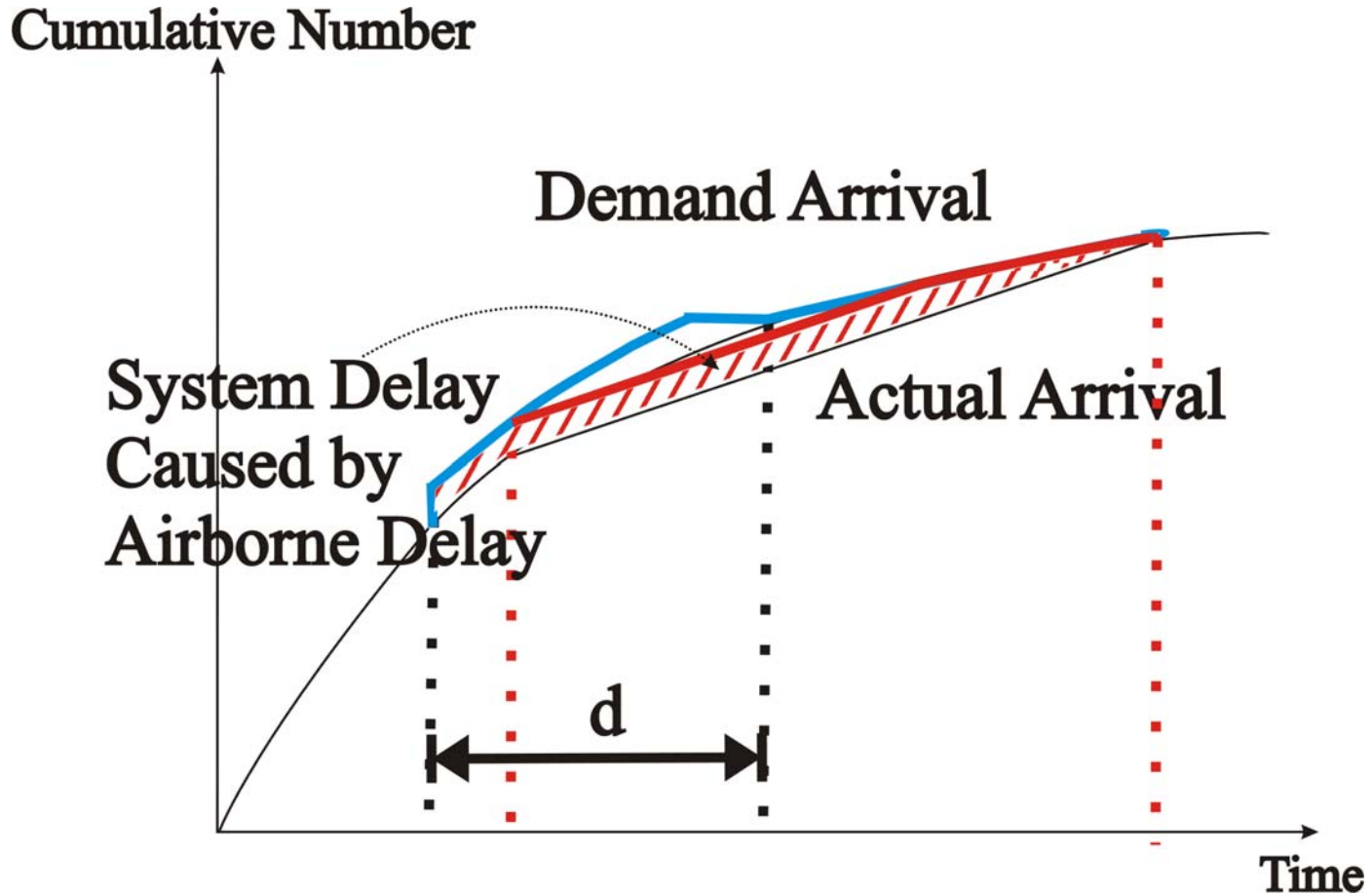


System Delay Impact of En Route Delay (example 1) Cont.



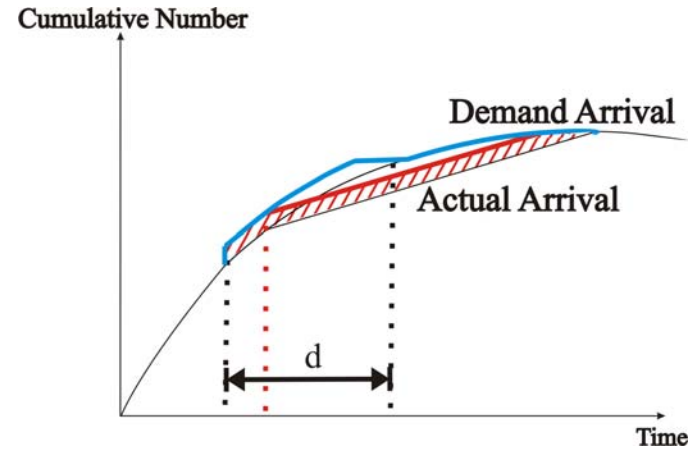
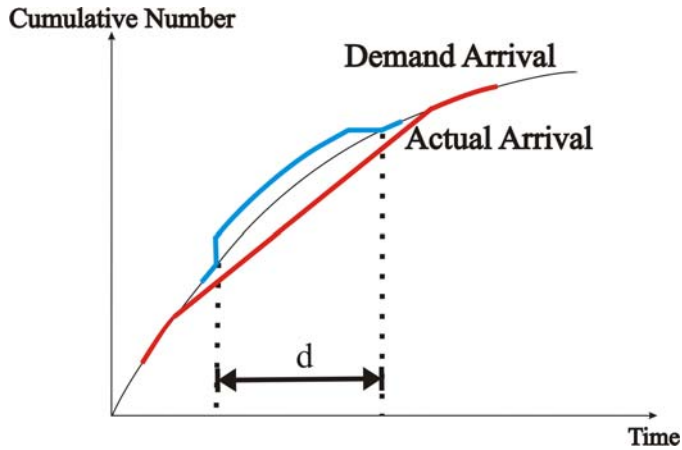
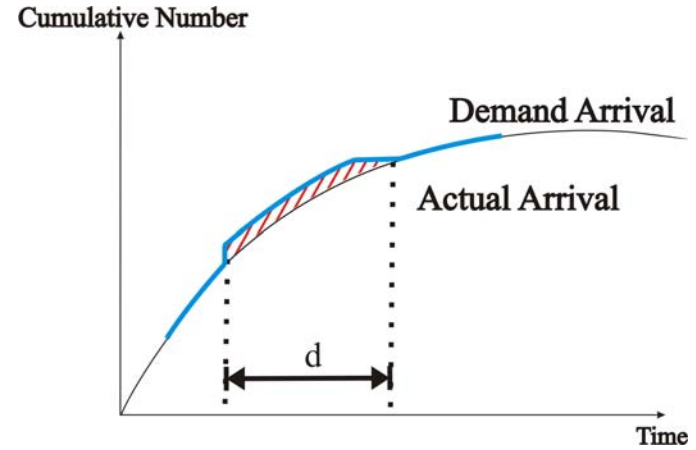
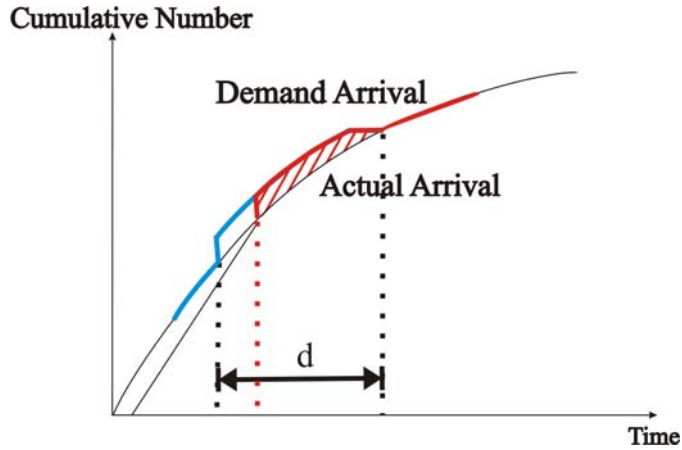


System Delay Impact of En Route Delay (example 1) Cont.





System Delay Impact of En Route Delay All Cases





Delay Multiplier

$$M = \frac{\Delta d_s}{d_E}$$

Change in system
delay caused by en
route delay

d_E

En route delay
duration



Measuring M

❑ Simulation

- Introduce an “exogenous” en route delay to a specific flight
- Observe change in system delay that results
- Somewhat tedious

❑ Estimation from operational data

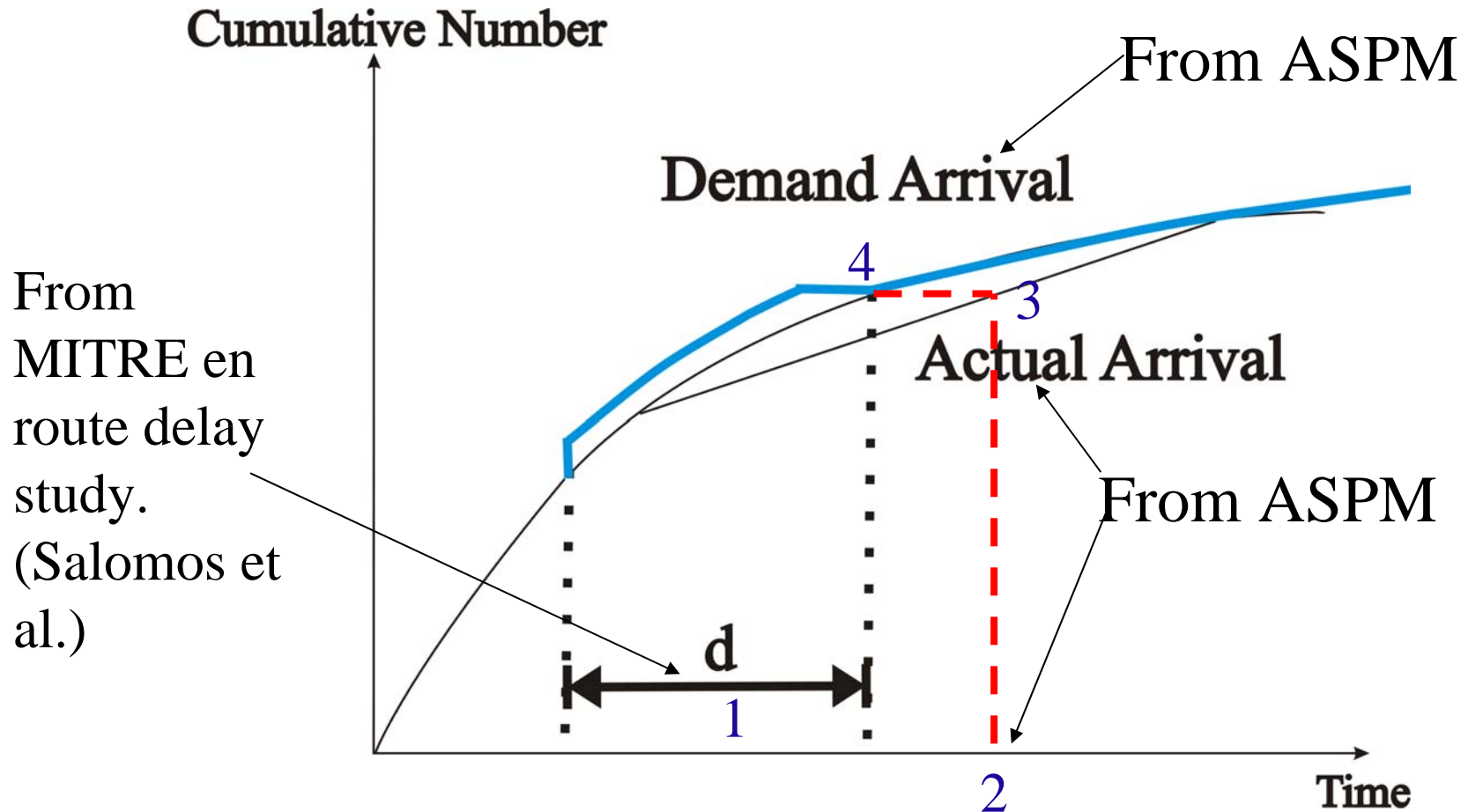


Estimation Procedure

- ❑ Measure an en route delay, d_f , for flight f
- ❑ Determine when flight f arrived at destination
- ❑ Estimate when f joined the arrival queue assuming FIFO
- ❑ Assume that without the en route delay f would have joined the queue d_f minutes sooner
- ❑ Calculate how earlier arrival would have affected total arrival delay at destination airport



System Delay Impact of En Route Delay



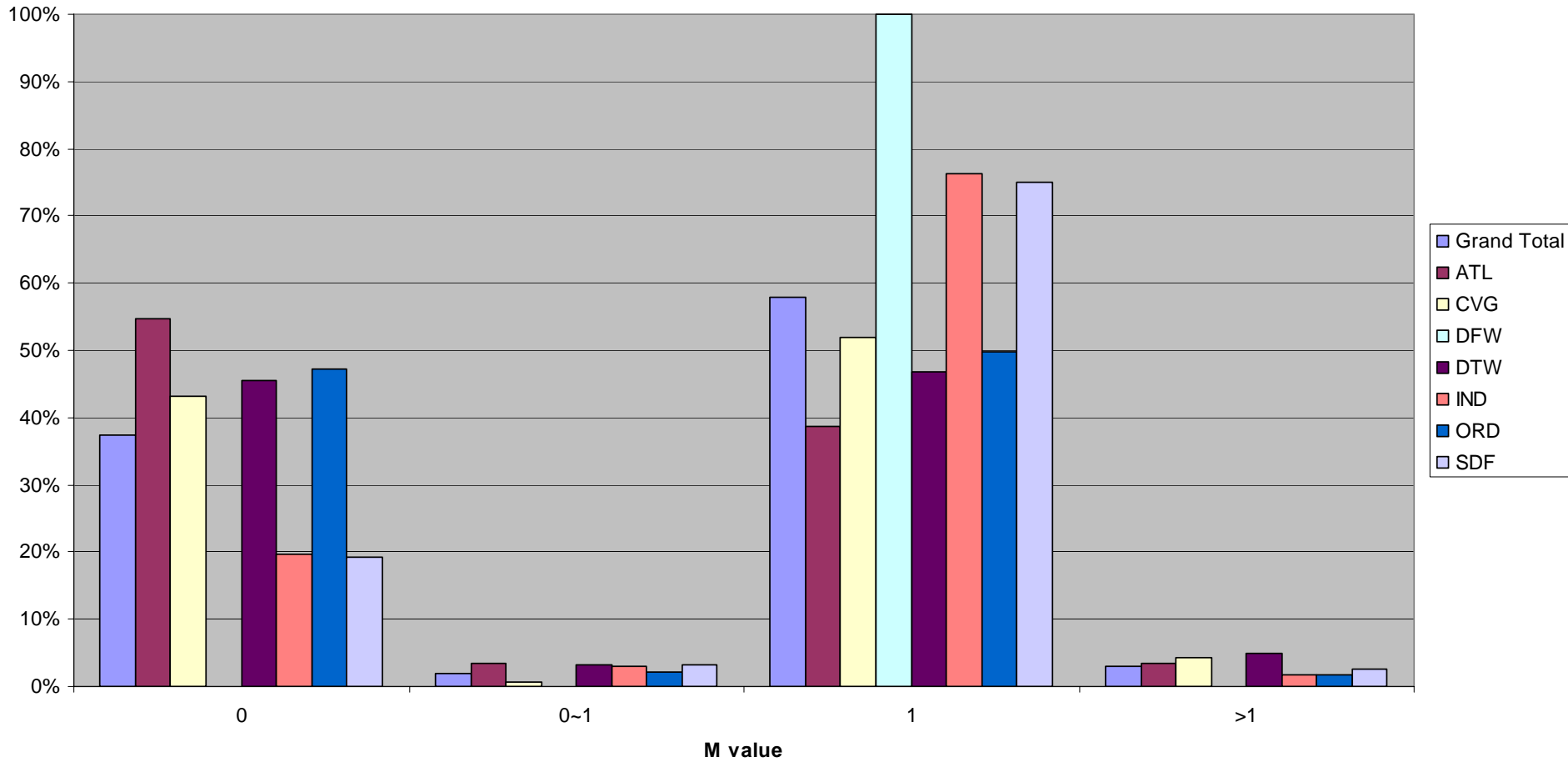


Results

- ❑ En route delays in ZID for a specific day
- ❑ Seven destination airports: ATL, CVG, DFW, DTW, IND, ORD, SDF
- ❑ ~2000 flights

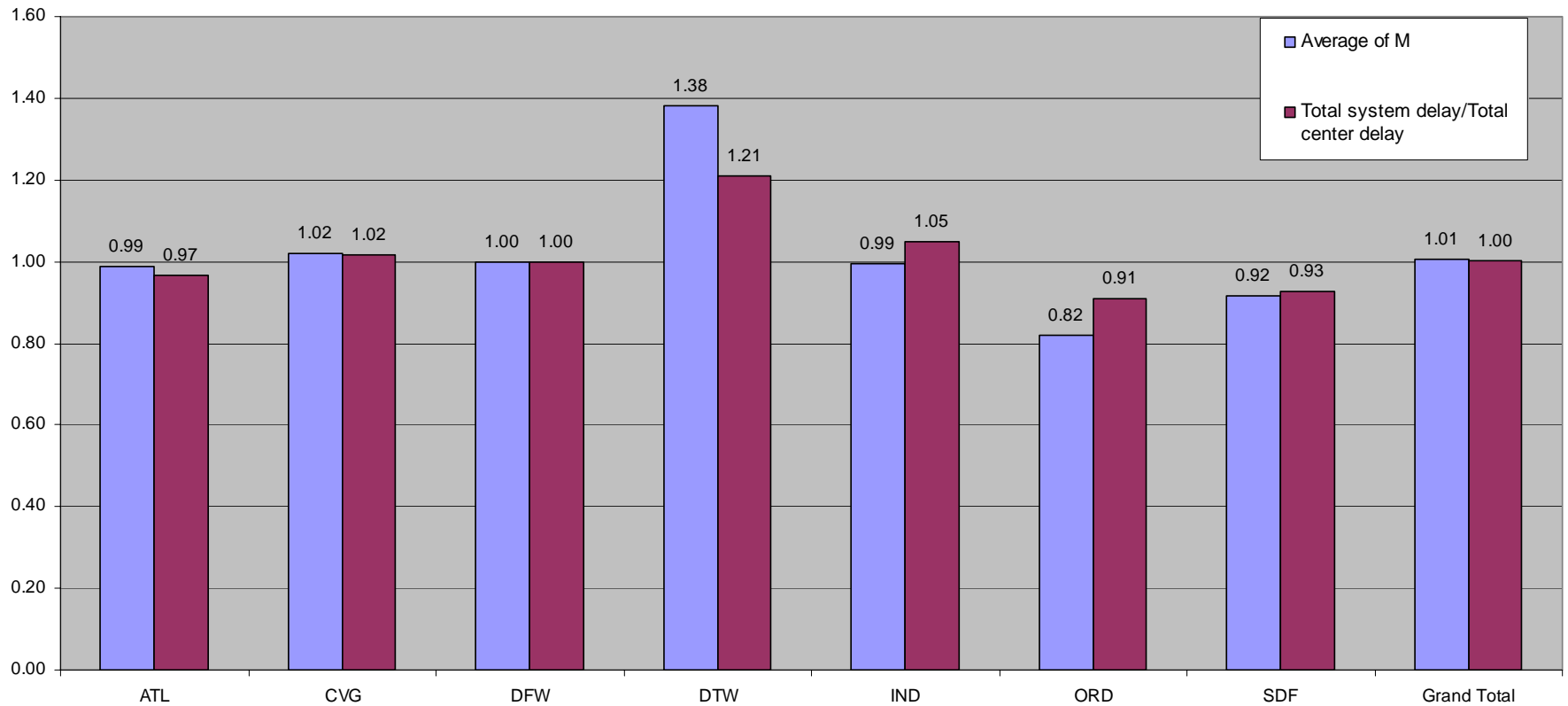


M-Value Distributions





M Value Averages



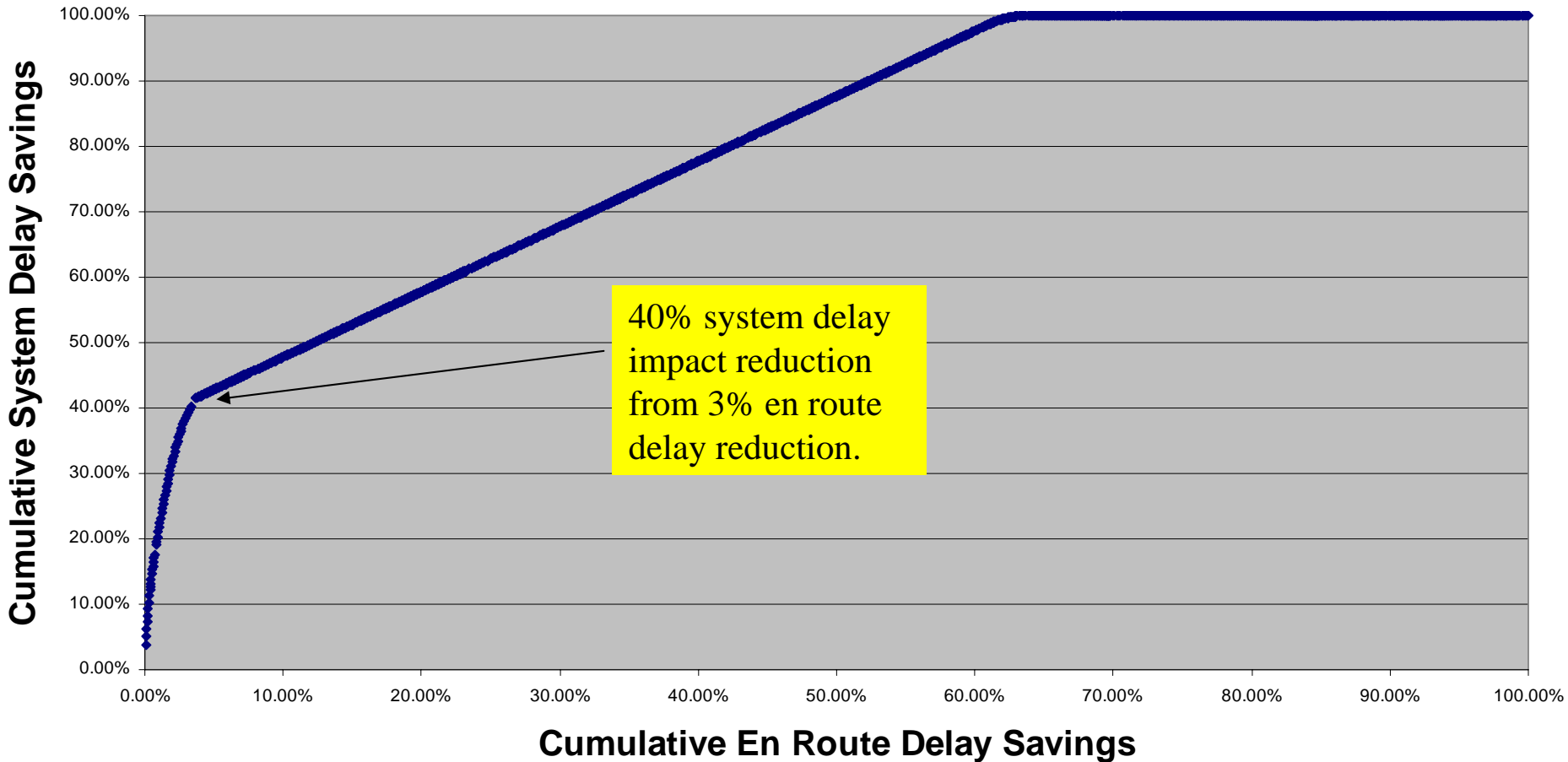


Targeting En Route Delay Reductions

- Identify flights with high and low M values in real time
- Give priority to high M value flights



Potential for Targeting En Route Delay Reductions





Conclusions

- ❑ Not a 1-to-1 mapping of en route delay to system delay
- ❑ *On average* 1 minute of en route delay causes 1 minute of system delay
- ❑ But there is a large variation in impact
- ❑ Implications for
 - Measuring sector performance
 - Prioritizing flights in real time



Thanks to

- ❑ Steve Bradford, Rich Jehlen, Diana Liang at FAA
- ❑ George Solomos at MITRE
- ❑ Jasenka Rakas at UCB