

FAA System-Wide Modeling

Uses, Models, and Shortfalls

Presented to: FAA/Eurocontrol TIM, Madrid

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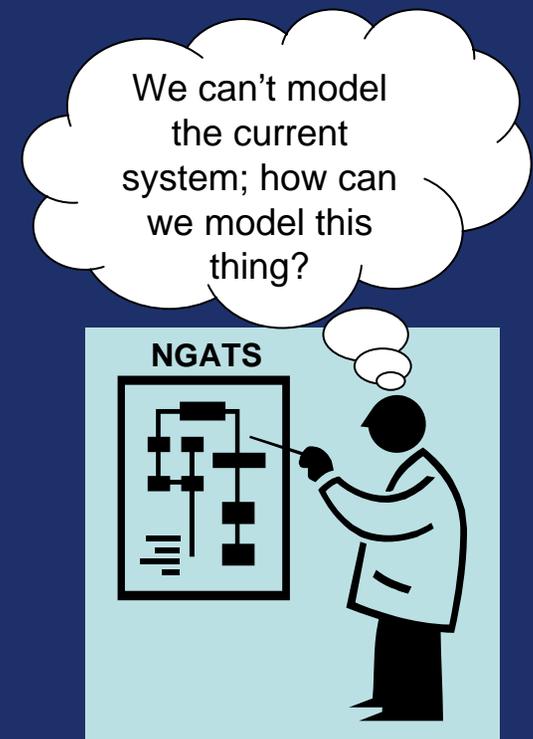


Federal Aviation
Administration



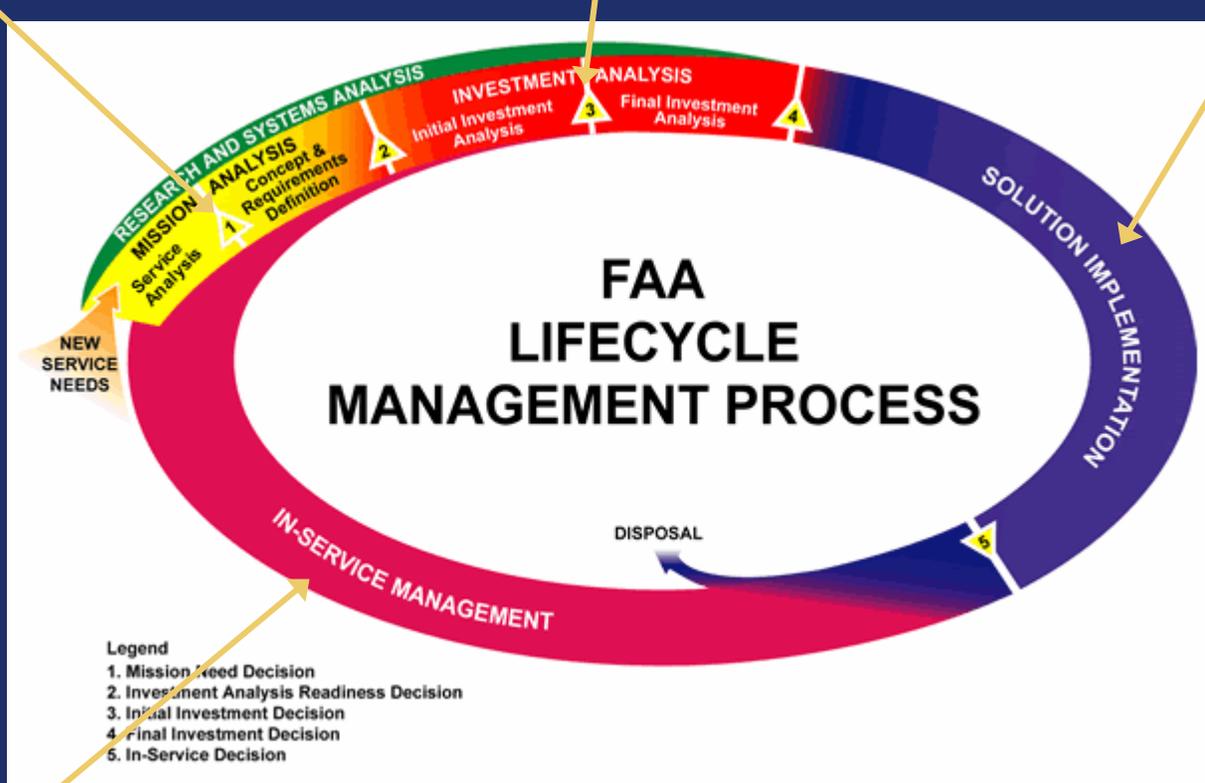
Overview

- **Uses of System-Wide Models**
- **FAA's Existing Models**
- **Modeling Shortcomings**
 - ATM Domain
 - Airport/Terminal
 - En Route
 - Flow Control
 - Airline Operations Center (AOC)
 - Model Use



Uses of System-Wide Models

Requirements Analysis Cost-Benefit Analysis Research & Development



Performance Assessment

Uses of System-Wide Models (cont.)

- **Portfolio optimization**

The Challenge: To select an optimum portfolio of aviation investments so as to maximize the overall economic return, subject to a budget constraint.

$$W = PV \{ \Delta S_{Consumer} + \Delta S_{Producer} - C_{Gov} - C_{Env} (noise, CO_2, NO_X, \dots) \}$$

Consumer
Surplus

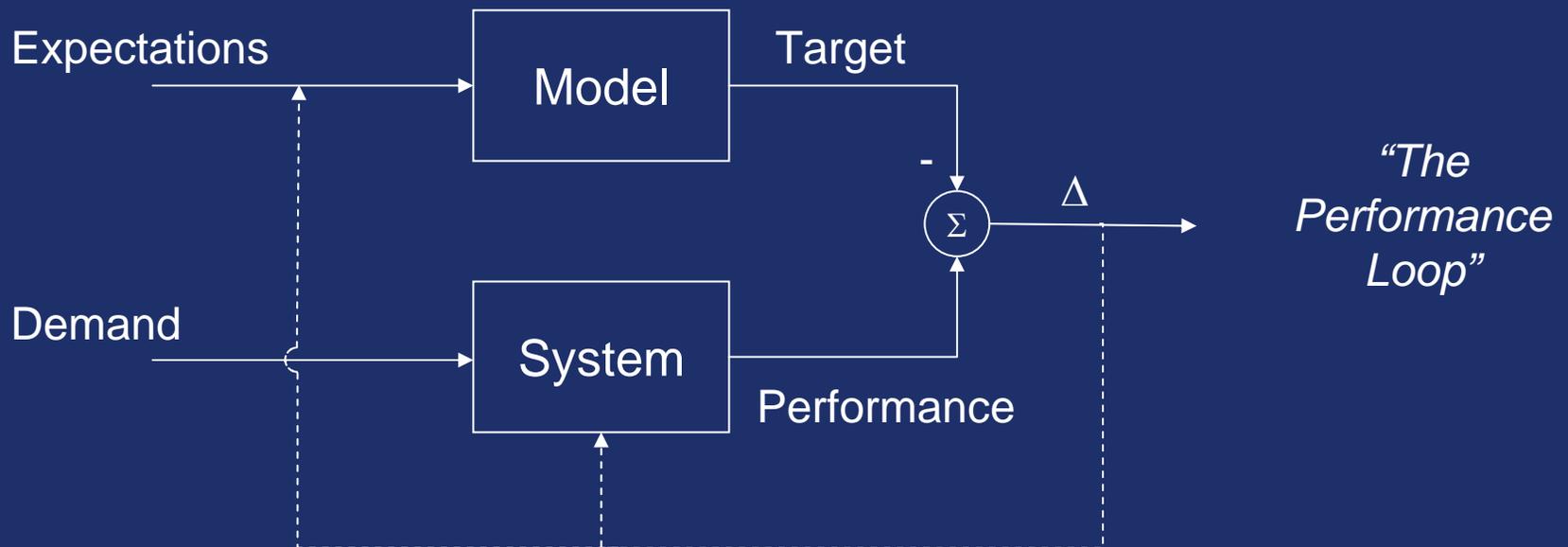
Producer
Surplus

Government
Costs

Environmental
Costs

Uses of System-Wide Models (cont.)

- System-wide performance assessment



FAA's Existing System-Wide Models

NASPAC

FAA Technical Center

SystemwideModeler

Mitre/CAASD

ACES

NASA

FACET

NASA

LMINET

LMI

AwSim/AERALIB

***Aerospace Engineering
and Research Associates***



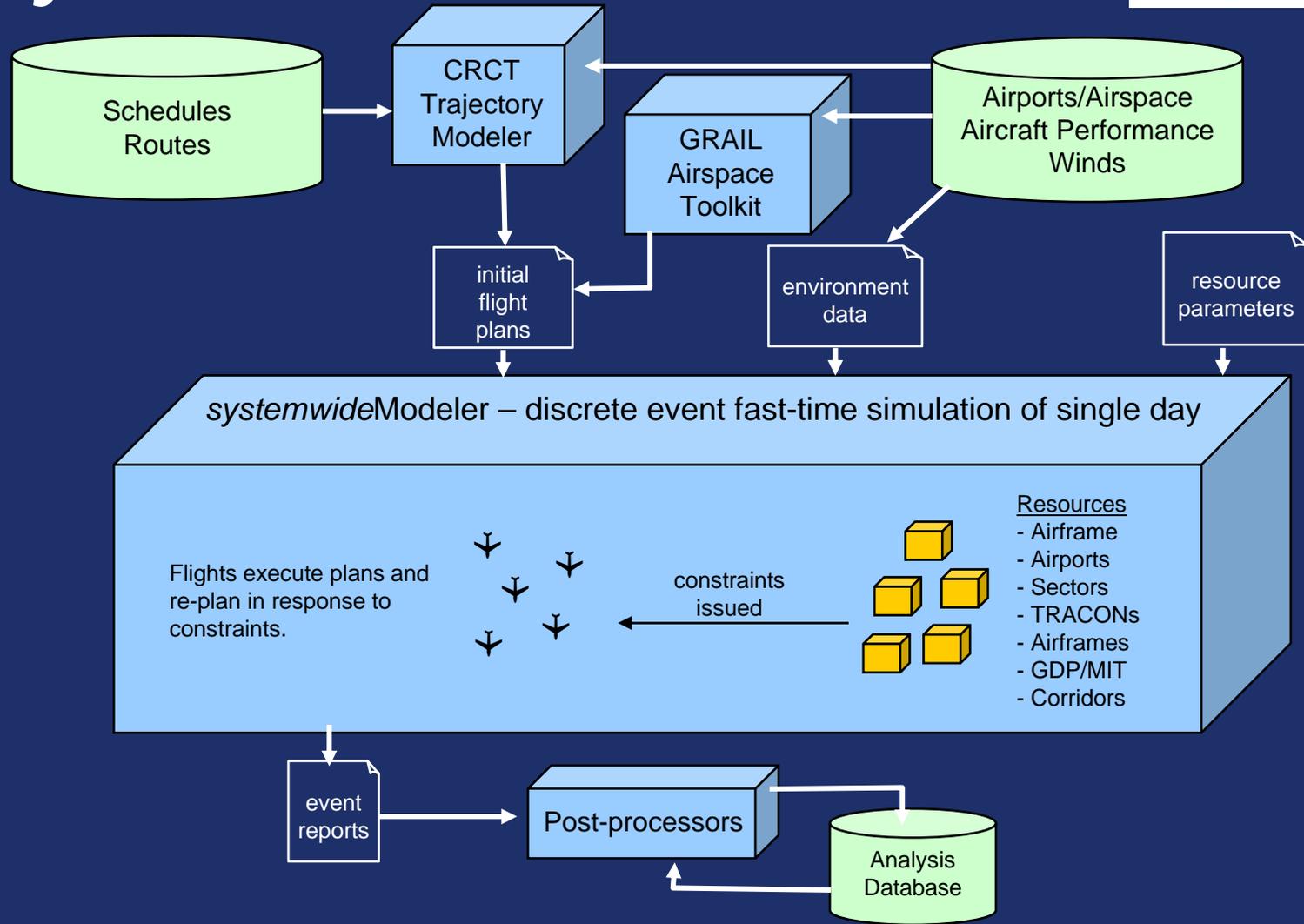


NASPAC

- **National Airspace System Performance Capability**
- **Fast-time discrete event simulation of entire NAS**
 - Also used for regional studies
- **Originally developed by Mitre in late 1980s**
- **SIMSCRIPT II.5**
 - Pre-processors and post-processors in Fortran, C, and Pascal
- **Inputs:**
 - Airport capacities
 - Routes
 - Arrival/departure fixes
 - Sector geometries and capacities
 - Schedule
- **Pre-processor develops aircraft itineraries from OAG schedule**
 - Network effect is included
 - G/A, military flights added



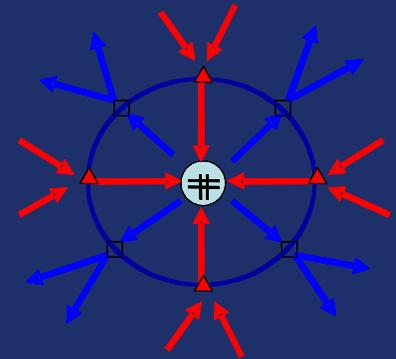
systemwideModeler



ACES



- Airspace Concepts Evaluation System
- Airport network, terminal airspace, en route sectors included
 - 243 airports, “open” network
- Four degree-of-freedom trajectory modeling
 - 4D wind field used (Rapid Update Cycle [RUC] model)
- Simplified terminal area modeling (Build 3)
 - Node-to-node trajectories
 - Flight dynamics not exercised
- Agent-based Traffic Flow Management (TFM)
 - ATCSCC
 - En Route ARTCCs
 - TRACONs
 - Towers
 - Airline Operations Centers (AOCs)

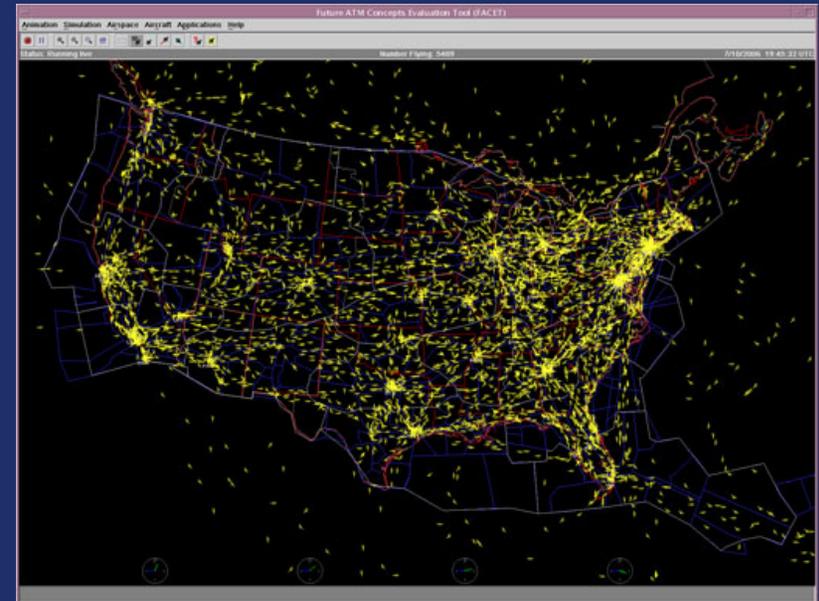


Source: Couluris, G., et al., “National Airspace System Simulation Capturing the Interactions of Air Traffic Management and Flight Trajectories,” AIAA Modeling and Simulation Technologies Conference, Austin, TX, Aug. 2003.

FACET



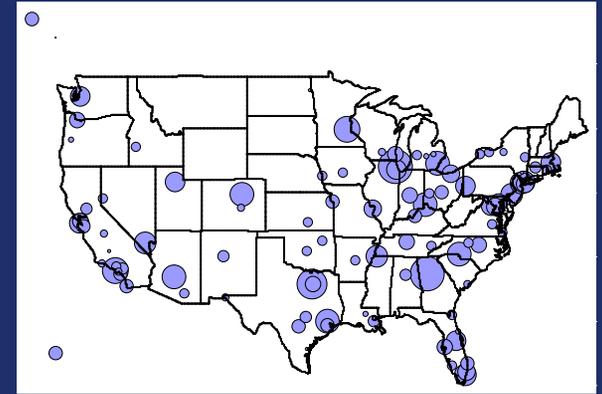
- **Future ATM Concepts Evaluation Tool**
- **Trajectory synthesis**
 - Flight plans
 - Direct routing
 - Wind-optimal routing
- **Conflict detection and resolution**
- **Metrics**
 - Airspace complexity



LMINET



- **Queuing model linking airport queues through sector queues**
- **102 airports included in network for delay calculation**
 - All airports considered for sector capacity
- **Flight times based on historical distributions**
- **Constrained schedule builder**



AwSim/AERALIB

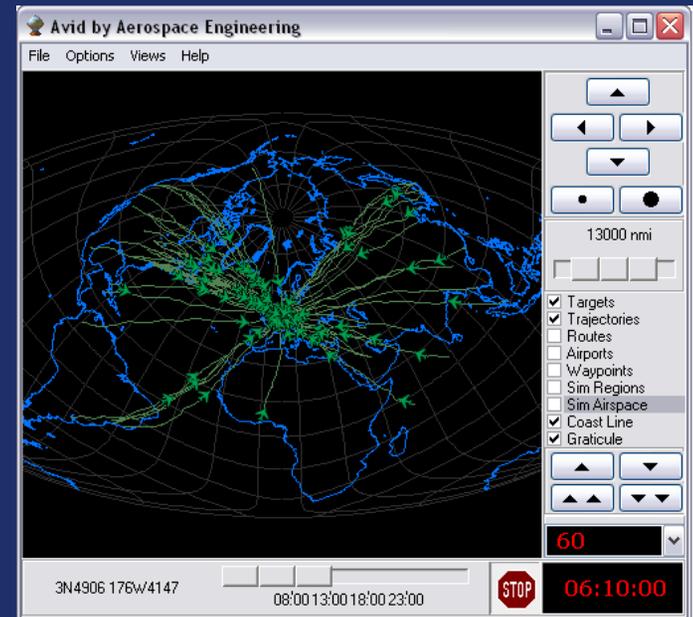


- **AwSim**

- Demand (i.e., schedule) generator
- Trajectory and target simulator
- Route structure or free flight
- Stochastic
- Conflict prediction
- Metrics
 - Sector loads
 - Traffic density and efficiency
 - Conflict counts and characteristics

- **AERALIB**

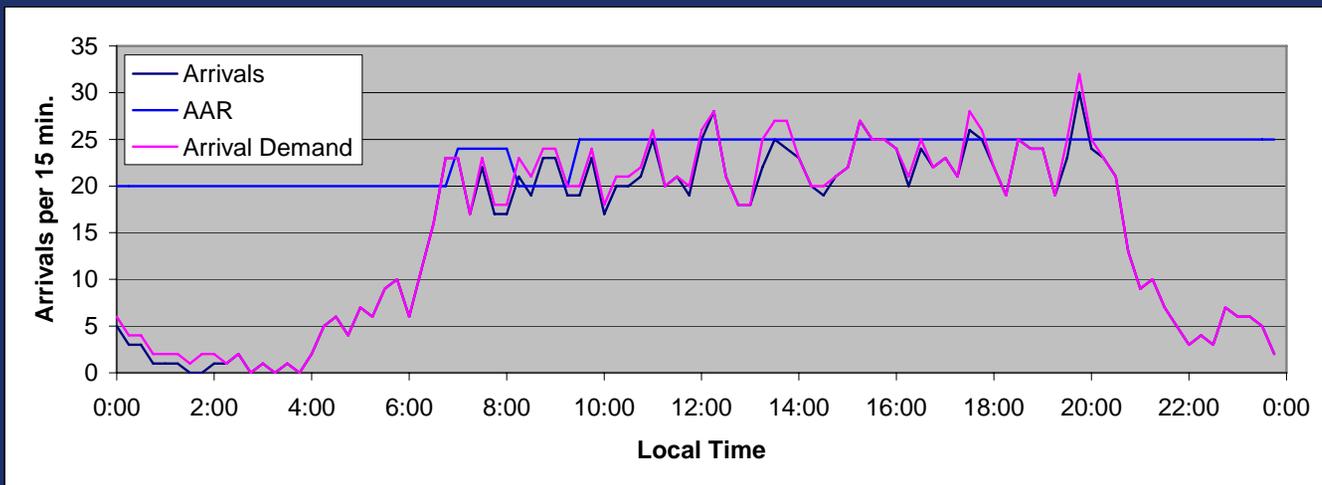
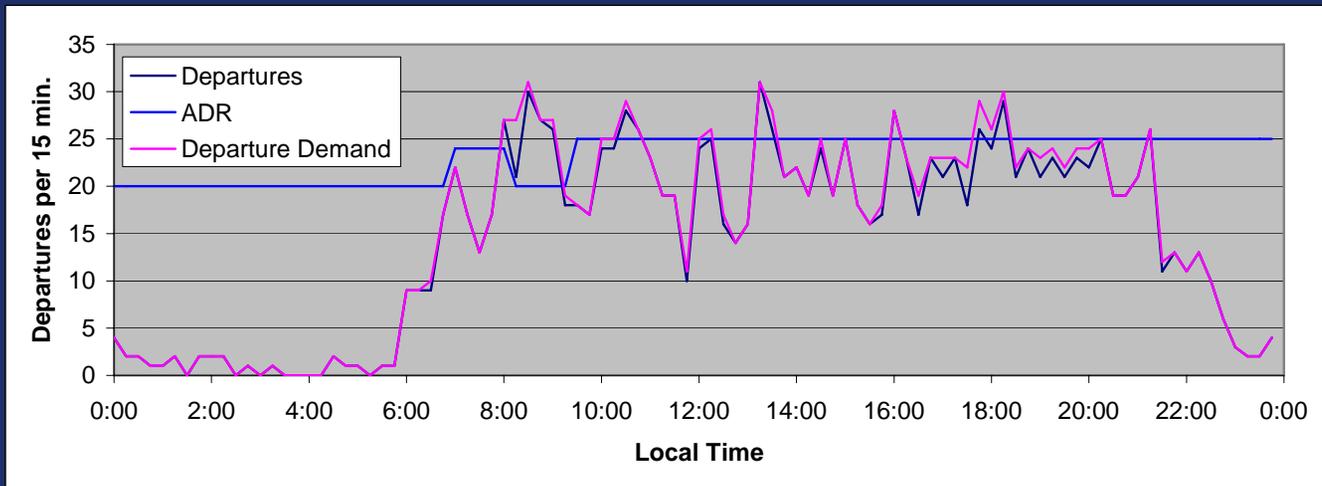
- Software libraries used for simulation/ATC system development
 - Core library
 - Trajectory library
 - Weather map library



Airport/Terminal Modeling Shortfalls

- **Deterministic Airport Acceptance Rate /Airport Departure Rate (AAR/ADR)**
 - **Terminal (TRACON) airspace capacity**
 - **Convection weather**
 - Re-routing
 - **Departure release delay**
 - **Surface congestion**
 - Taxiways
 - Gates
 - De-icing
 - **Tail number tracking**
 - Delay propagation
 - **Passenger tracking**
 - Connections
- } *Coupled*

Airport Acceptance/Departure Rate



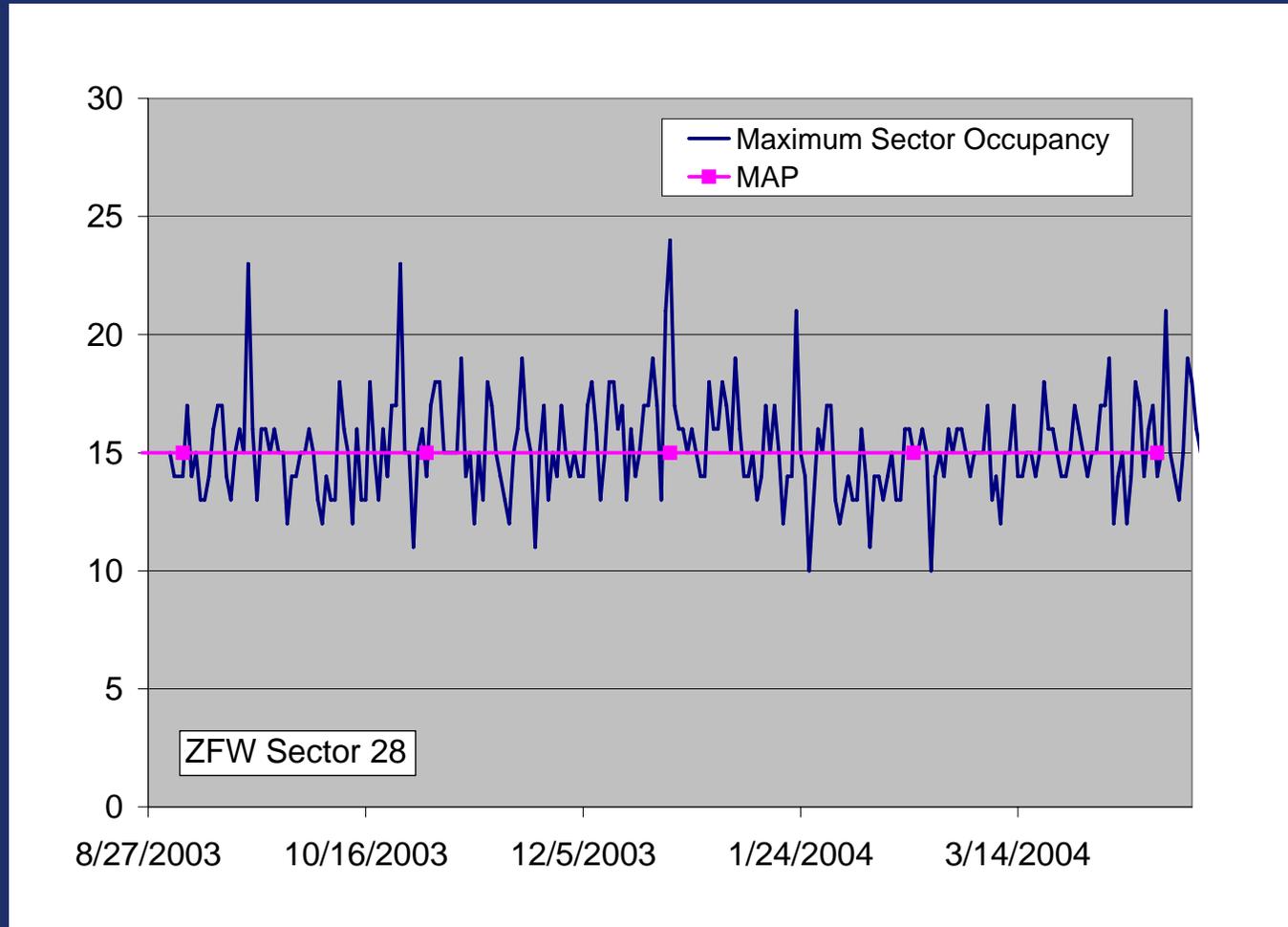
Chicago O'Hare, 15 Aug. 2006

En Route Modeling Shortfalls

- **Static and deterministic sector capacity**
 - Monitor Alert Parameter (MAP)
- **Response to sector overload**
 - Rerouting
- **Metering**
 - Time-based metering
 - Miles In Trail (MIT)
- **Convective weather**
 - Dynamic sector capacity
 - Tactical re-routes



Daily Maximum Sector Capacity

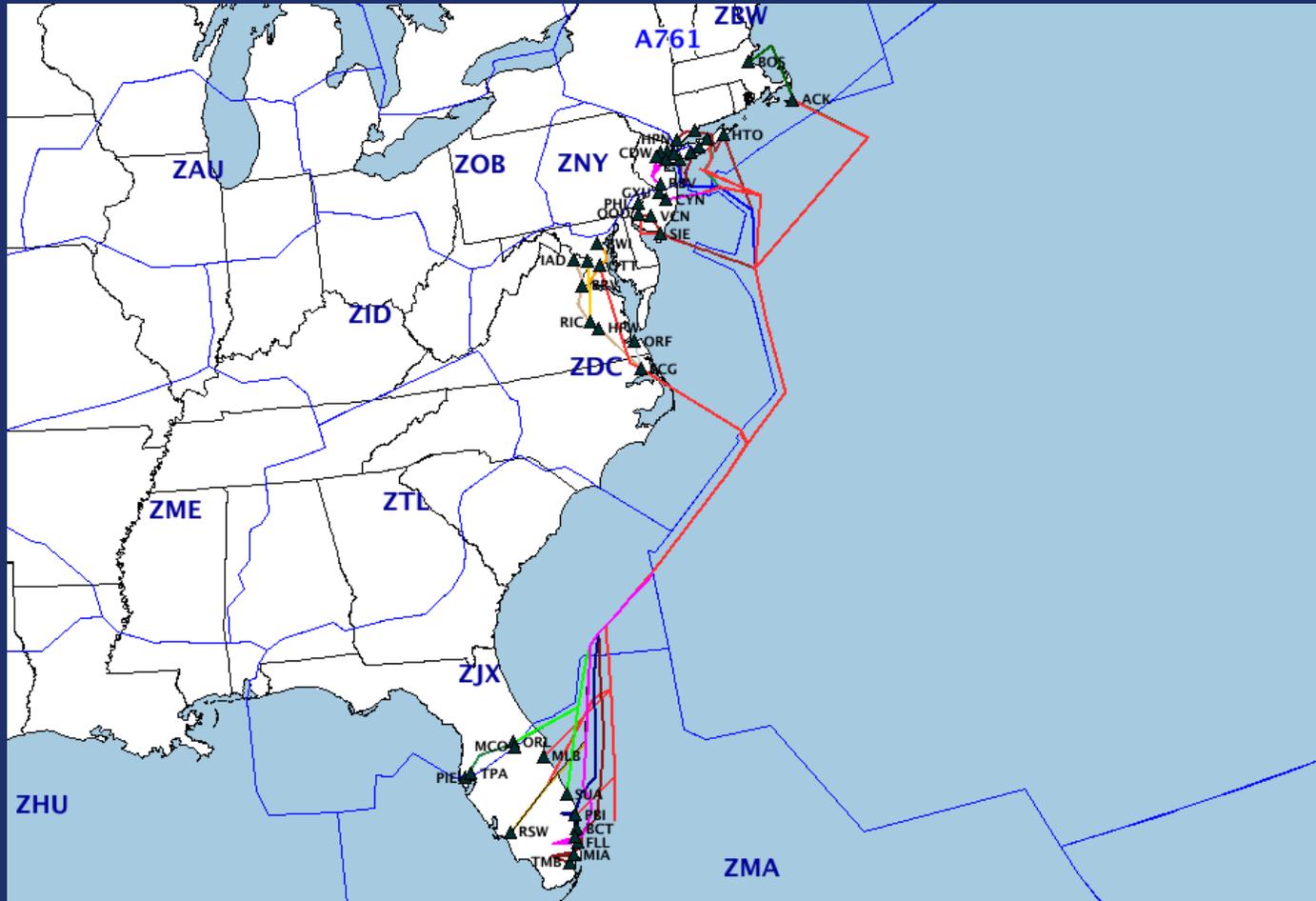


Flow Control Modeling Shortfalls

- **Ground stops/ground delays**
 - Airport constraints (GDPs)
 - Airspace constraints (AFPs)
- **Strategic re-routes**
 - Severe Weather Avoidance Program (SWAP)
 - Canadian Off-load



A761 Route



AOC Modeling Shortfalls

- **Cancellations**
- **Ground Delay Program (GDP) response**
- **Re-routes**

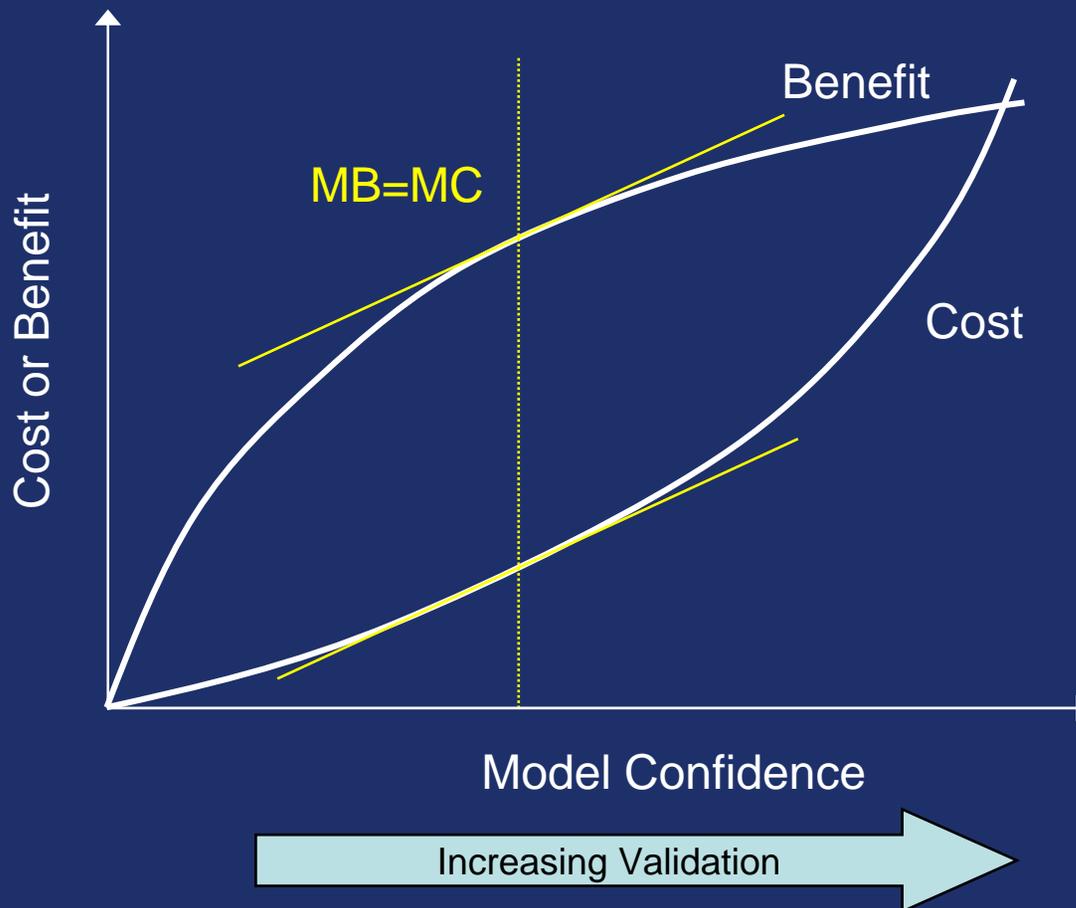


Model Use Shortfalls

- **Ease of Set-up**
- **Mapping aircraft type to performance**
- **Monte Carlo replication**
 - Flight schedules
 - Wind field
 - Aircraft performance
 - Routings
 - etc.
- **Visualization**
- **Validation**



Validation Cost/Benefit Calculus



Source: R. Sargent, "Verifying and Validating Simulation Models," Proceedings of the 1996 Winter Simulation Conference