Regional Metering Decision Support Tool and NAS Genome Mental Model

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En Route Modeling and FACET Workshop

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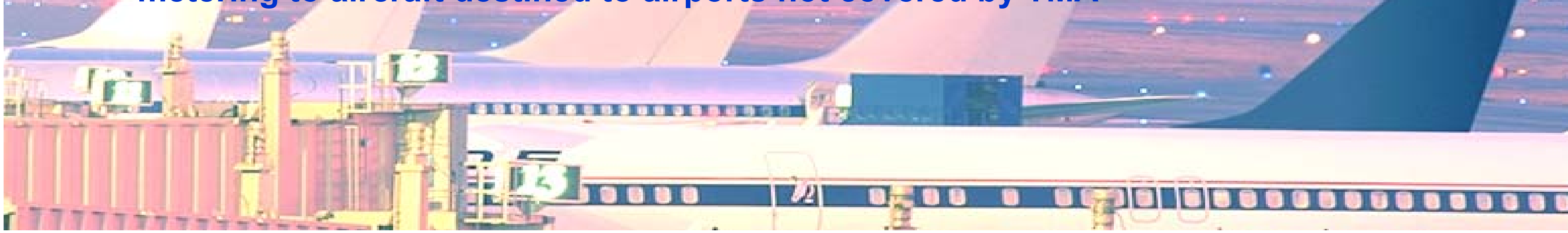
Presentation Outline

- Regional Metering Description
- Benefit Mechanisms and Technical Performance Metrics
- Data Sources
- Analysis Methodology
- NAS Genome Mental Model
- Final Remarks

Regional Metering Description

- RM is an ATM DST for the local/regional traffic flow management of flights that are en-route to congested airspace and/or airport terminal areas
- This DST introduces “tactical” TFM capabilities, based on a novel integration of state-of-the-art CTAS capabilities that enable operationally efficient flow-rate control of en-route traffic
- These capabilities enable new TFM and ATC procedures to replace the manual technique of MIT spacing and other flow restrictions commonly used today to pass-back flow delays to ATC facilities that are upstream of the congested airspace/airport
- RM will enable traffic managers to visualize regional flows and demand between upstream and downstream centers
- RM extends arrival metering upstream of an impacted terminal, and provides metering to aircraft destined to airports not covered by TMA



Regional Metering Description (Cont.)

- RM can be applied on a much finer scale, thus meting out delay to aircraft over a wider spatial area with a greater degree of equity
- RM will provide traffic managers with a tool to efficiently plan, coordinate, and implement metering restrictions between centers
- Downstream centers will be able to identify congestion early and formulate a tailored set of time-based restrictions to smooth out the incoming flow
- The upstream centers will take those restrictions and distribute delays efficiently while aircraft are transiting through their airspace
- RM builds upon and is seen as a potential enhancement to TMA and McTMA

RM Quantitative Benefit Mechanisms

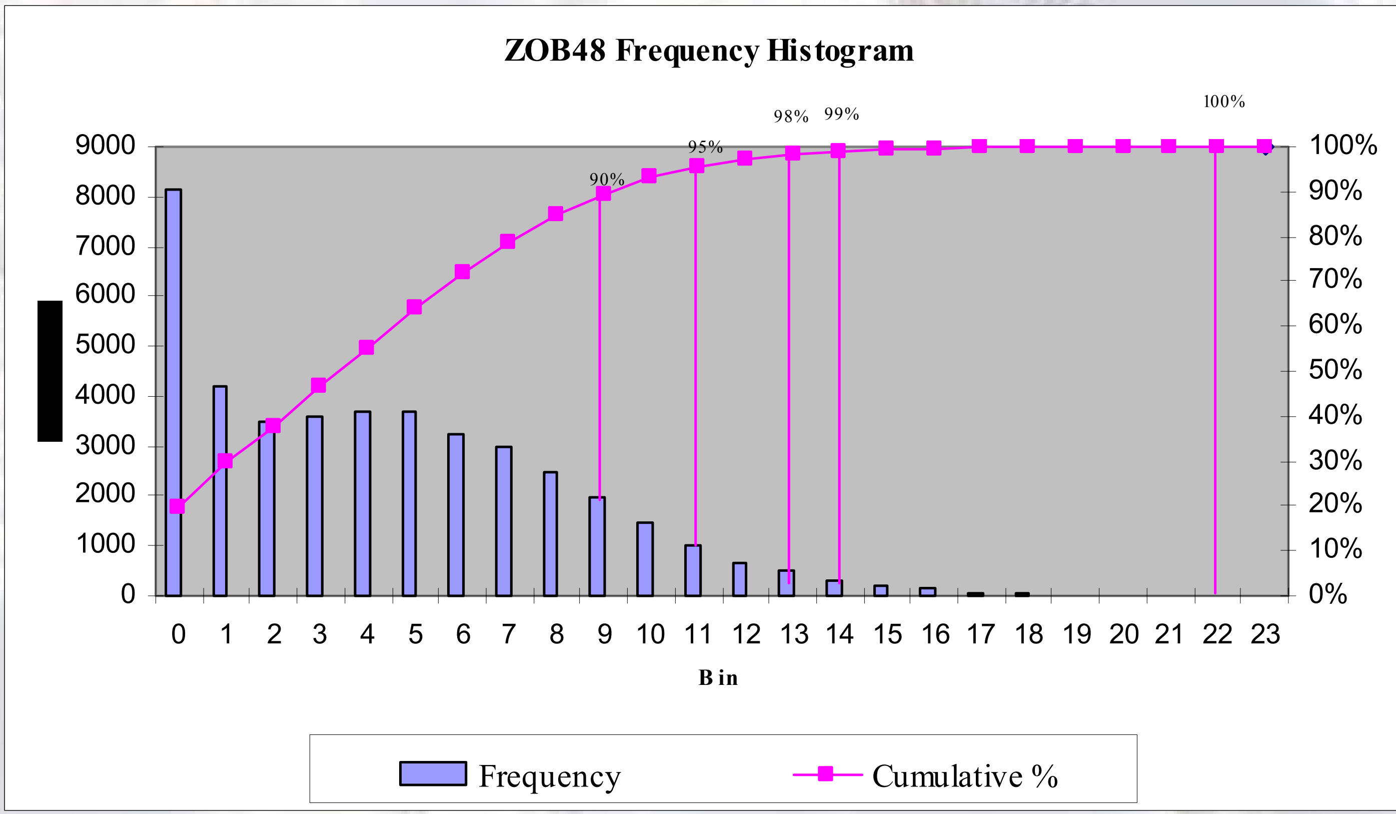
- Time-based metering enables more efficient flow-rate restrictions versus MIT
    - Continuous/balanced vs. quantized spacing intervals
    - Metering rate optimization
    - Synchronized merge
    - En-route delay equity
- Collaborative substitution using delay banking for user-preferred delay allocation within an airline and among airlines
- Path-independent delay conformance – Independent Routing

Data Sources

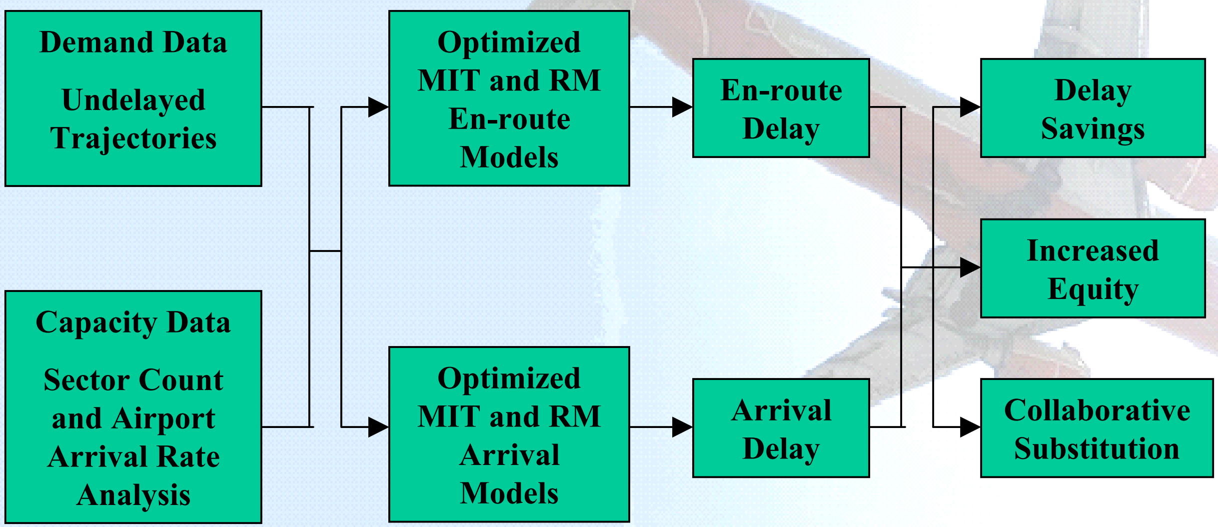
- ETMS Data
  - Raw flight plan messages needed to drive trajectory prediction software
- TP/FACET Data
  - Predicted sector crossing times are computed for all flights in the NAS during a specified time period
  - These predictions are used as demand input to models
- POET Data – used to derive historical sector capacities
- Actual MIT Data from ATCSCC logs
- Actual default AAR Data from static ETMS data

POET Capacity Analysis

Histogram Showing Sector Volume from One Month of POET Data



Optimized Arrival and En-route MIT and RM Models



METRON AVIATION

Optimized En-route MIT Model

- Flights bundled into stream classes based on the sector from which the flight will enter the center that contains the constrained sector
- Algorithm determines minimal set of restrictions that will satisfy sector capacities
  - Start time determined by first flight to cause capacity to be exceeded
  - Stop time is when no further flights will cause a capacity overload
  - MIT restriction increased for stream class which causes the least increase in delay with some decrease in sector volume
  - Algorithm iterates in 5 MIT increments until over capacity situation is resolved
- Algorithm represents the way TMCs currently select MIT restrictions

Optimized En-route RM Model

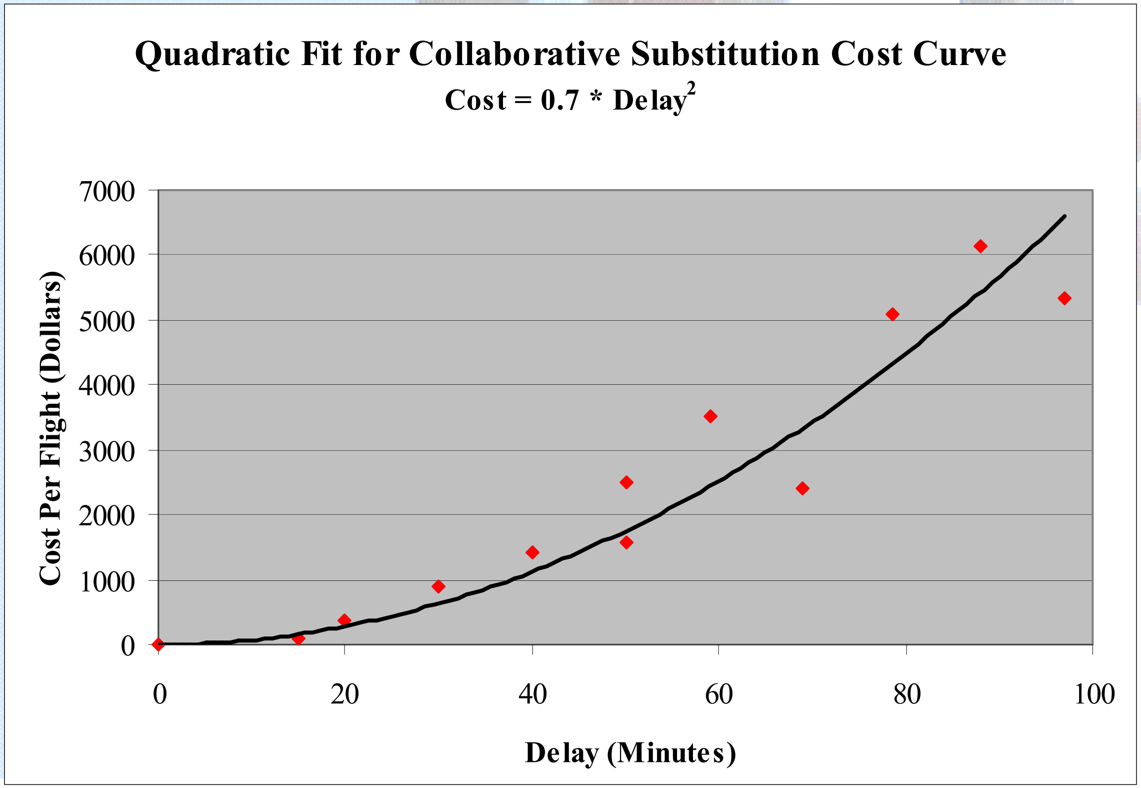
- Flights grouped into stream classes the same way as in the Optimized MIT model
- Algorithm determines the first flight that would cause the sector capacity constraint to be exceeded
- Determine the earliest time at which one of the flights will leave the sector
- This earliest sector exit time is then assigned as the earliest time that the next flight outside the sector can enter
- Algorithm keeps delaying aircraft until sector capacity restraint is no longer violated

Collaborative Substitution

- Determine amount of delay absorbed before takeoff by comparing scheduled with actual off times
- Calculate en-route delay from en-route RM model
- Create delay buckets based on significant levels of operational delay
- Determine which flights can be swapped where later flights moves up one time bucket while earlier flight does not move down

Collaborative Substitution (Cont.)

- Can make procedure more realistic by using a continuous curve rather than buckets
- Sample quadratic cost curve



METRON AVIATION

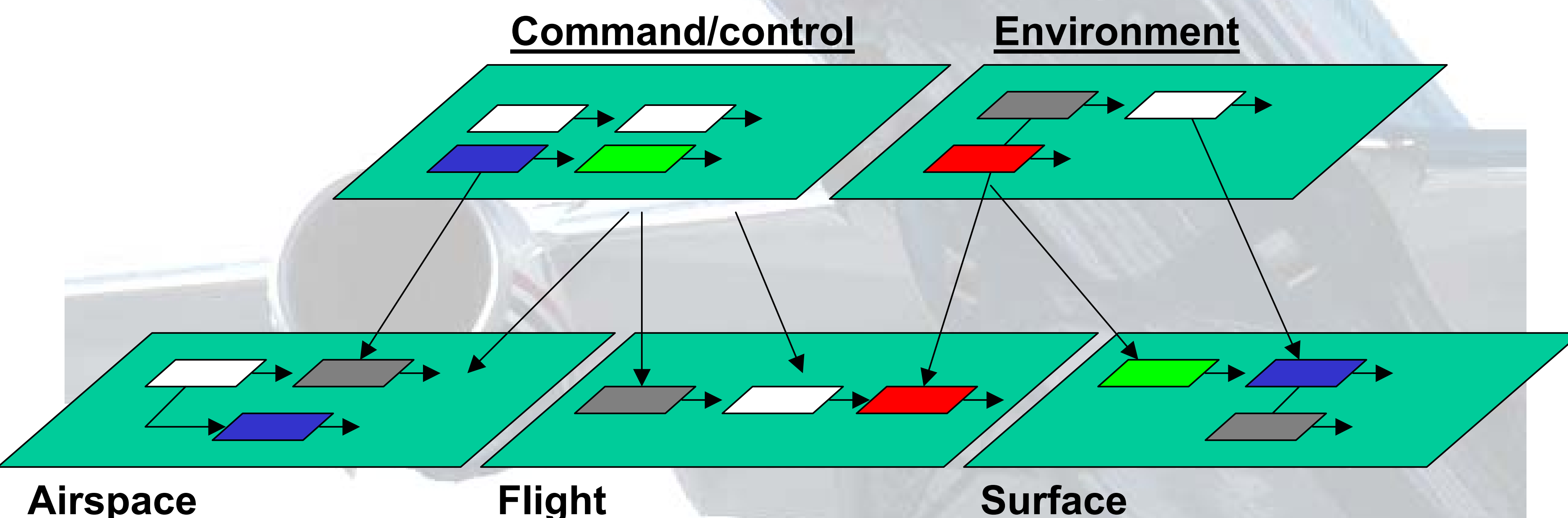
Equity Measures

- Variance measures the average value of the squared deviation of delay from its mean - An offshoot of this measure is the coefficient of variation that is the square root of the variance divided by the average delay
- The Gini coefficient is a statistical measure of dispersion within a group of values, calculated as the average difference between every pair of values in the data set divided by two times the average of the sample
- The McLoone coefficient specifically assesses the equity in the distribution of the lower half of the delay distribution - It compares the amount of delay an aircraft below the median of the distribution actually received with the amount they would have received had they been given the same amount as the median aircraft

NAS "Mental Model" - Objectives

- Describe NAS-wide details and abstract key system features
- Infrastructure for understanding NAS behavior from different perspectives
- Enable community-wide access to express and evolve this understanding
- Emulate behaviors under different conditions and experiment with changes

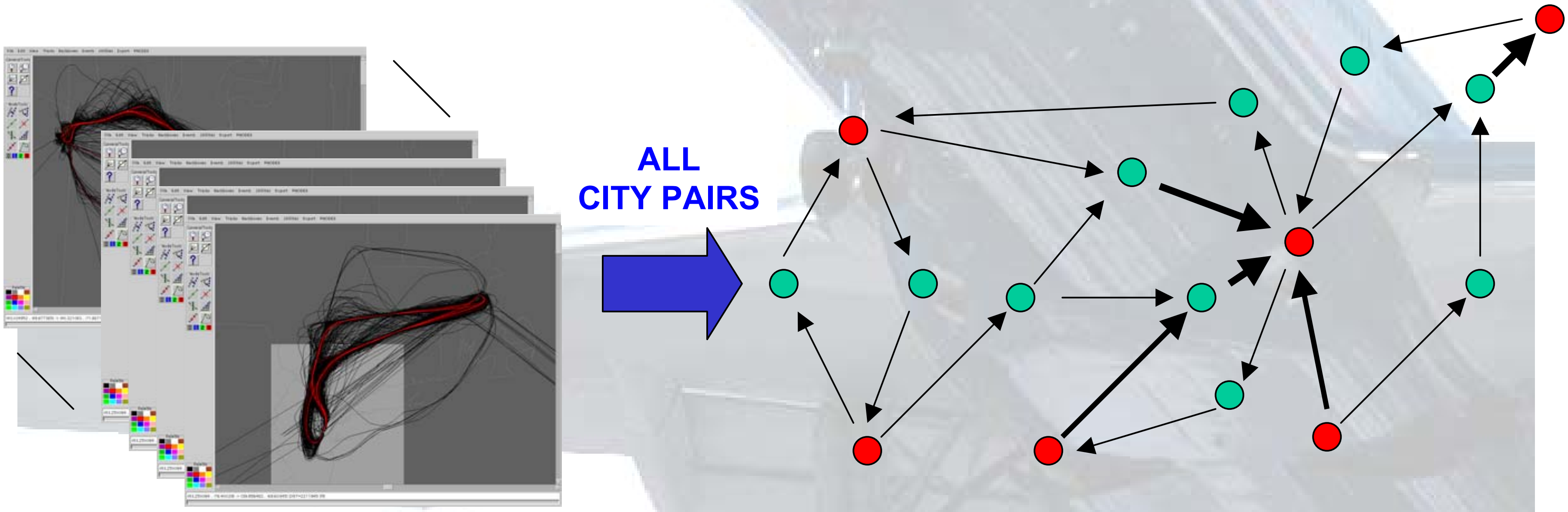
in assumptions and sub-element behavior



METRON AVIATION

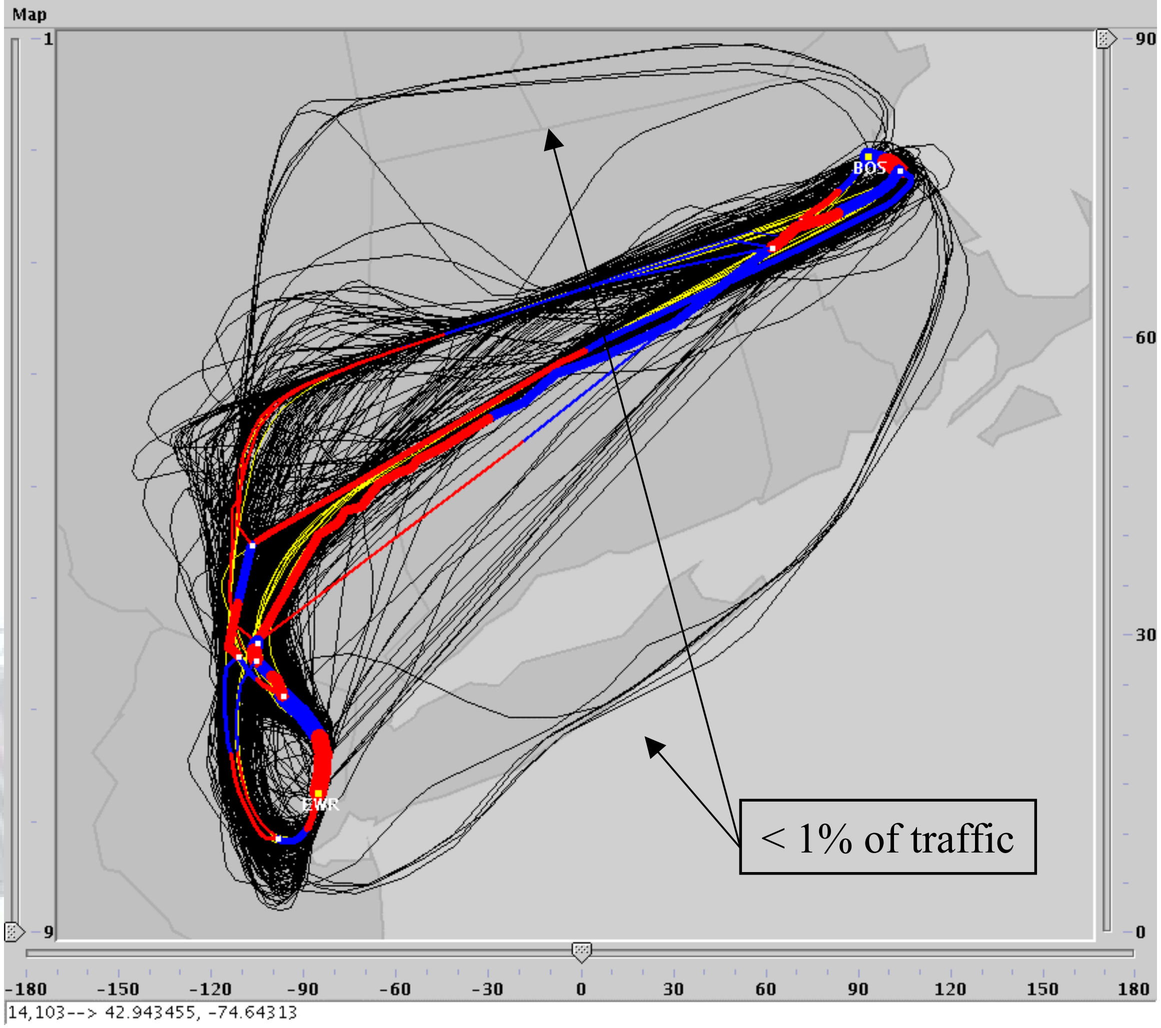
Data-driven NAS Network

- Construct radar-based network representation of flows throughout NAS
- Maintain all traffic information regarding volume, timing, city-pairs, carriers, aircraft types and routings available from ETMS
- Key enabling step for application of powerful mathematical techniques



NAS Network – BOS/EWR Element

BOS/EWR Traffic
(May02 – 636 tracks)



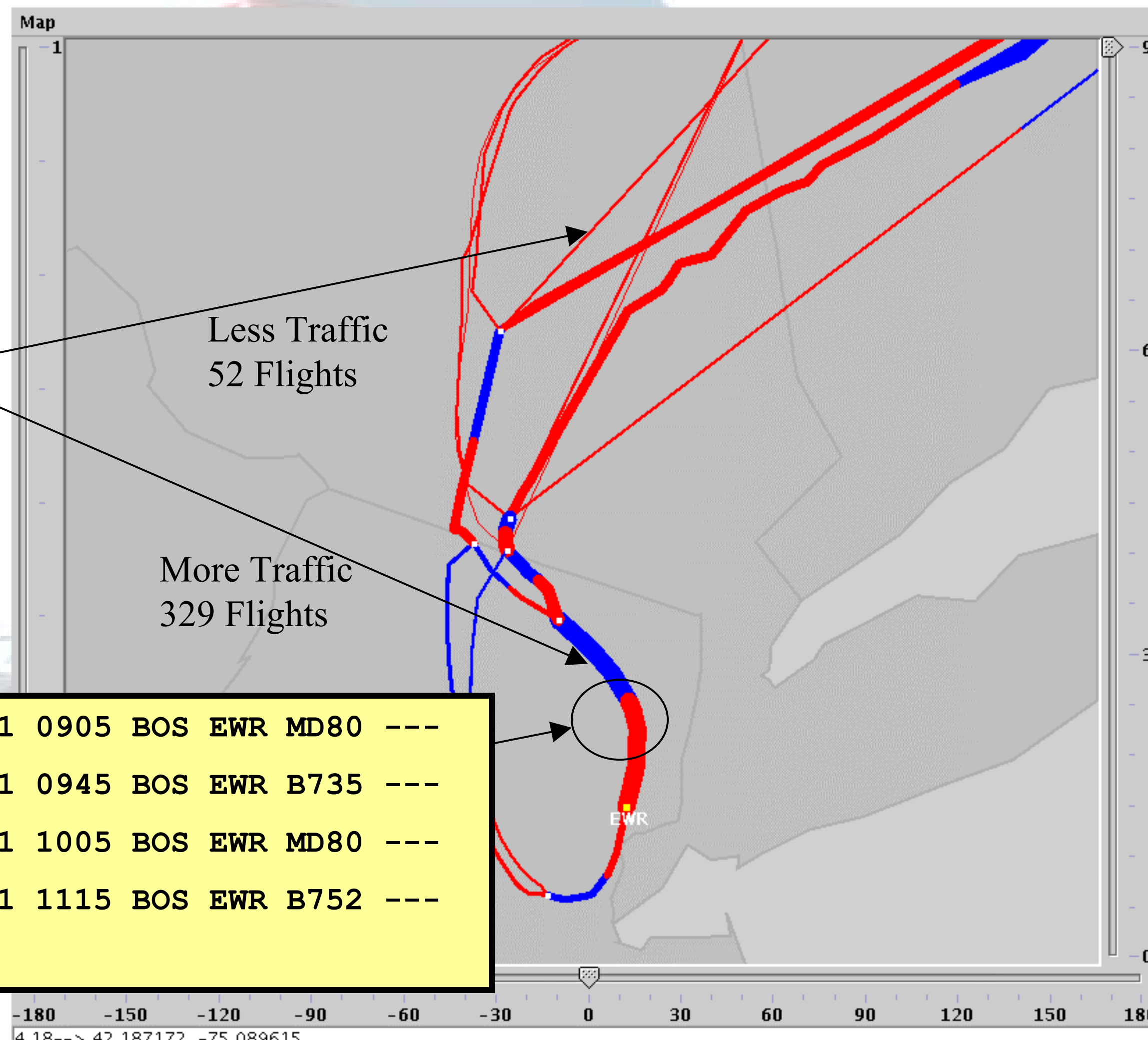
- ETMS Tracks
- Backbones
- Network Path

- Leaving Node
- Entering Node

NAS Network – Flows and Connection to Database

BOS/EWR Traffic

- Line Thickness Indicates Flow Size
- Path Directionality from Blue to Red



- Links to Database

505410635	AAL1854	2002-05-01	0905	BOS	EWR	MD80	---
505411040	COA1172	2002-05-01	0945	BOS	EWR	B735	---
505413941	AAL1582	2002-05-01	1005	BOS	EWR	MD80	---
505416971	UAL662	2002-05-01	1115	BOS	EWR	B752	---

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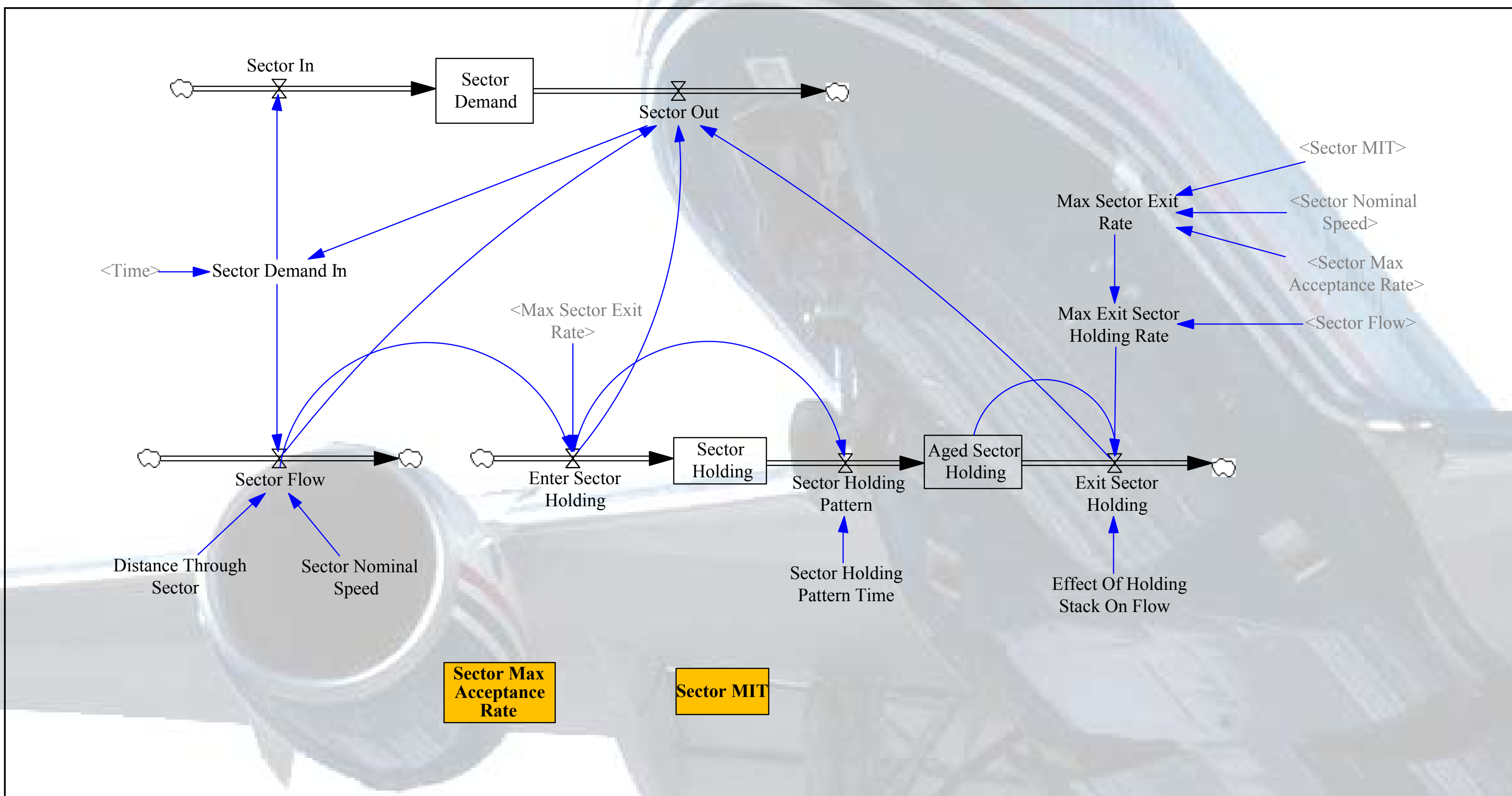
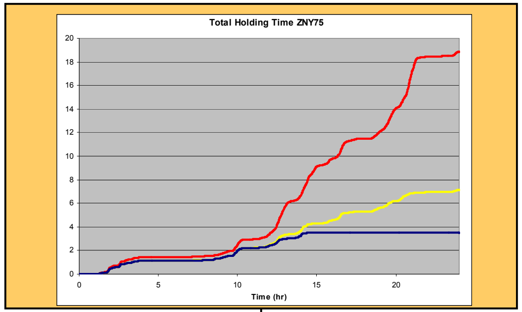
NAS Mental Model: Abstract Sector Model



Effects of MIT Levels Upstream
(ORD->EWR "TUBE" All NYC Airport Traffic – 30 May 2002)



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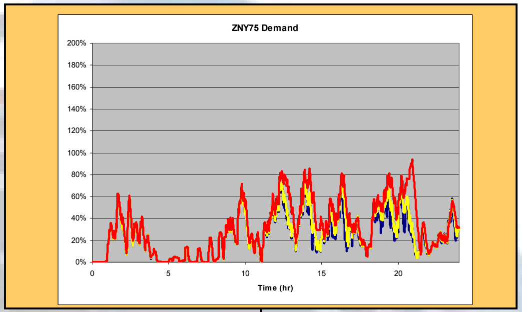
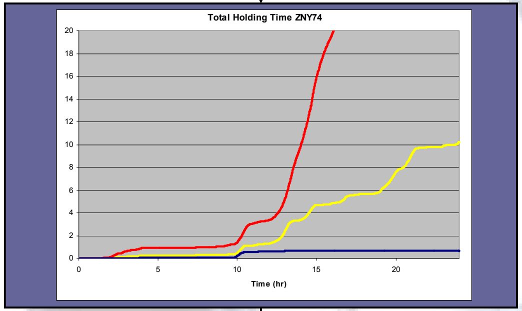


Sector Demand vs. Time ("Tube" traffic only)



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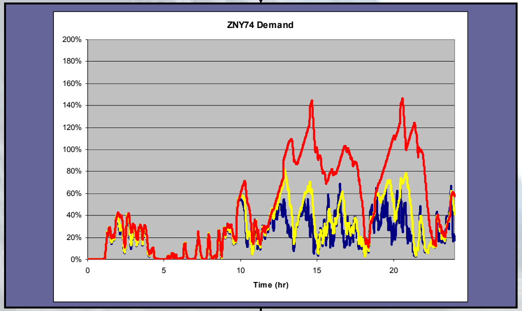
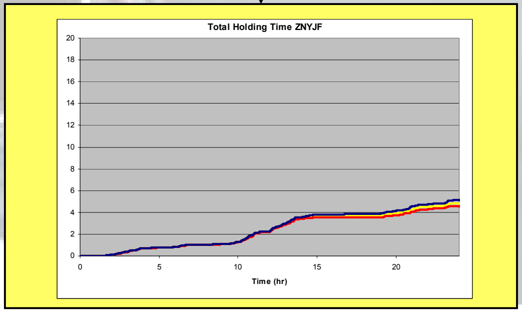


Cumulative Sector Holding Time for Different MIT Levels (hours)



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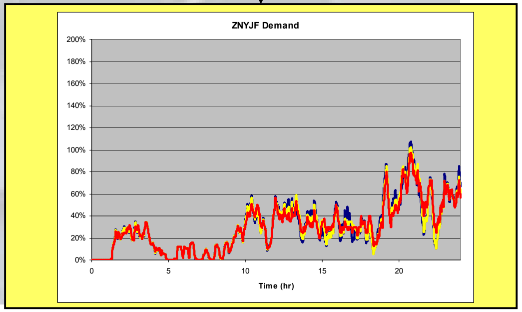

MIT
- 10
- 40
- 50

Final Remarks

- We have created models to analyze en-route and arrival delays resulting from MIT and RM restrictions
- Through our RM benefits assessment, we have developed a methodology to compute delay savings, equity, and collaborative substitution metrics which should be generally applicable to the study of the benefits of other DST systems
- The Genome project is creating a network representation of the NAS and exploring its behavior through a high-level Mental Model