FAA System-Wide Modeling

Uses, Models, and Shortfalls

Presented to: FAA/Eurocontrol TIM, Madrid
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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

We can’t model the current system; how can we model this thing?
Uses of System-Wide Models

- Requirements Analysis
- Cost-Benefit Analysis
- Performance Assessment
- Research & Development

Legend:
1. Mission Need Decision
2. Investment Analysis Readiness Decision
3. Initial Investment Decision
4. Final Investment Decision
5. In-Service Decision

FAA LIFECYCLE MANAGEMENT PROCESS
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.

\[ W = PV\left\{ \Delta S_{\text{Consumer}} + \Delta S_{\text{Producer}} - C_{\text{Gov}} - C_{\text{Env}}(\text{noise, CO}_2, \text{NO}_X, \ldots) \right\} \]
Uses of System-Wide Models (cont.)

- System-wide performance assessment

The Performance Loop
## FAA’s Existing System-Wide Models

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<td>AwSim/AERALIB</td>
<td>Aerospace Engineering and Research Associates</td>
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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**

- **Schedules Routes**
- **CRCT Trajectory Modeler**
- **GRAIL Airspace Toolkit**
- **Airports/Airspace Aircraft Performance Winds**

**Initial flight plans**

**Environment data**

**Resource parameters**

**Flights execute plans and re-plan in response to constraints.**

**Constraints issued**

**Event reports**

**Post-processors**

**Analysis Database**

**Resources**
- Airframe
- Airports
- Sectors
- TRACONs
- Airframes
- GDP/MIT
- Corridors

**systemwideModeler – discrete event fast-time simulation of single day**
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)

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
# Ground Stops/Ground Delays

## ATCSCC Advisory

### ATCSCC ADVZY 028 BOS/ZBW 11/09/2006 CDM GROUND DELAY PROGRAM

**Message:**
- **CTL ELEMENT:** BOS
- **ELEMENT TYPE:** APT
- **ADL TIME:** 1625Z
- **DELAY ASSIGNMENT MODE:** DAS
- **ARRIVALS ESTIMATED FOR:** 09/1900Z - 10/0059Z
- **CUMULATIVE PROGRAM PERIOD:** 09/1900Z - 10/0059Z
- **PROGRAM RATE:** 36
- **FLT INCL:** ALL CONTIGUOUS US DEP
- **DEP SCOPE:** (2NDTIER+CYZ_APT) ZBW ZAU ZDC ZID ZJX ZMP ZNY ZOB ZTL
- **ADDITIONAL DEP FACILITIES INCLUDED:**
- **CANADIAN DEP ARPTS INCLUDED:** CYNZ CYOW CYUL CYYZ
- **DELAY ASSIGNMENT TABLE APPLIES TO:** ZBW
- **MAXIMUM DELAY:** 72
- **AVERAGE DELAY:** 21.6
- **REASON:** WEATHER / WINDS
- **REMARKS:**

**Effective Time:** 091628 - 100159

**Signature:** 06/11/09 16:28

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**Federal Aviation Administration**

16 November 2006
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