

Sensitivity of Advanced Traffic Flow Management to Different Weather Scenarios

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Detect the Difference

Presentation Outline

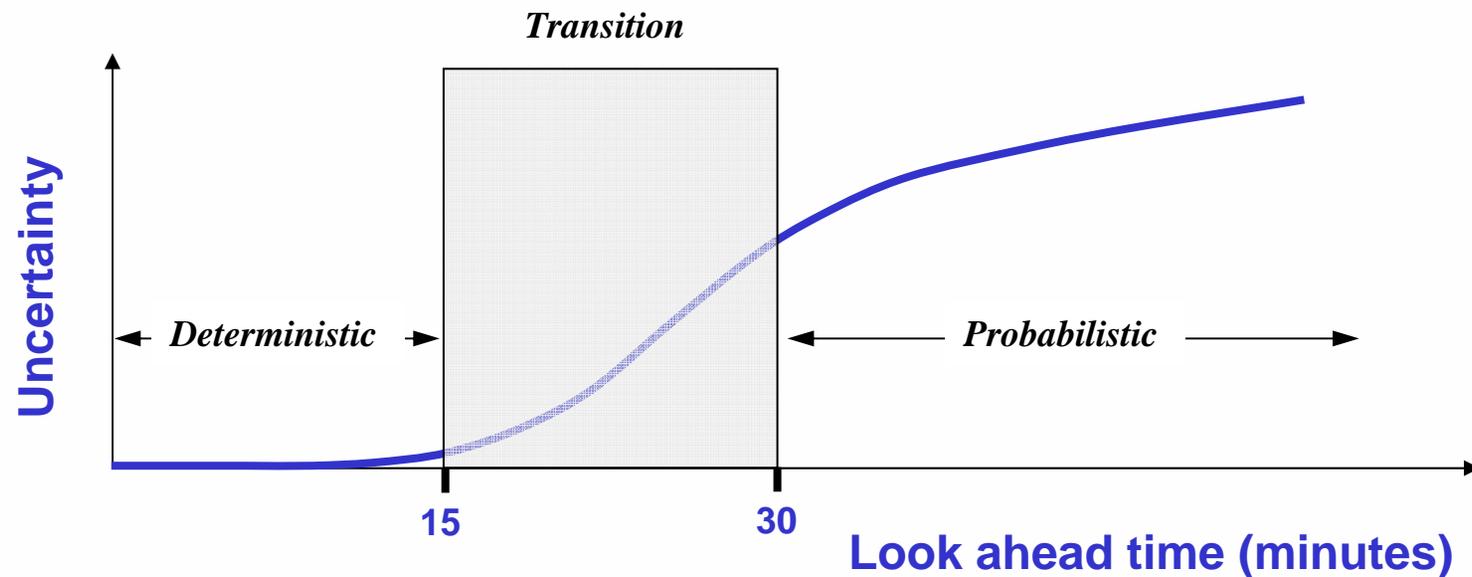
- PlayBook2 overview
- NAS-wide TFM relationships
- PlayBook2 testing results
- Conclusions



PlayBook2 Overview

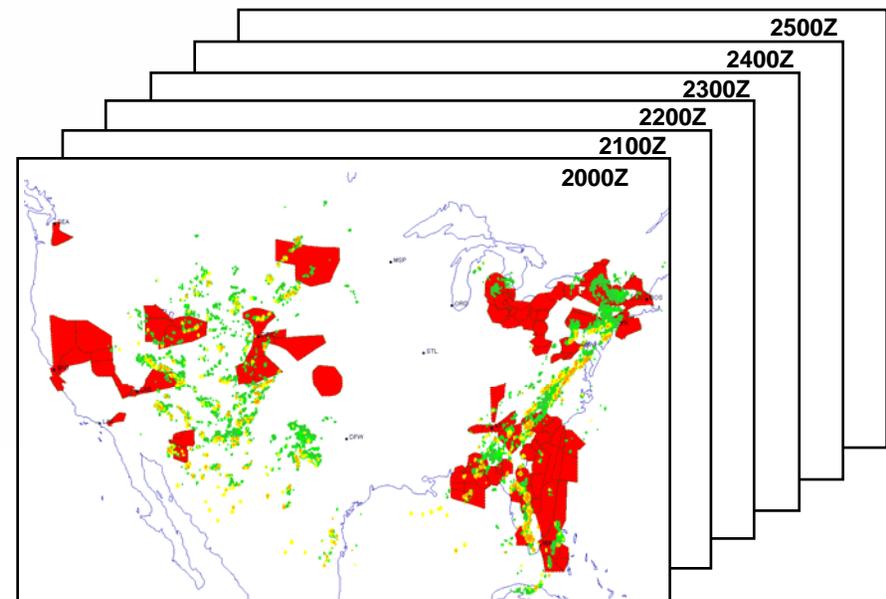
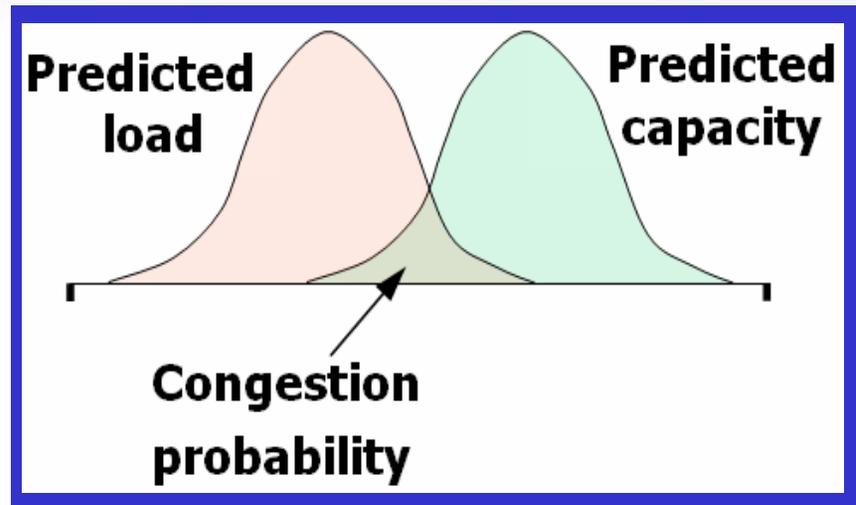
System Uncertainties

- Both demand and capacity are uncertain beyond about 15-30 minutes



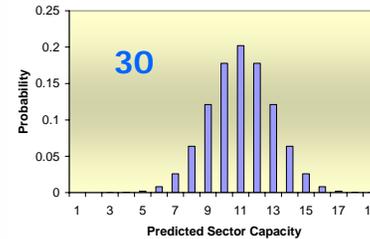
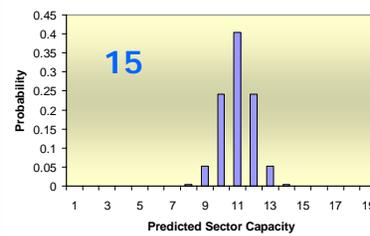
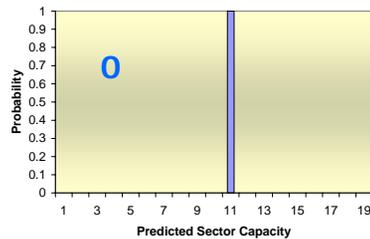
The PlayBook2 Approach

- **Analyze traffic and weather data and forecasts**
- **Unify all relevant demand information**
 - Historical trends, flight plans, weather and winds, TFM initiatives, etc.
- **Unify all relevant capacity information**
 - All types of weather phenomena, SUAs, security events, volcanic ash, etc.
- **Create system capacity and loading forecasts with probability distributions**
- **Construct congestion forecast database**

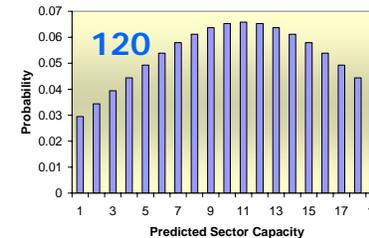
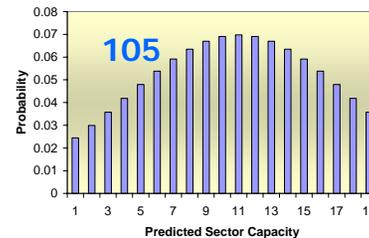
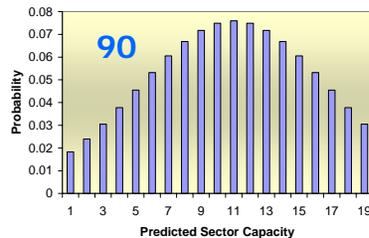
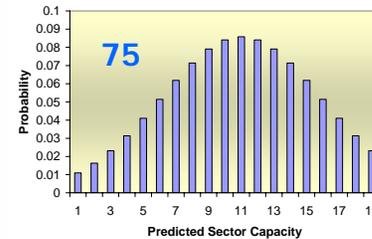
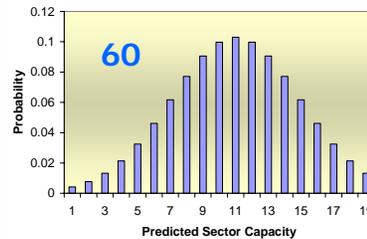
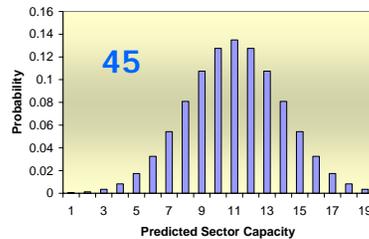


Sector Capacity PDF

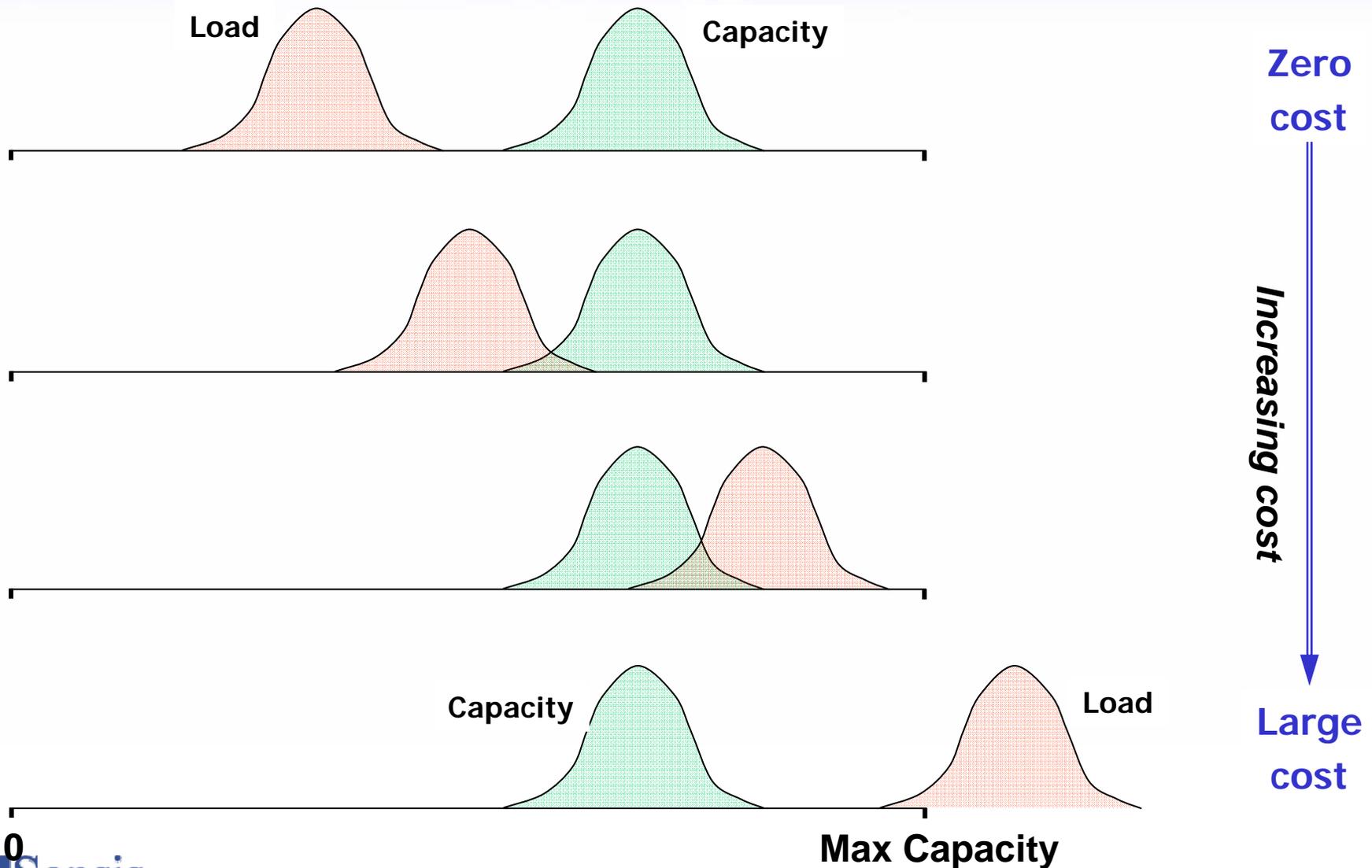
0 – 120 minute look ahead time, impacted capacity = 10, MAP = 18



Sector loadings too

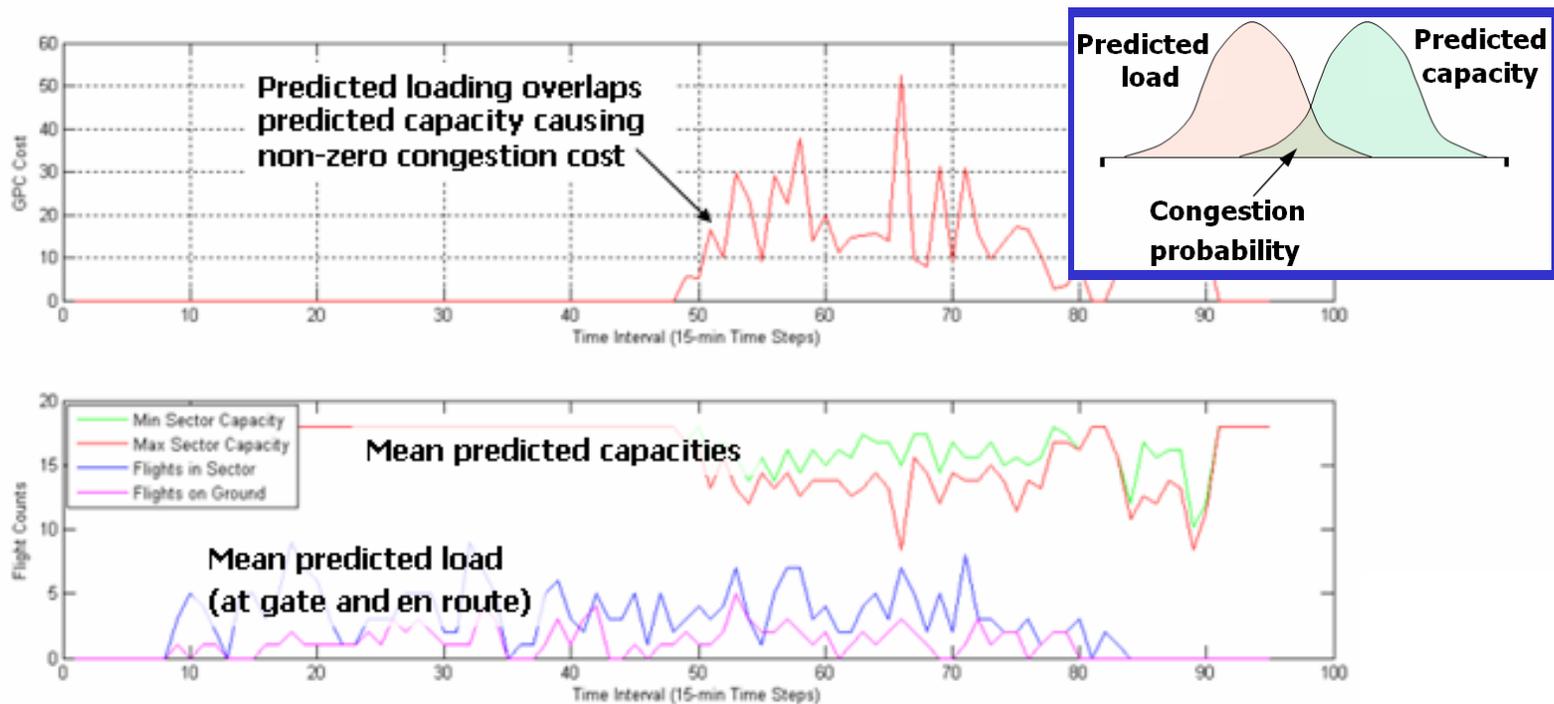


Sector Congestion Cost



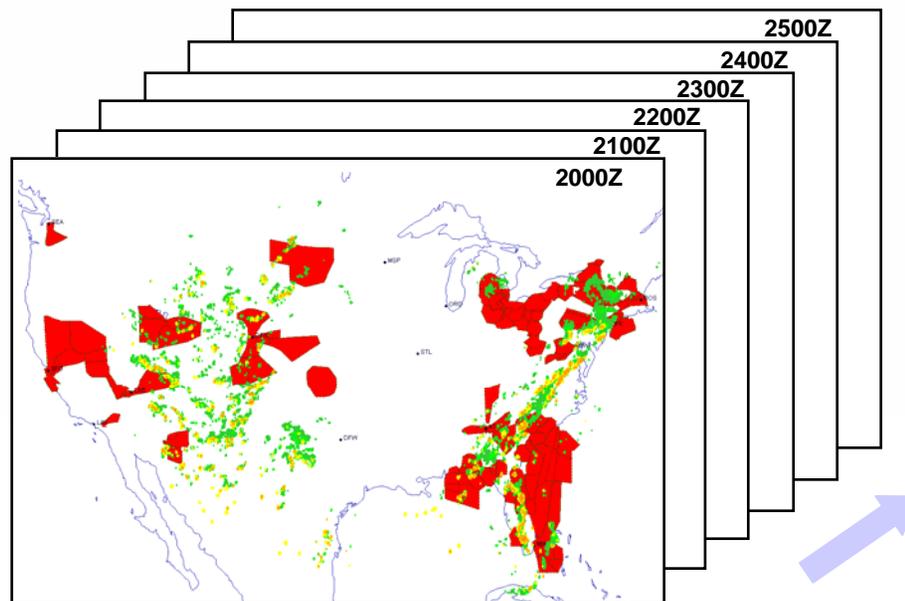
Use Demand and Capacity to Forecast NAS Congestion

- Demand and capacity forecasts
 - All sectors, all look-ahead times within scheduling window
- Compute congestion likelihood



A Congestion Map

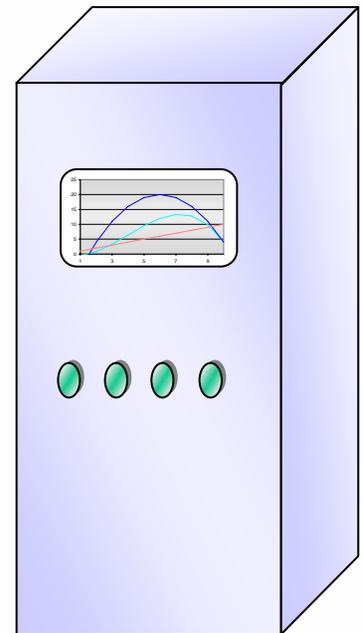
- Congestion severity across the NAS
 - Forecasted at terminal areas and en route airspace
- We have now characterized the TFM problem without loss of generality
 - Forecasted congestion cost accounts for uncertainties



*Look ahead
time horizon,
1–6 hours*

An Example TFM Optimization

- We can now evaluate TFM strategies
 - Flow-based, trajectory-based, hybrids, etc.
- Our current optimization concept under development
 - Trajectory-based
 - Use gate delays and reroutes, on a flight-by-flight basis
 - To manage congestion, according to a congestion sensitivity parameter
 - Adjust congestion sensitivity parameter to minimize delay



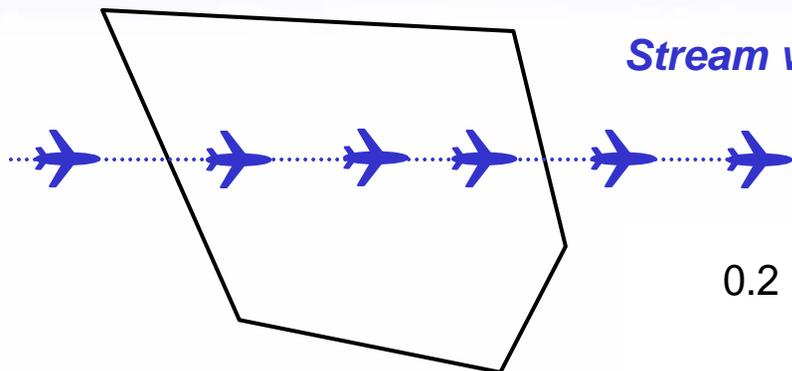


NAS-Wide Traffic Flow Management Relationships

Results: Congestion and Delay

- How are congestion and delay related?
 - For a given scenario

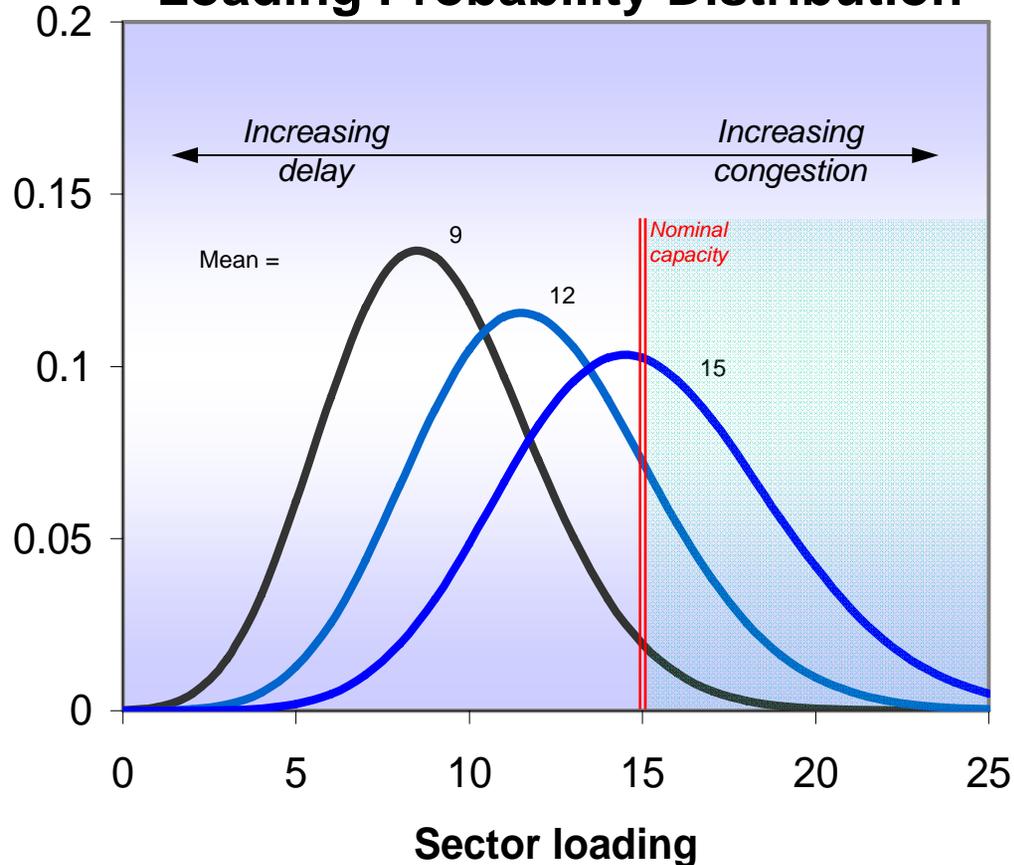
Poisson Traffic Model



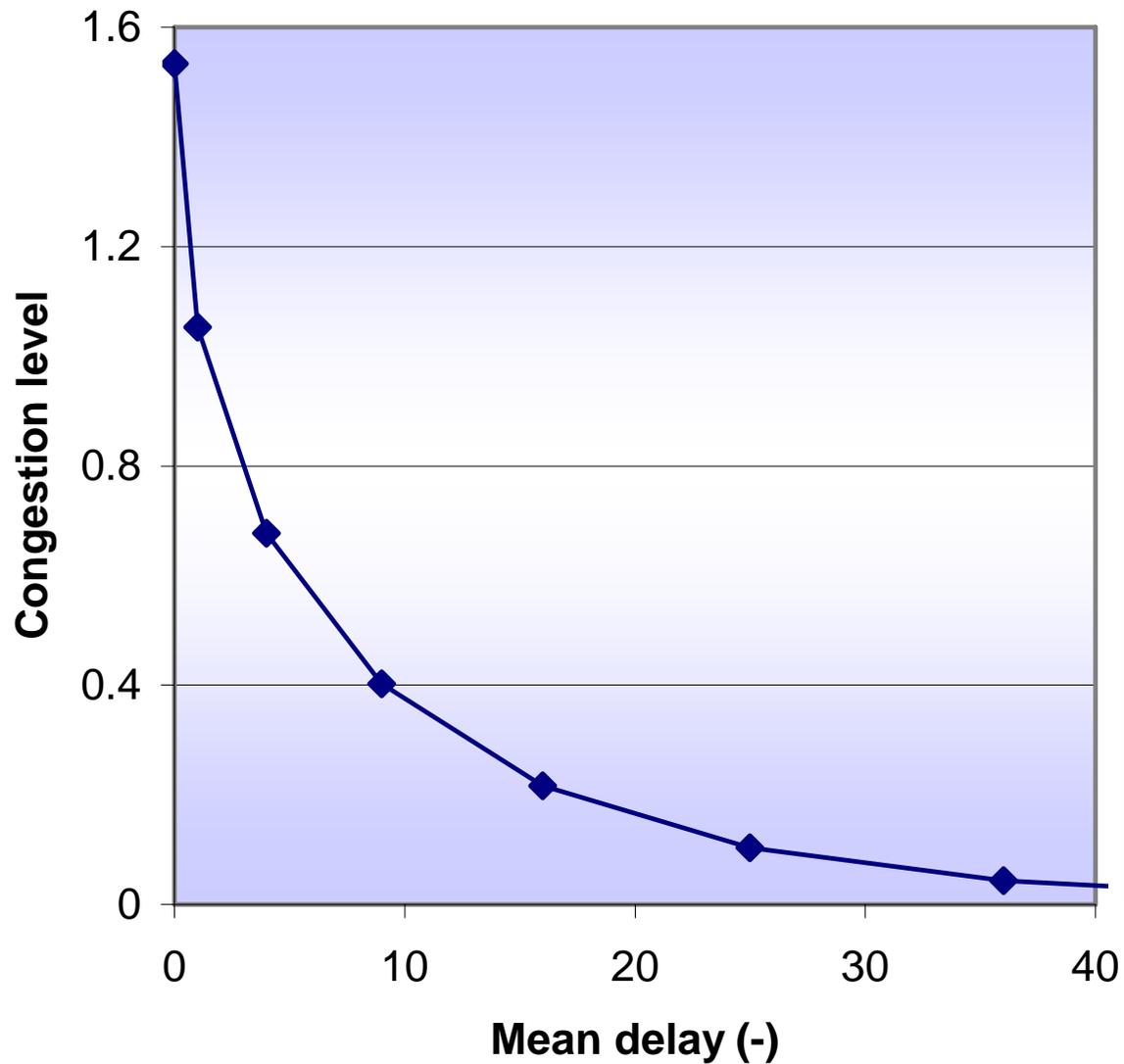
Stream with inter-arrival variation

$$f(n) = \frac{\mu^n e^{-\mu}}{n!}$$

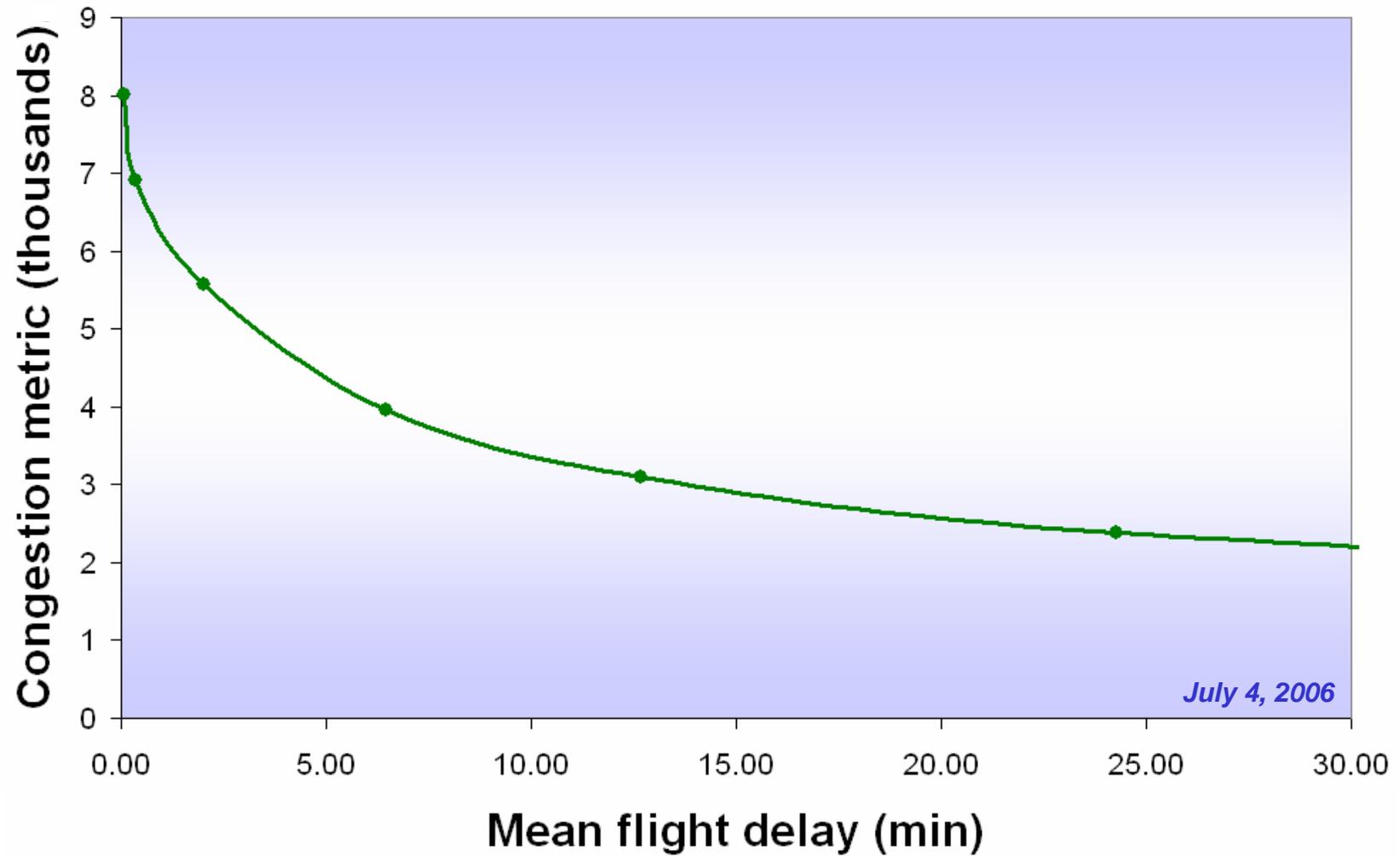
Loading Probability Distribution



Poisson Congestion-Delay Tradeoff



PlayBook2 Congestion-Delay Tradeoff



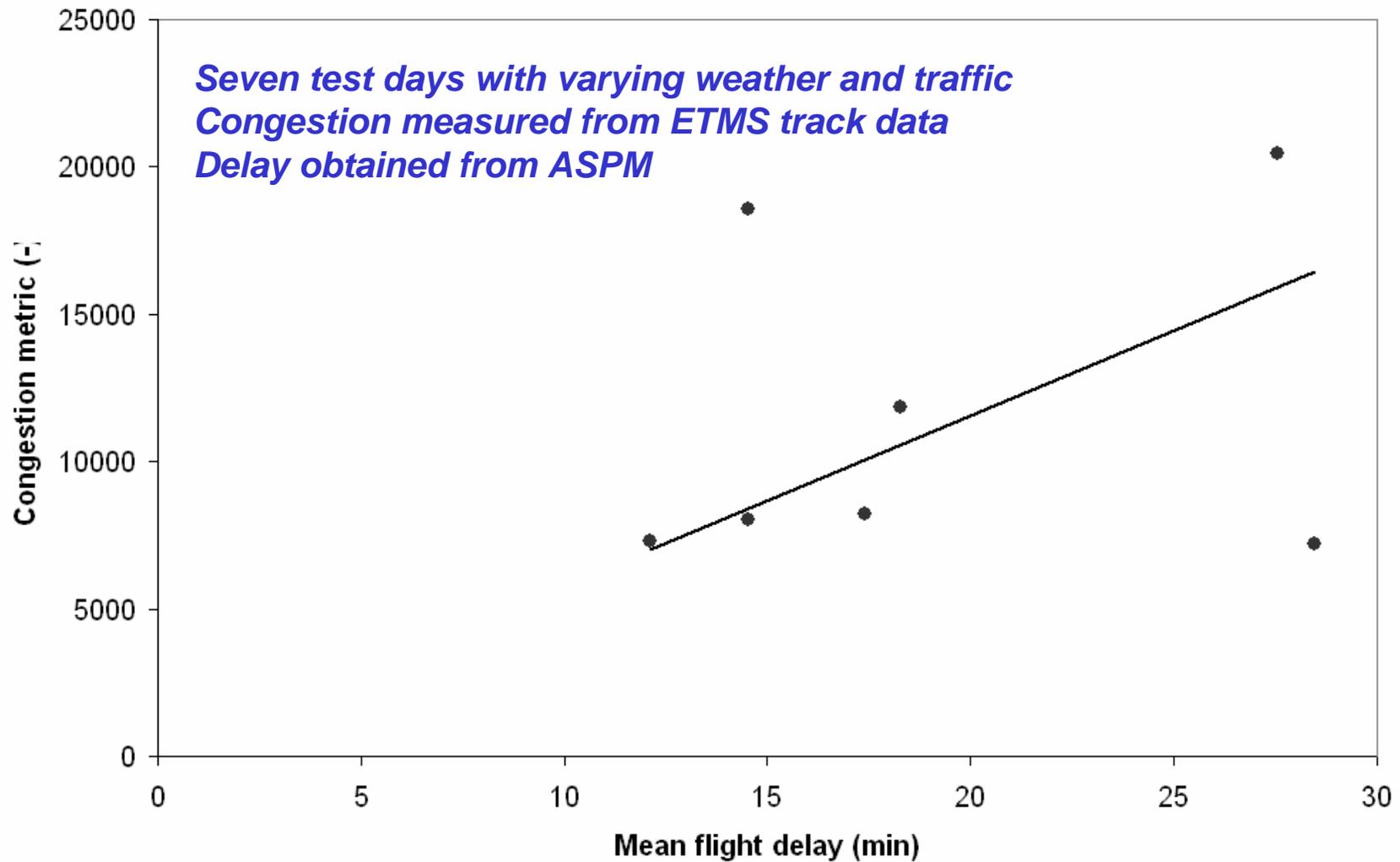


PlayBook2 Testing Results

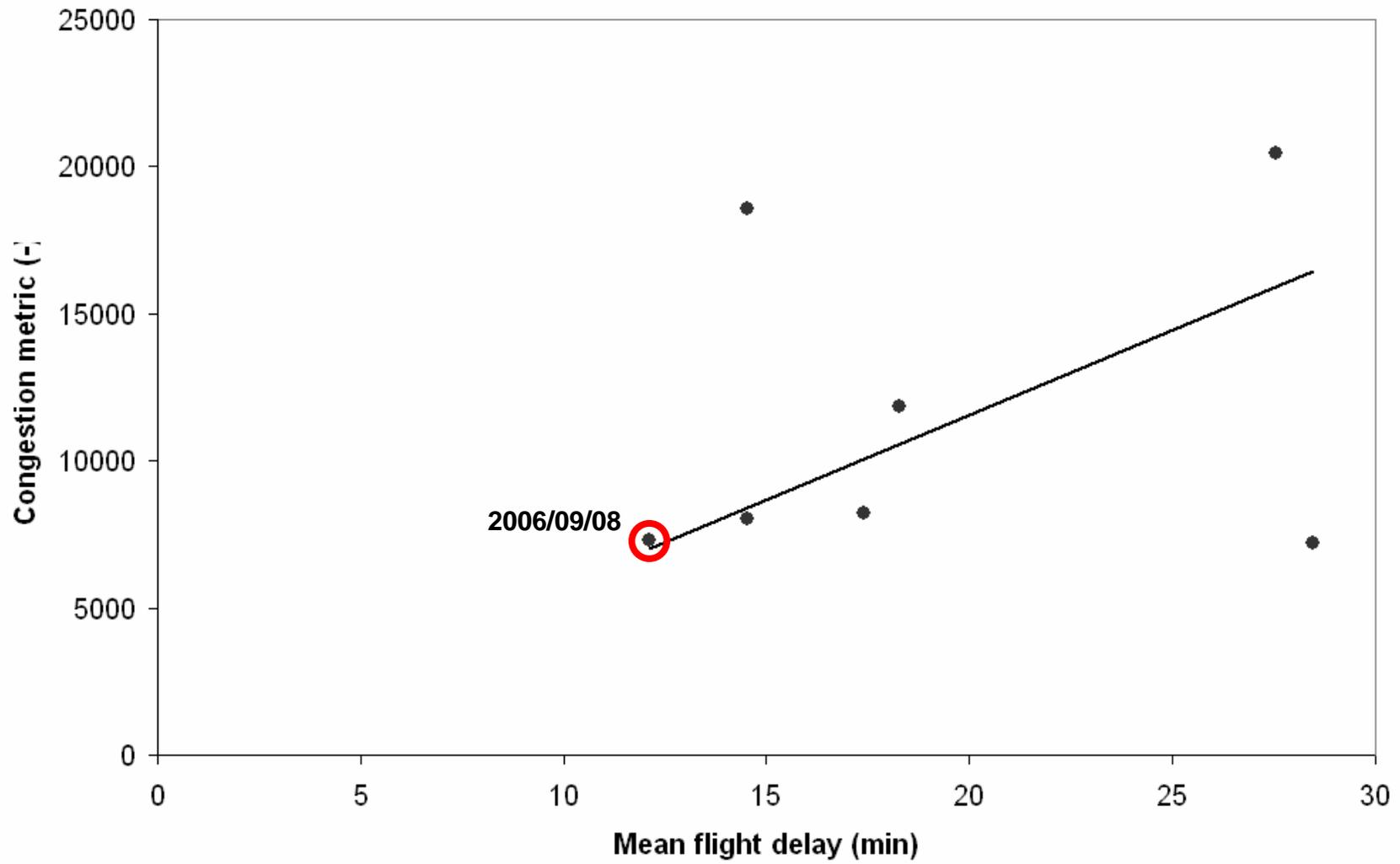
A Baseline Set of Test Days

- **Seven days**
 - July 2006 to January 2007
- **Three light traffic days**
 - Two Sundays, one holiday
 - Ranging from light weather to heavy weather
- **Four normal-heavy traffic days**
 - Two Thursdays, two Fridays
 - Ranging from light weather to heavy weather
- **No significant surface snow or icing events**

ETMS Performance



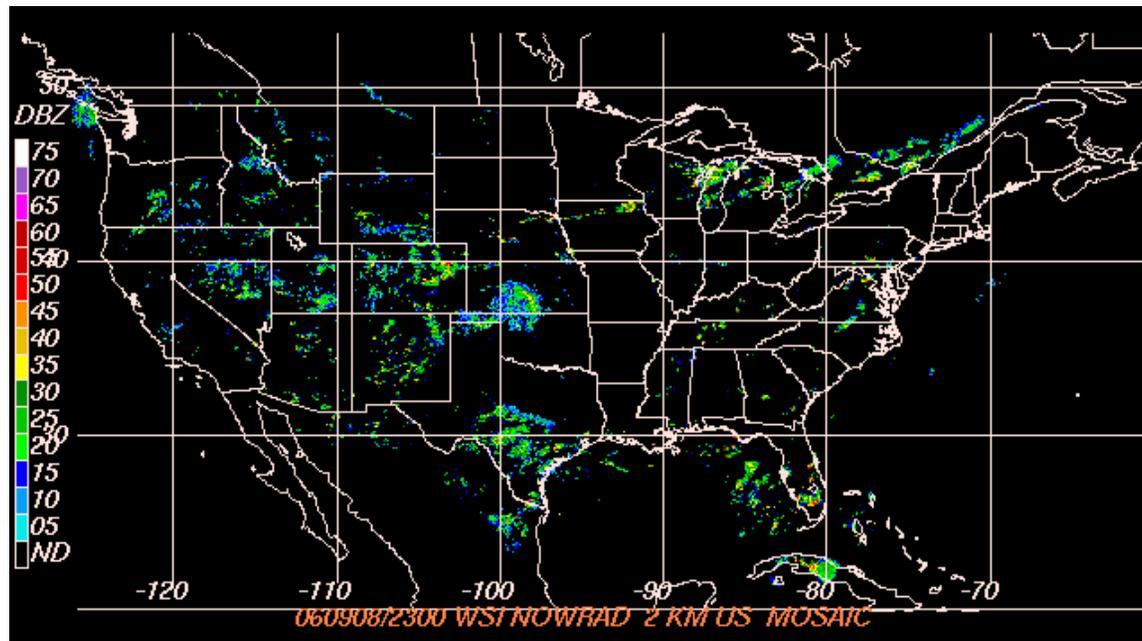
ETMS Performance



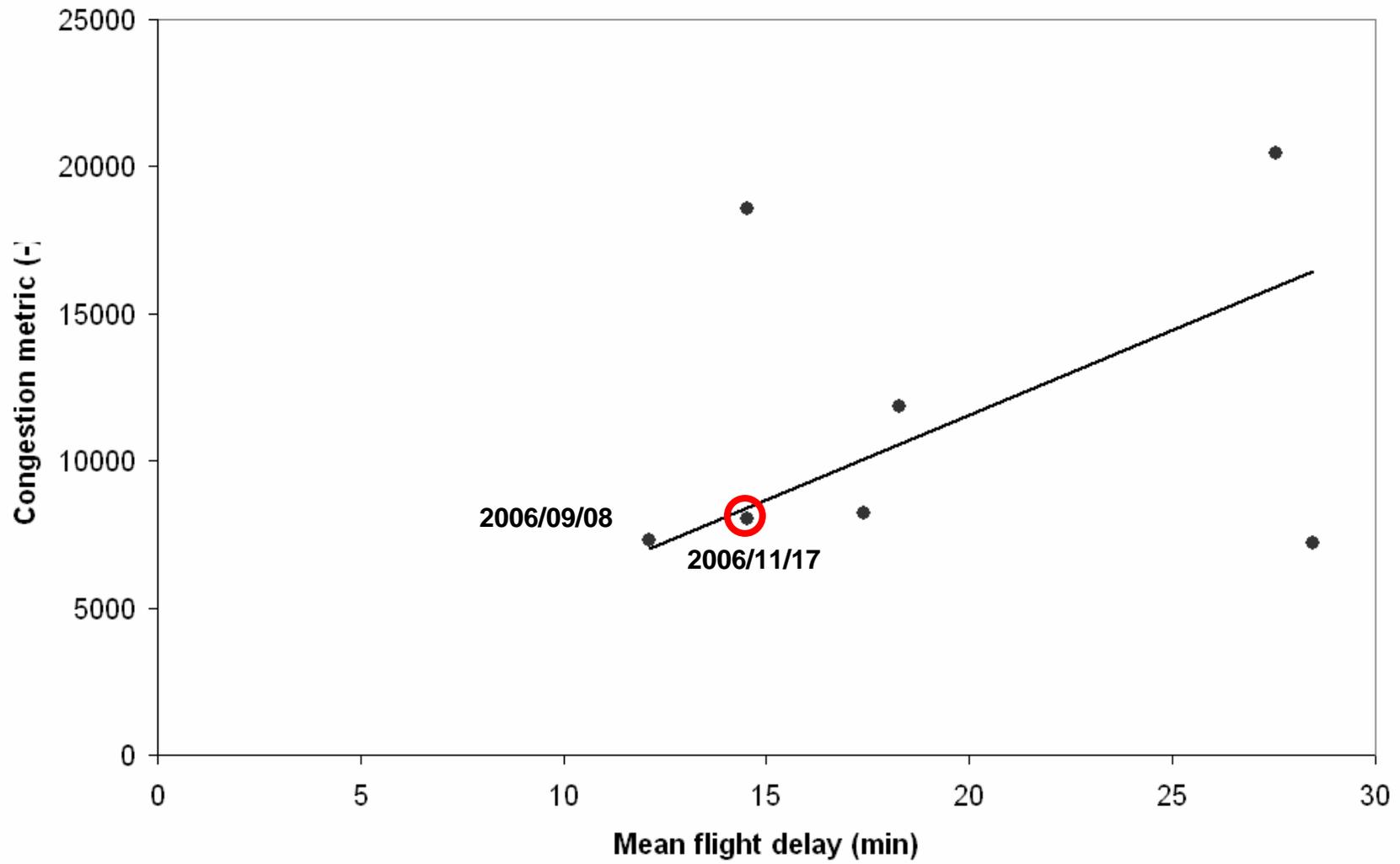
2006/09/08

■ Friday

- Traffic: Normal weekday (50,580 IFR tracks)
- Weather: Clear



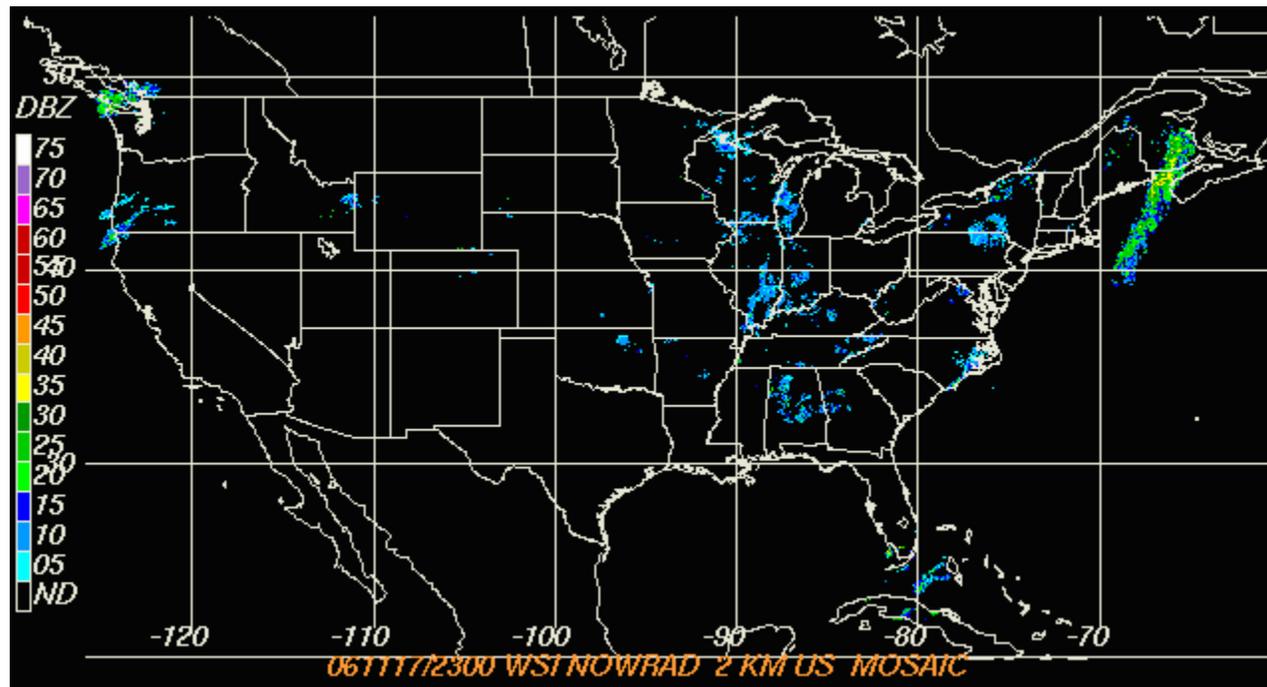
ETMS Performance



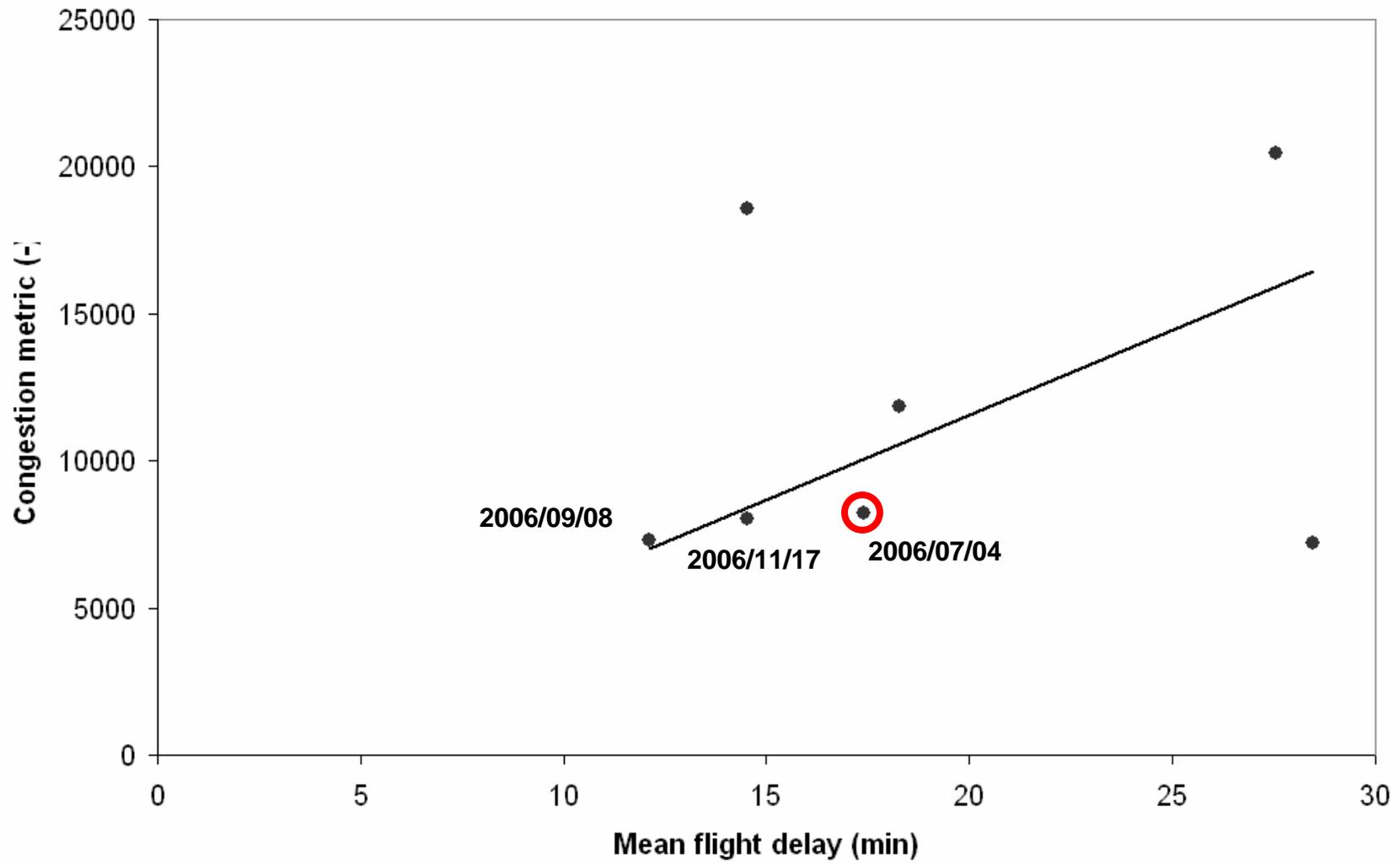
2006/11/17

■ Friday

- Traffic: Normal weekday (52,153 IFR tracks)
- Weather: Clear

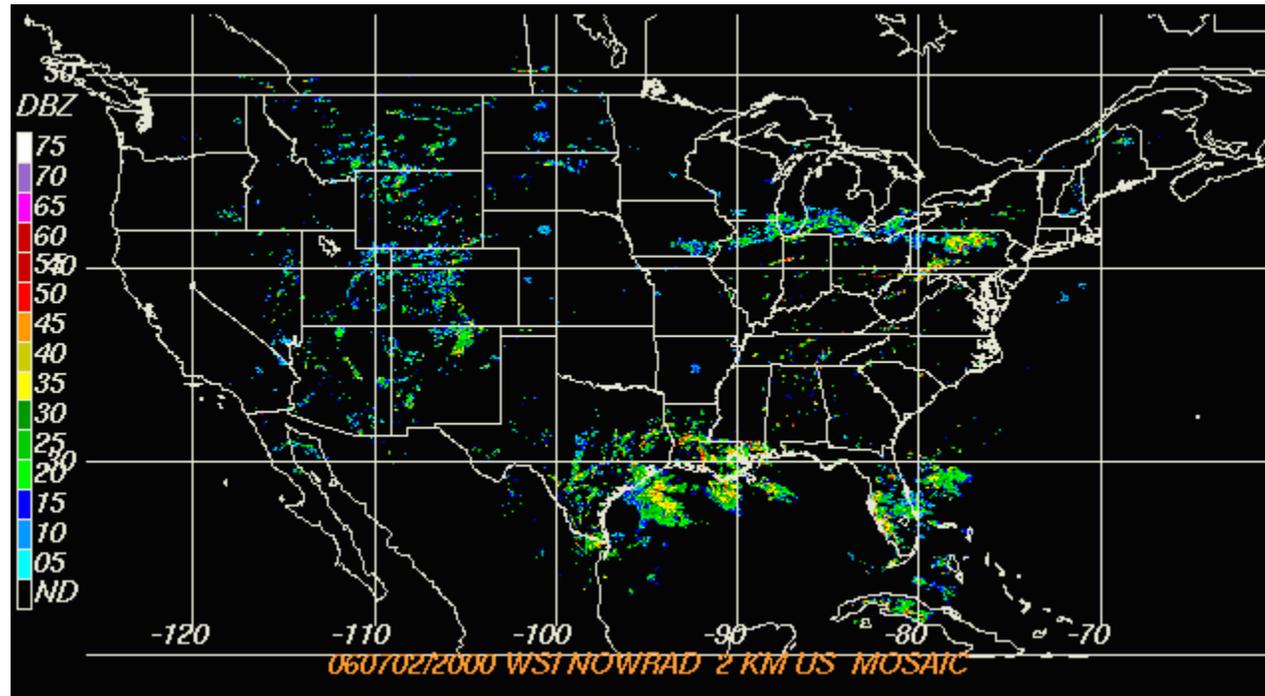


ETMS Performance

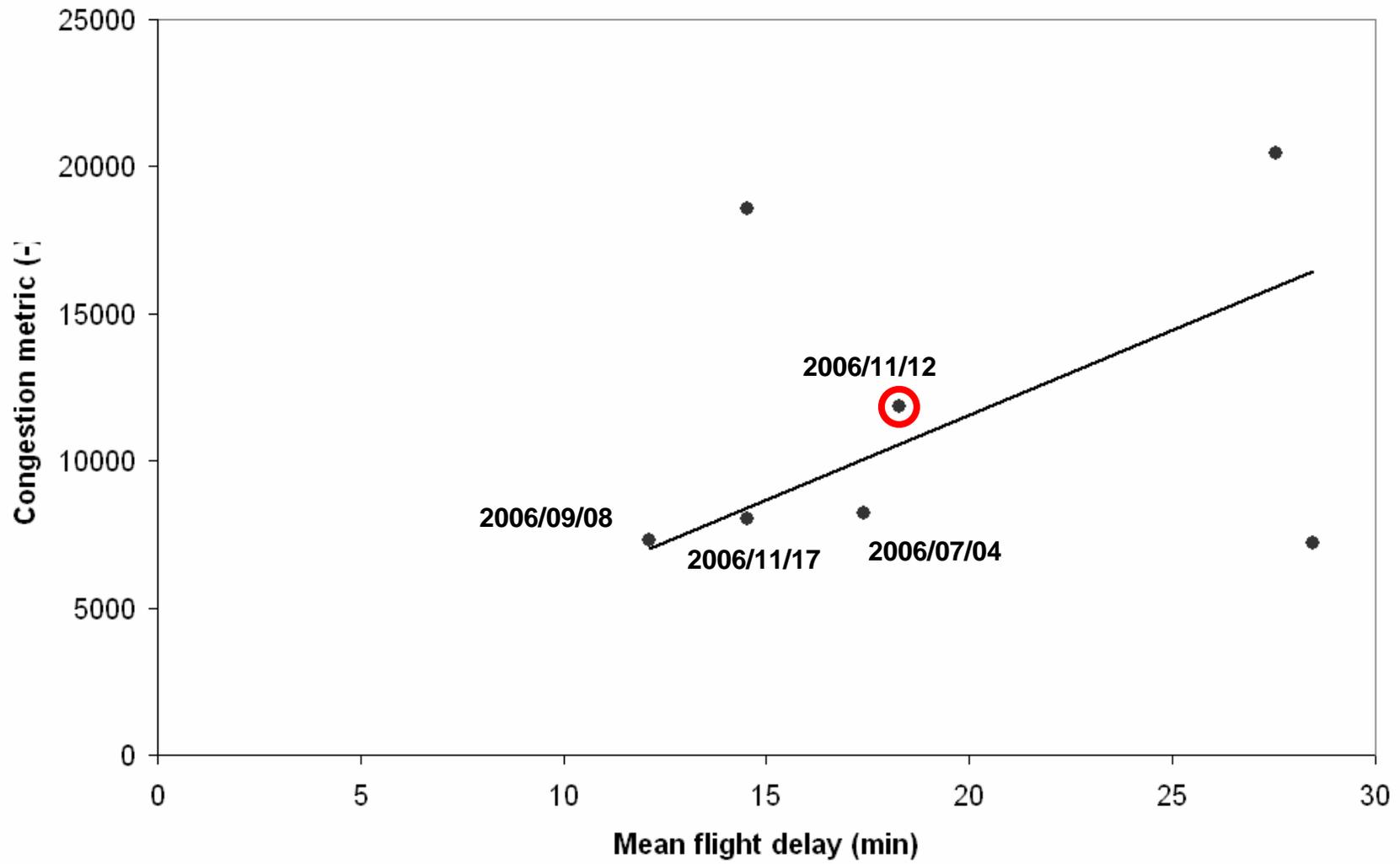


2006/07/04

- Tuesday / holiday
 - Traffic: Light (43,059 IFR tracks)
 - Weather: Moderate



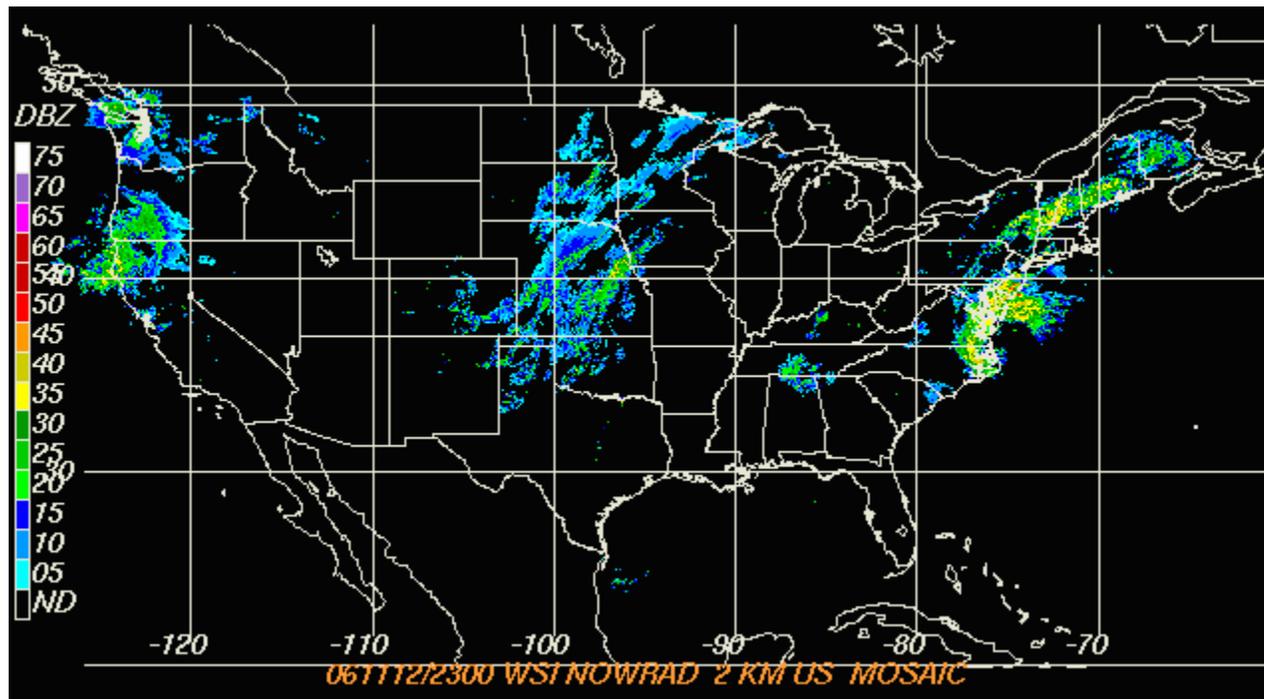
ETMS Performance



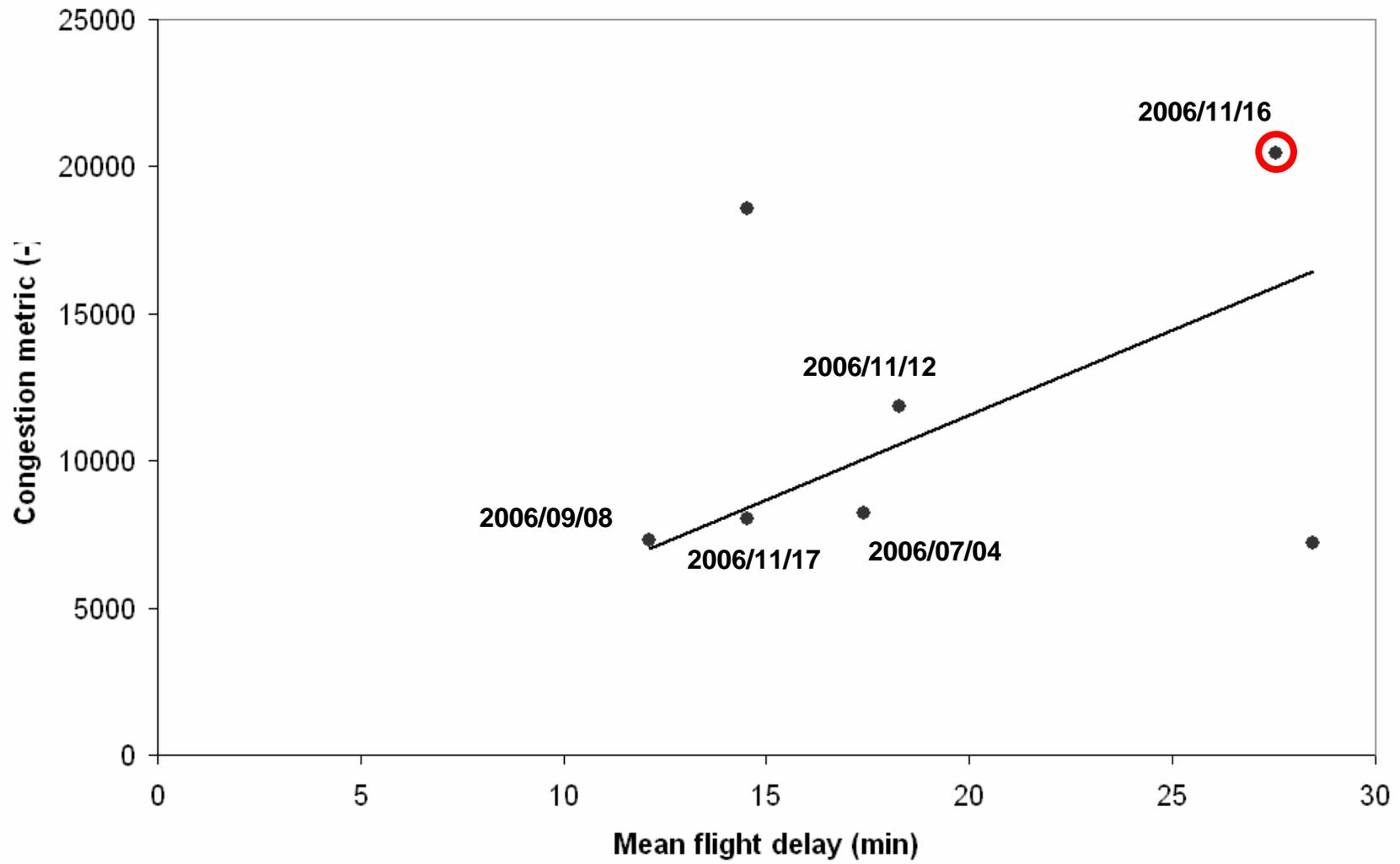
2006/11/12

■ Sunday

- Traffic: Light (42,037 IFR tracks)
- Weather: Moderate-heavy



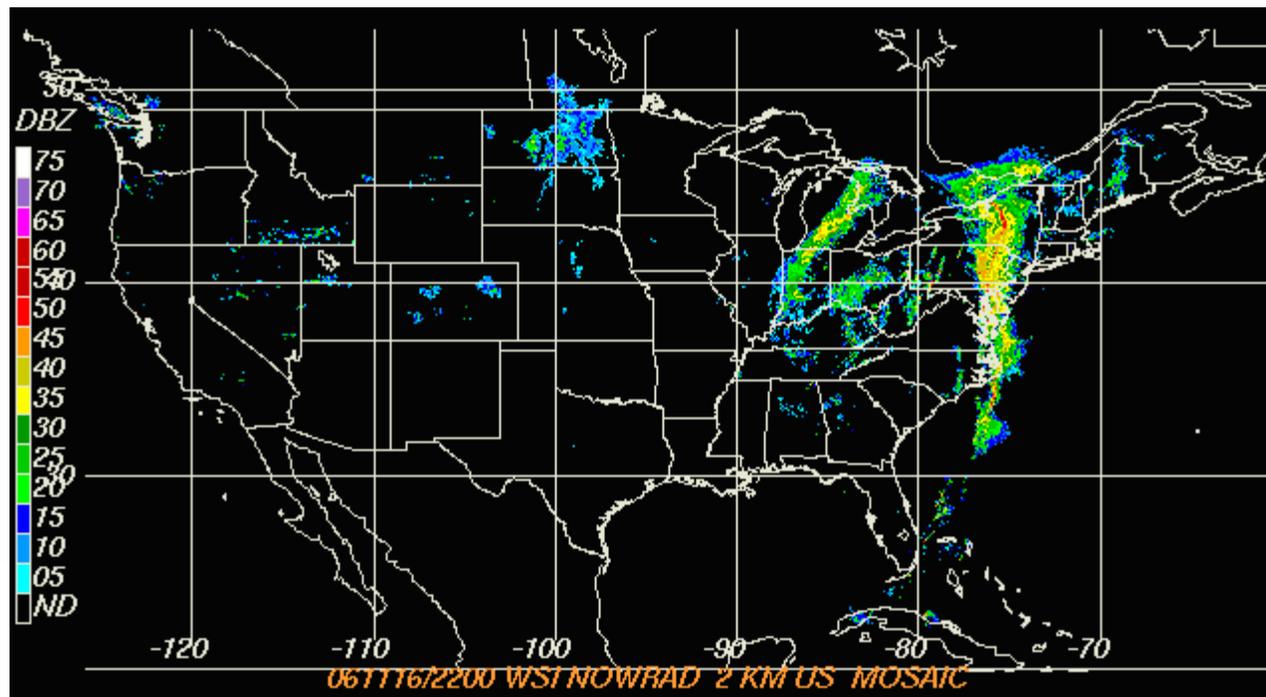
ETMS Performance



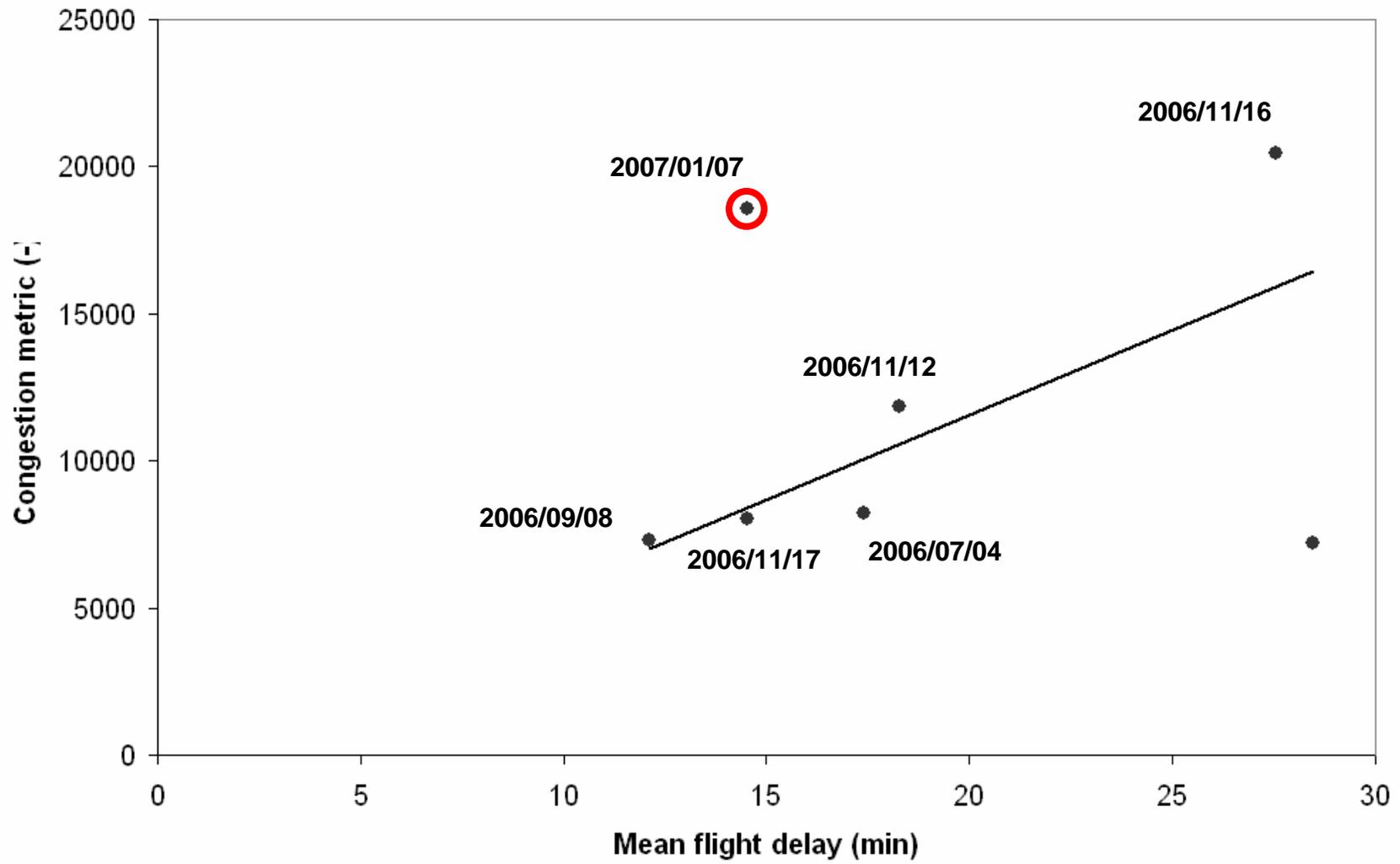
2006/11/16

■ Thursday

- Traffic: Normal weekday (50,466 IFR tracks)
- Weather: Heavy in midwest and NE corridor



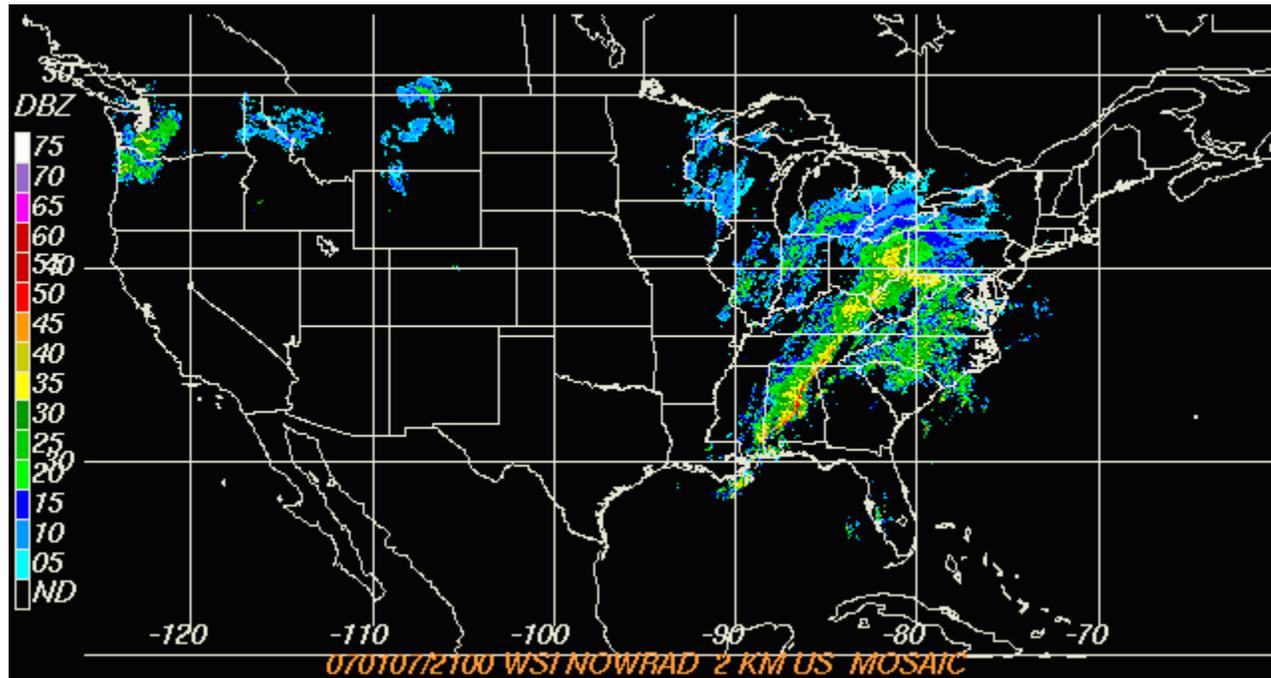
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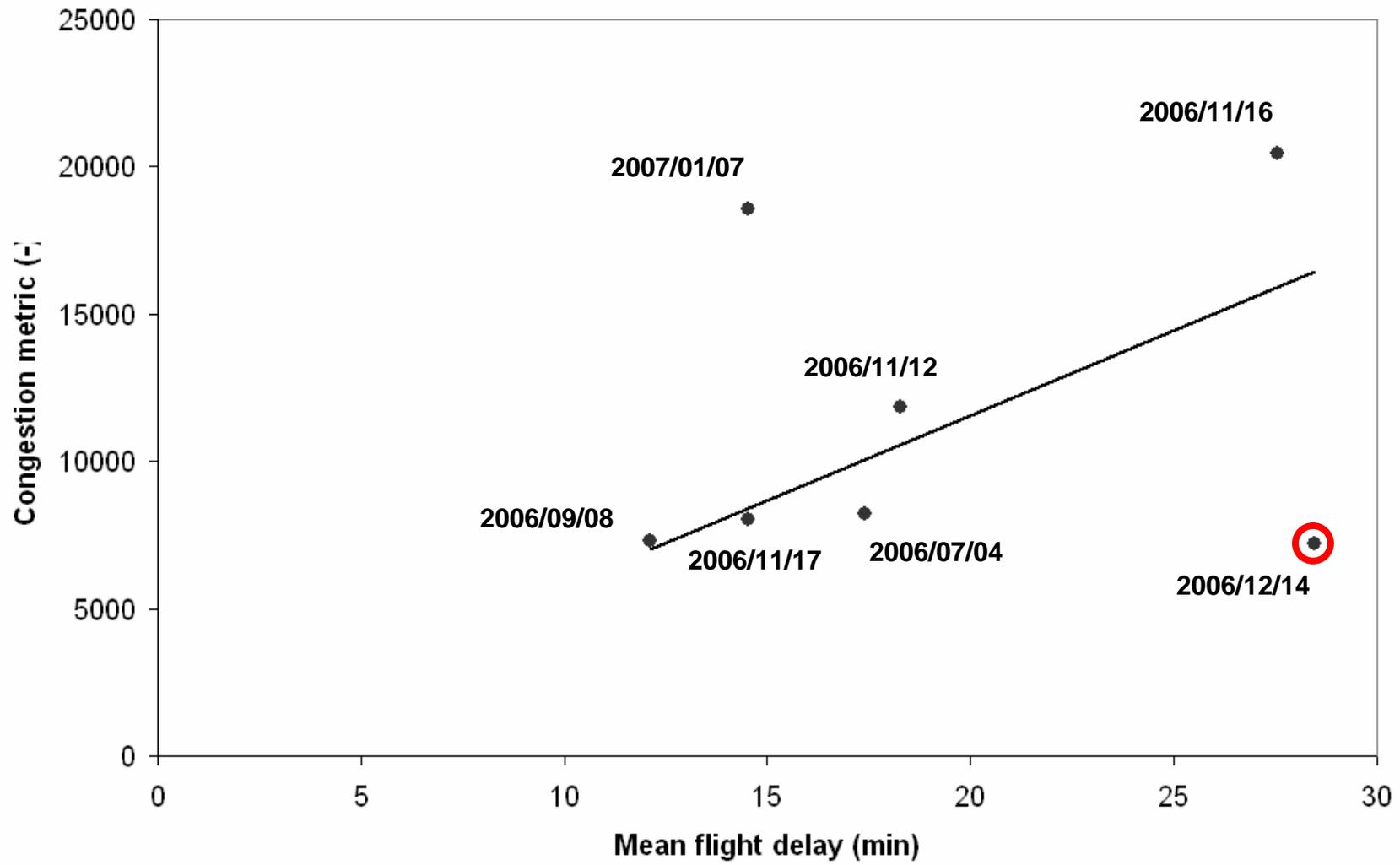
2007/01/07

■ Sunday

- Traffic: Light (39,692 IFR tracks)
- Weather: Heavy in midwest and NE corridor



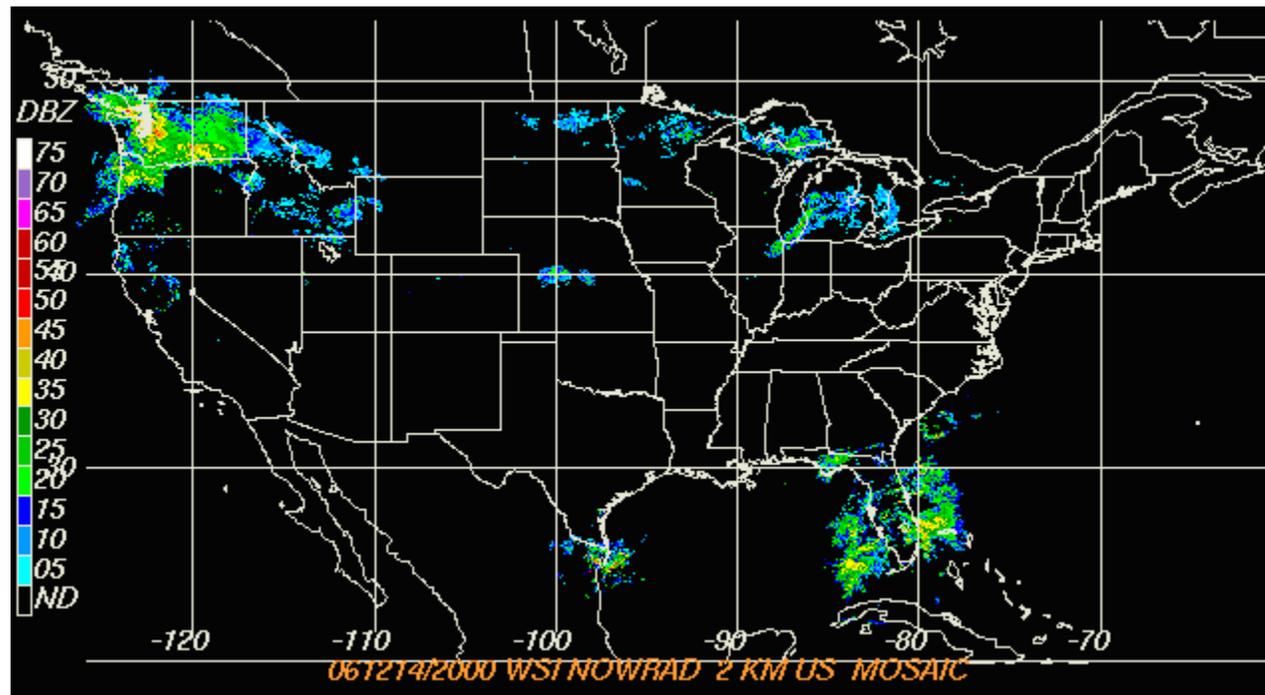
ETMS Performance



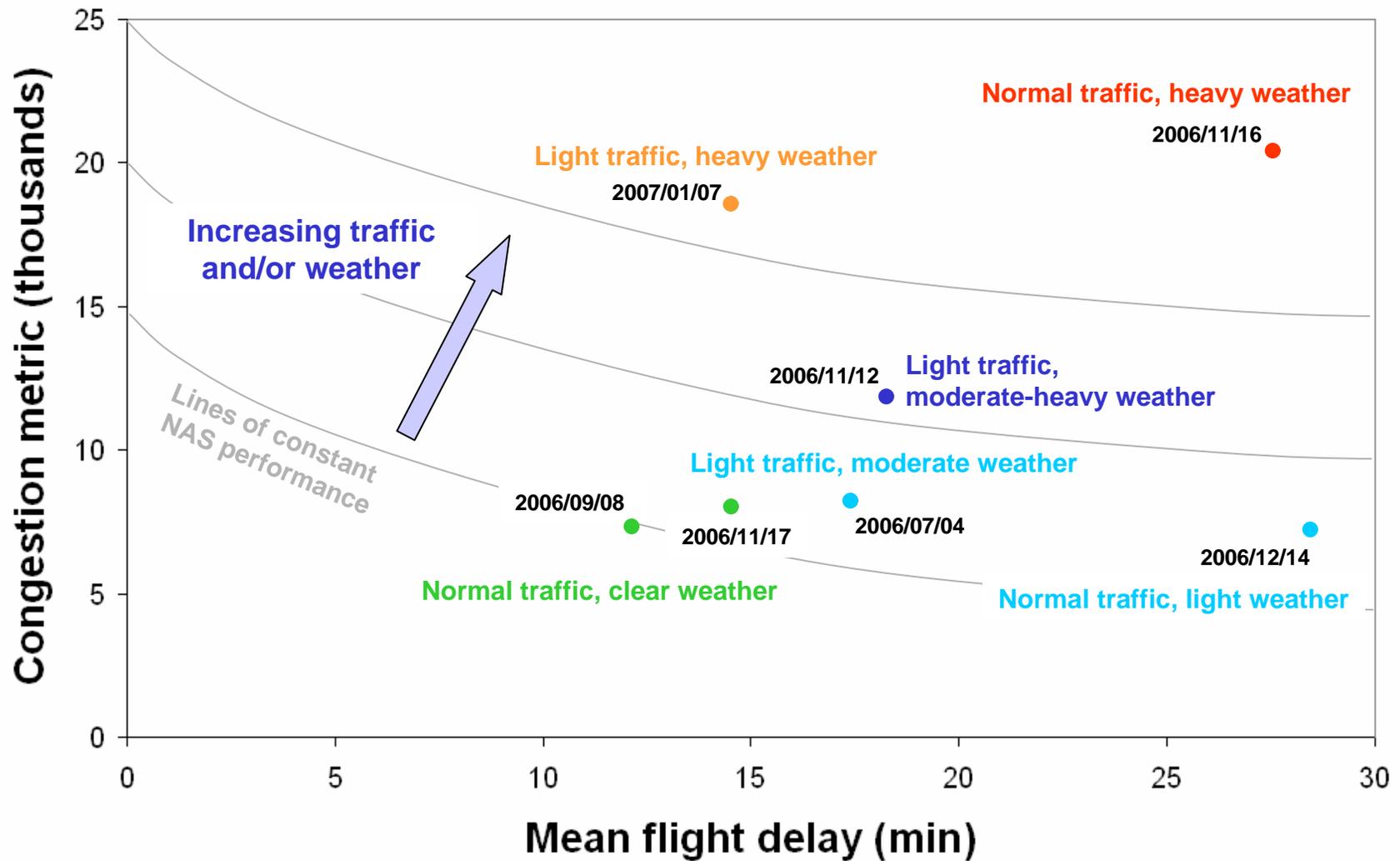
2006/12/14

■ Thursday

- Traffic: Normal weekday (50,069 IFR tracks)
- Weather: Moderate



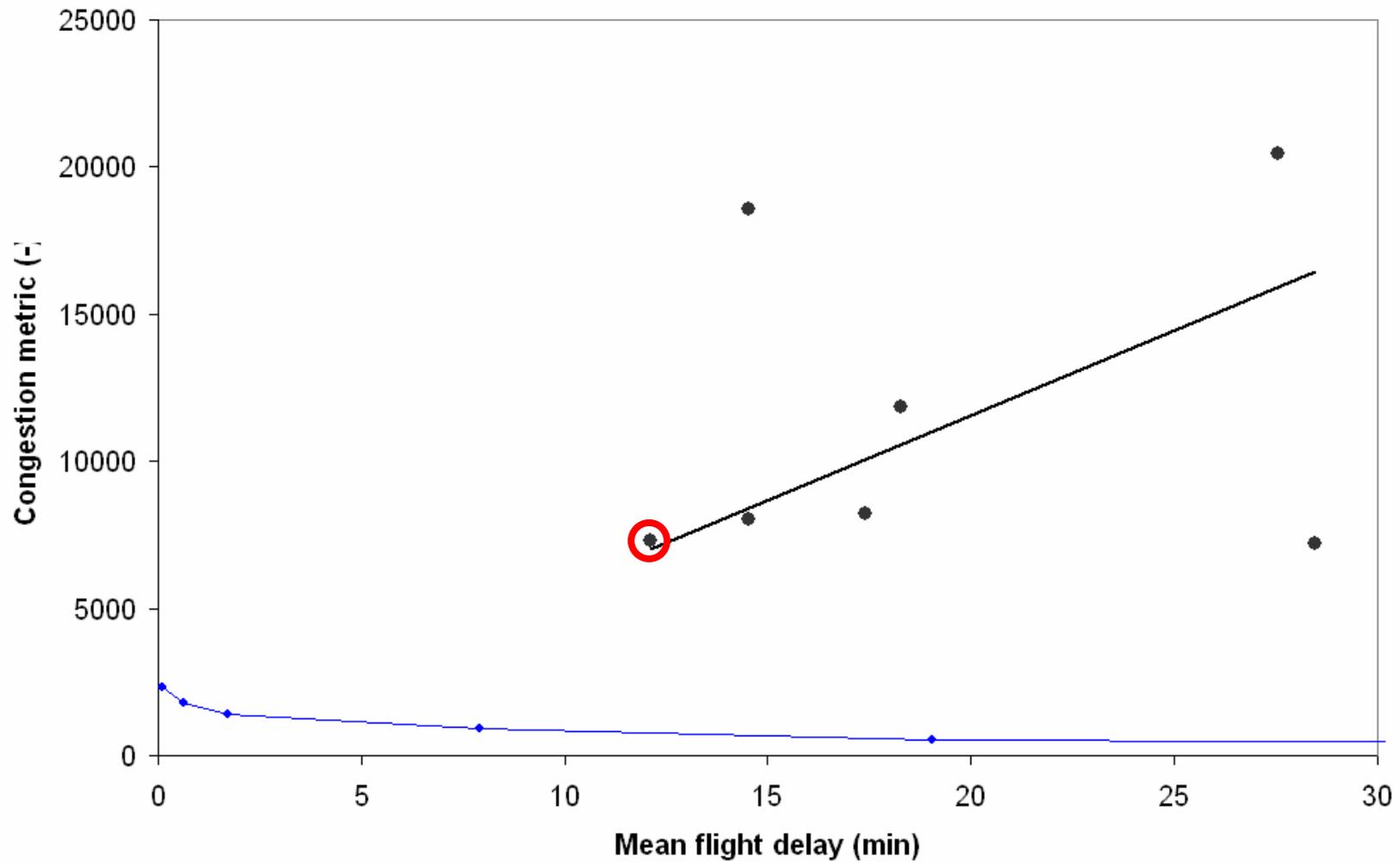
ETMS Performance Comparison



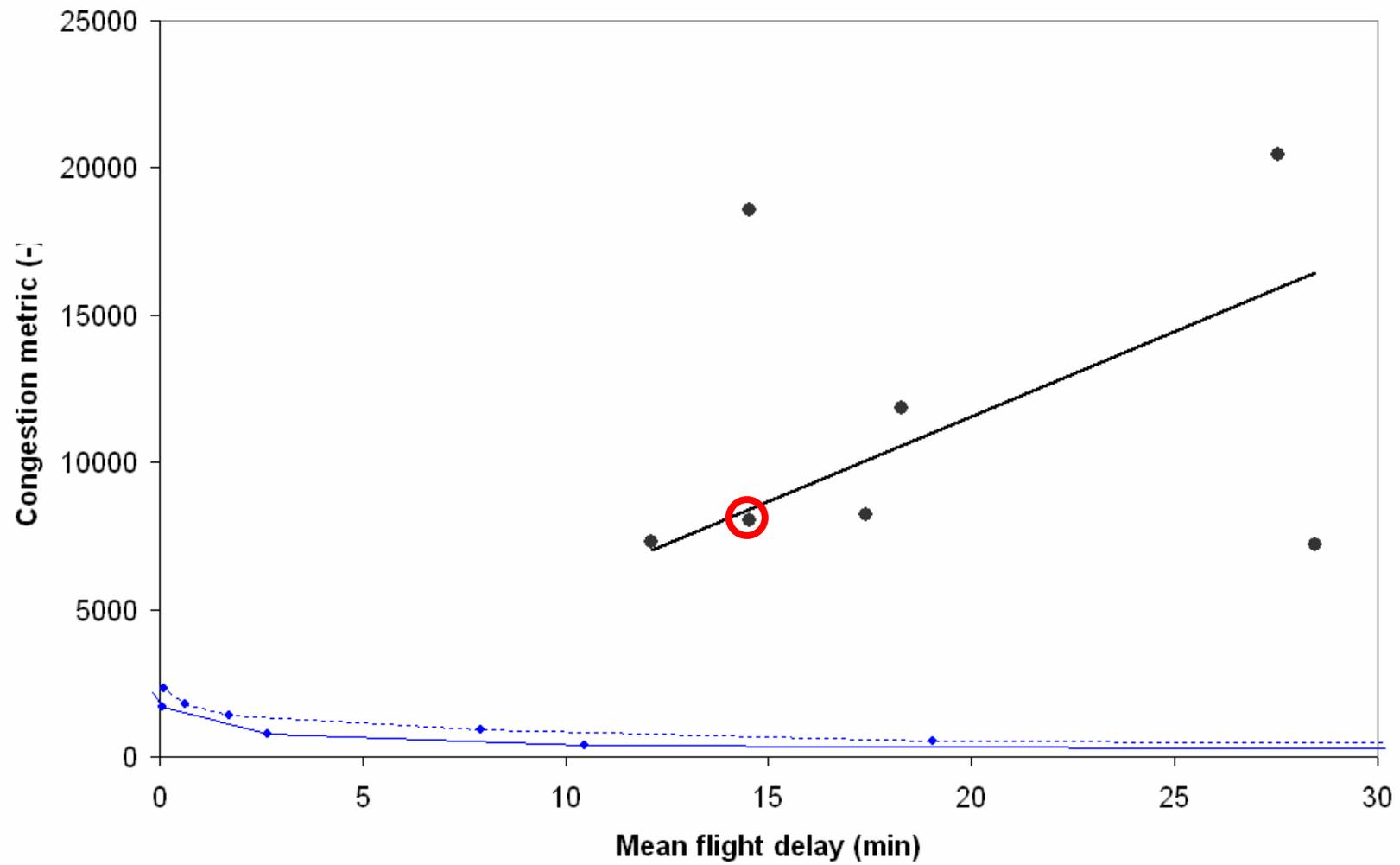
PlayBook2 Comparisons

- Re-run the seven days using PlayBook2
 - PlayBook2 TFM initiatives
 - Gate delay, re-routing
 - Traffic schedule derived from ETMS data
 - WSI-supplied weather data
 - Capacity reduction models

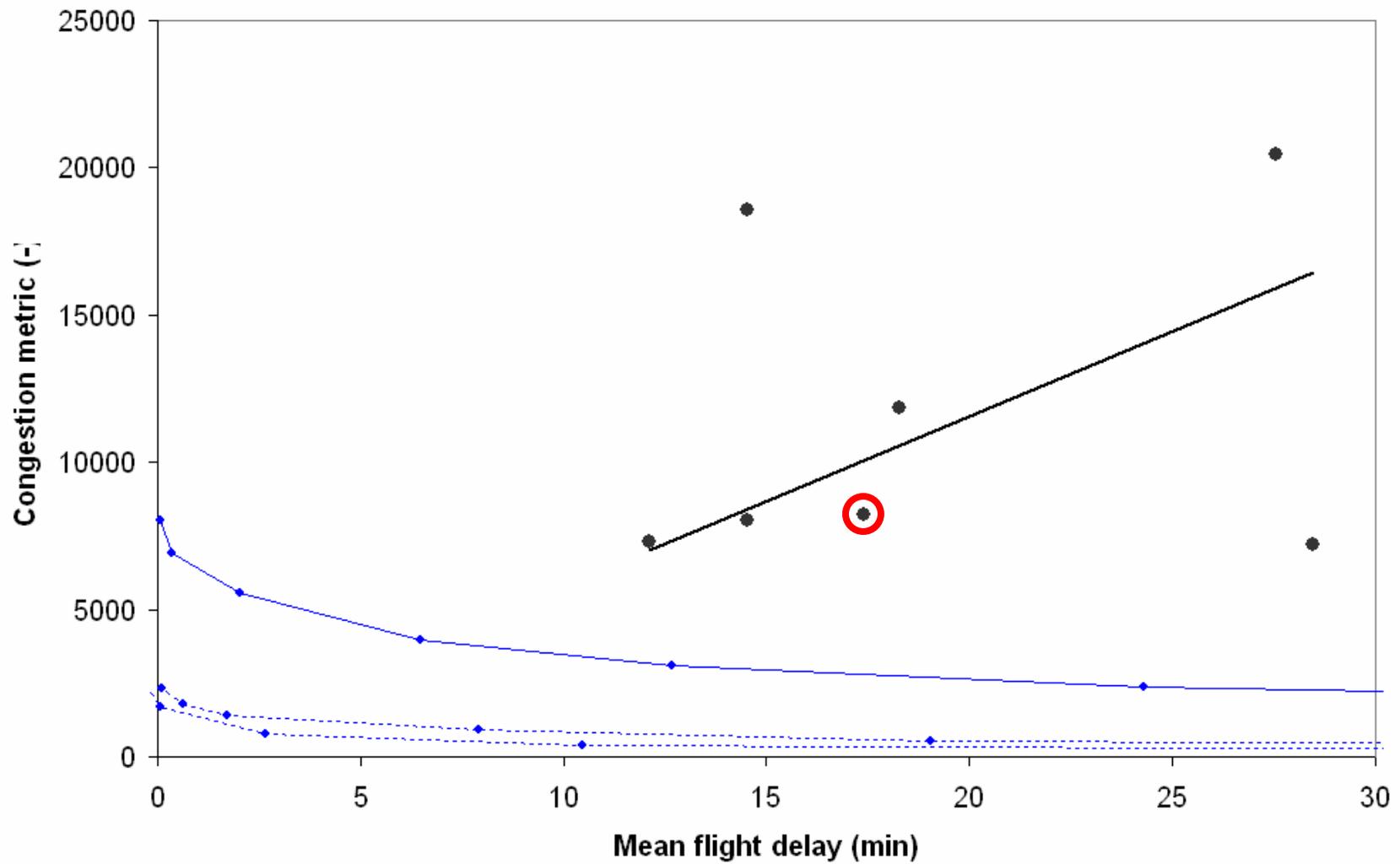
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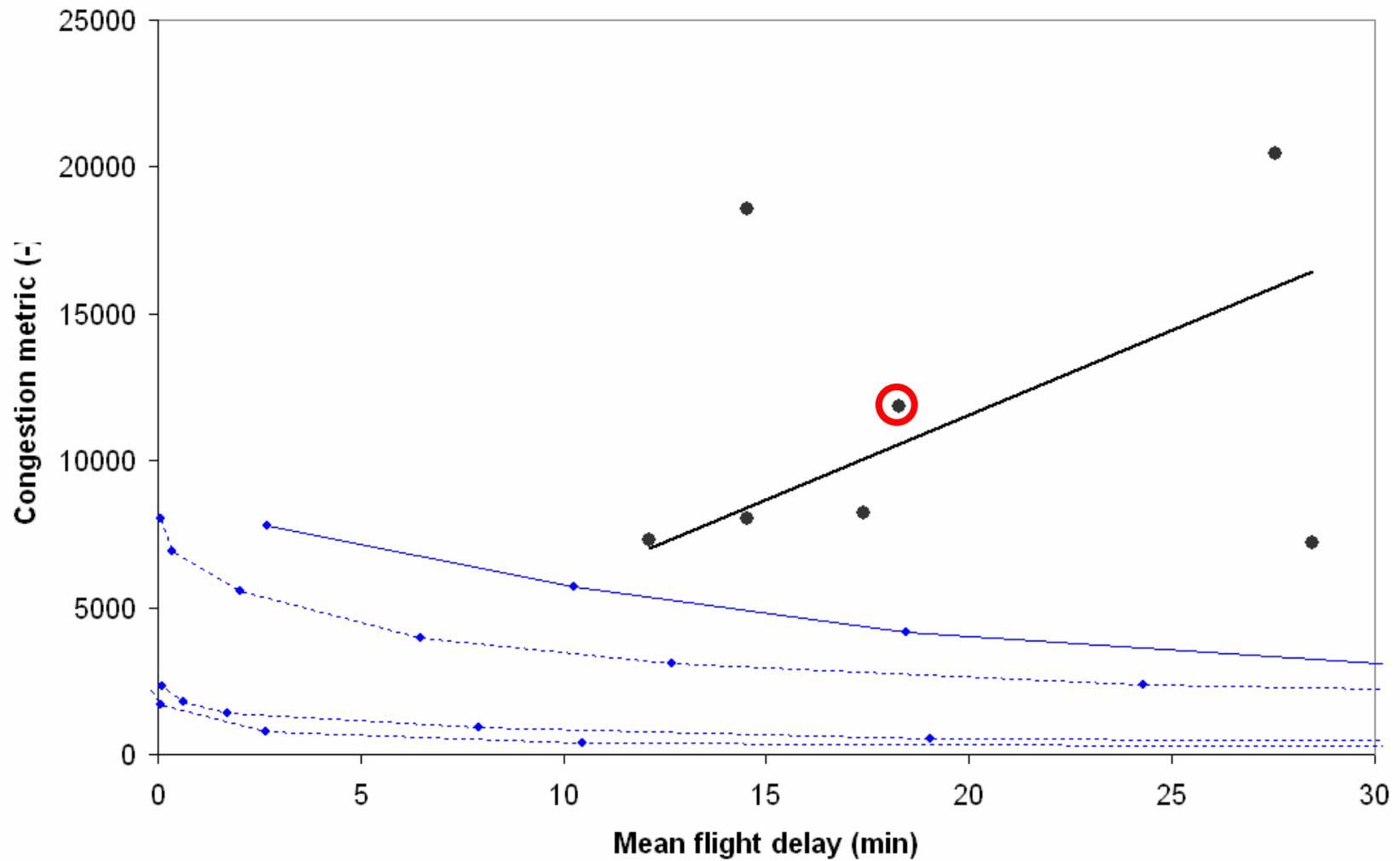
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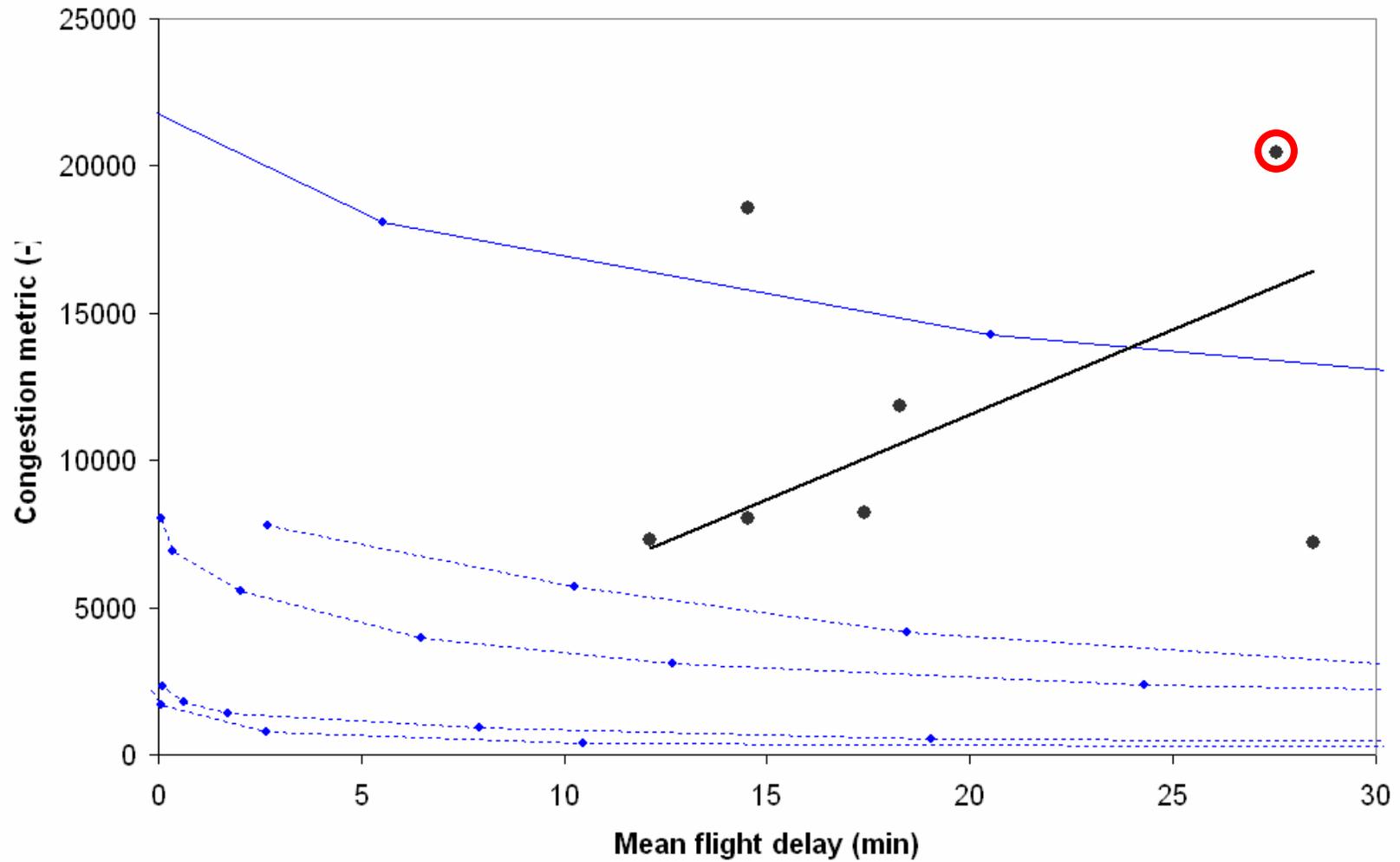
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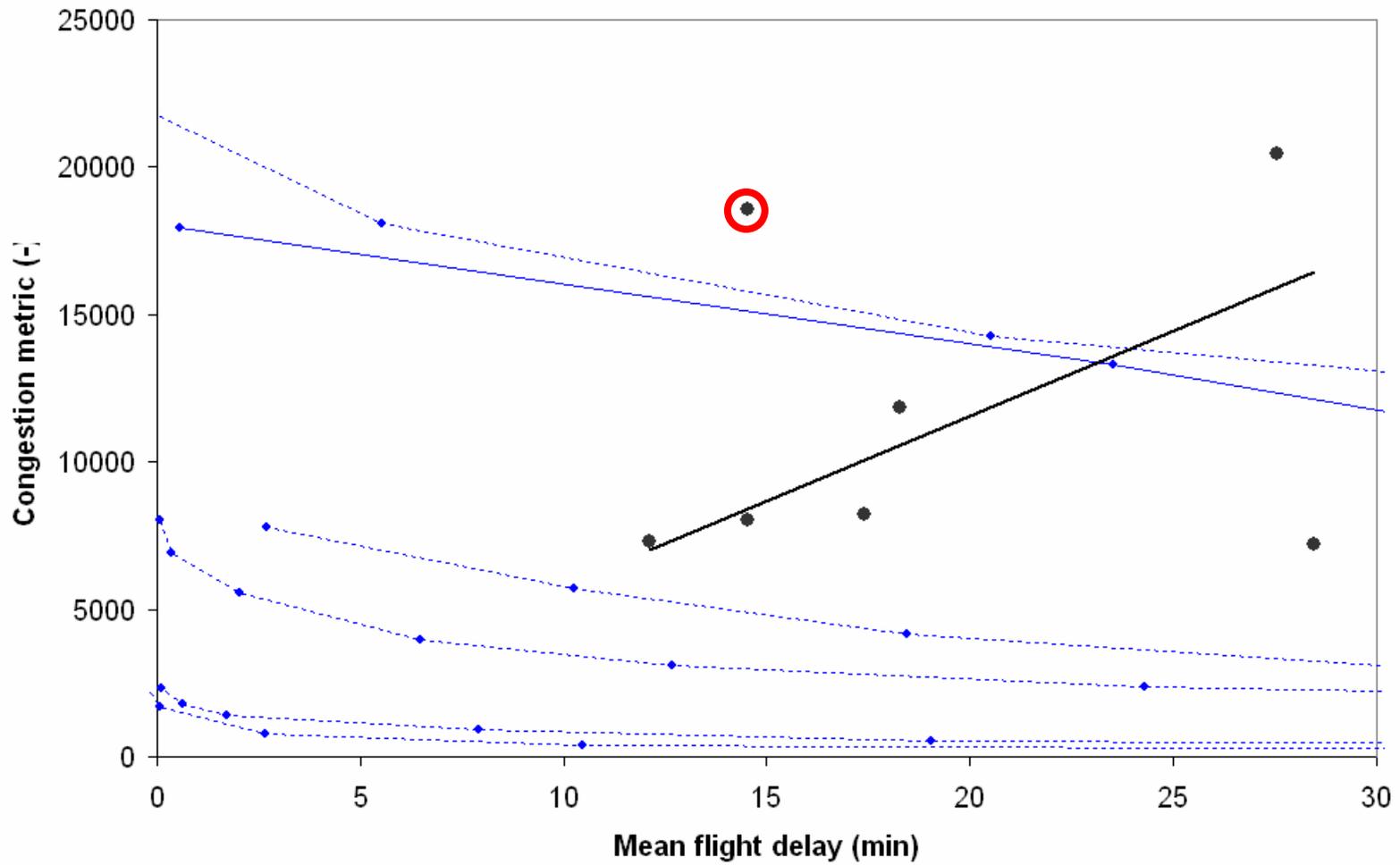
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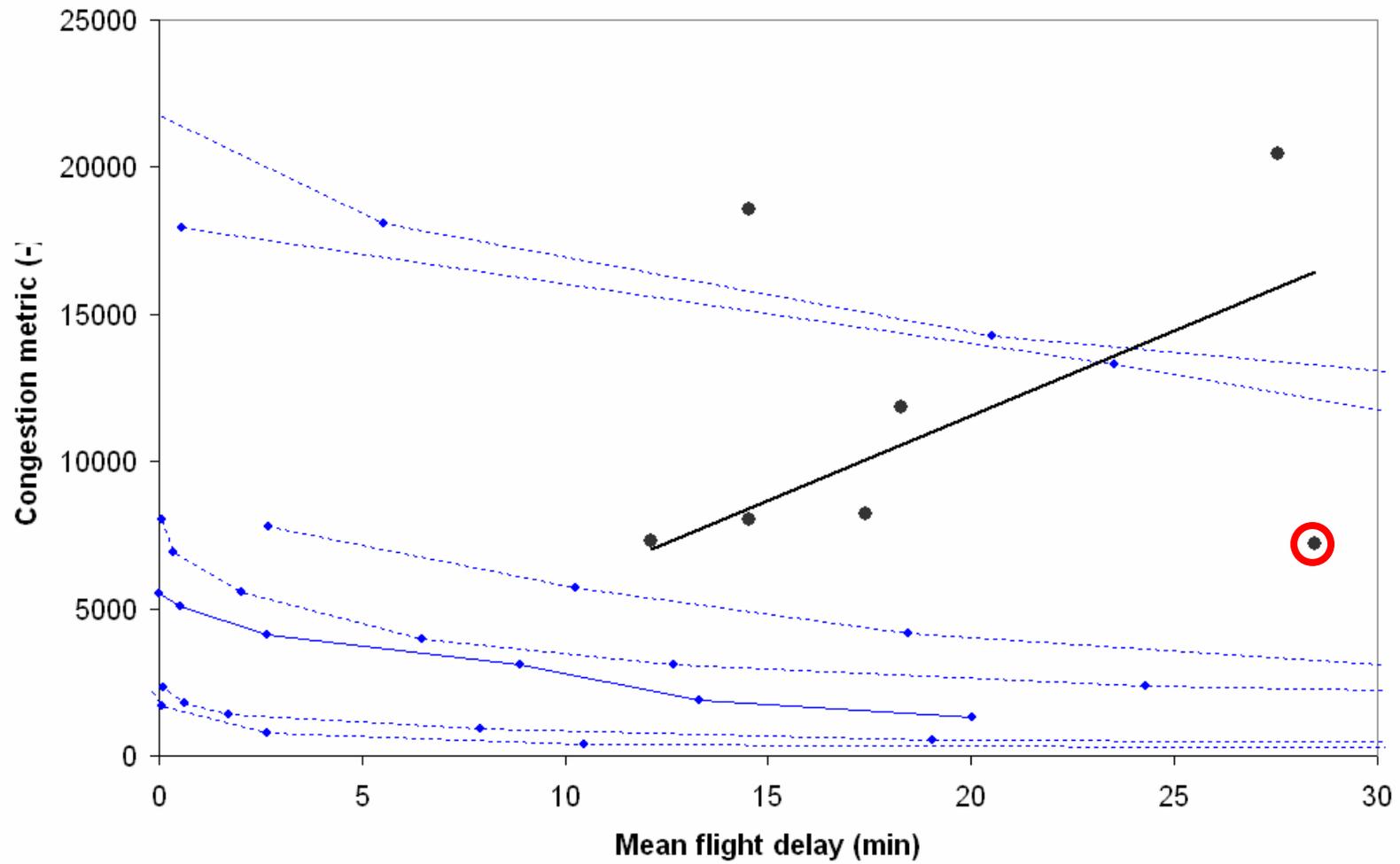
2006/11/16



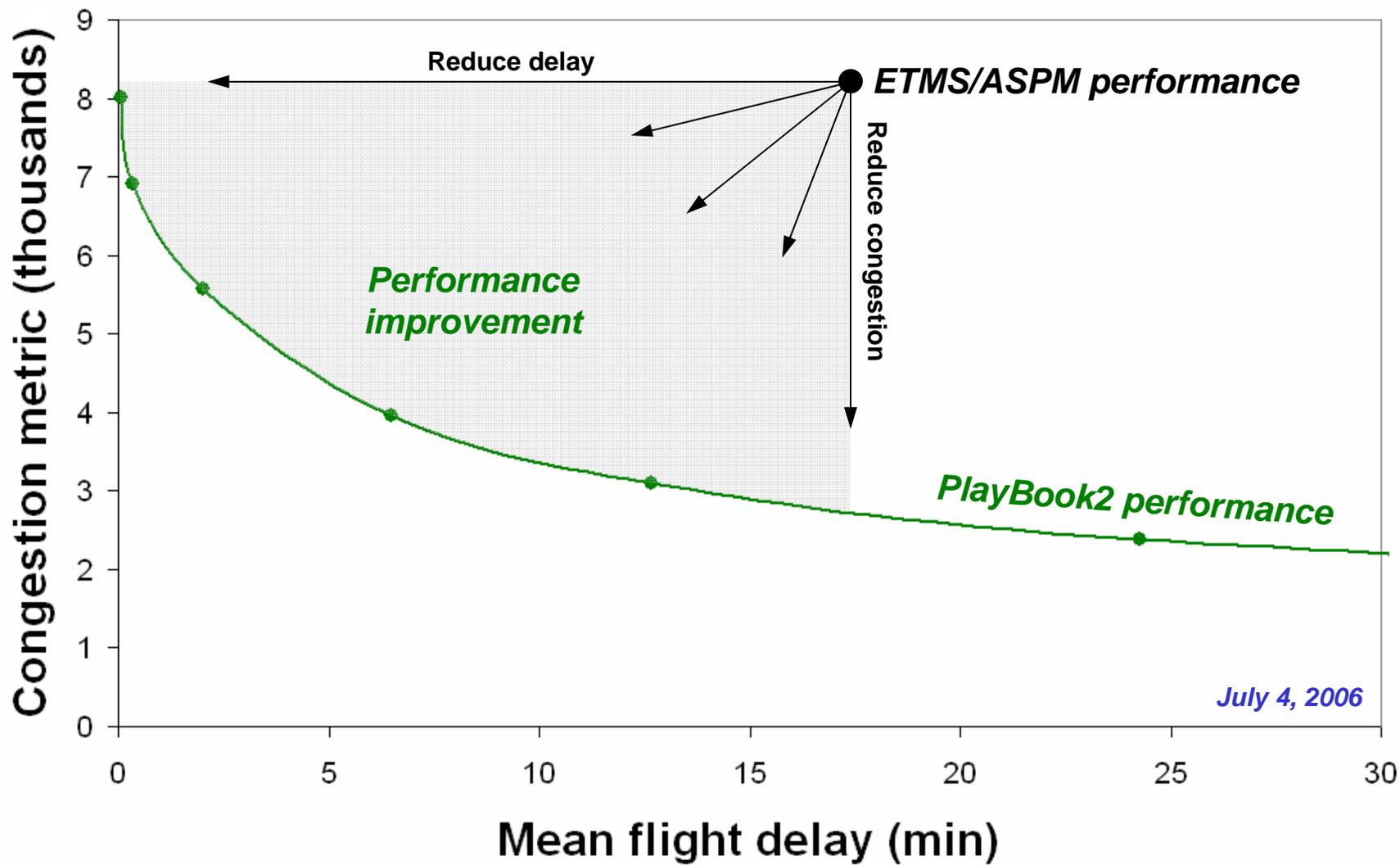
2007/01/07



2006/12/14



2006/07/04



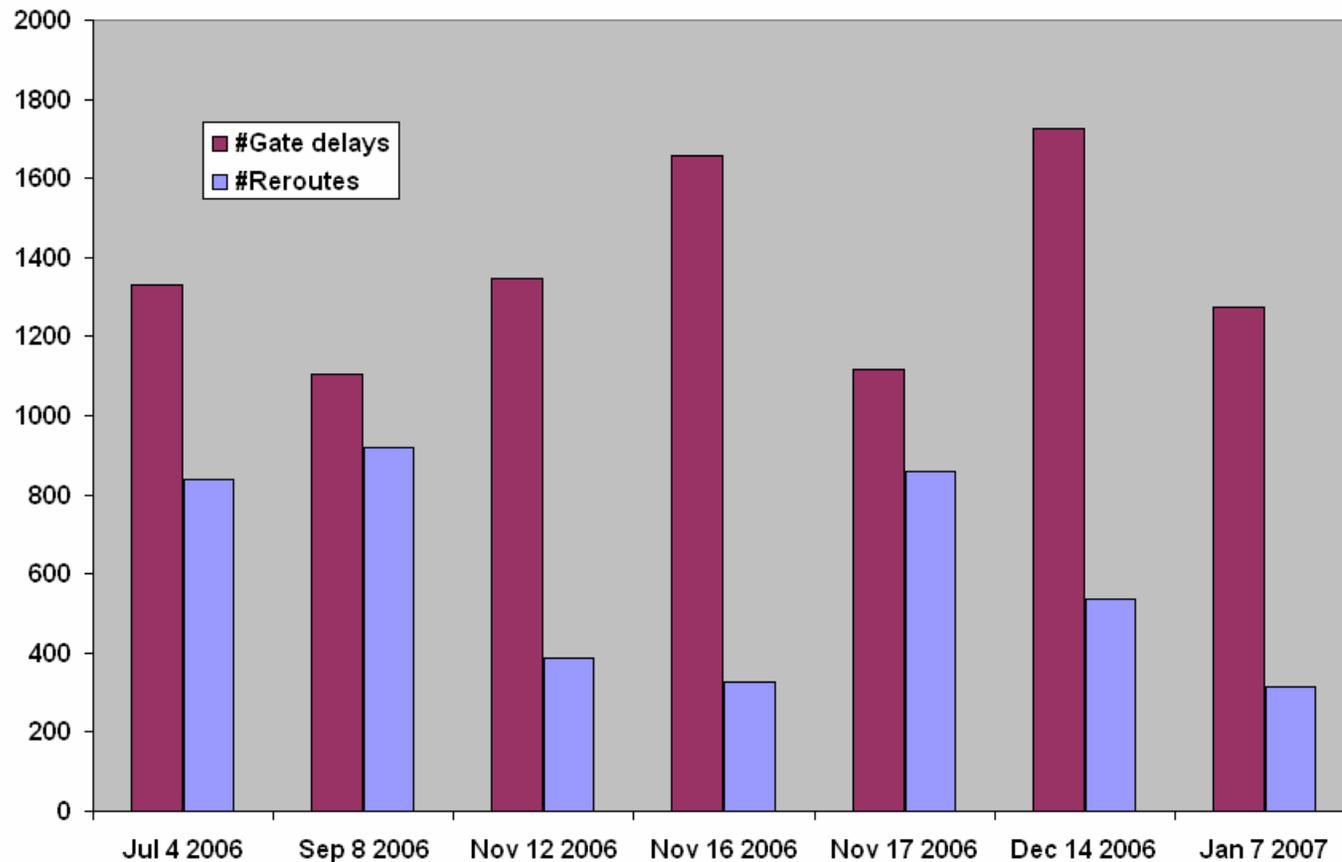
July 4, 2006

How to Process a Variety of Days?

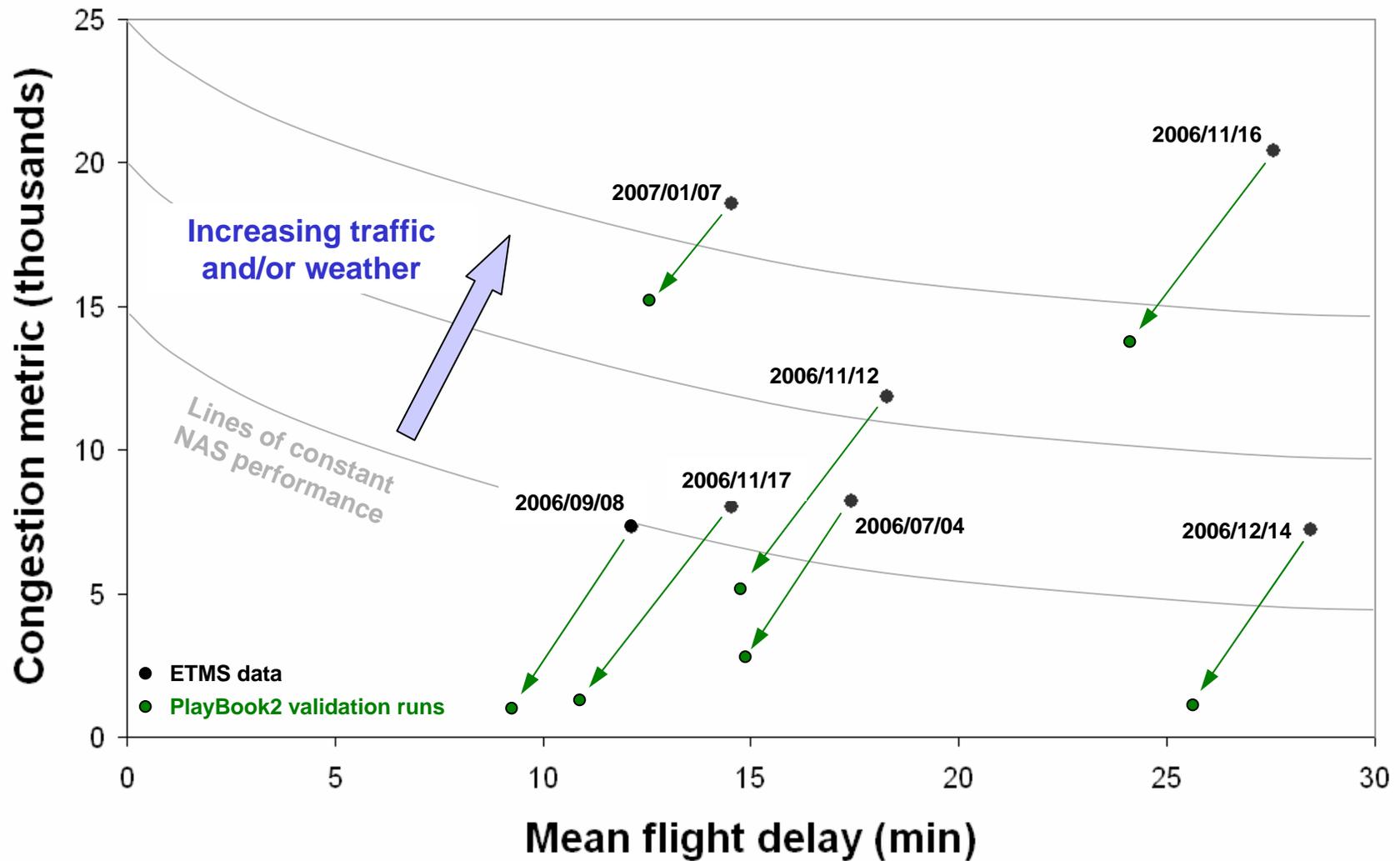
- A range of combinations of traffic and weather conditions
- Configure PlayBook2 to minimize need for operator intervention
- Solution: Use two thresholds
 - Process flights until congestion level OR flight count threshold is met

The Critical Flights

- About 2,000 flights per day are key to resolving the TFM problem



ETMS Performance Comparison

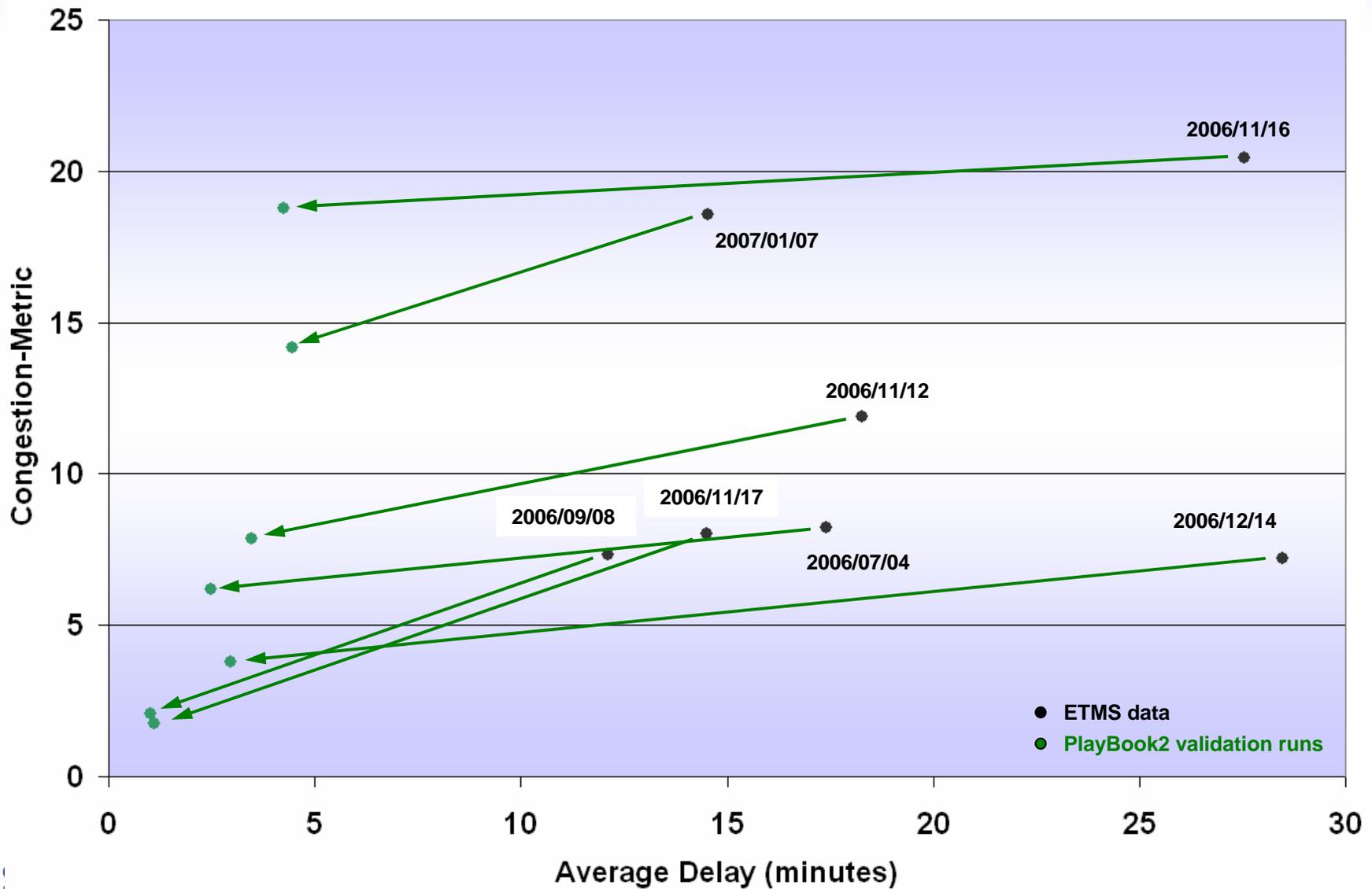


Conclusions

- Advanced TFM methods can improve NAS traffic flow
- Results from test set of seven diverse days suggests that a single TFM solution can efficiently process many different types of days in the NAS
- Advanced TFM tools likely do not require tuning for each day
- Future work
 - Collaborative TFM distributing PlayBook2 trial planner and data to operators
 - Equity analysis and evaluation
 - HITL testing and evaluation of how to implement
 - Further testing

Backup

ETMS Performance Comparison

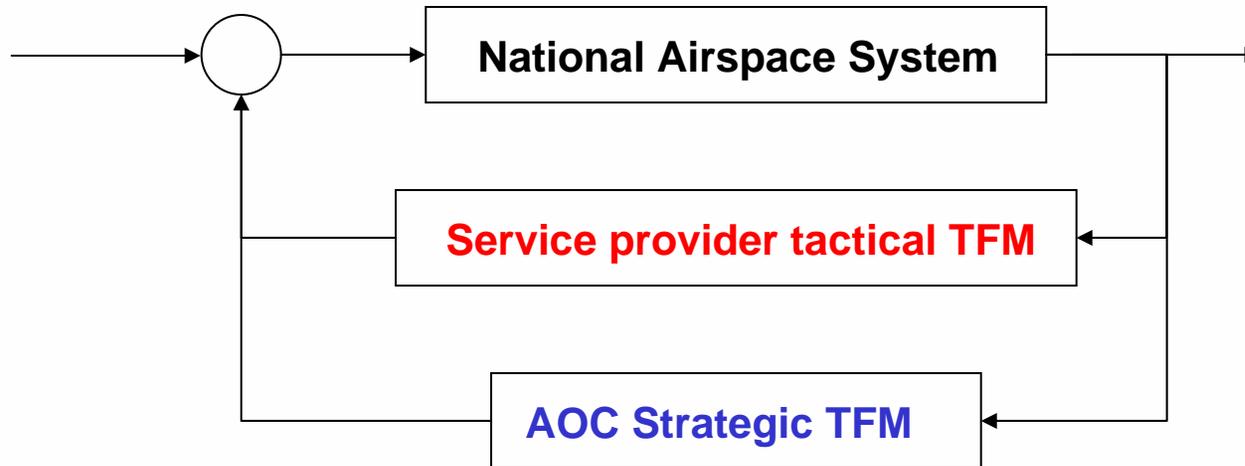


Collaborative TFM

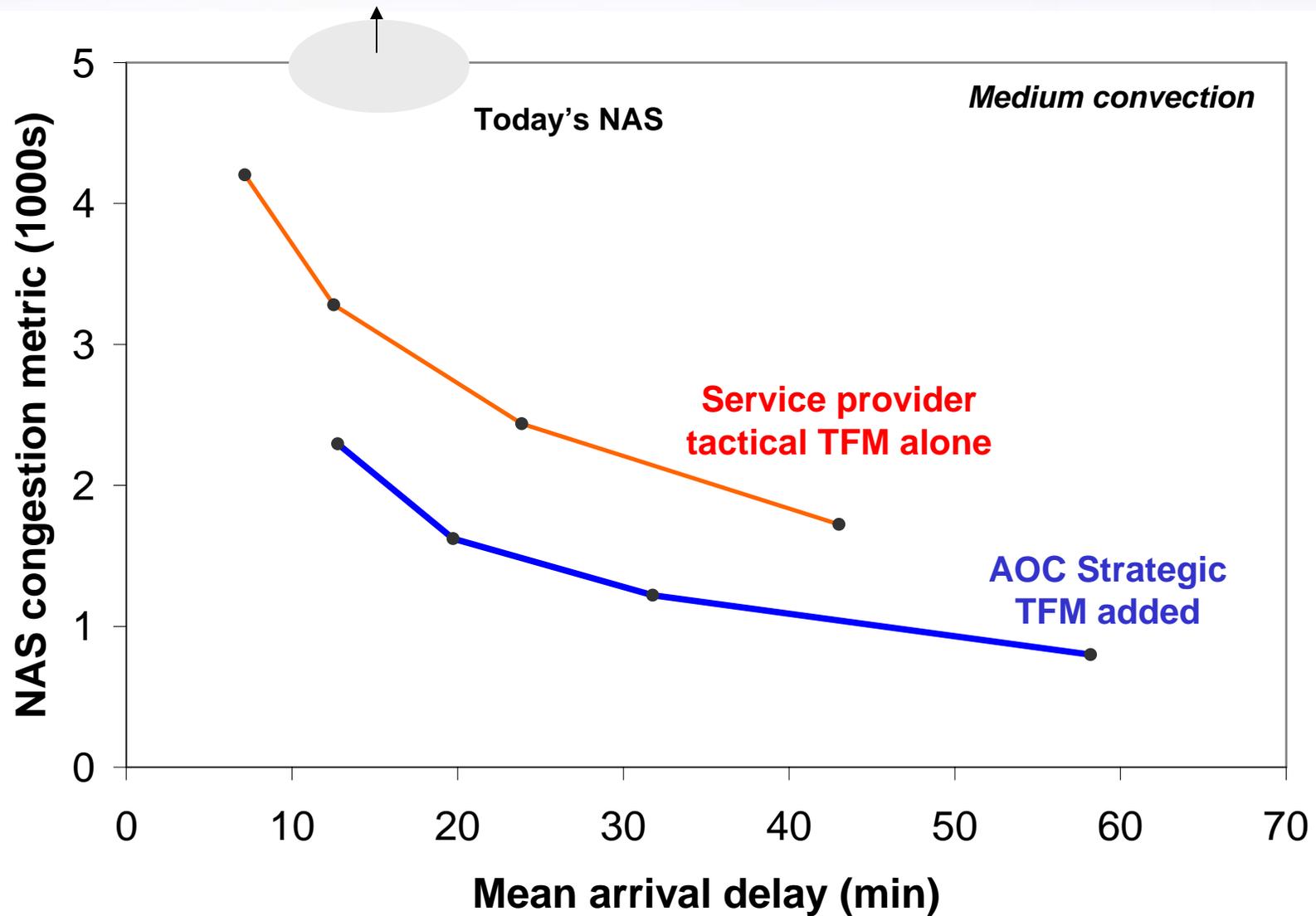
PlayBook2 CDM

- Distribute NAS system information to operators ahead of time
 - Loading, capacity and congestion forecasts
 - Trial planning DST software
- AOC time horizon = AOC look ahead time

PlayBook2 CDM



Aggregate Congestion-Delay



Collaborative TFM Summary

- Distributing data and DST to operators can help resolve the TFM problem
 - Reduce service provider work load by a factor of 3 or more
 - Allow operators opportunity to make their own decisions
- Inner and outer TFM loop improves overall NAS performance
- Need to analyze problem of gaming

