JPDO Systems Modeling and Analysis

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JPDO Systems Modeling and Analysis Division (SMAD)

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JPDO Organizational Changes

- Yuri Gawdiak has joined the JPDO as the lead for the newly created Systems Modeling and Analysis Division (SMAD).

- This division will continue the SEAD's work on modeling the NextGen architecture and systems.

- SMAD will also provide analytical support to other JPDO offices to include the Enterprise Architecture and Engineering Division, the Portfolio Management Division, and the Policy Division.

JPDO Organizational Changes

- Yuri comes to the JPDO from NASA and has extensive experience in aeronautical engineering and analysis.
- He managed the development and transfer of air traffic management and safety applications to the FAA and industry and was the program manager of the Engineering for Complex Systems program.
- Most recently, he has been performing strategic analyses within NASA's Program Analysis and Evaluation Office.

Systems Modeling and Analysis Division

- **Priorities:**
  - Better coordination with Enterprise Architecture & Portfolio Management Divisions
  - Support improved Operational Improvement prioritizations and sequencing
  - Develop and implement comprehensive verification & validation strategy

- **Approach:**
  - Collect requirements and schedule targets from JPDO divisions
  - Conduct technical interchange meetings with partner organizations & programs to get lessons learned, expectations, issues, requirements, and identify possible tools/products that are mutually beneficial
  - Develop integrated SMA division plan

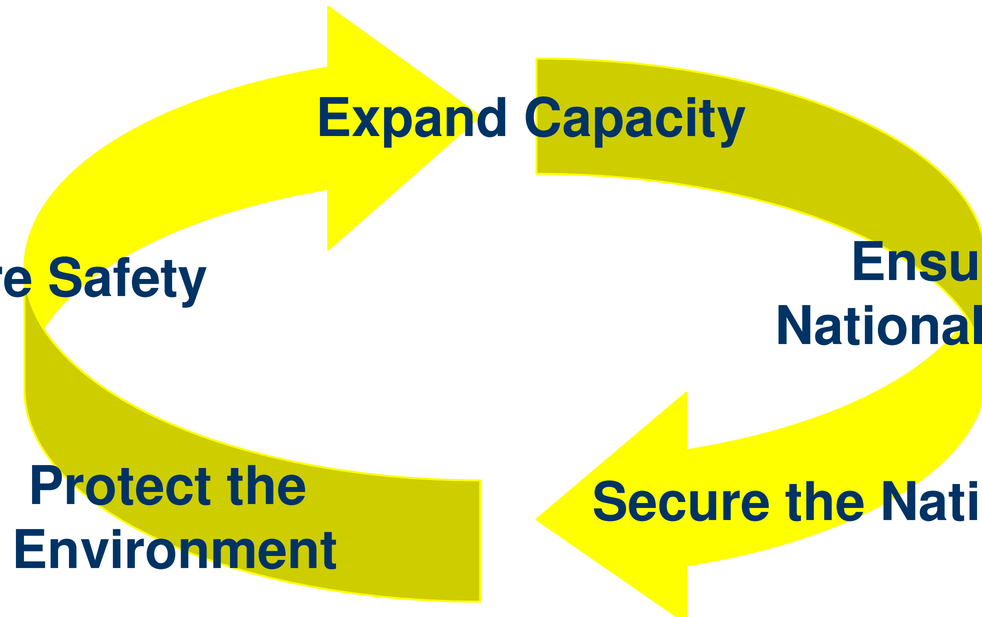
SMAD Key Planning Elements

- Stakeholder Identification

- Requirements Analysis
  - Fixes to existing functions
  - Upgrades/performance improvements
  - New functions/gap fillers

- Current key goals in the SMAD plan
  - Improve turn-around time improvements/quick response capability
  - Integrated JPDO/FAA support schedule
  - Strategic upgrades (including long term validation approaches)

JPDO Goals


Expand Capacity
Ensure Safety
Ensure our National Defense
Protect the Environment
Secure the Nation
Retain U.S. Leadership in Global Aviation

What is NextGen?

- Next Generation Air Transportation System
- The "end state" of the JPDO's work (2025)

Operating Principles

- **"It's about the users…"**
- **System-wide transformation**
- **Prognostic approach to safety assessment**
- **Globally harmonized**
- **Environmentally compatible to foster continued growth**

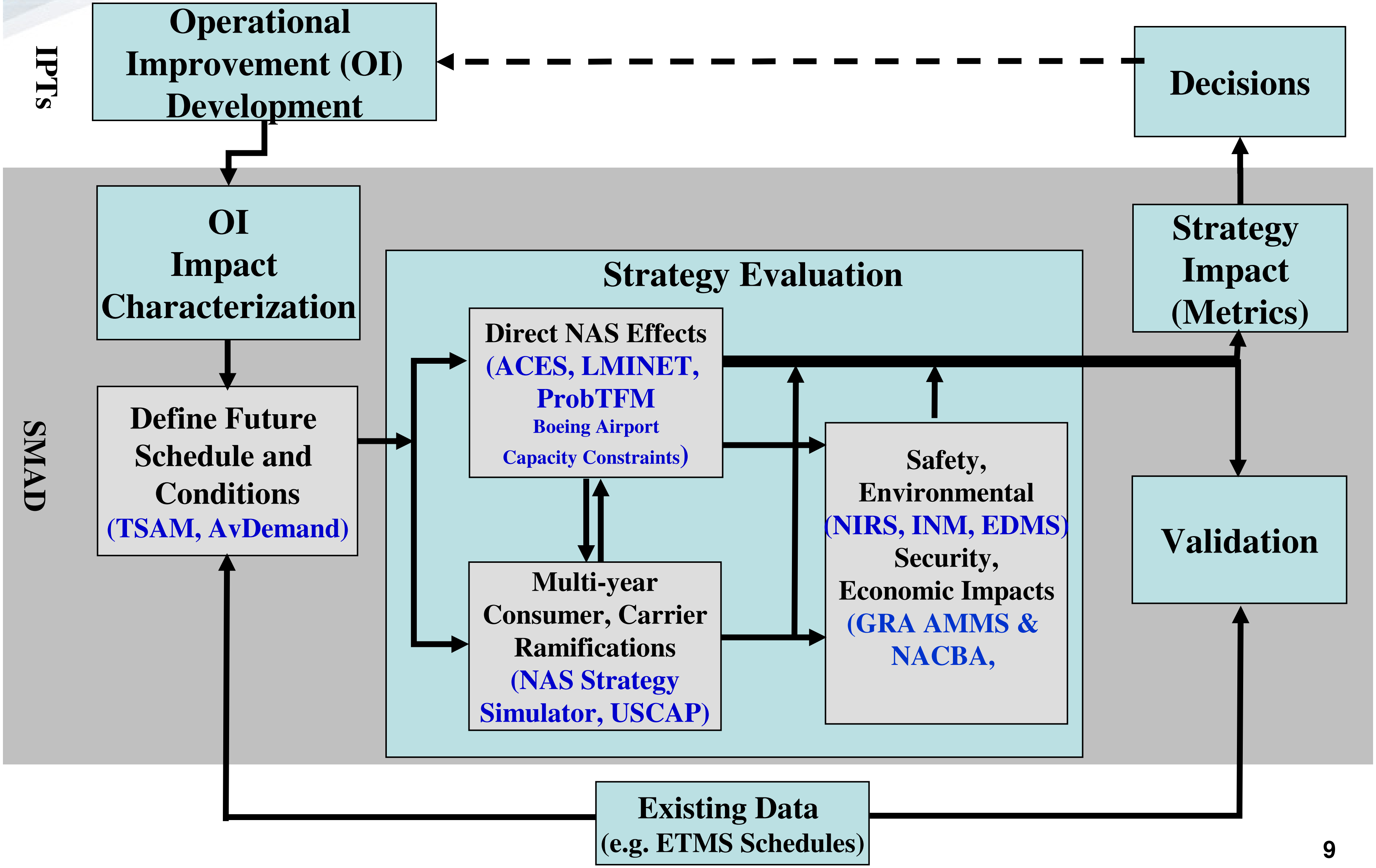
Key Capabilities

- **Net-Enabled Information Access**
- **Performance-Based Services**
- **Weather-Assimilated Decision Making**
- **Layered, Adaptive Security**
- **Broad-Area Precision Navigation**
- **Trajectory-Based Aircraft Operations**
- **"Equivalent Visual" Operations**
- **"Super Density" Operations**

Operational Improvements (OIs)

- Each segment in the Portfolio Roadmap is composed of a set of Operational Improvements
- Each OI indicates a particular step towards achieving one or more of the JPDO key capabilities (e.g., trajectory-based operations) and thus achieving one or more of the JPDO national goals (e.g., capacity)
- The SMAD models groups of OI's and individual OI's to evaluate the performance of the NextGen
- Not all OIs have been modeled
  - *Some are too vague*
  - *Some cannot be addressed by our current models*

SMAD Modeling and Analysis Framework

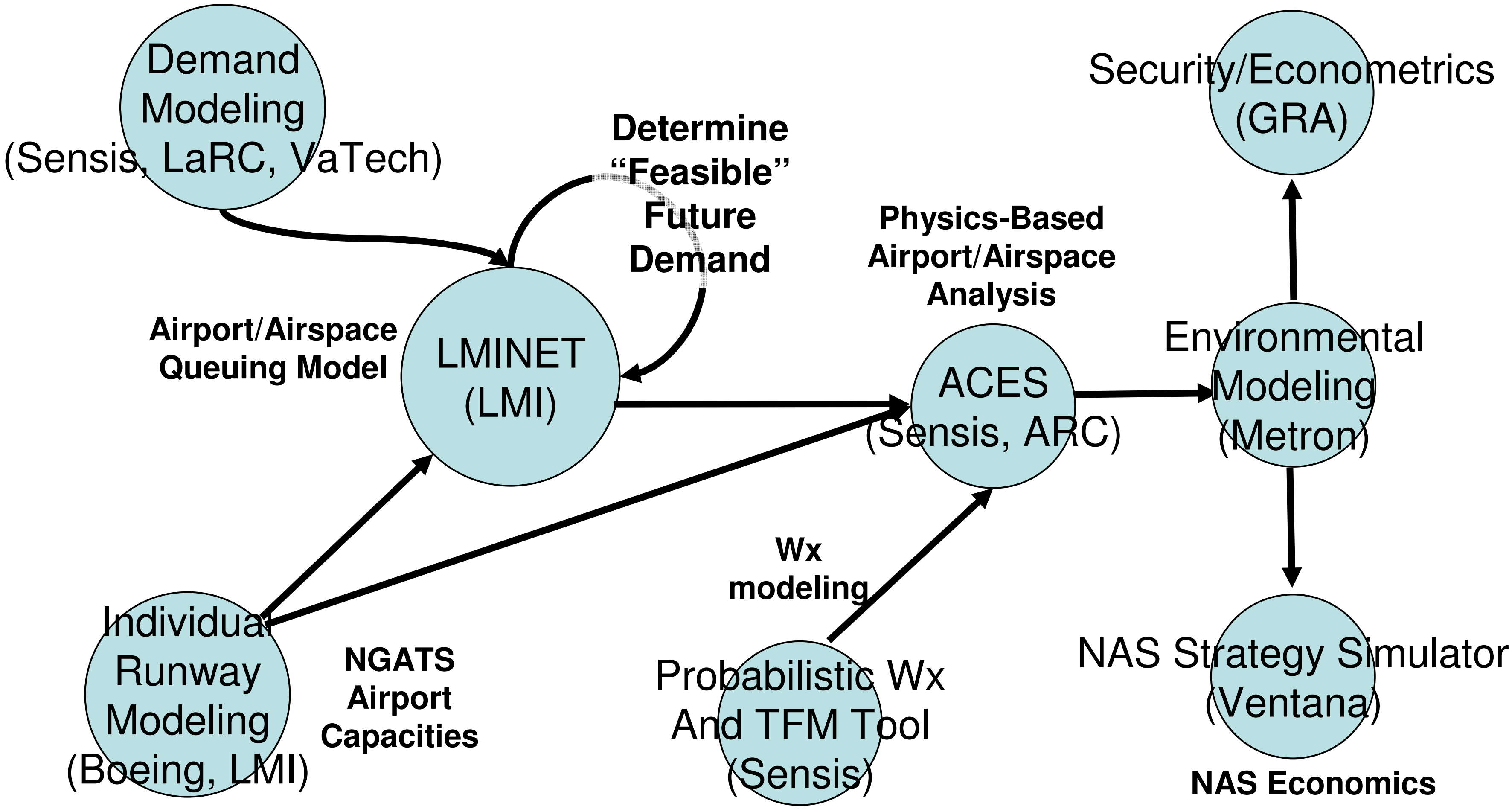


SMAD Modeling and Simulation Tools

- **ACES** (NASA-Ames/Sensis): Agent-based simulation of individual aircraft flying one day of NAS activity
- **LMINET** (LMI): Queuing model for airports and sectors of one day of NAS activity.
- **ProbTFM Tool** (Sensis): Tool for designing and evaluating probabilistic traffic flow management in heavy weather
- **AvDemand** (Sensis): Calculates future NAS demand based on FAA forecasts
- **AvAnalyst** (Sensis): Analysis and visualization tool for NASA ACES simulation outputs
- **TSAM** (LaRC, VaTech): Transportation Systems Analysis Model – demand generation and NAS-wide modeling and analysis
- **NAS-Wide Environmental Impact Model** (Metron, NASEIM): Detailed calculator of noise and emissions based on individual flight trajectories from ACES
- **GRA Screening Model** (GRA): For each passenger service airport, model describing current security lanes and processing rates; may be adapted for additional lanes or changes in processing rates
- **FAA NAS Strategy Simulator** (Ventana): Multi-year, macro-level simulation of annual system statistics of demand, NAS activity, FAA costs and revenues
- **Airport Capacity Constraints Model** (Boeing): For 35 OEP airports, computes detailed capacity as a function of runway configuration, operational procedures, and ground infrastructure.

Integrated Modeling and Analysis Process

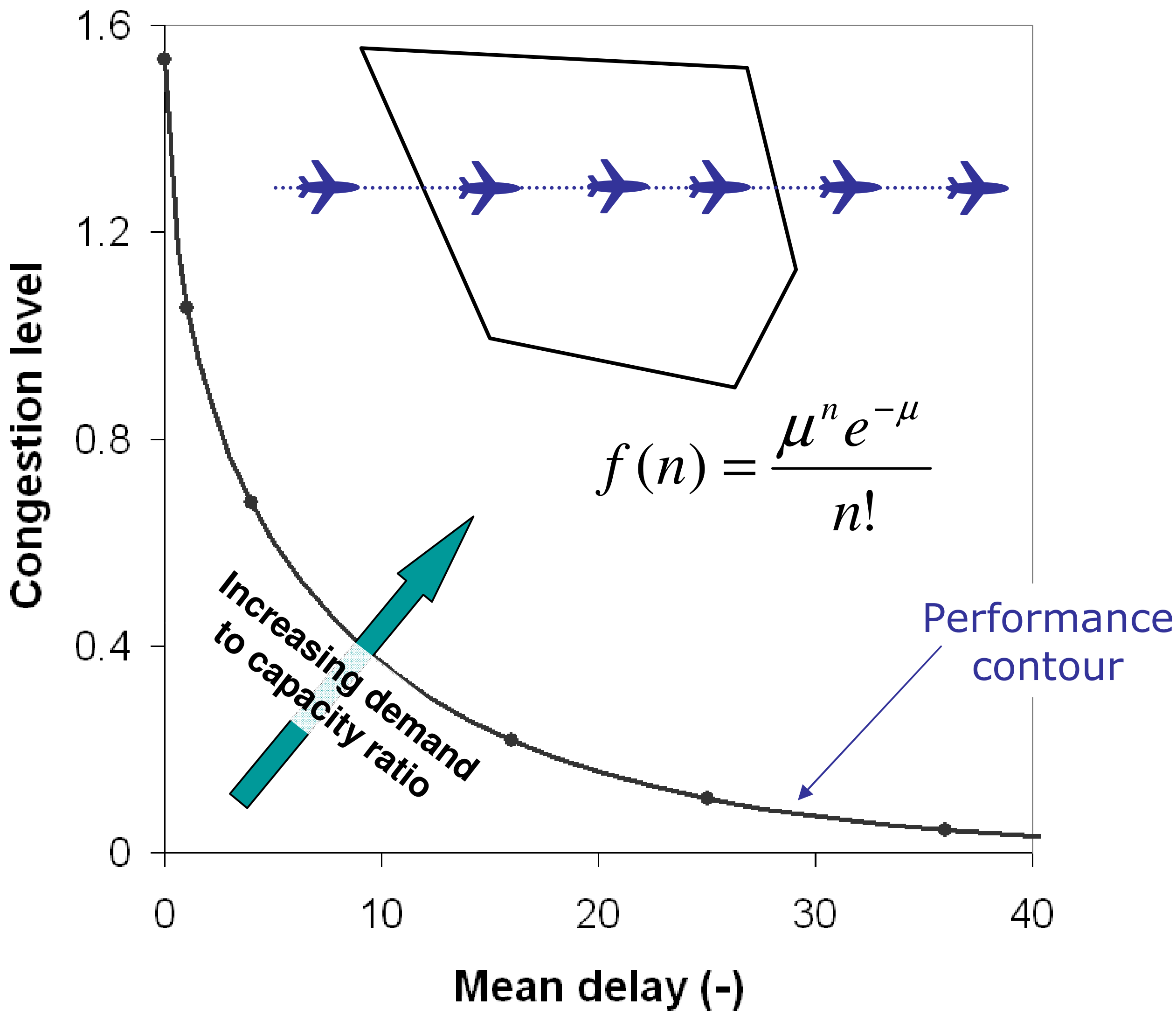
SMAD has brought together best-in-class modeling and simulation tools and expertise to support JPDO analyses



Recent NAS Tradeoff Studies

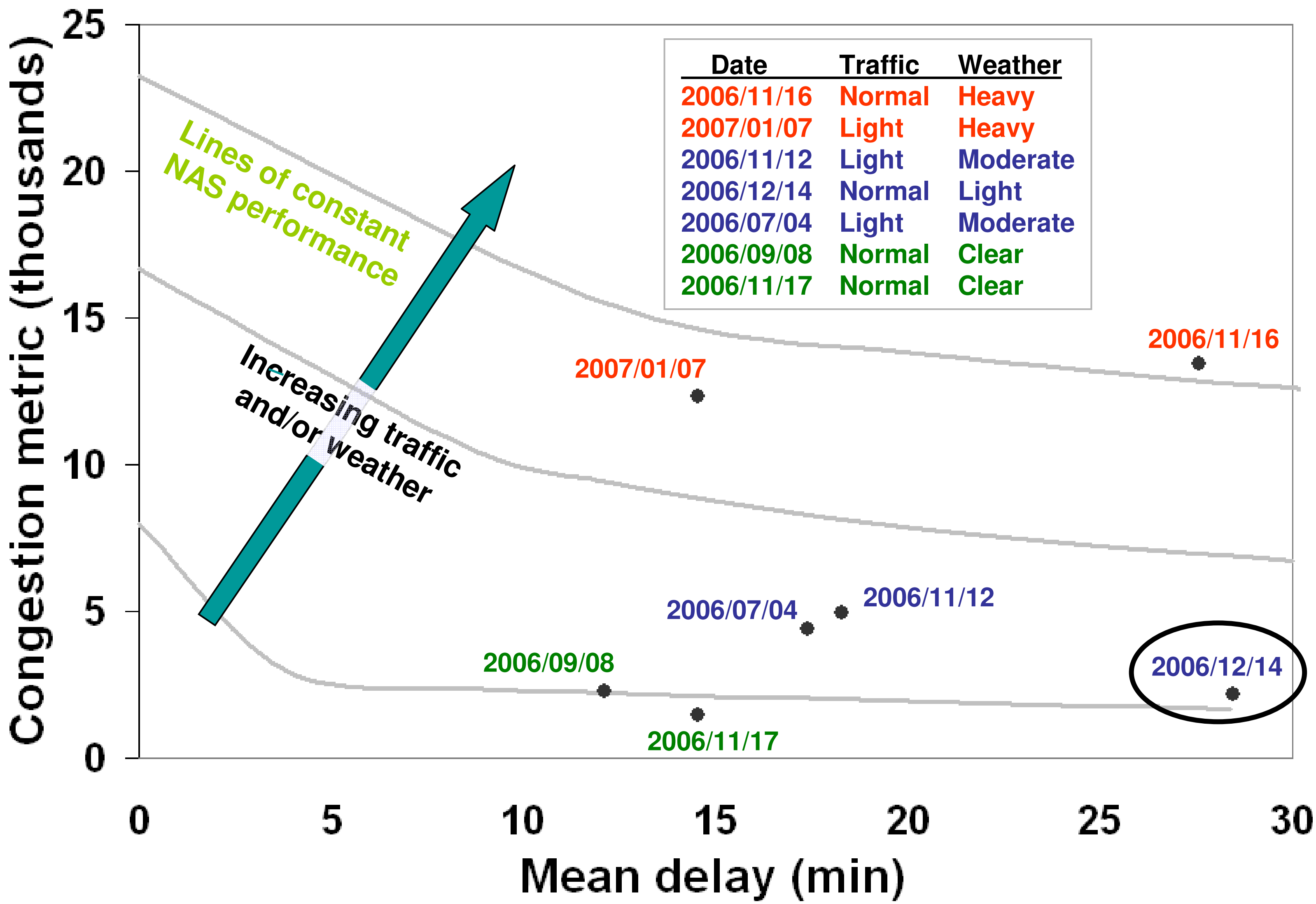
- Congestion modeling
- Critical flights
- Delay distribution
- NAS performance sensitivity

Poisson Congestion-Delay Tradeoff



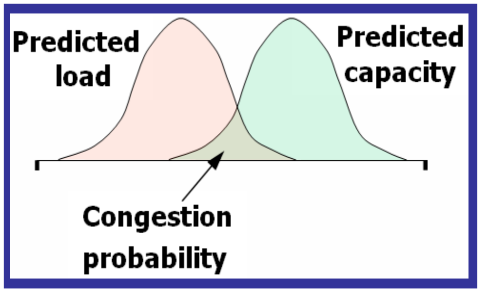
$$f(n) = \frac{\mu^n e^{-\mu}}{n!}$$

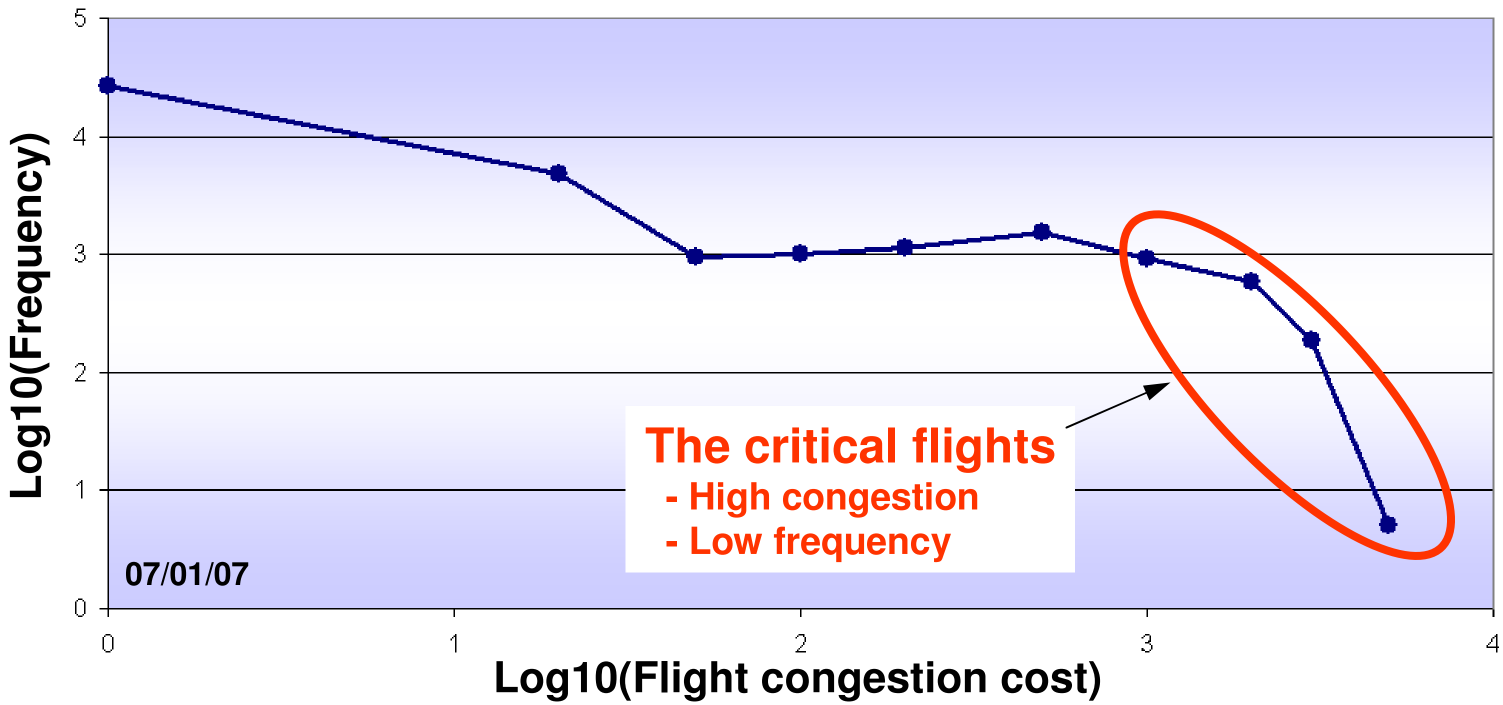
NAS Performance Contours



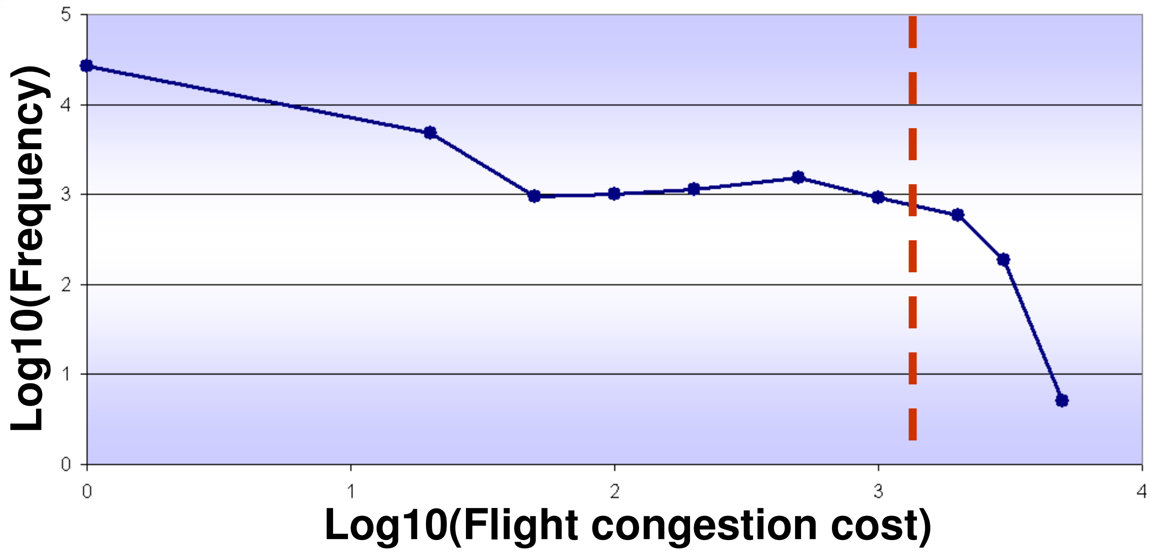
Critical Flights

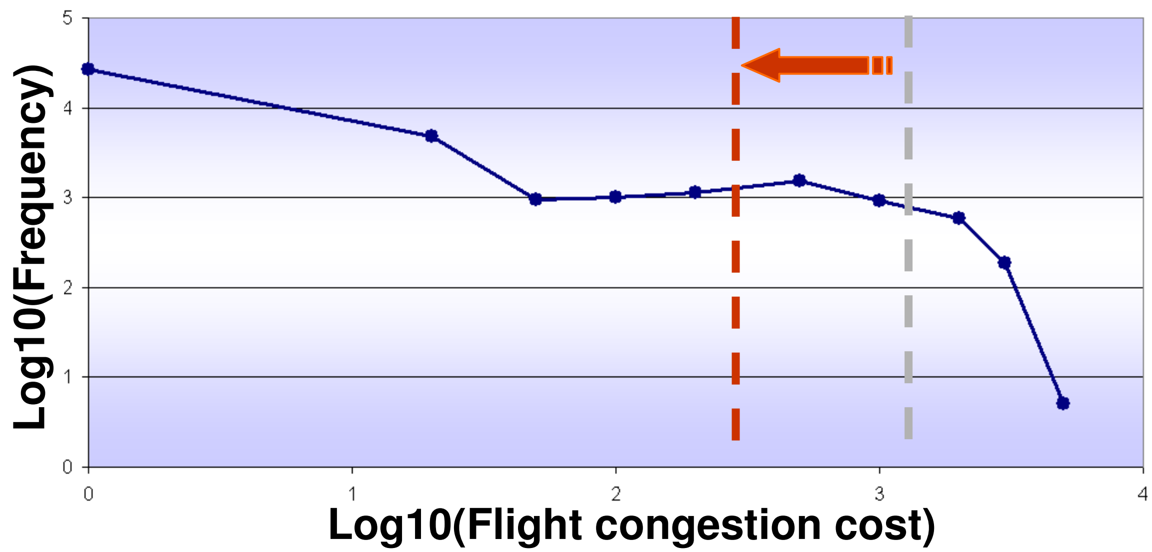
- TFM optimization via steepest gradient
  - Stochastic evaluation of forecasted congestion
    - Convolve capacity and loading PDFs
  - Rank flights by their congestion cost
  - Delay / reroute flights that exceed congestion threshold





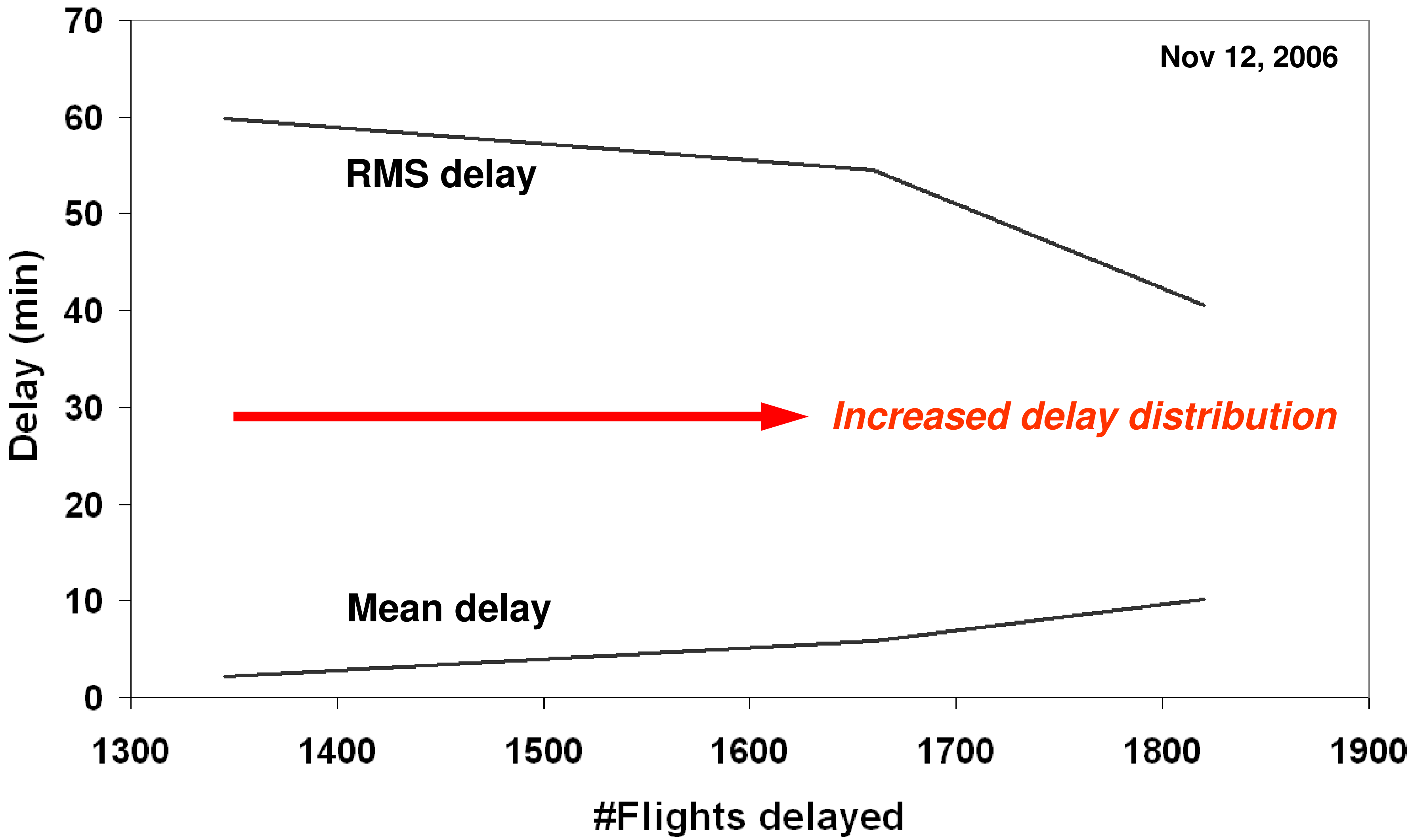
Delay Distribution





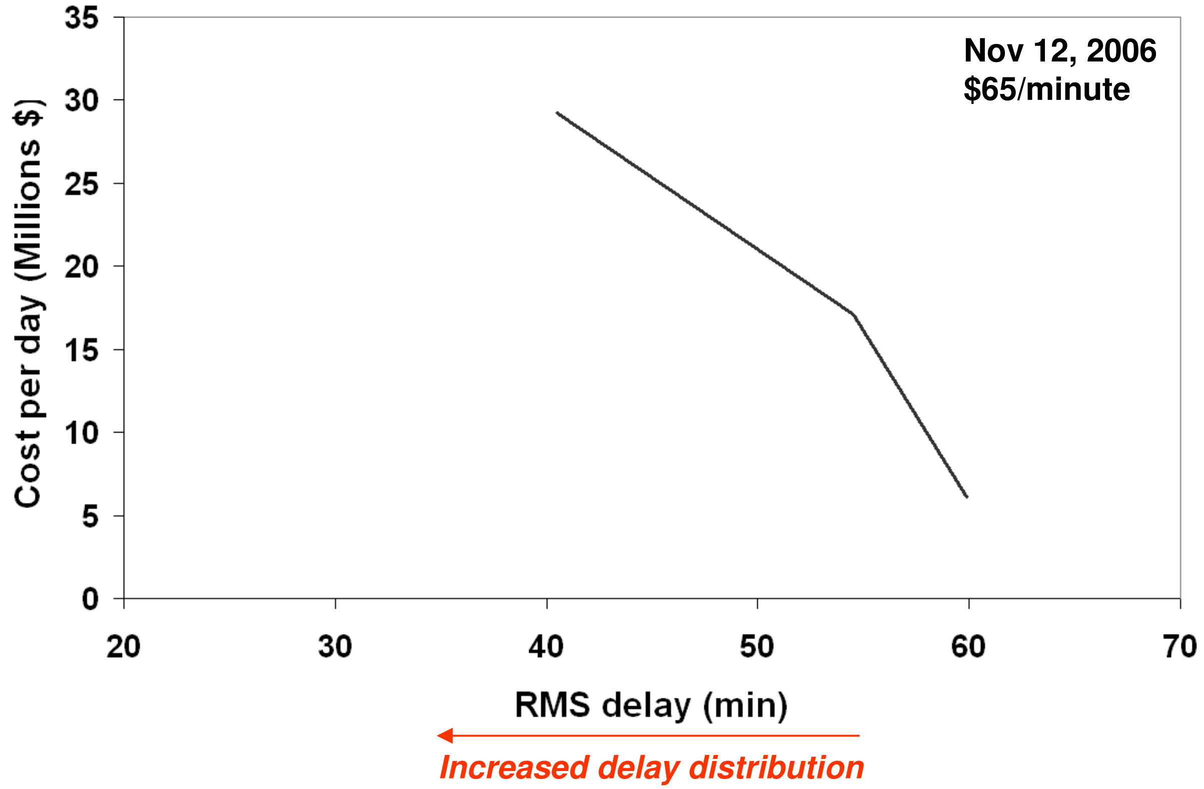
↑ #Flights delayed
↓ Delay/flight delayed
↓ Efficiency of delay
↑ Total delay

Mean vs RMS Delay

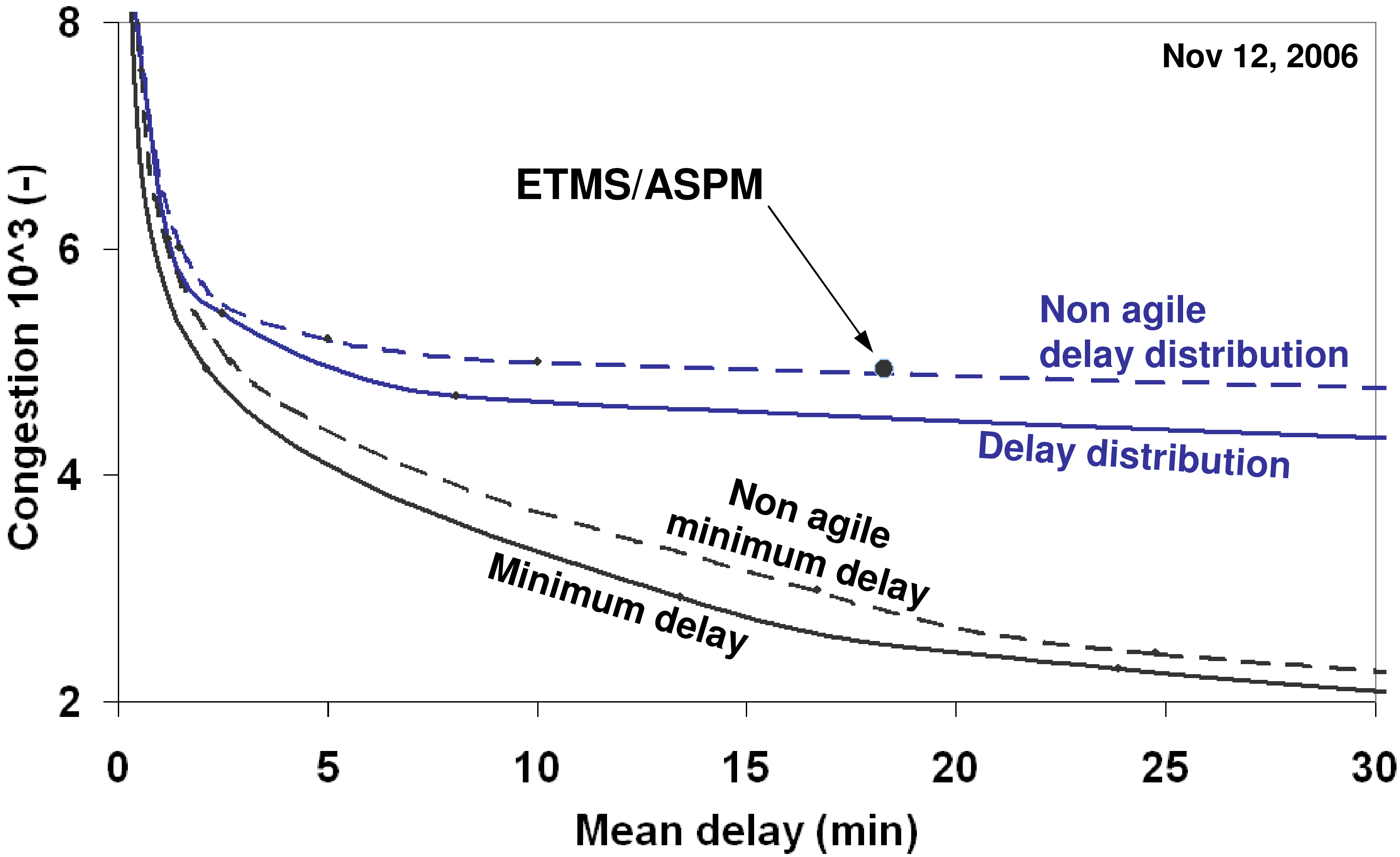


Cost of Distributing Delay

- RMS delay can be reduced by spreading delay to more flights
  - But at the cost of increased total delay

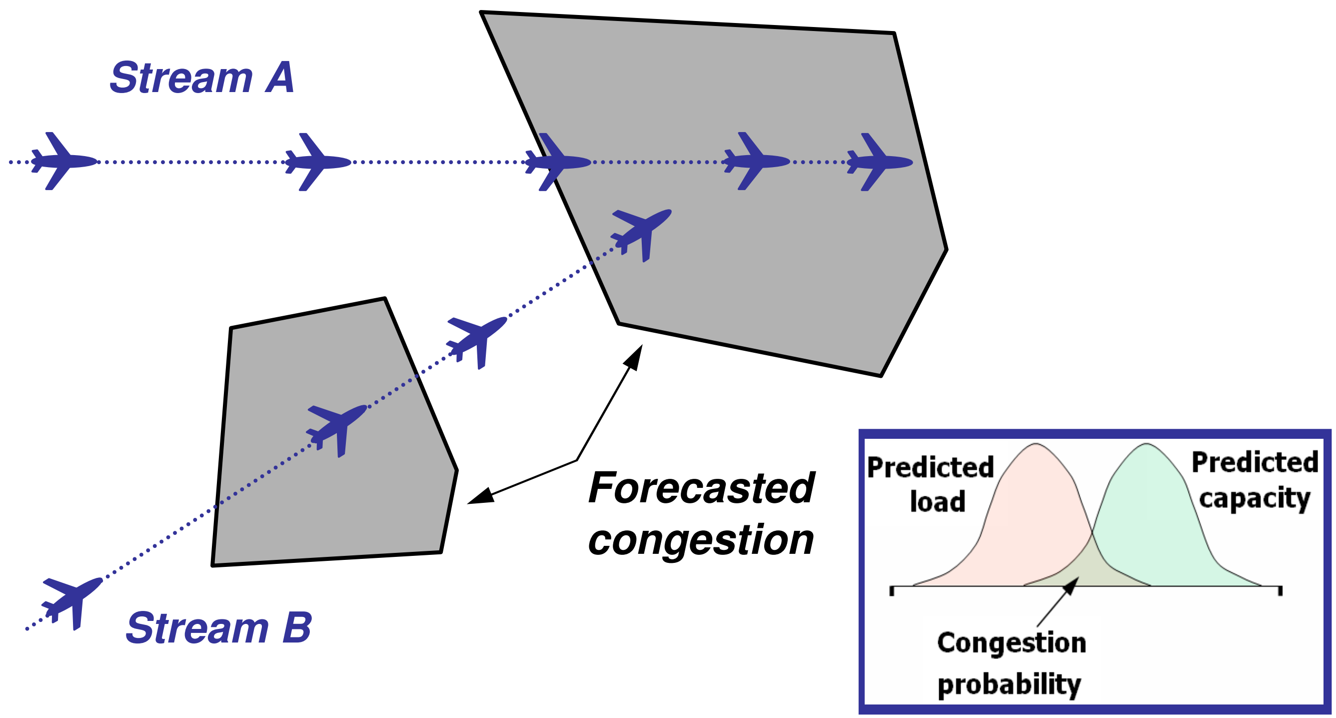


Min(Delay) and Distributed Delay Solutions



BACKUP

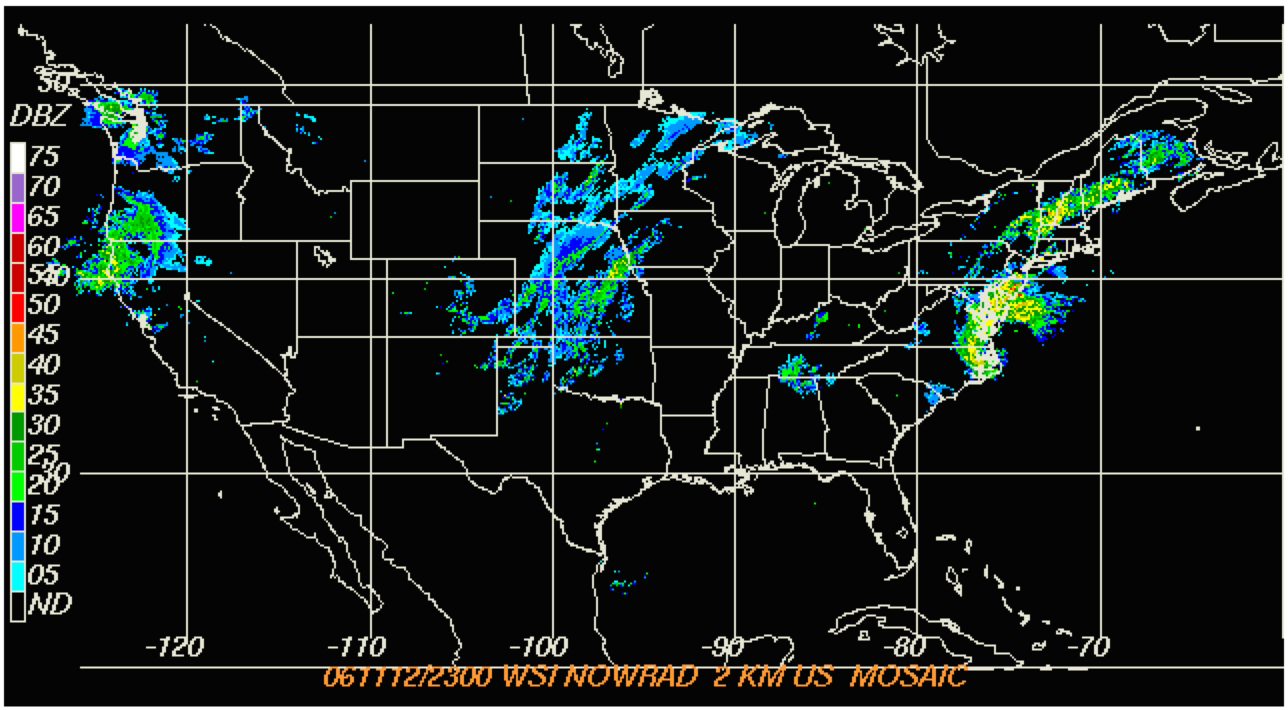
Performance-Based TFM



***Egalitarian TFM*: Minimize max(delay)**
***Utilitarian TFM*: Minimize sum(delay)**

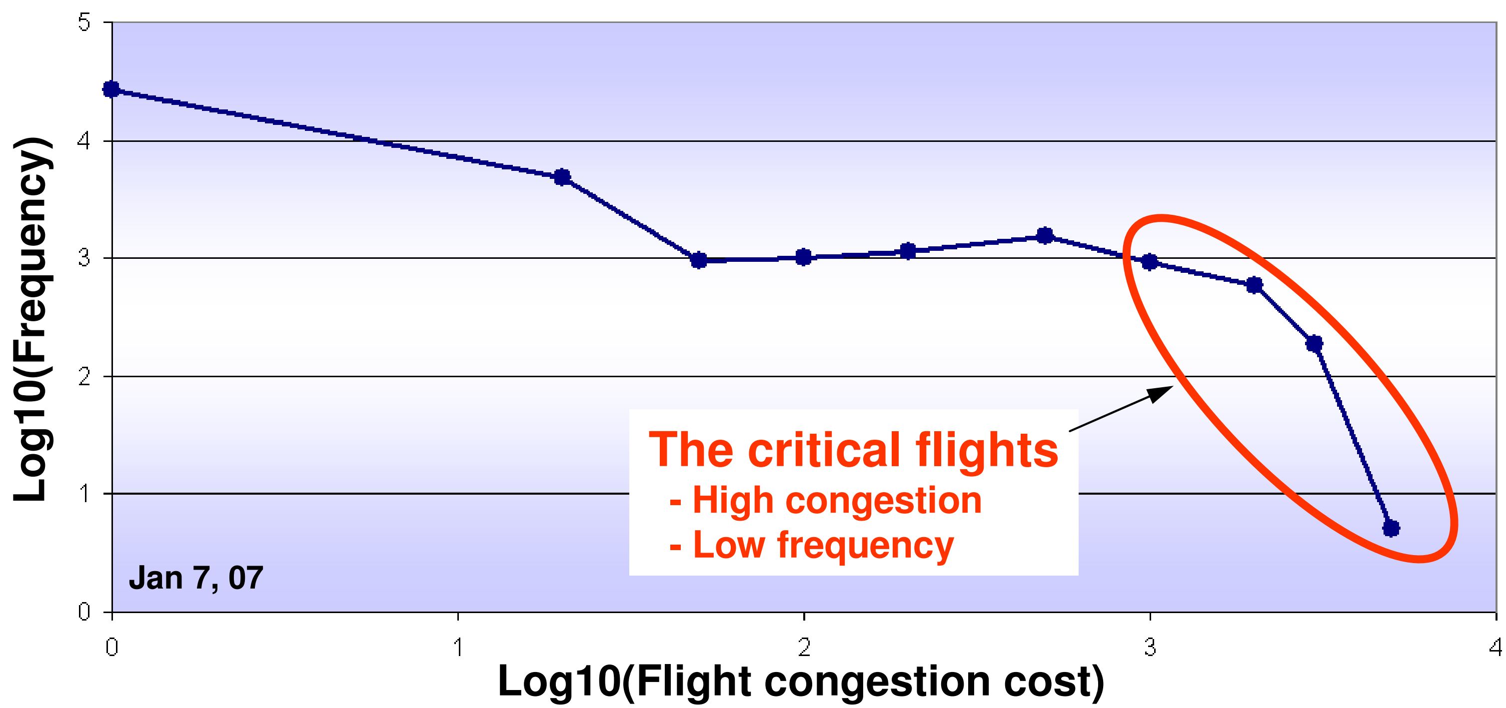
2006/11/12

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



ProbTFM Optimization

- Is the egalitarian premise correct?
  - We find a great variation in flight congestion cost, with a few flights with very high costs



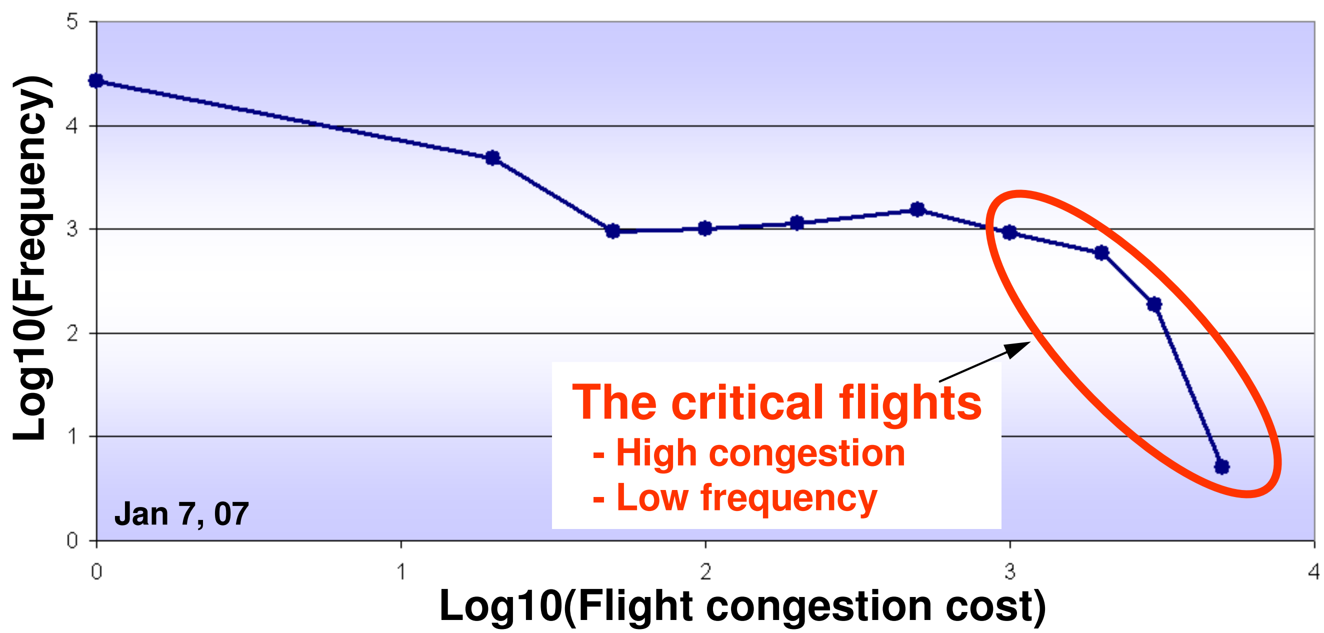
The policy decision needs to be informed of NAS performance relationships …

Recent results

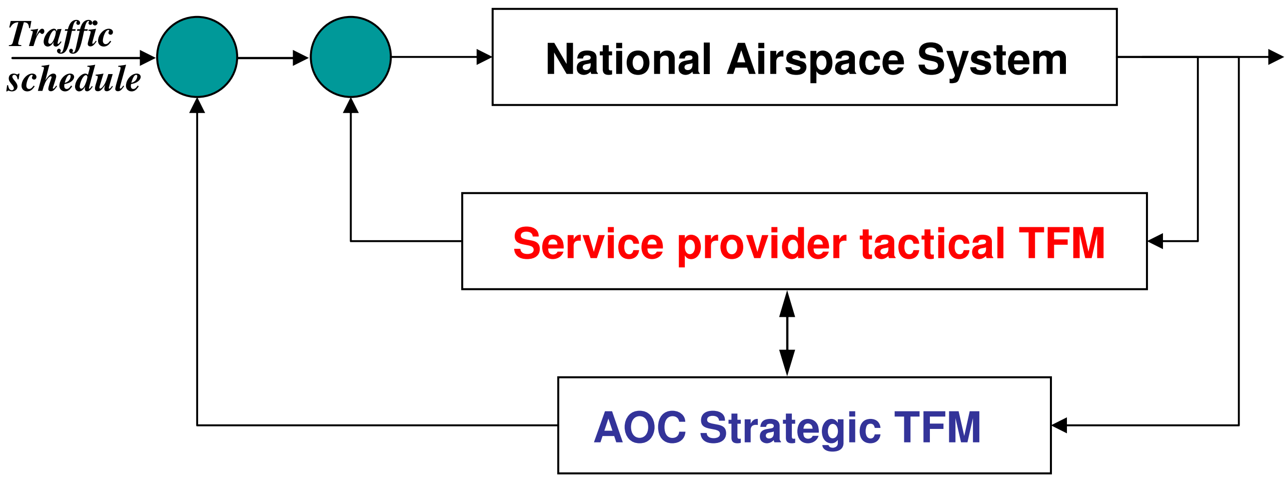
- Probabilistic CDM

Probabilistic CDM

- Performance-based probabilistic TFM
  - Premise: Flight plans and traffic schedule are a rich solution with many constraints and preferences built-in
    - Should minimize deviation from traffic schedule
  - Try to minimize control effort for a given NAS performance target
    - Give operators visibility into flight costs and the tools; let them solve the problem



Prob CDM


Traffic schedule
National Airspace System
Service provider tactical TFM
AOC Strategic TFM