

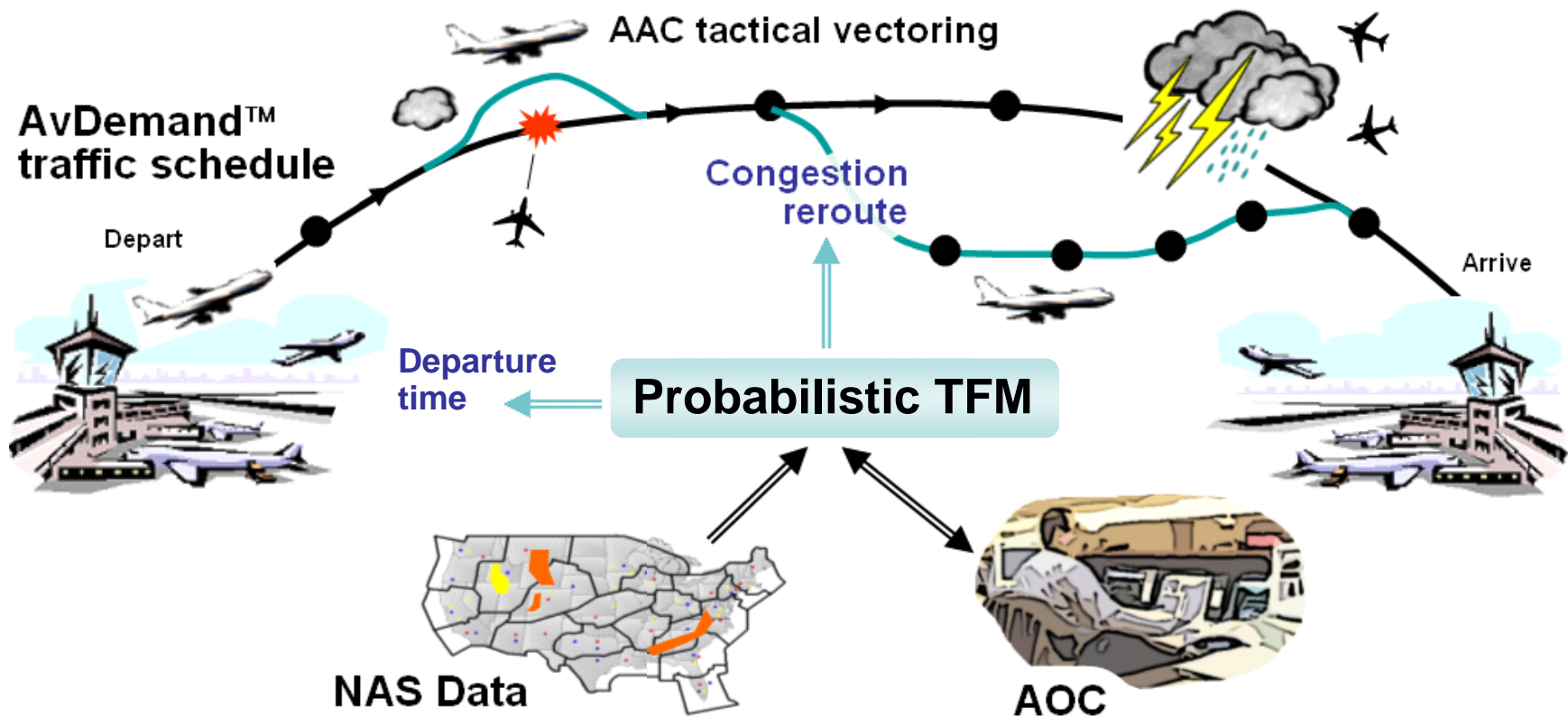
National Airspace System Probabilistic Traffic Flow Management in Inclement Weather

March 15, 2006

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Ari Stassert, Anna Drabowski, Jim Phillips, Alex
Huang, Fred Wieland, Greg Carr

Sensis Technology Center

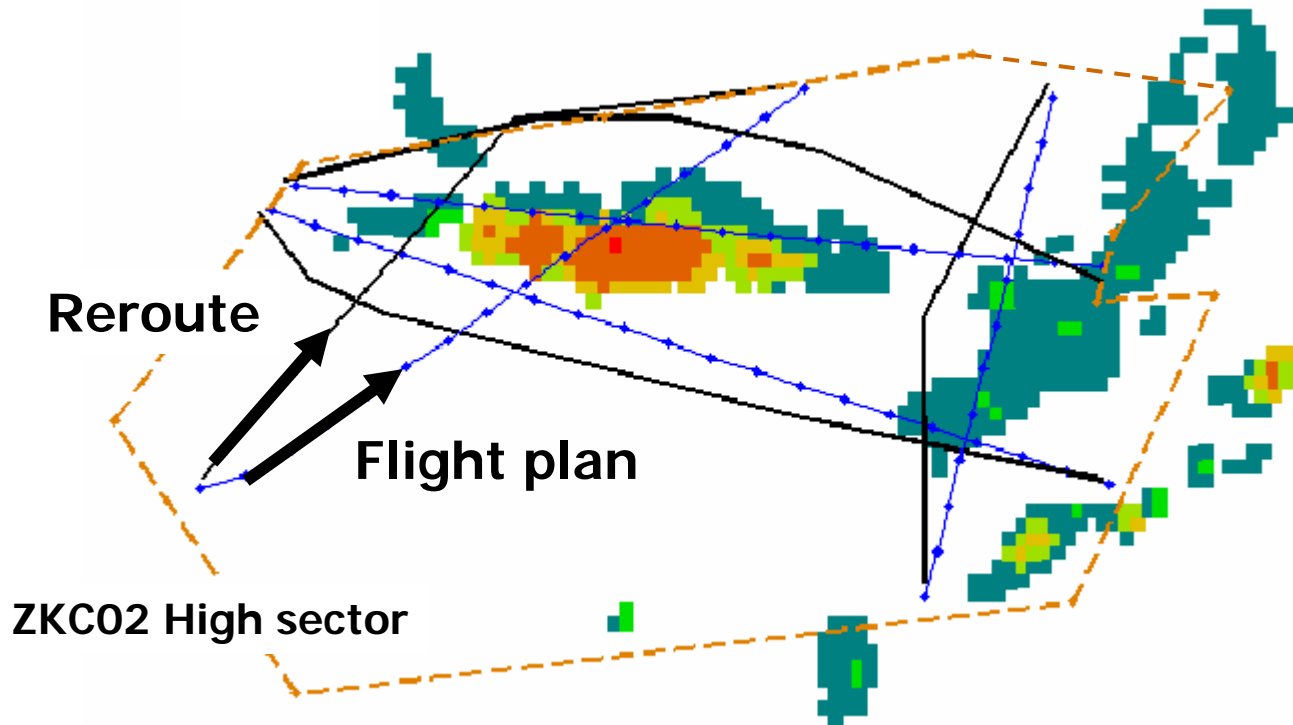
Probabilistic TFM



Trajectory-based Weather Impact

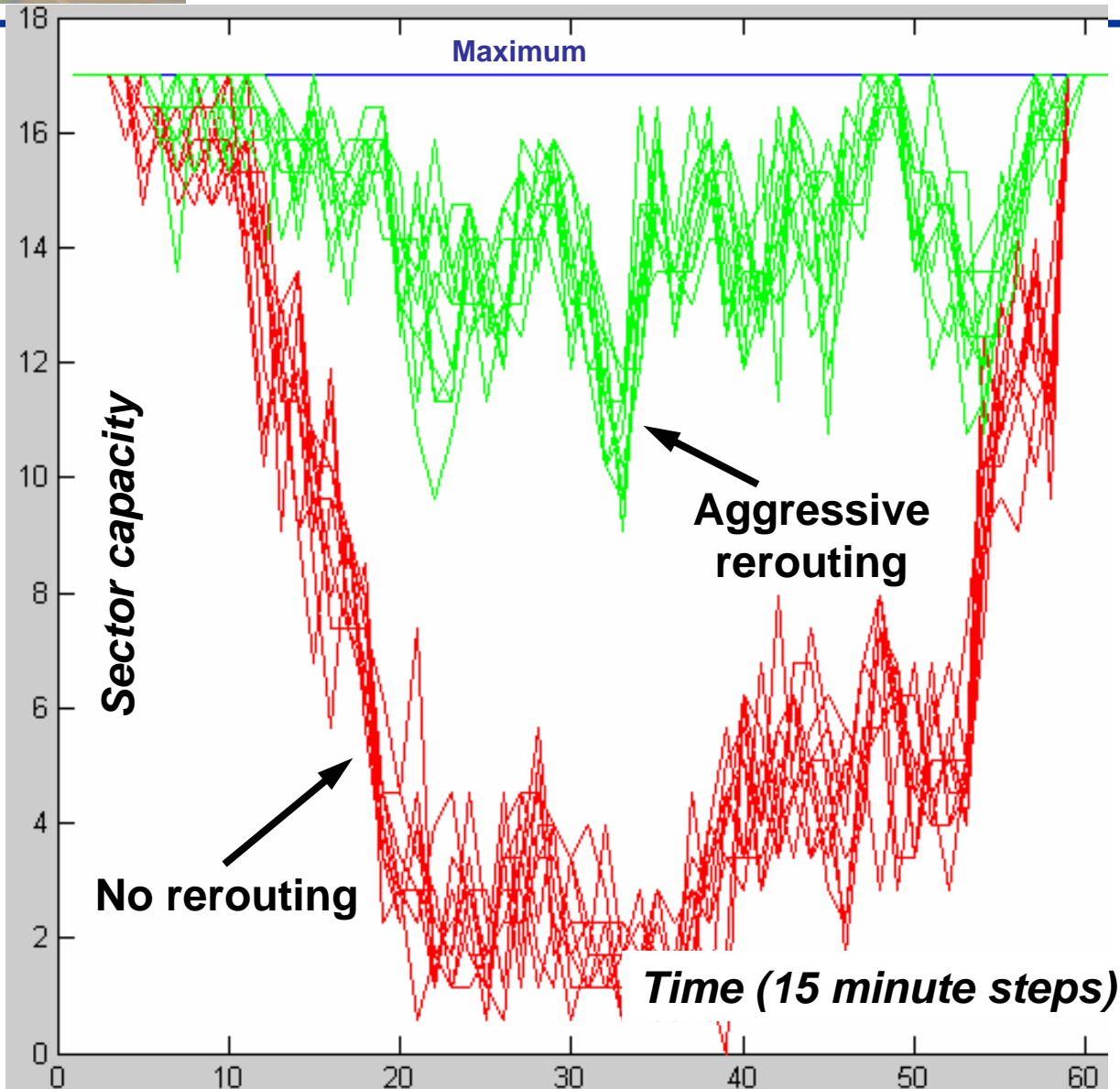
Analyze specific trajectory, not just flow through sector

Analyze Wx impact on the specific trajectory



Count a route as unavailable only if reasonable reroutes are also unavailable

Sector Capacity PDF

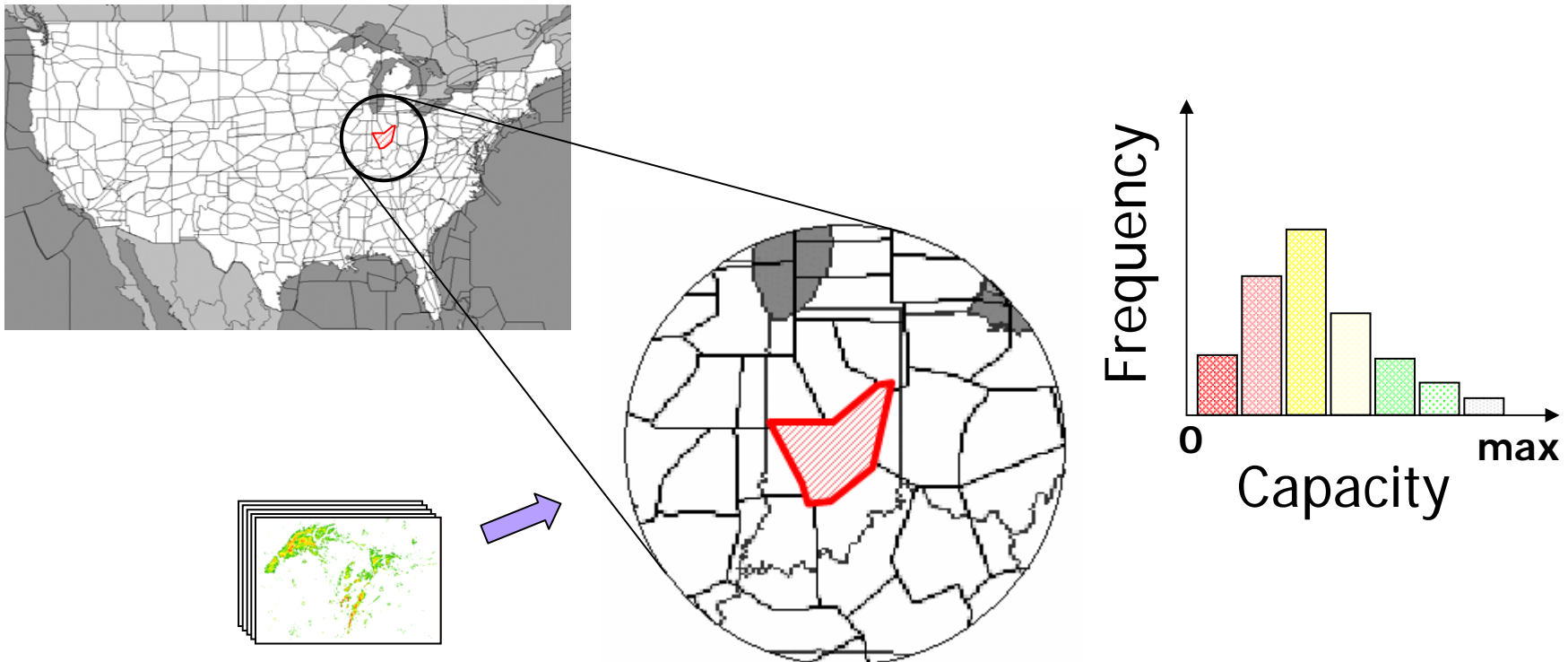


Example MSC' results for May 10, 2004. Sector ZKC02. Randomly select 30 flights that transit the sector and compute upper and lower bounds. Repeat this 10 times to check for convergence.

Result: Good convergence found. 30 flights selected at random reproduce upper and lower bound estimates with low variance.

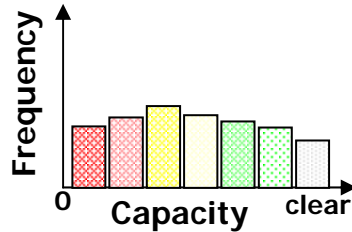
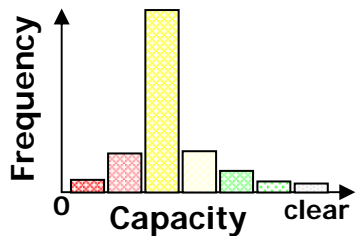
Uncertain Storm Forecast

- Result: A forecasted sector capacity probability distribution function (PDF)
 - For all sectors, all time horizons, all time slots



Computing Airspace Demand and Capacity Probability

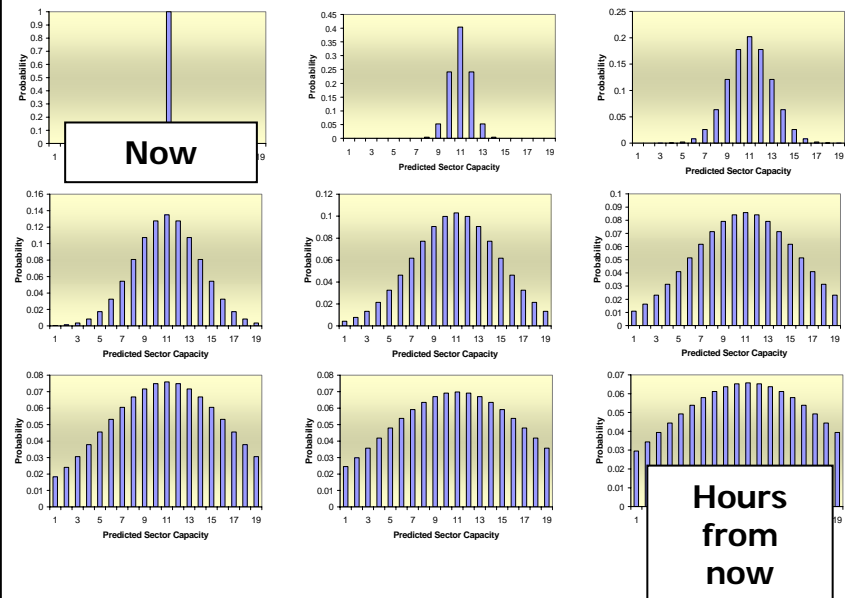
Sector Capacity Probability



- Short look-ahead time
- Clear weather
- Extreme weather
- Accurate storm forecast
- Long look-ahead time
- Medium convective weather
- Inaccurate storm forecast

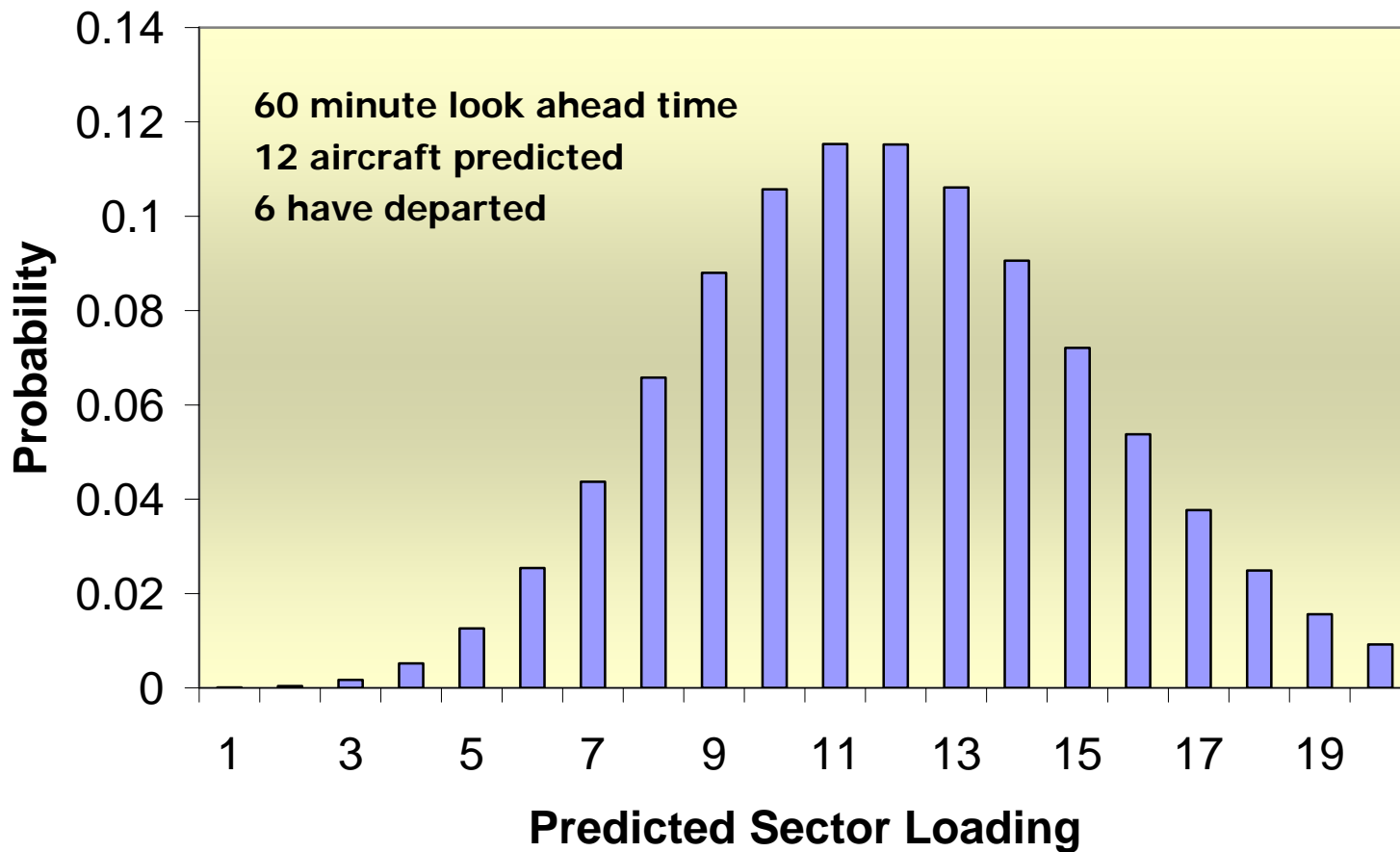
Many factors impact PDF shape

Sector Capacity Probability

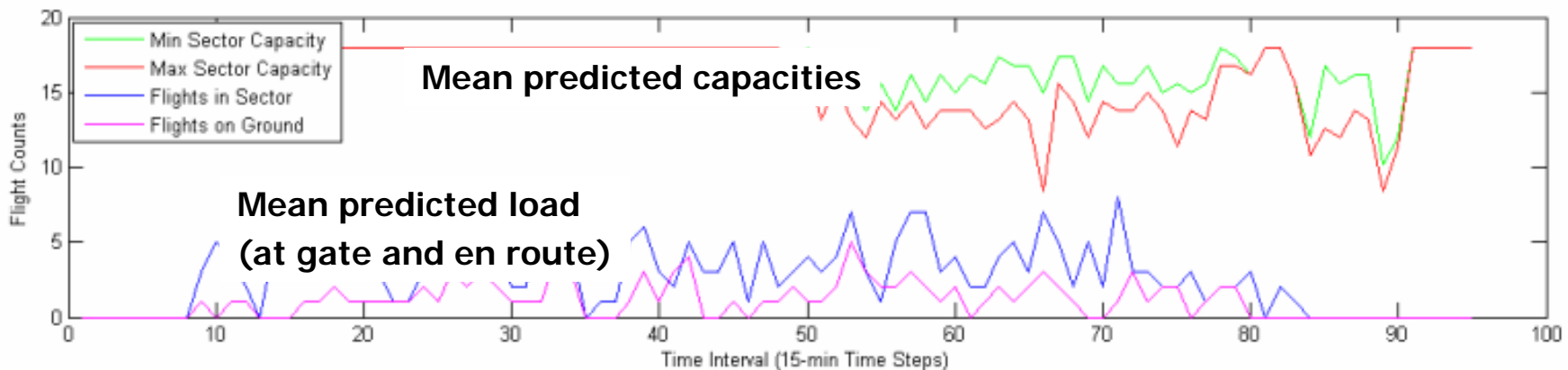
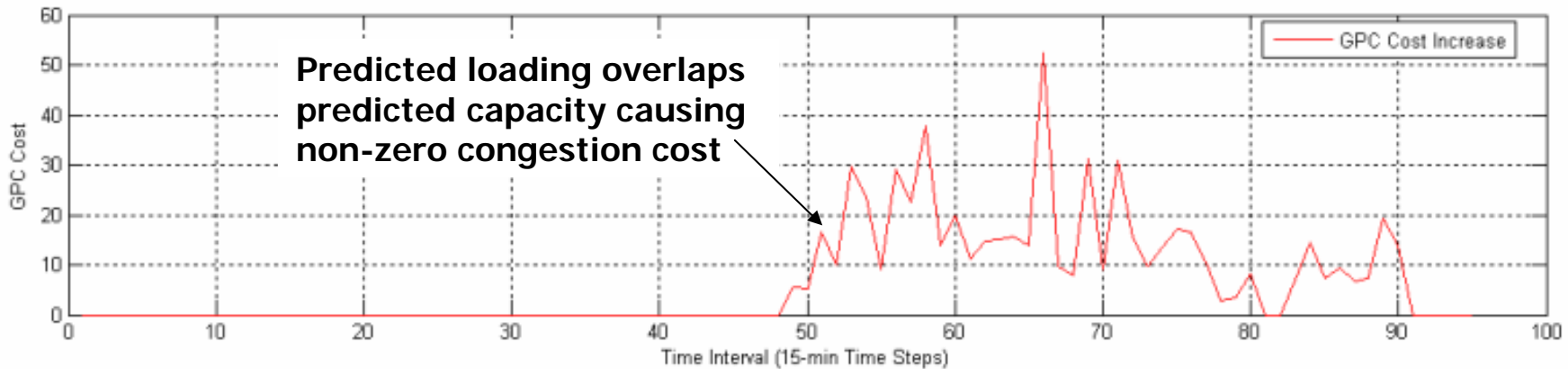


Capacity uncertainty grows dramatically with length of look-ahead

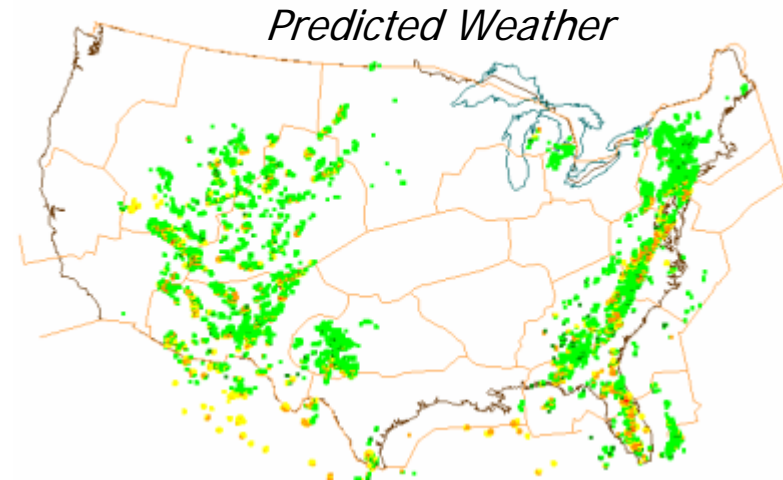
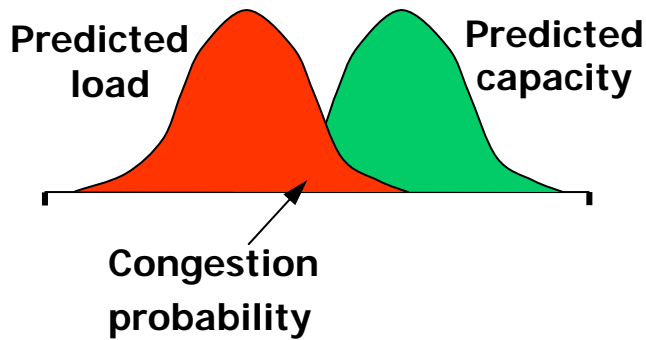
Example Sector Loading PDF



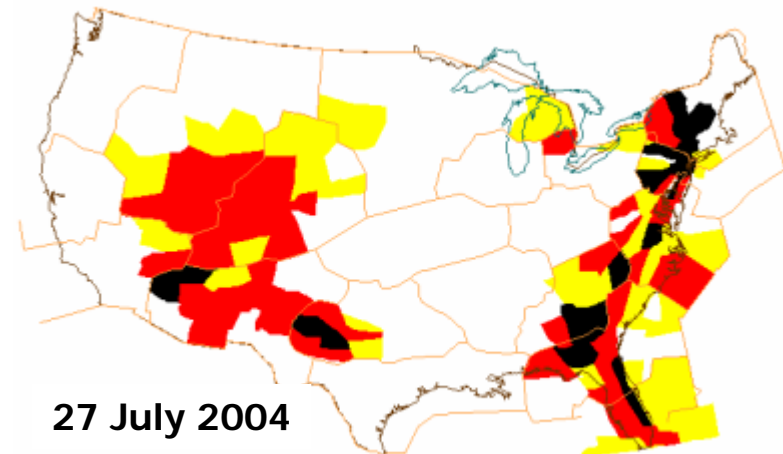
Congestion Cost Time History



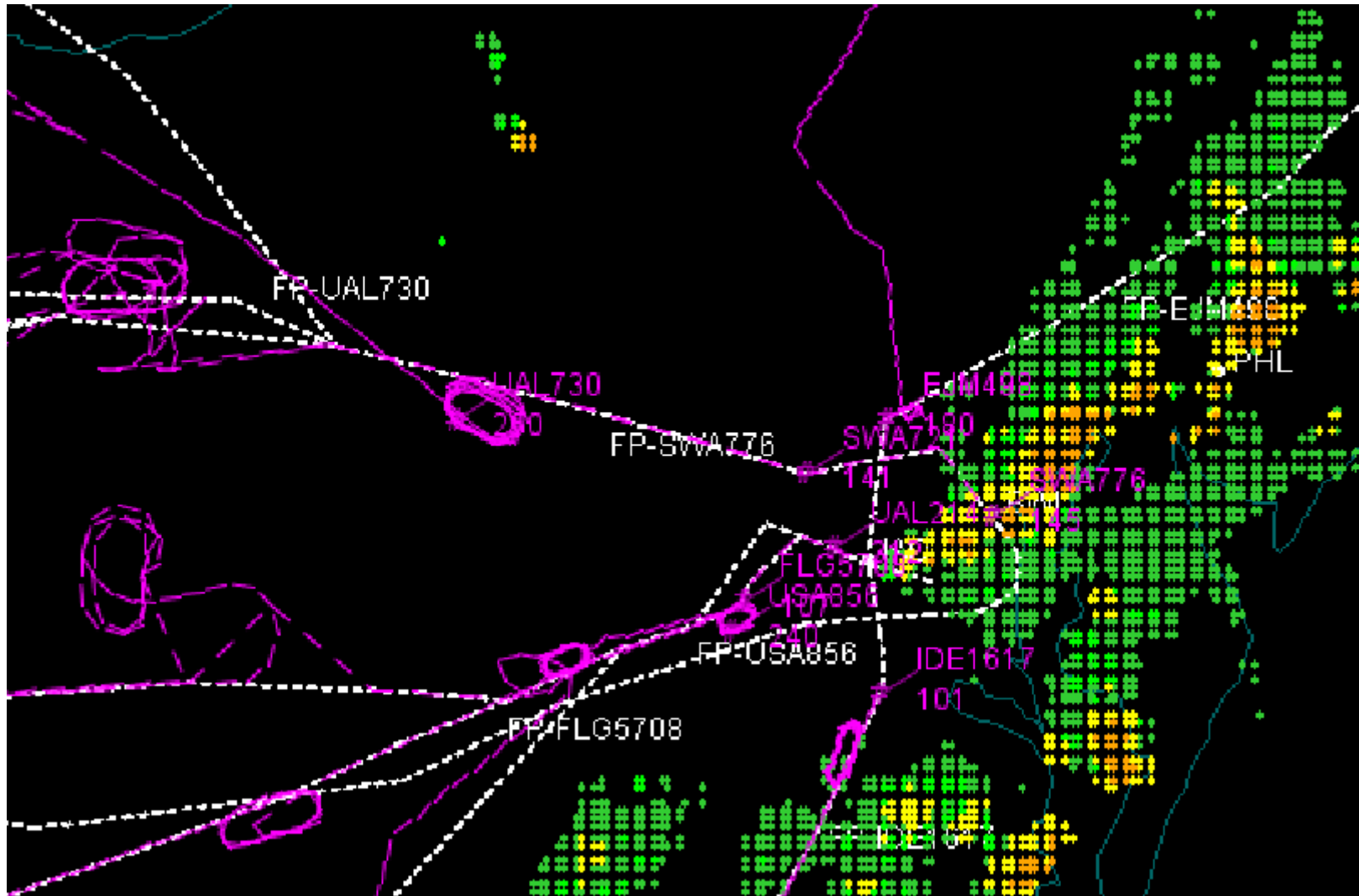
Congestion: Load vs Capacity



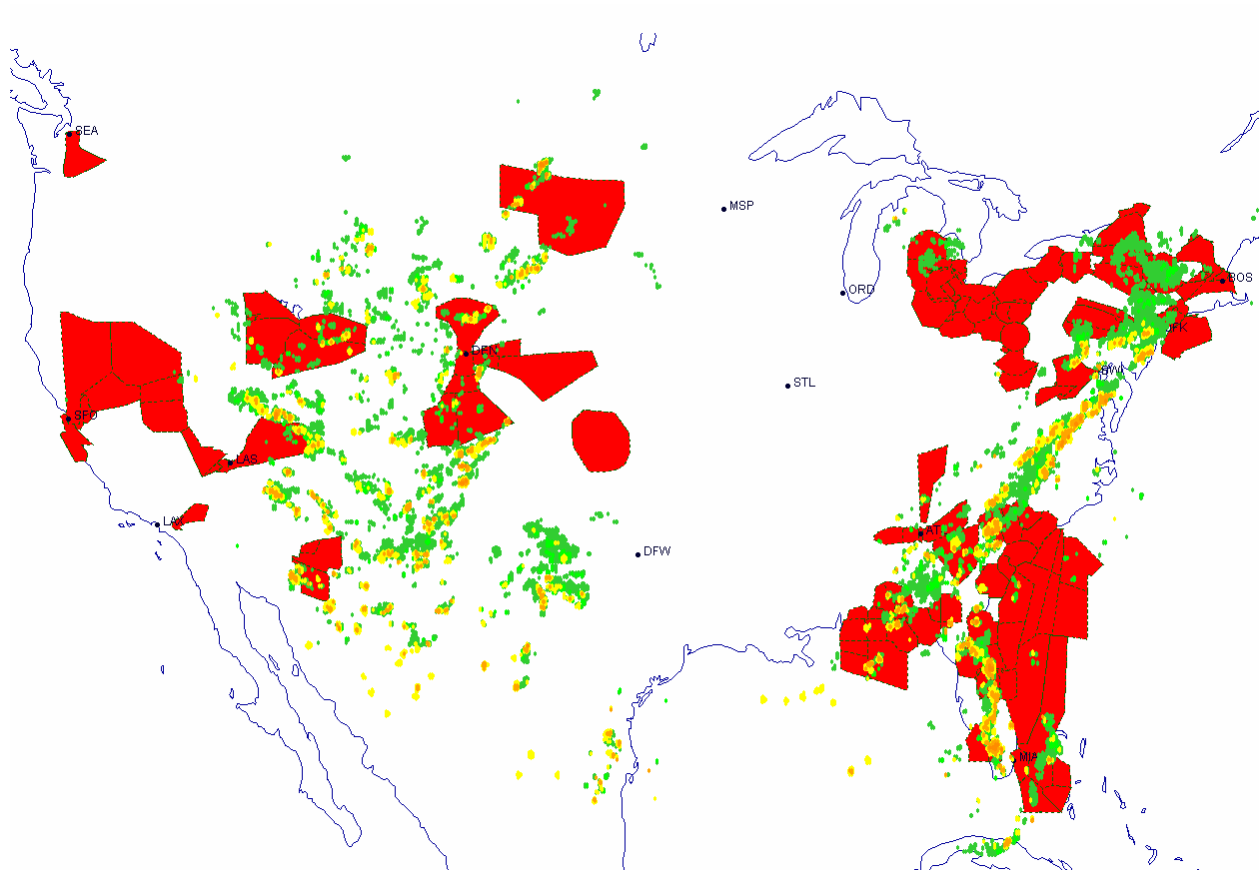
Congestion map: a combination of the predicted weather impact and predicted traffic



0145 MidAtlantic, 27Jul04

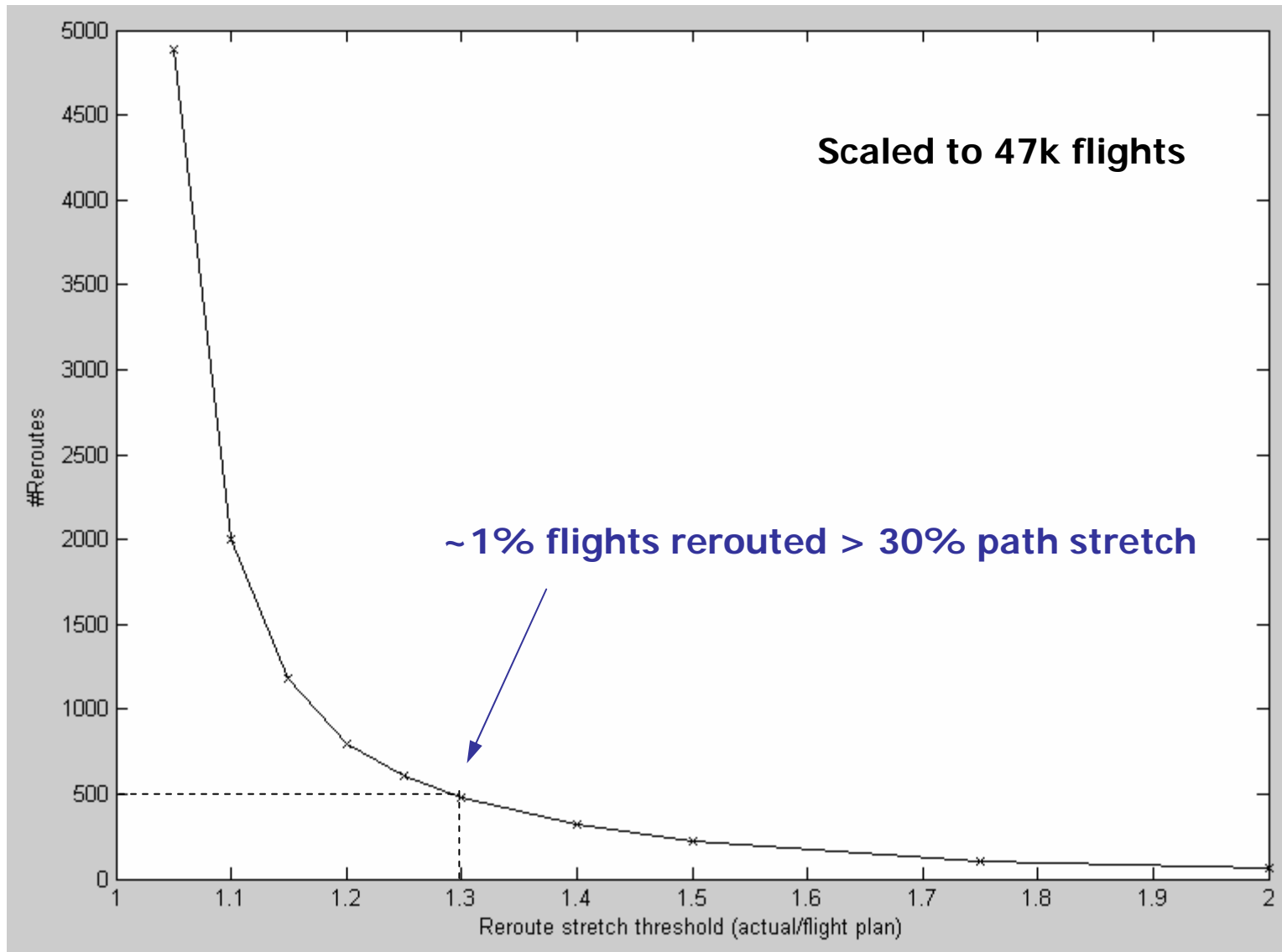


2200 Congestion Map



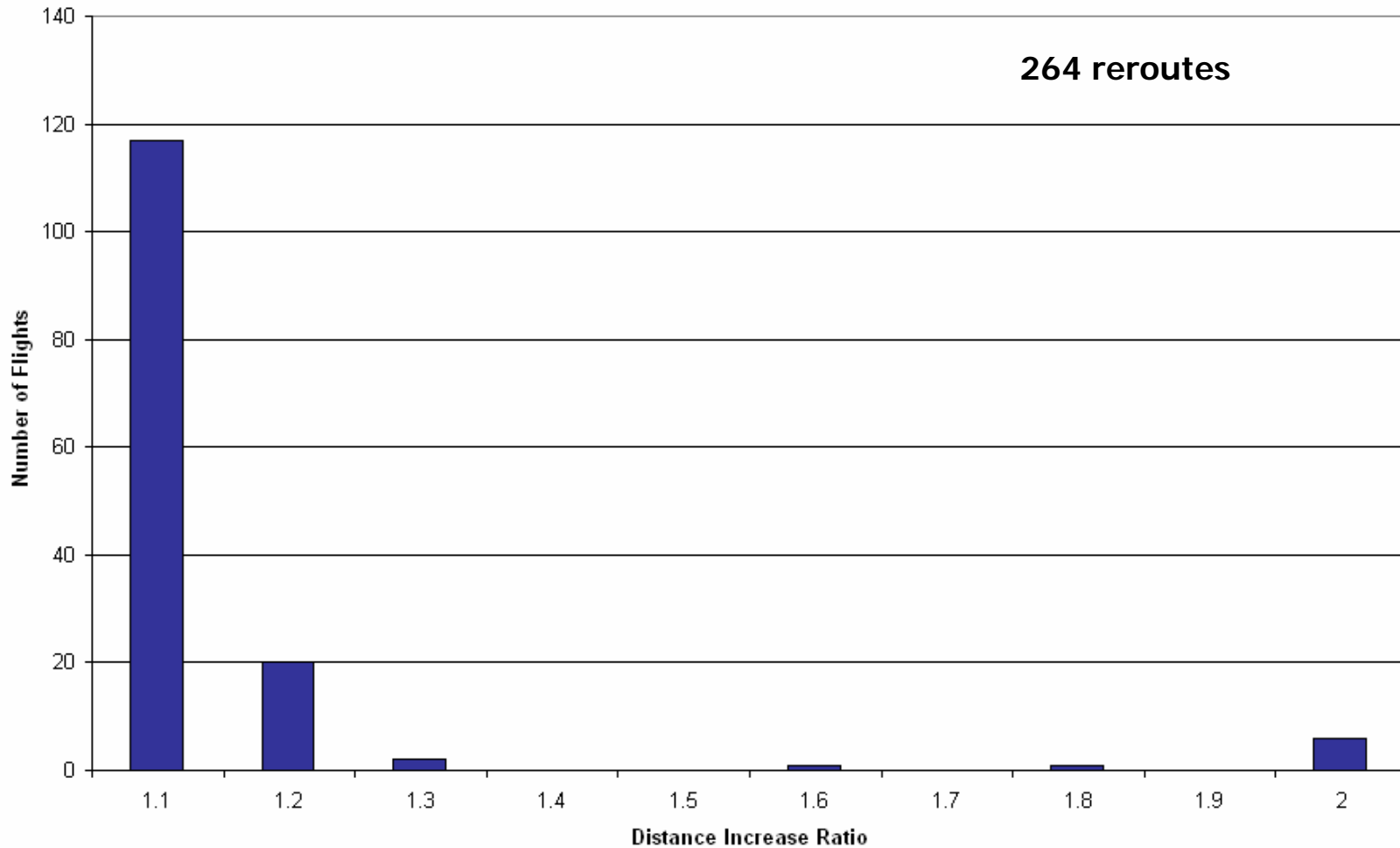


ETMS Reroute Count

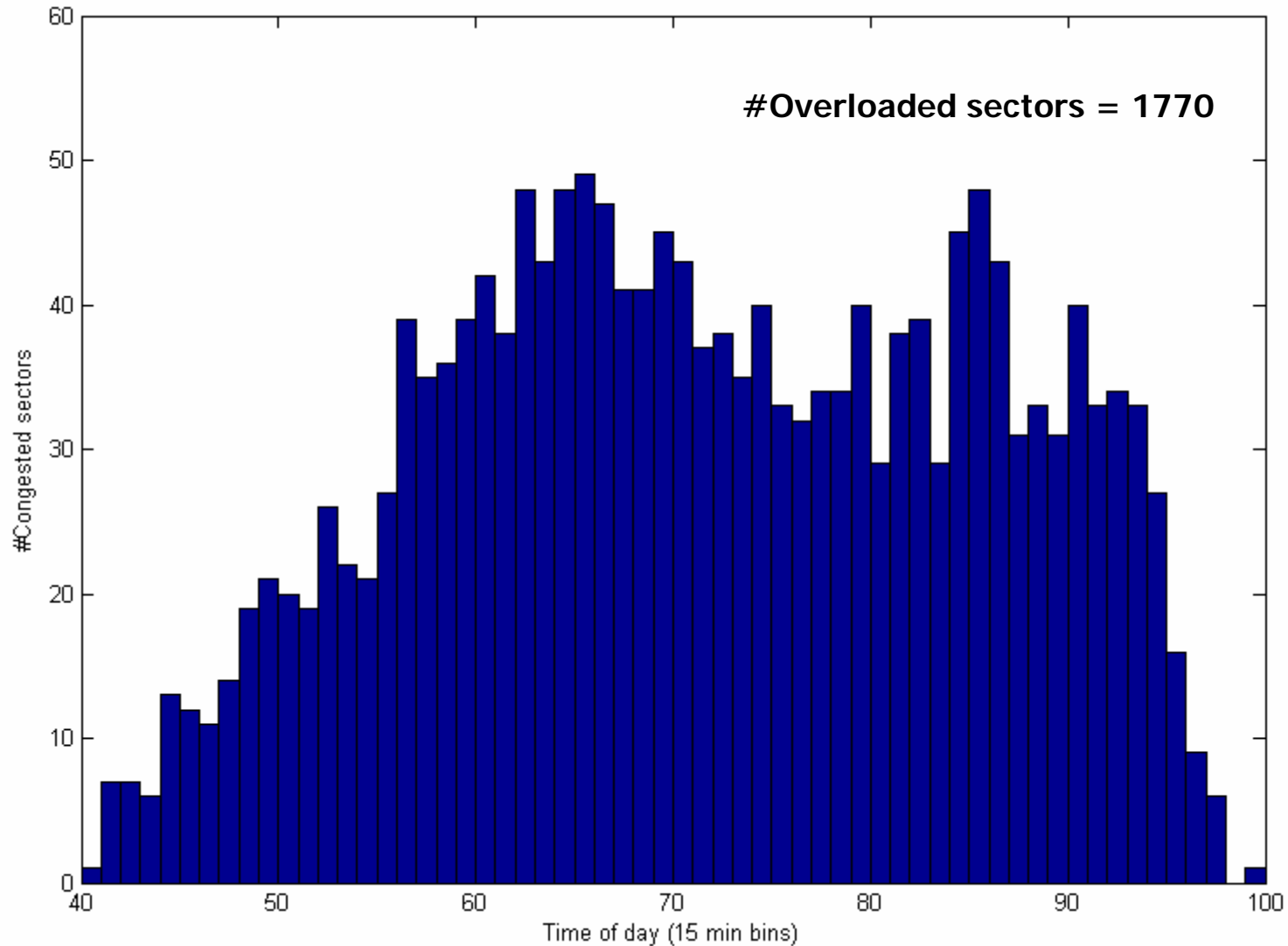


Significantly Fewer Rerouter With Our Flight Planner

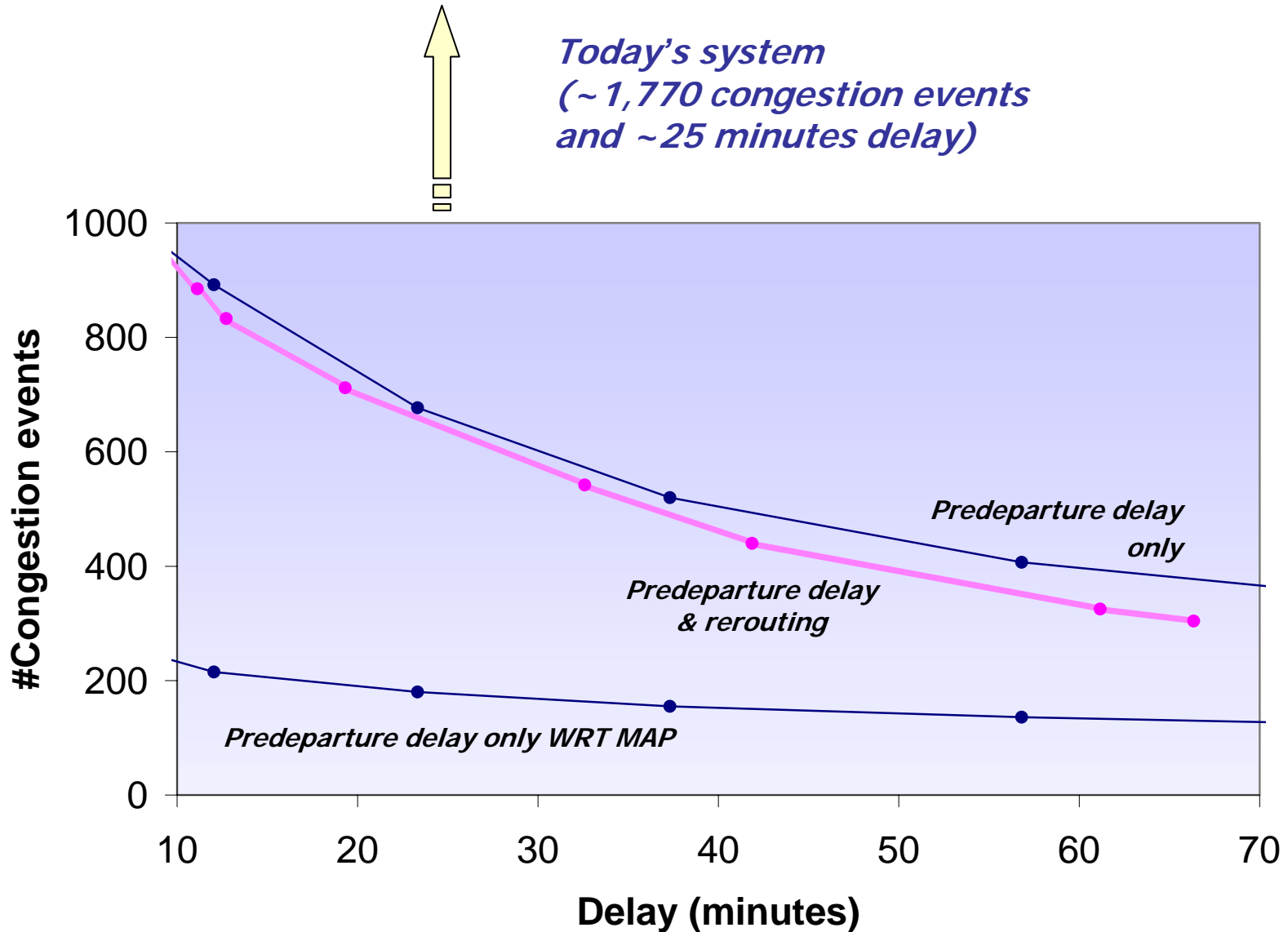
Jul 27, 2004 - Reroute Statistics



ETMS Congestion Profile

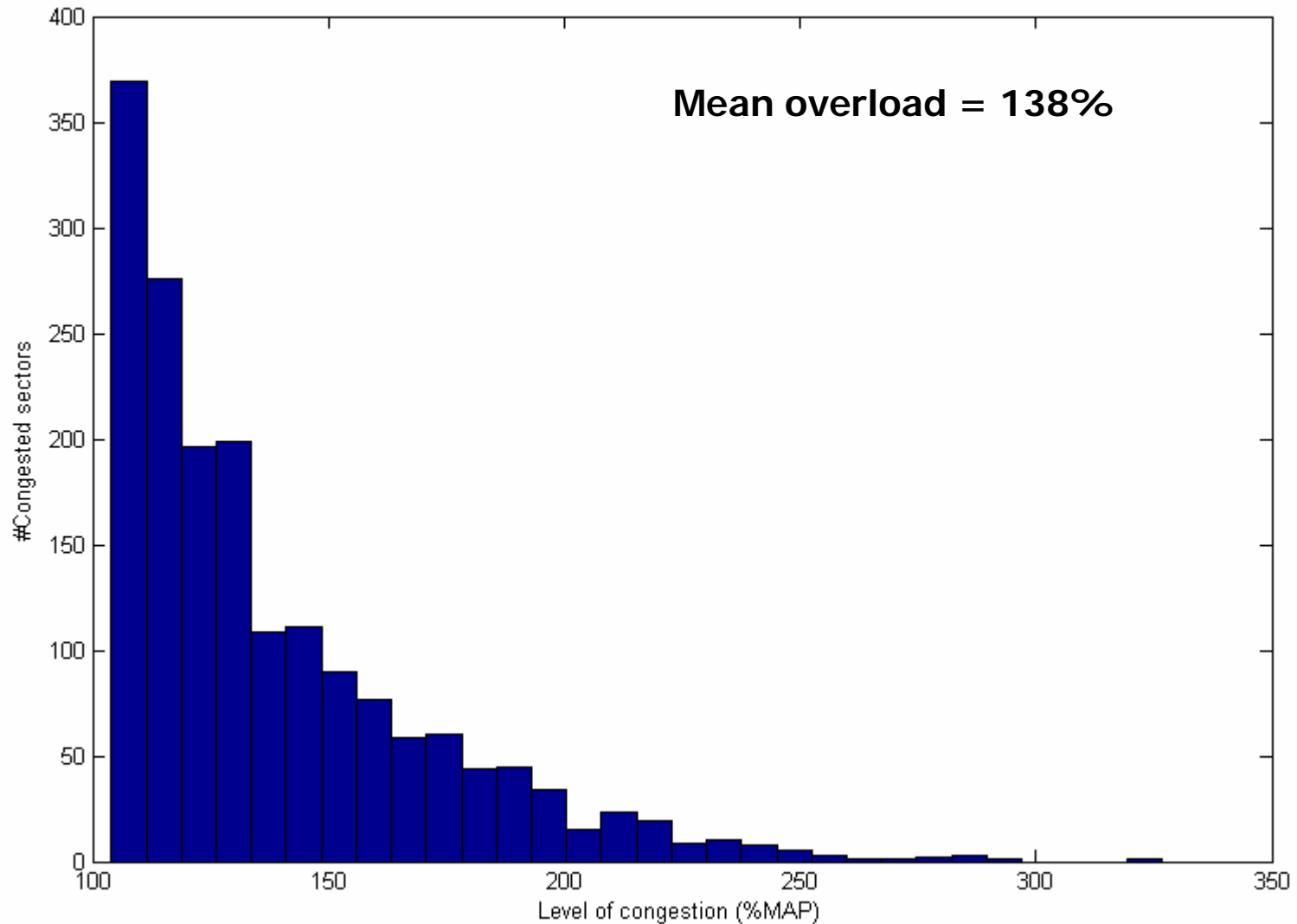


Congestion/Delay Tradeoff Comparison

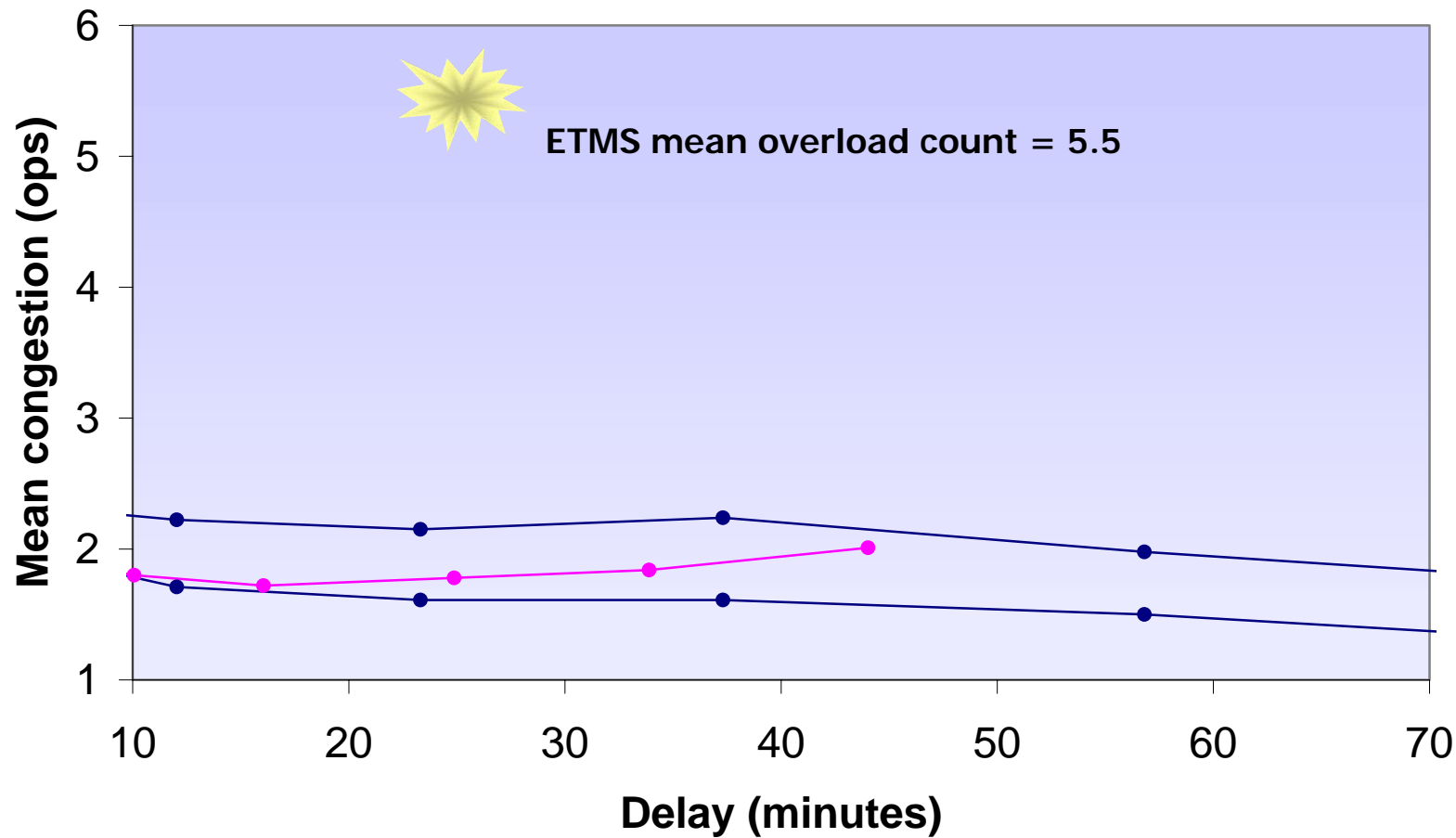




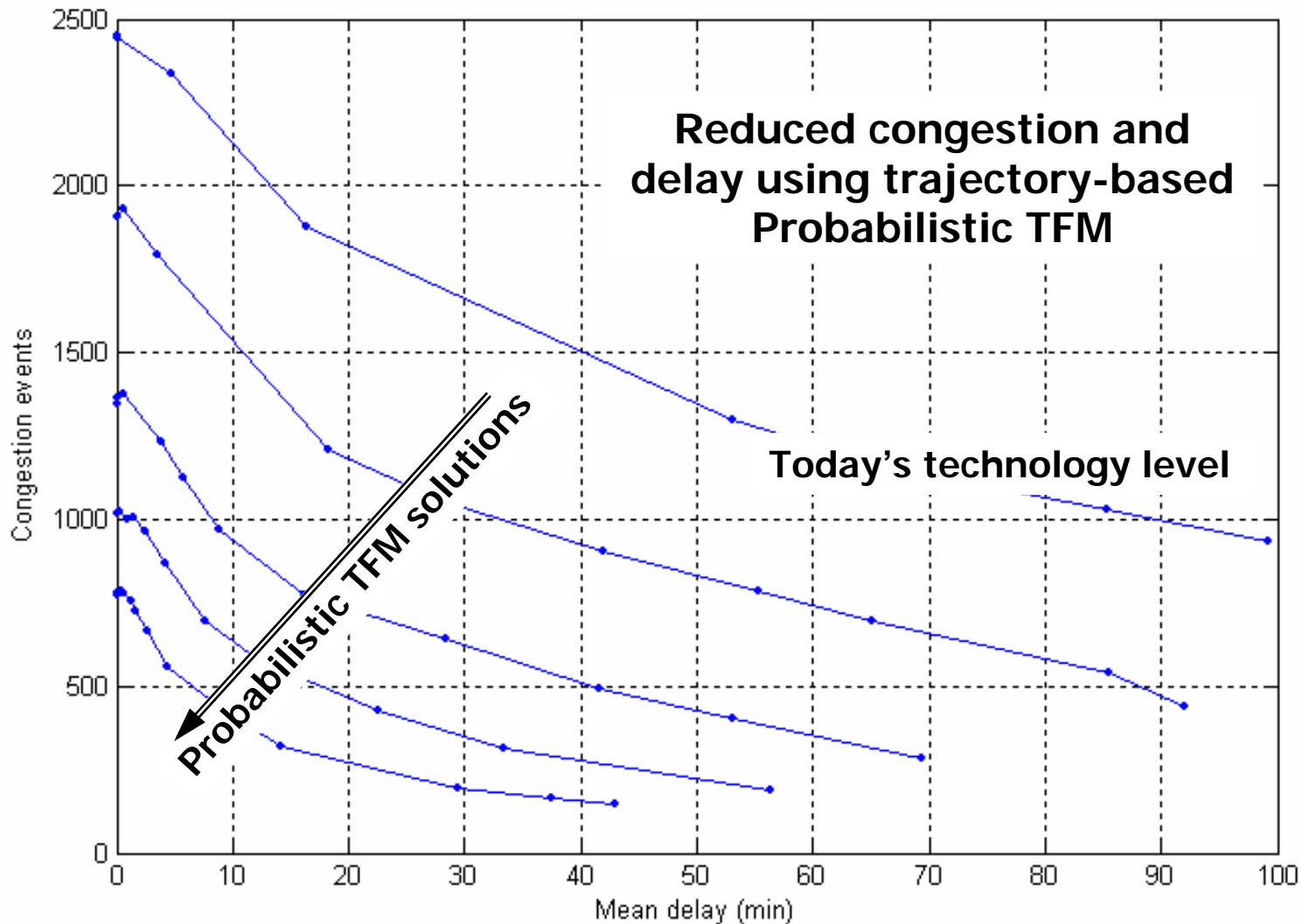
ETMS Congestion Distribution



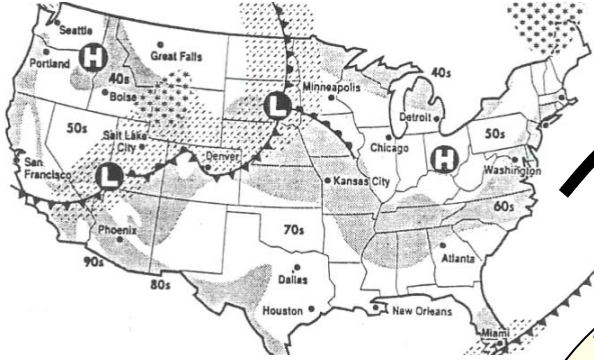
Mean Overload Comparison



An Improved NAS

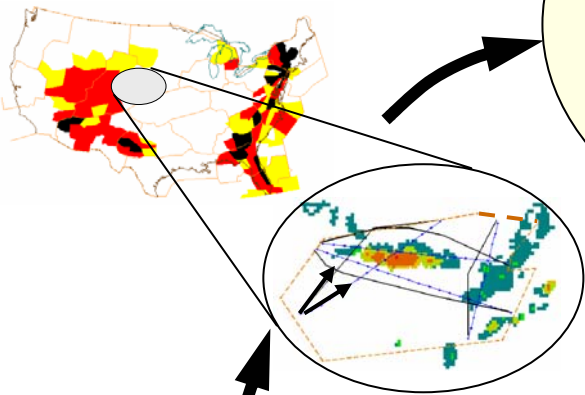
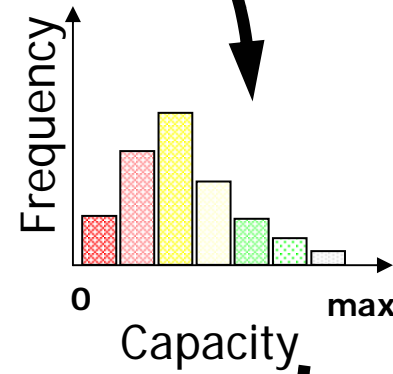
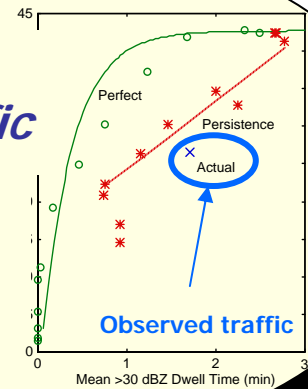


Traffic Planning with Uncertainty



Weather impacts airspace, but the forecasted capacity and loading are uncertain.

The result: Robust traffic flow in the future NAS.



Trajectory-based traffic flow optimization using dynamic congestion map.

Predicted load (red curve) and Predicted capacity (green curve)

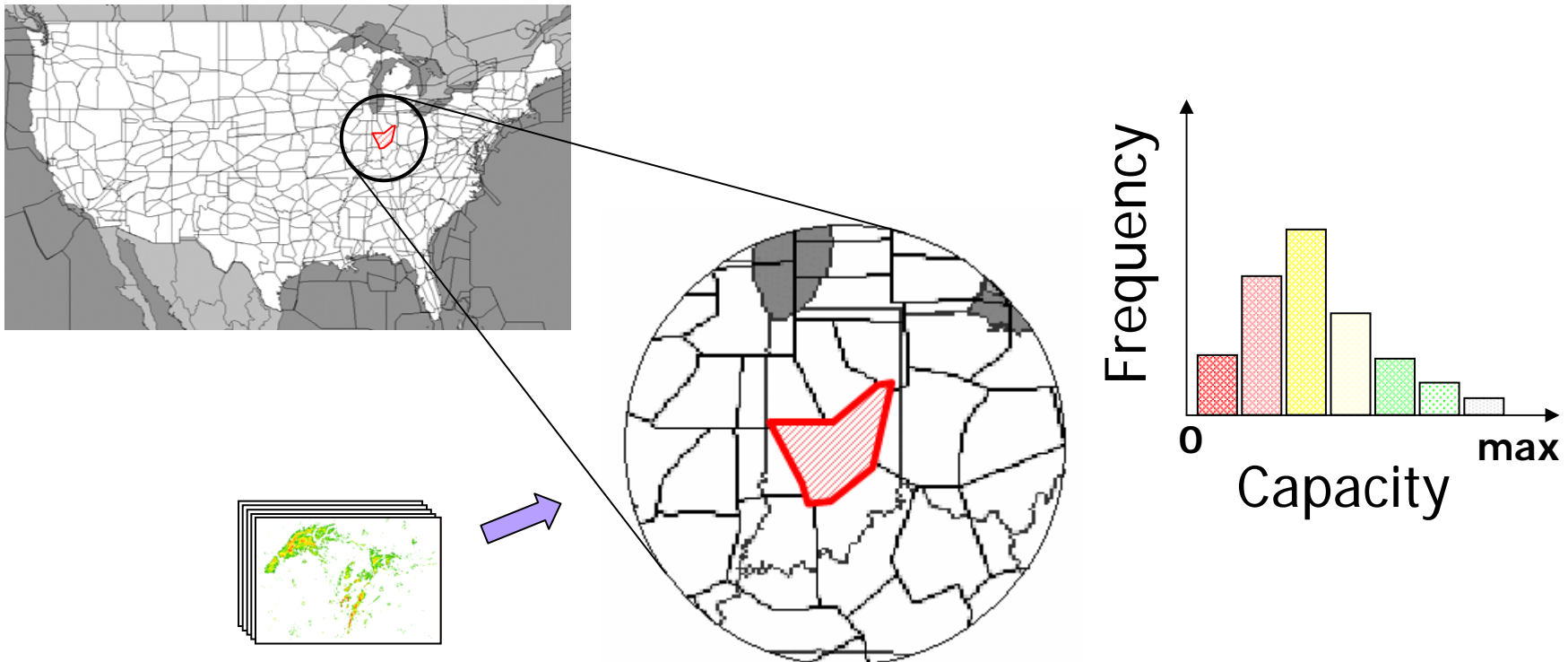
Congestion probability

Traffic load exceeding capacity => congestion.

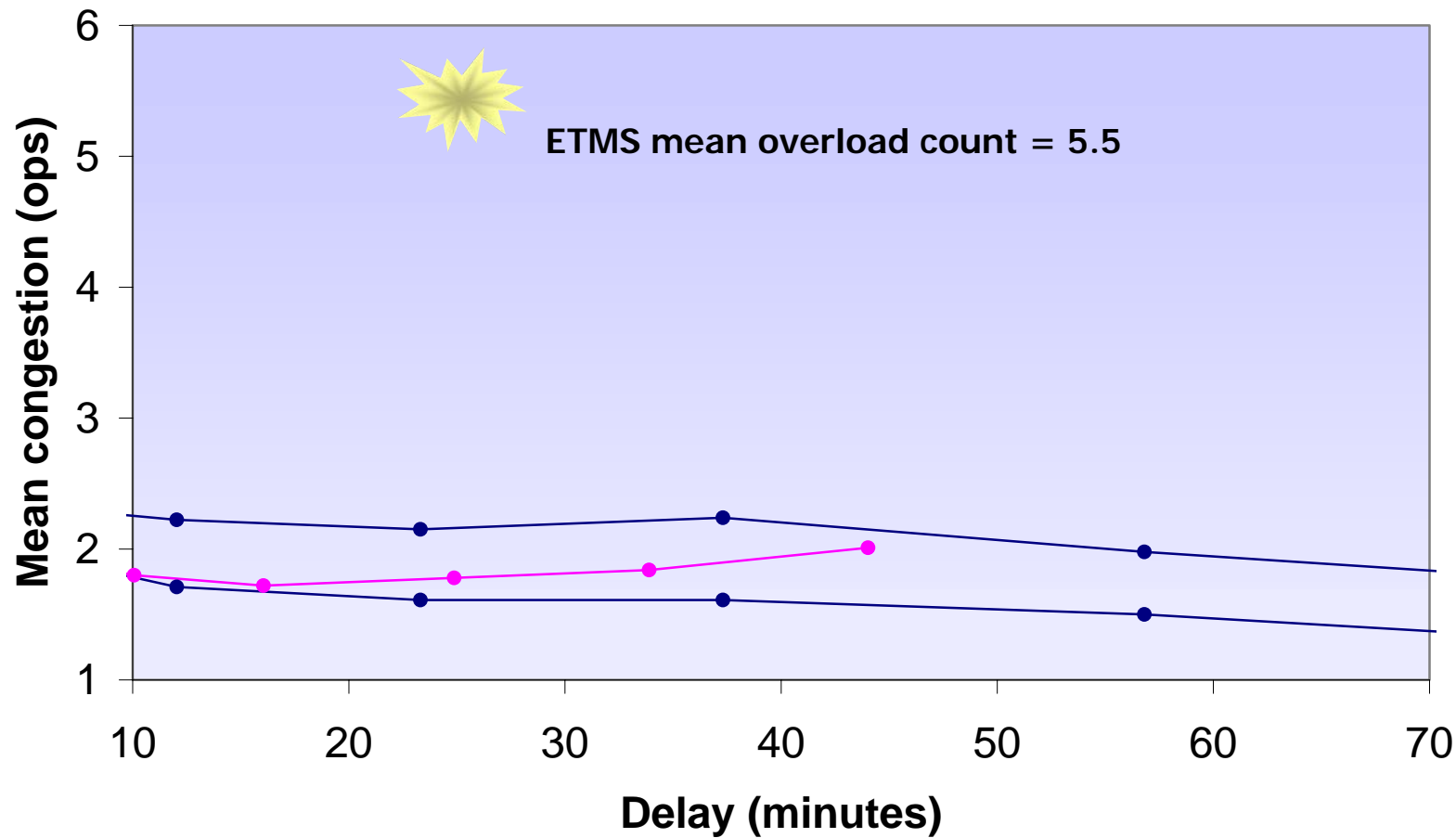
Backup

Probabilistic TFM

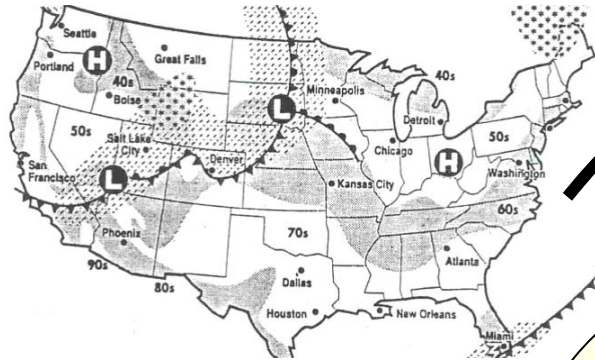
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Mean Overload Comparison

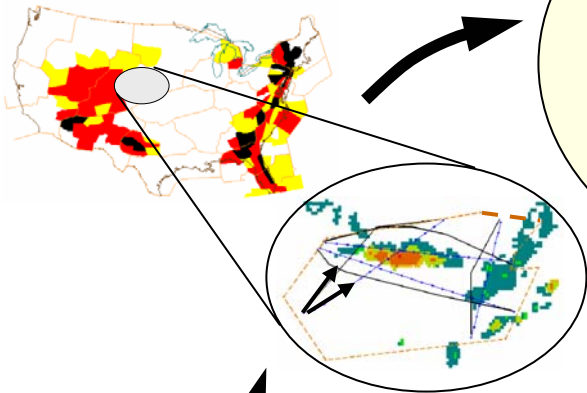
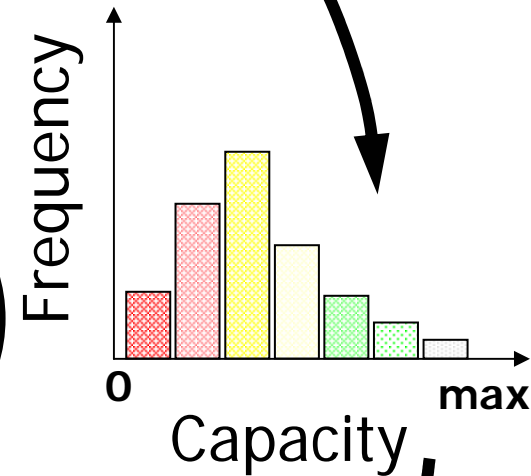
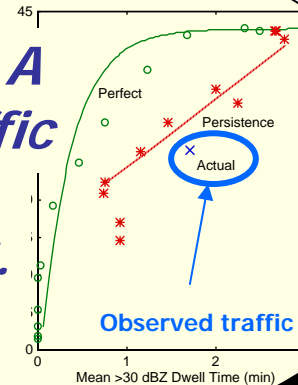


Traffic Planning with Uncertainty

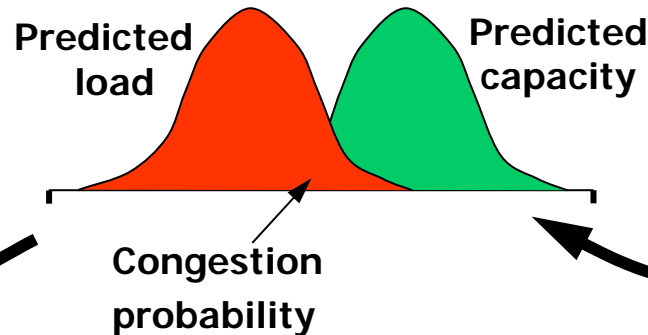


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