CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

User Benefits of RNAV Departure Operations at DFW and ATL

Dr. Ralf H. Mayer

FAA – ATPAC Meeting
Washington, DC
11 April 2007

CAASD

MITRE

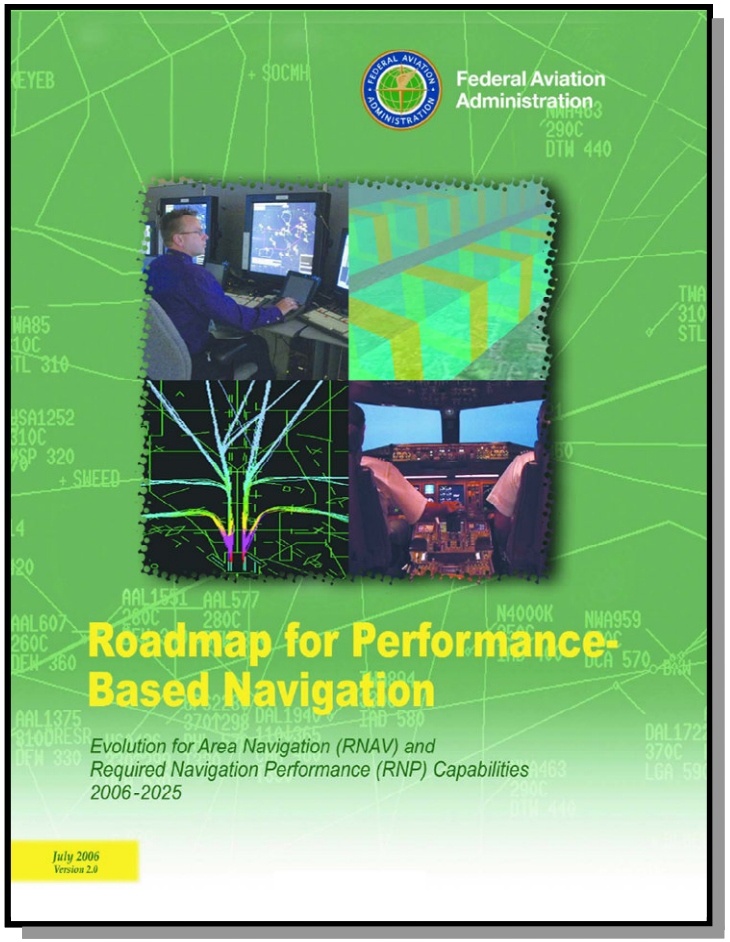
F083-B07-015

Outline

- **Background**
  - **FAA Roadmap for Performance-Based Navigation**
- **Terminal RNAV Departure Operations at Dallas-Fort Worth International Airport (DFW) and Hartsfield-Jackson Atlanta International Airport (ATL)**
  - **Procedure design**
  - **Operational changes**
  - **Benefit Mechanism**
    - Benefit Metric: Departure efficiency
- **Monte Carlo Model Evaluation of Operational Changes**
  - **Departure Efficiency Benefits**
    - Departure Capacity
    - Departure Delay
- **Post-Implementation Operational Evaluation**
  - **Departure Efficiency**
- **Summary**

MITRE

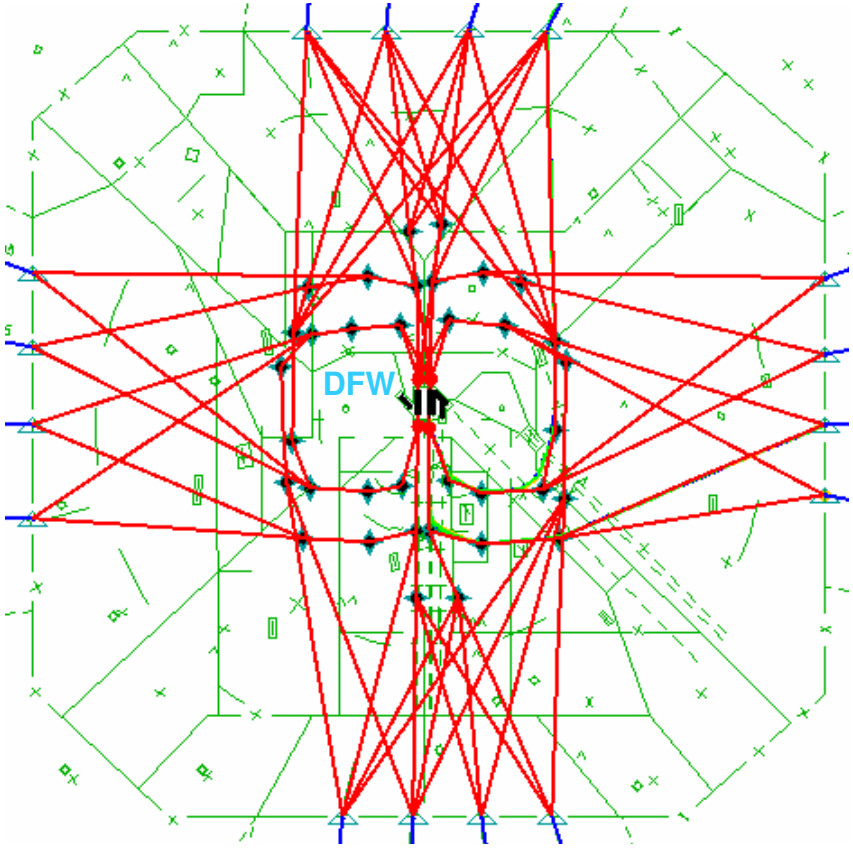
Background



- **Area Navigation (RNAV) Operations**
  - ***… a method of navigation which permits aircraft operation on any desired flight path …***
    - GPS / DME / IRU
  - **Implementation framework:**
    - FAA AC 90-100, *U.S. Terminal and En Route Area Navigation (RNAV) Operations*, January 2005
    - *Roadmap for Performance Based Navigation: Evolution for RNAV and RNP Capabilities 2006-2025, July 2006*
- **Terminal RNAV Operations**
  - **Over 190 RNAV Departure and Arrival procedures implemented**
  - **Key implementation sites:**
    - Dallas-Fort Worth
    - Atlanta

MITRE

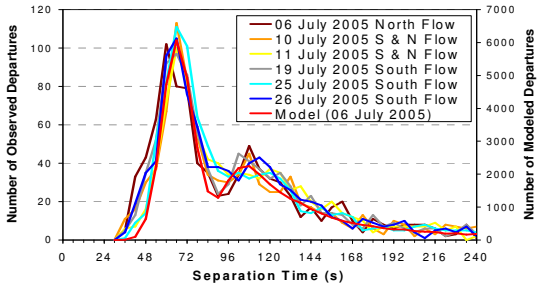
DFW Departure Procedure Design



- **Procedures**
  - **16 RNAV Departure Procedures**
- **Implementation Date**
  - **6 September 2005**
- **Key Design Objectives**
  - **Improved departure efficiency**
    - Increased departure capacity
    - Reduced departure delay
  - **Improved airspace utilization**
    - RNAV-enabled diverging operations within approved noise footprint
- **RNAV Equipage**
  - **~84% (/E, /G, /R, /J, /L, /Q)**

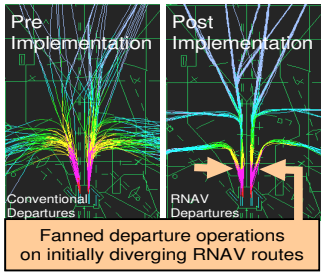
MITRE

Overview of the Evaluation Process



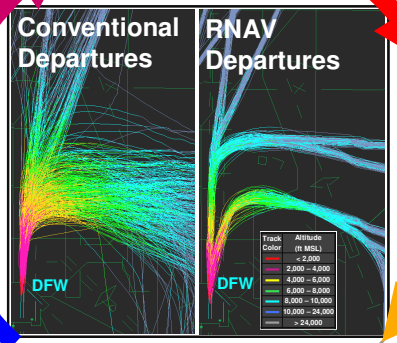
(1) Measure
Pre-Implementation Performance

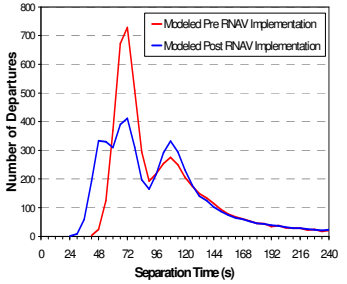
(2) Identify
Potential Benefit Mechanisms Associated with Proposed Post-Implementation Operations



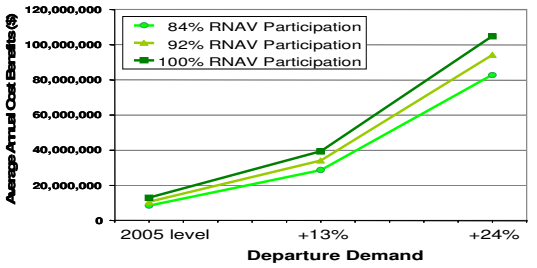
Fanned departure operations on initially diverging RNAV routes

(3) Model
Pre- and Post-Implementation Performance

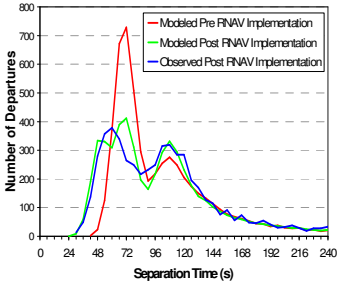




(4) Estimate
Post-Implementation Benefits

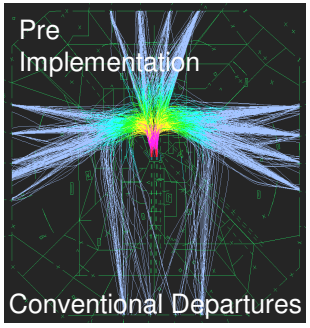


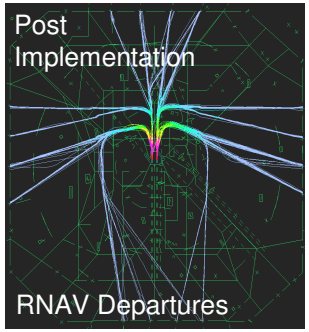
(5) Validate
Post-Implementation Benefits



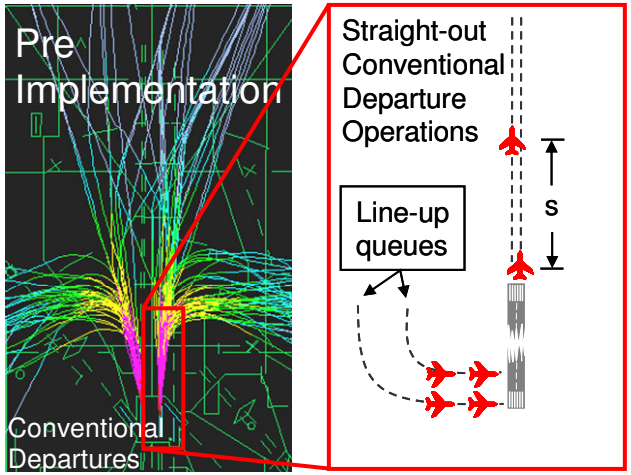
Pro-cedure

Imple-mentation





Key Operational Change



Applicable Separation Standards:

- Radar Separation
  - (FAAO 7110.65, 5-5-4)
- Wake Turbulence Separation
  - (FAAO 7110.65, 5-5-4)

Applicable Separation Standards:

- Radar Separation
  - (FAAO 7110.65, 5-5-4)
- **Same Runway Separation**
  - **(FAAO 7110.65, 3-9-6)**
- Wake Turbulence Separation
  - (FAAO 7110.65, 5-5-4)

Benefit Mechanism

- Application of **Same Runway Separation** standards to qualifying departures on initially diverging routes enables a reduction in effectively applied separation and results in improved departure efficiency

MITRE

Benefit Metric
Departure Efficiency

$$\text{Departure efficiency} = \frac{\text{Number of departures}}{\text{Unit of time}}$$

$$\text{Improved departure efficiency} = \frac{\text{Increased number of departures}}{\text{Unit of time}}$$

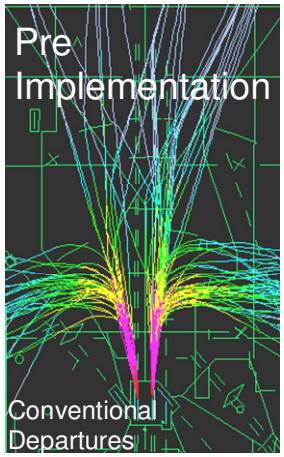
⇩

less time between departures
(reduced inter-departure time)

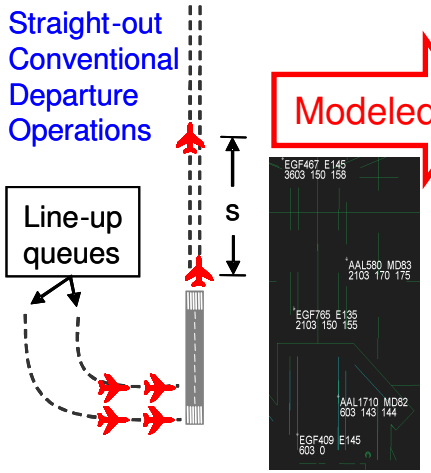
- **Departure Efficiency Metric**
  - **Distribution of measured inter-departure time values**

MITRE

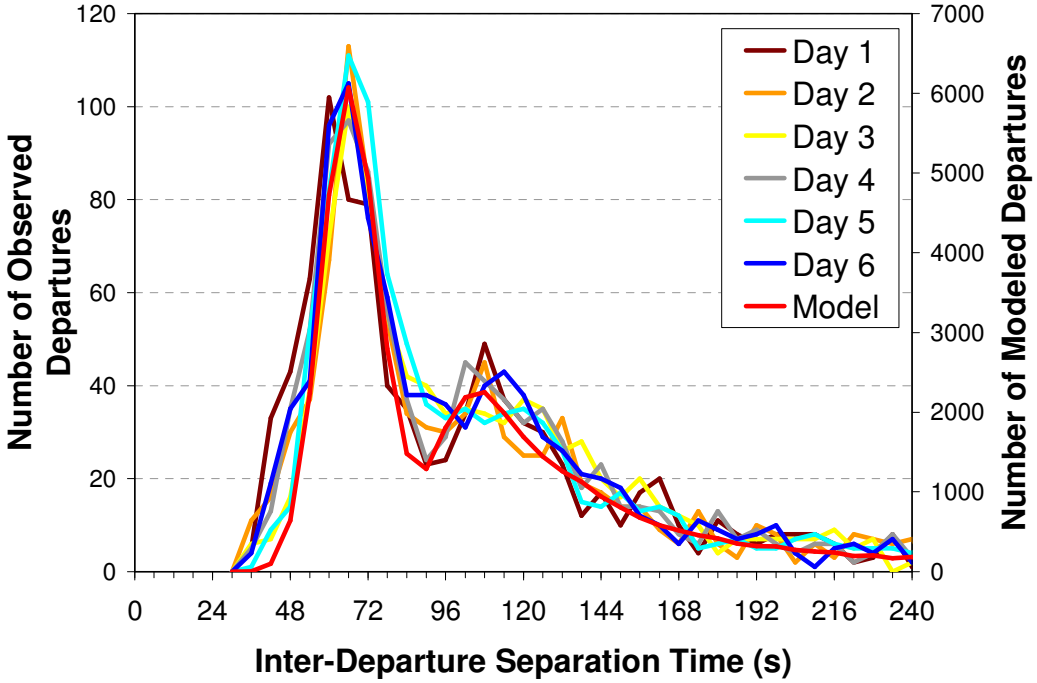
Pre-Implementation Departure Efficiency Model Validation



Observed



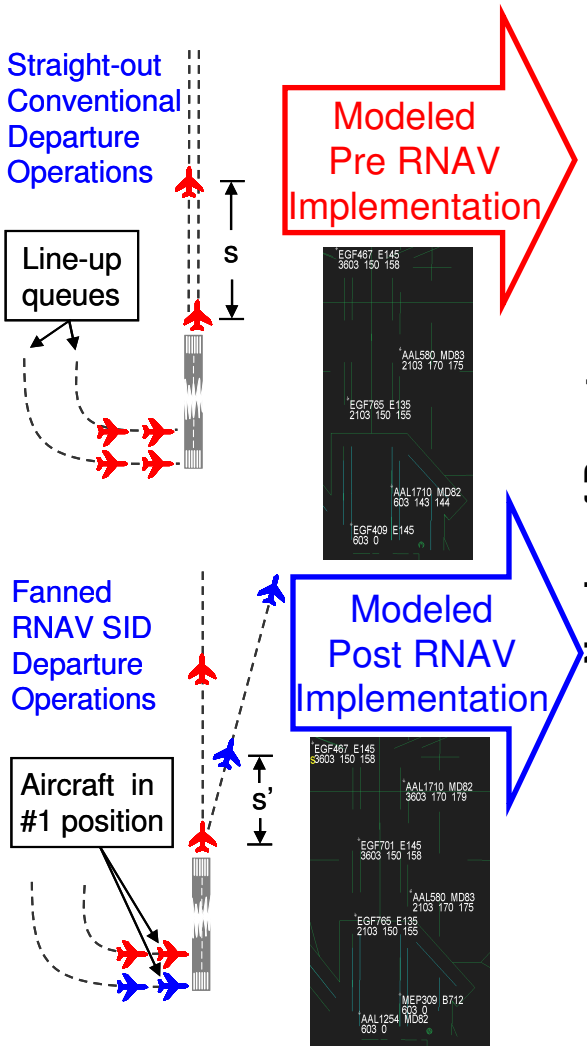
Modeled

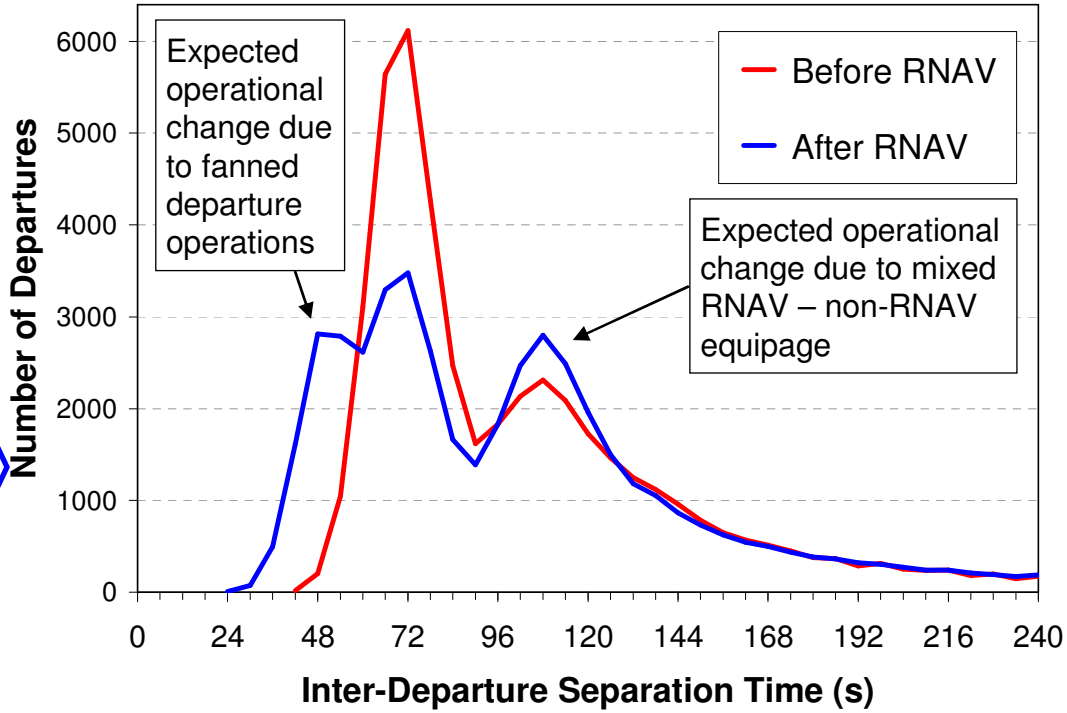


Results based on about 1,000 observed operations per day and approximately 50,000 modeled departure operations

MITRE

Modeled Departure Efficiency



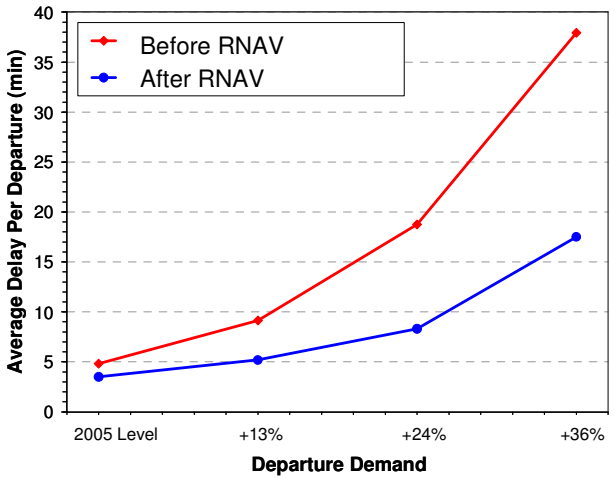


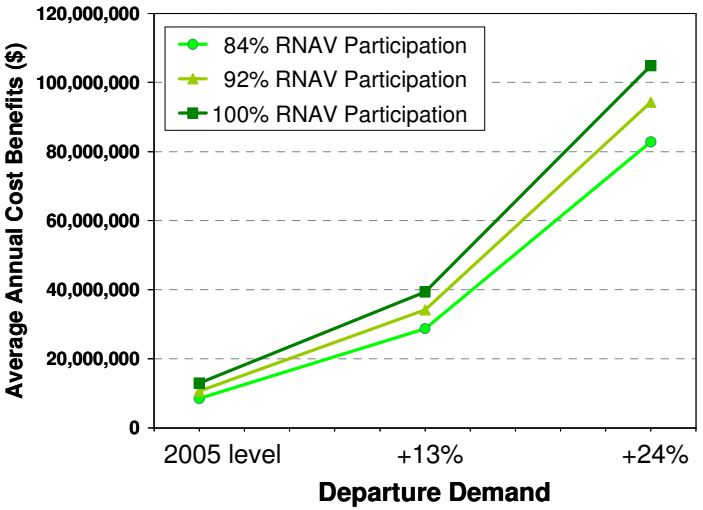
Results based approximately 50,000 modeled departure operations per modeled scenario

MITRE

Modeled Departure Efficiency Benefits

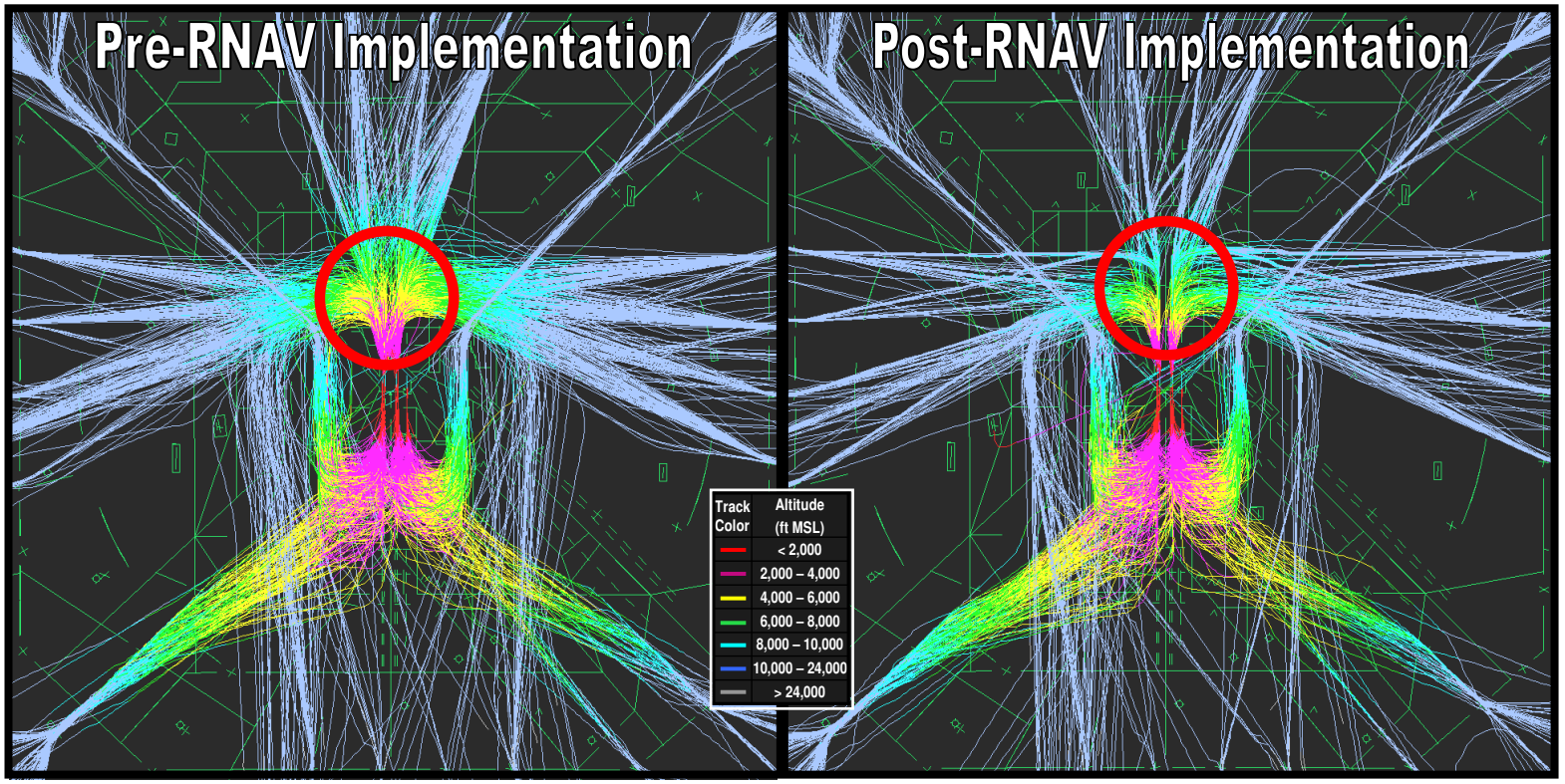
- **Airport departure capacity gain**
  - **11 to 20 additional operations per hour (84% to 100% RNAV participation)**
- **Average departure delay reduction per aircraft**
  - **1.3 minutes (Pre vs. Post Impl.)**
    - 2005 Level of departure demand
- **Annual departure delay reduction benefits to users**
  - **$8.5 million/year**
    - 84% RNAV participation
    - 2005 Level of departure demand





MITRE

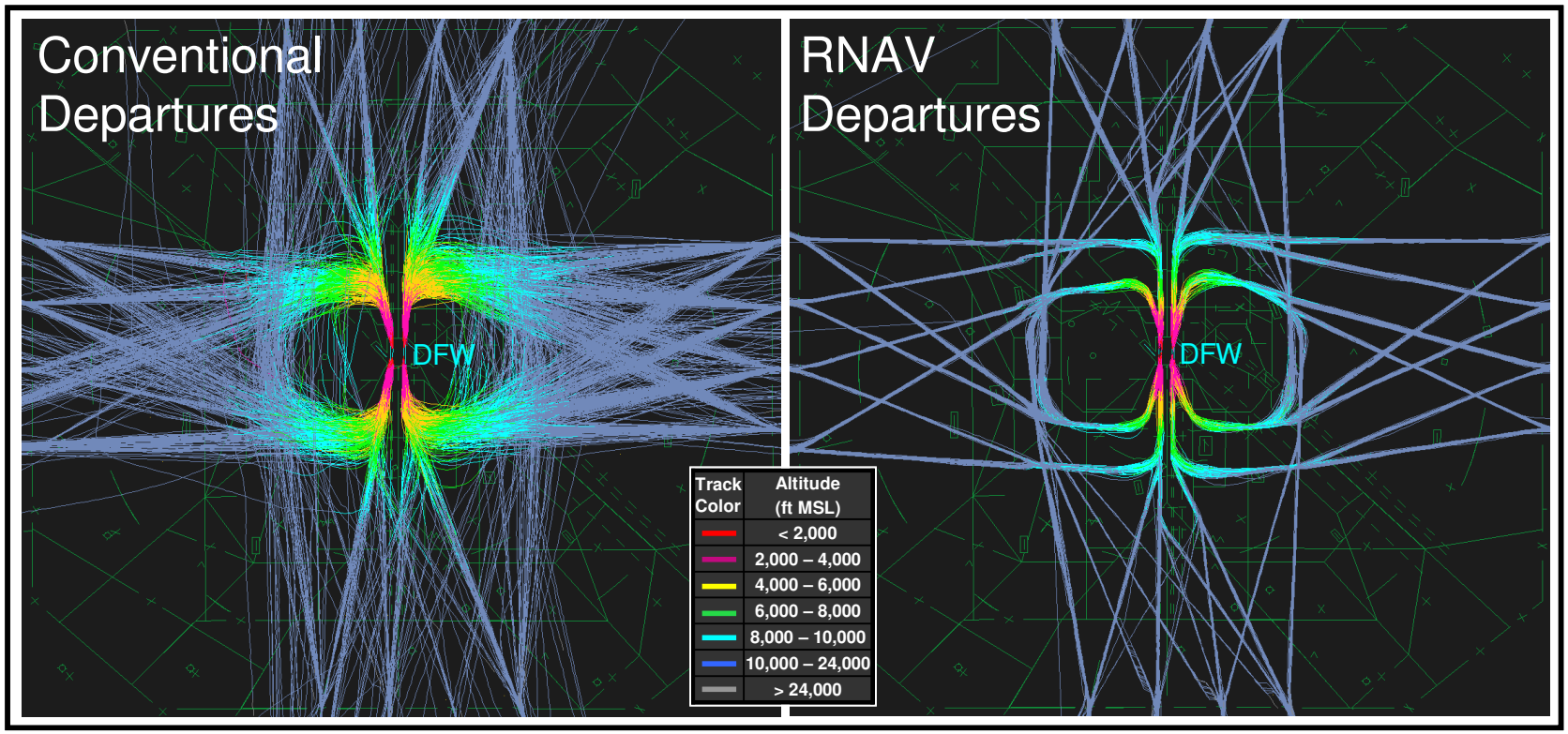
Post-Implementation Operational Evaluation
Visualization of Operations



DFW arrival and departure operations in North-flow operational configuration

MITRE

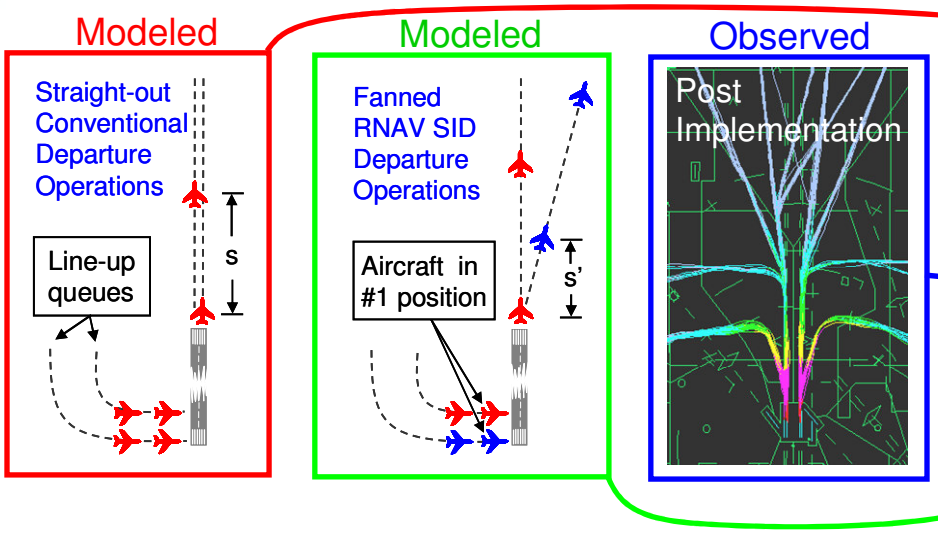
Post-Implementation Operational Evaluation
Visualization of Departure Operations

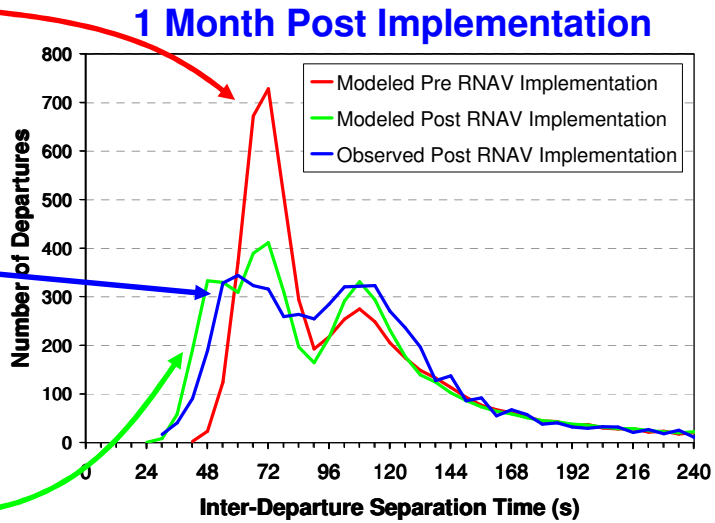


DFW departure operations in both North-flow and South-flow operational configuration

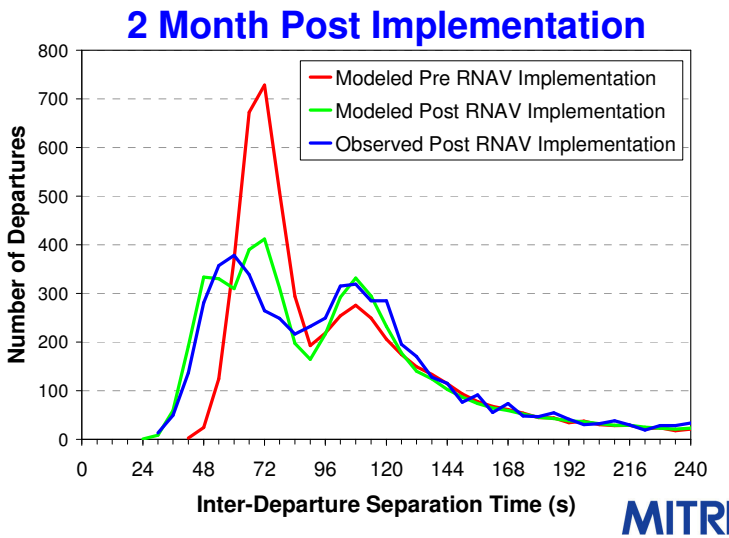
MITRE

Validation of DFW Departure Efficiency Benefits



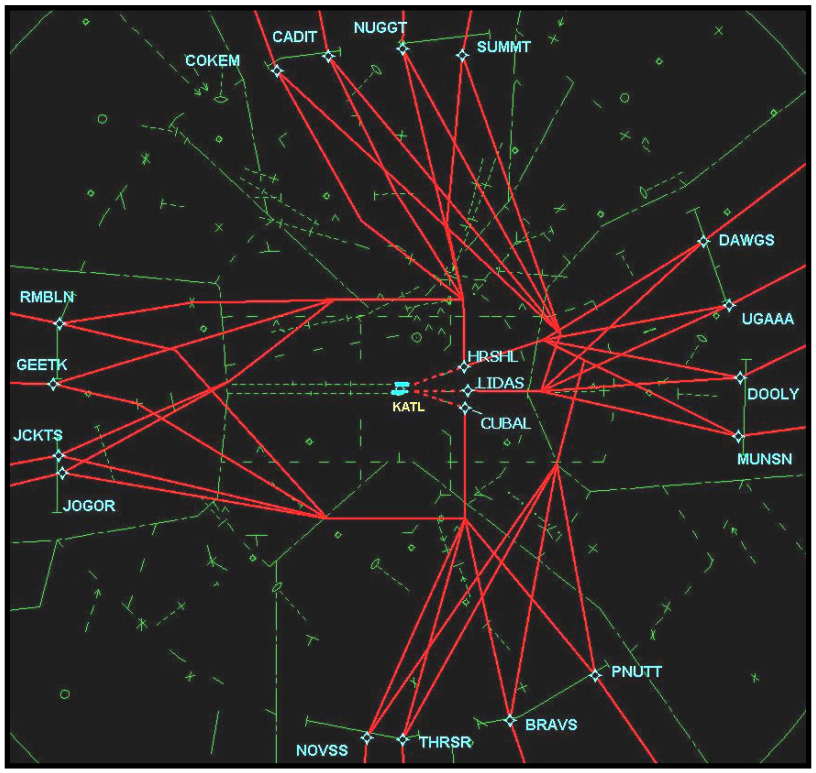


- **Validation of Model Estimates**
  - Observed operational changes indicate that departure efficiency benefits were largely realized within the first two months after implementation



MITRE

Revised ATL Departure Procedure Design



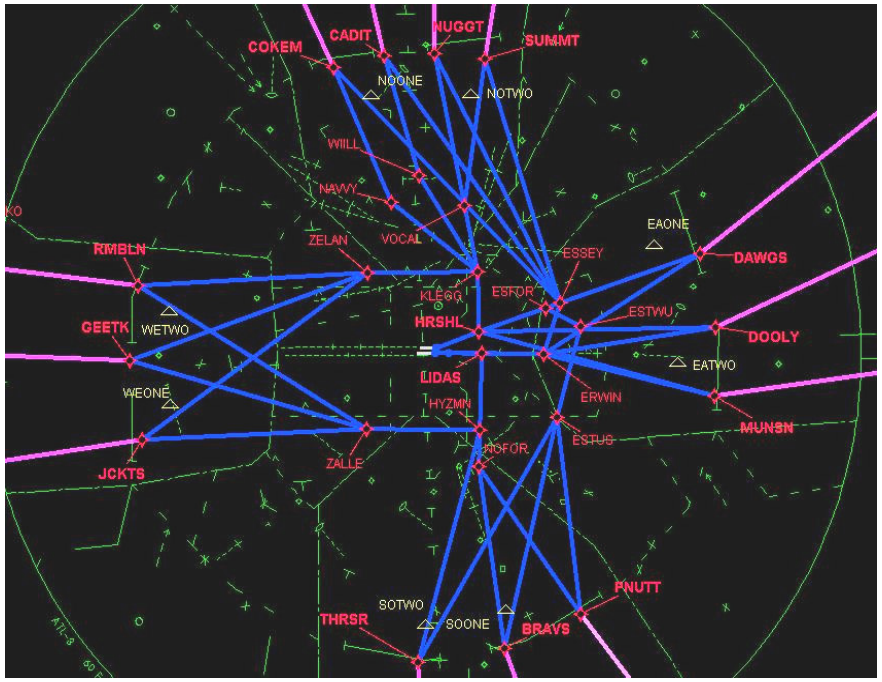
ATL East Flow Revised RNAV Departures

- **Revised Procedures**
  - **16 RNAV Departure Procedures**
- **Implementation Dates**
  - **13 April 2006**
    - Diverging courses in East Ops
  - **TBD, Summer 2007**
    - Diverging courses in West Ops
- **Key Design Objectives**
  - **Improved departure efficiency**
    - Increased departure capacity
    - Reduced departure delay
  - **Improved airspace utilization**
    - RNAV-enabled diverging operations within approved noise footprint

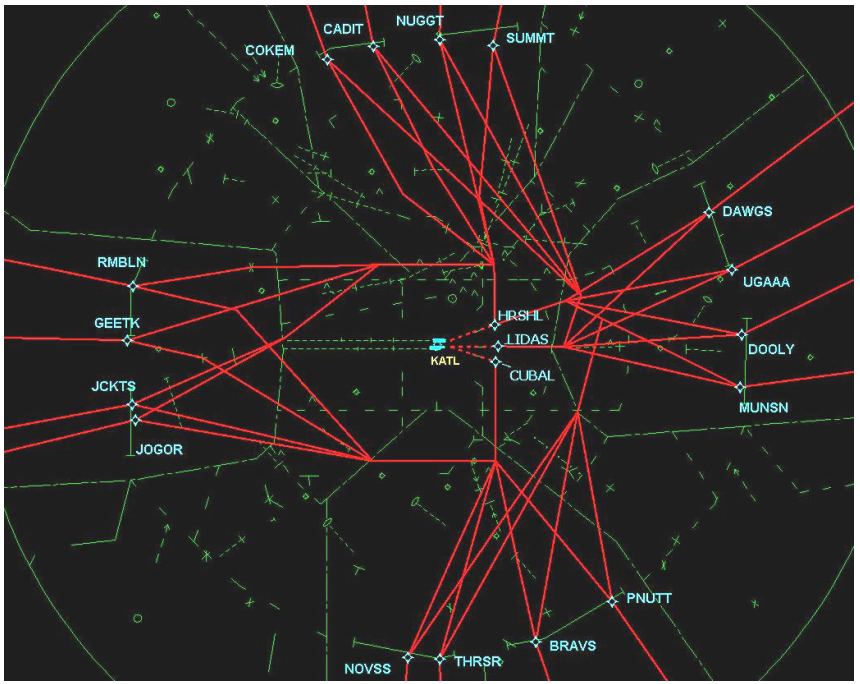
MITRE

ATL RNAV Departure Procedures
East Flow Operations

Baseline (2005)



Revised (2006)



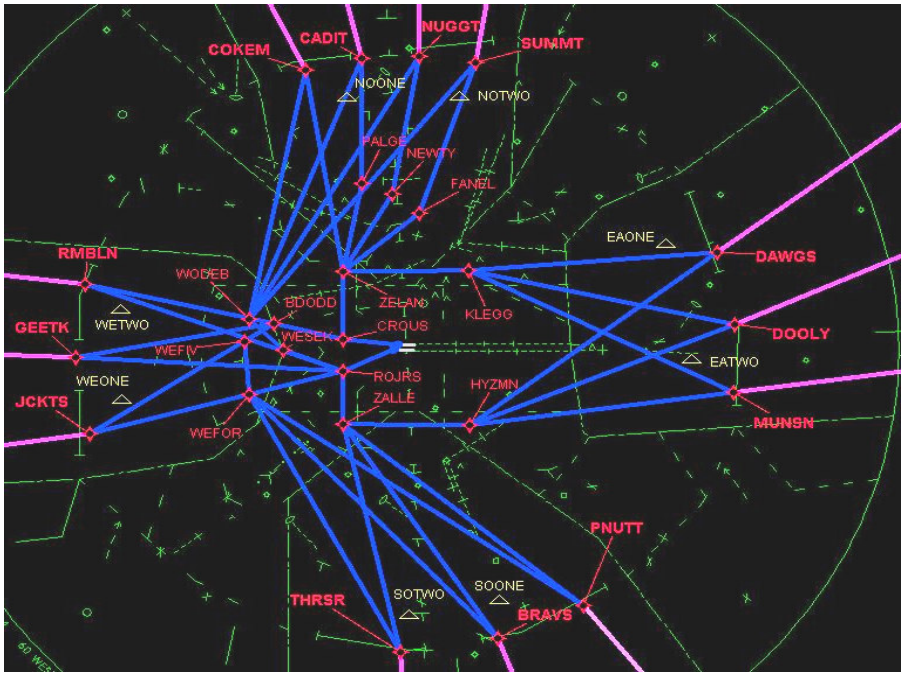
Key operational change:

- **Revised RNAV procedures enable diverging departure operations off runway 09L to CUBAL and LIDAS**
  - **Implementation: April 2006**

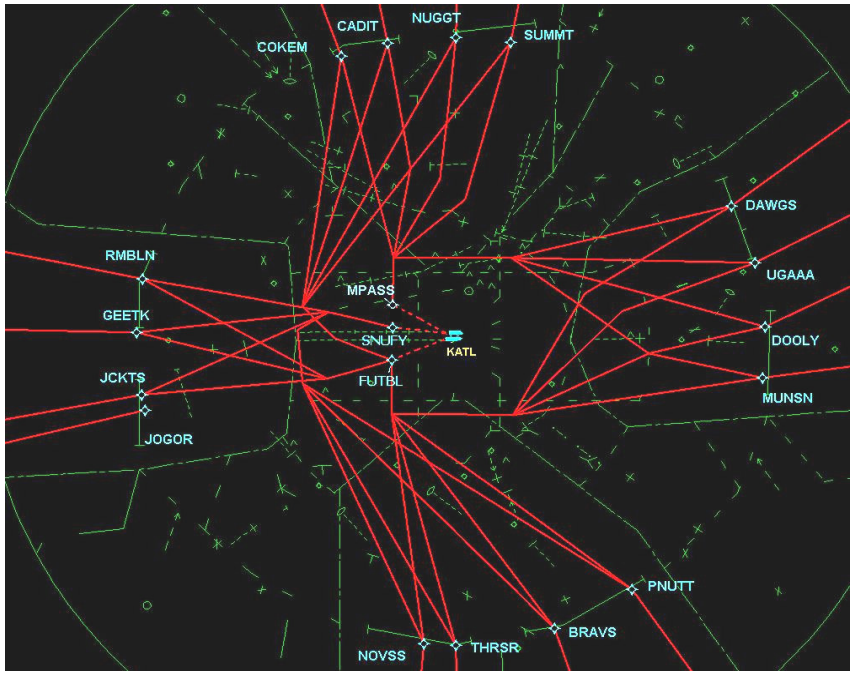
MITRE

ATL RNAV Departure Procedures
West Flow Operations

Baseline (2005)



Revised (2007)

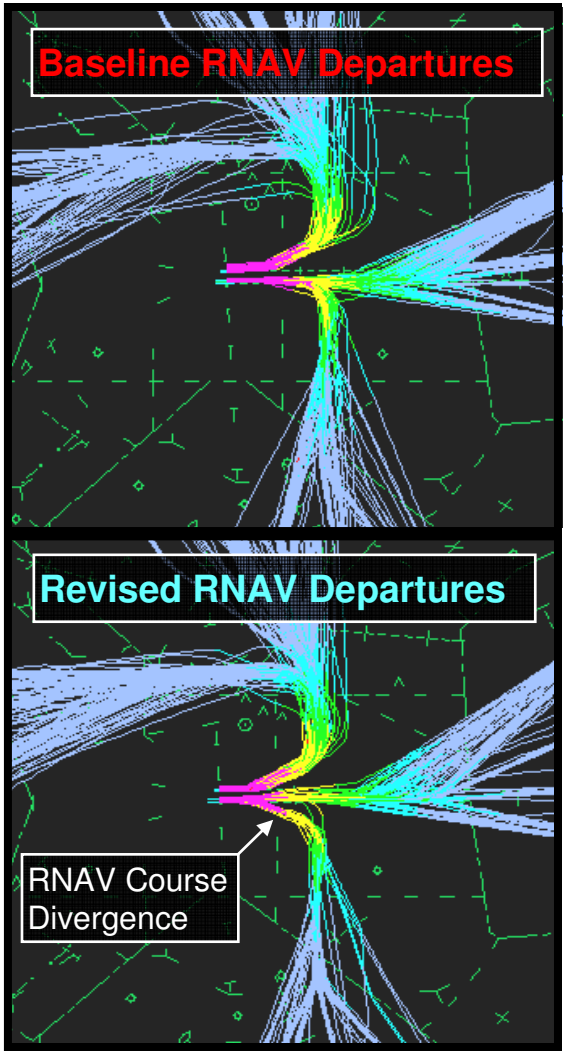


Key operational change:

- **Revised RNAV procedures will enable diverging departure operations off Runway 26L to SNUFY and MPASS**
  - **Expected implementation: Summer 2007**

MITRE

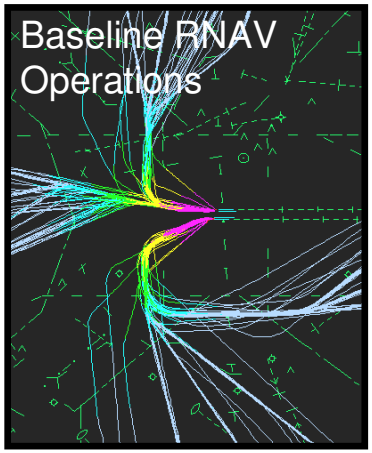
ATL RNAV Departure Procedures Operational Considerations



- **Procedure revisions enable diverging departure operations on one airport complex only:**
  - **East Flow Operations**
    - **South complex (2006)**
  - **West Flow Operations**
    - **North complex (2007)**
- **Departure demand differs on the two airport complexes:**
  - **North complex has greater departure demand**
    - **Approximately 100 flights more per day**
  - **South complex has more Heavy/B757 class aircraft**
    - **Approximately 80 flights more per day**

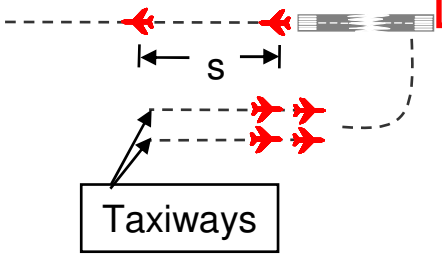
MITRE

Model Validation

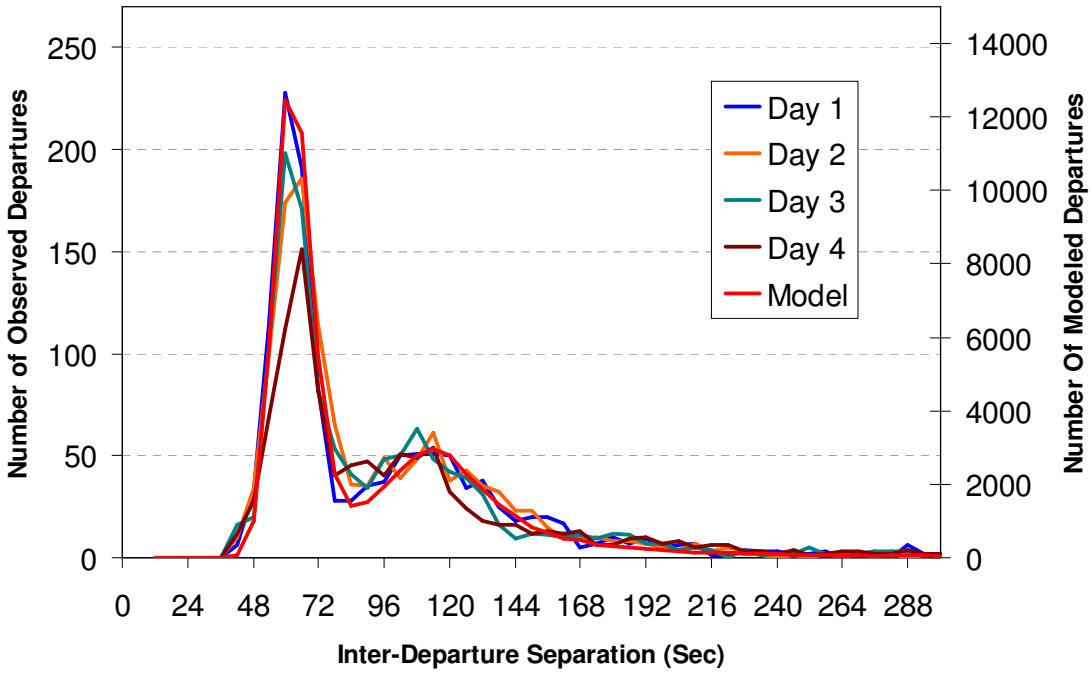


Observed

Straight-out Departure Operations



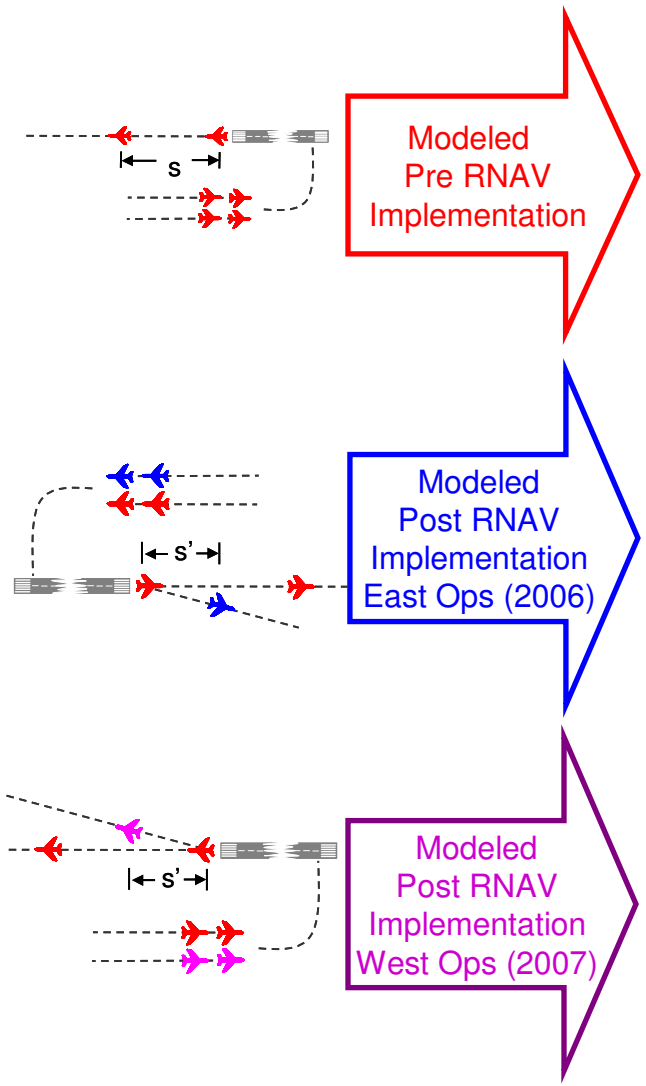
Modeled

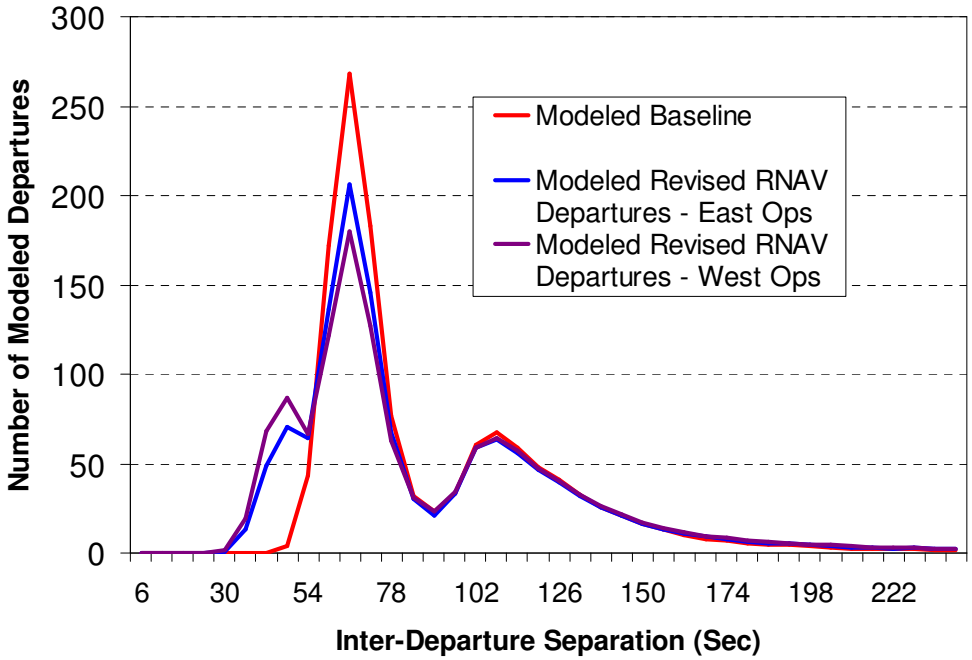


Results based on about 1,200 observed operations per day and approximately 250,000 modeled departure operations

MITRE

Model Evaluation of Departure Efficiency



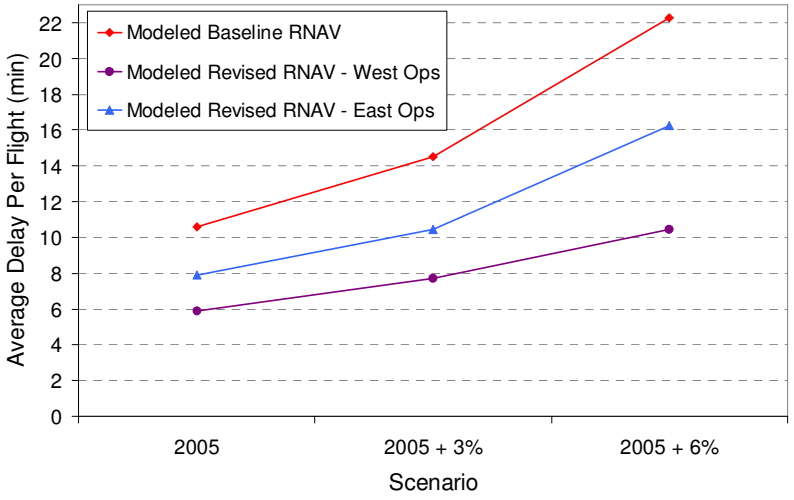


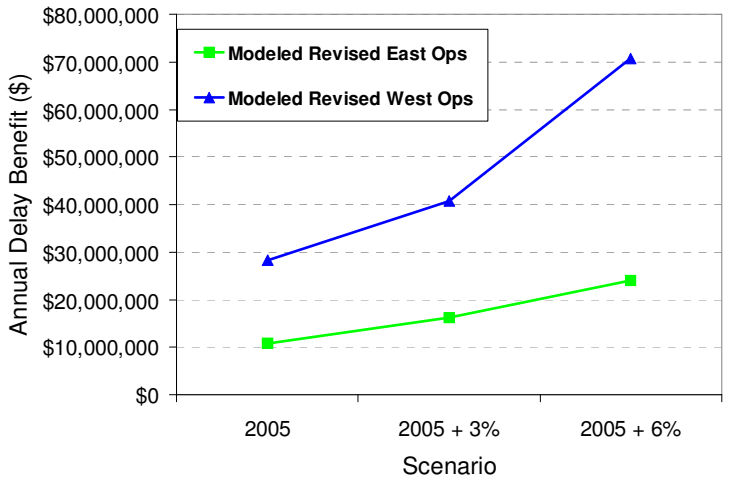
Results based on approximately 250,000 modeled departure operations per modeled scenario

MITRE

Modeled Departure Efficiency Benefits

- **Airport departure capacity gain**
  - **About 10 additional operations per hour**
- **Average departure delay reduction per aircraft**
  - 2005 Level of departure demand
    - **2.5 minutes in East ops (2006)**
    - **4.5 minutes in West ops (2007)**
- **Annual departure delay reduction benefits to users**
  - 2005 Level of departure demand
    - **$8.5M per year (2006 impl.)**
    - **$34M per year (2007 impl.)**

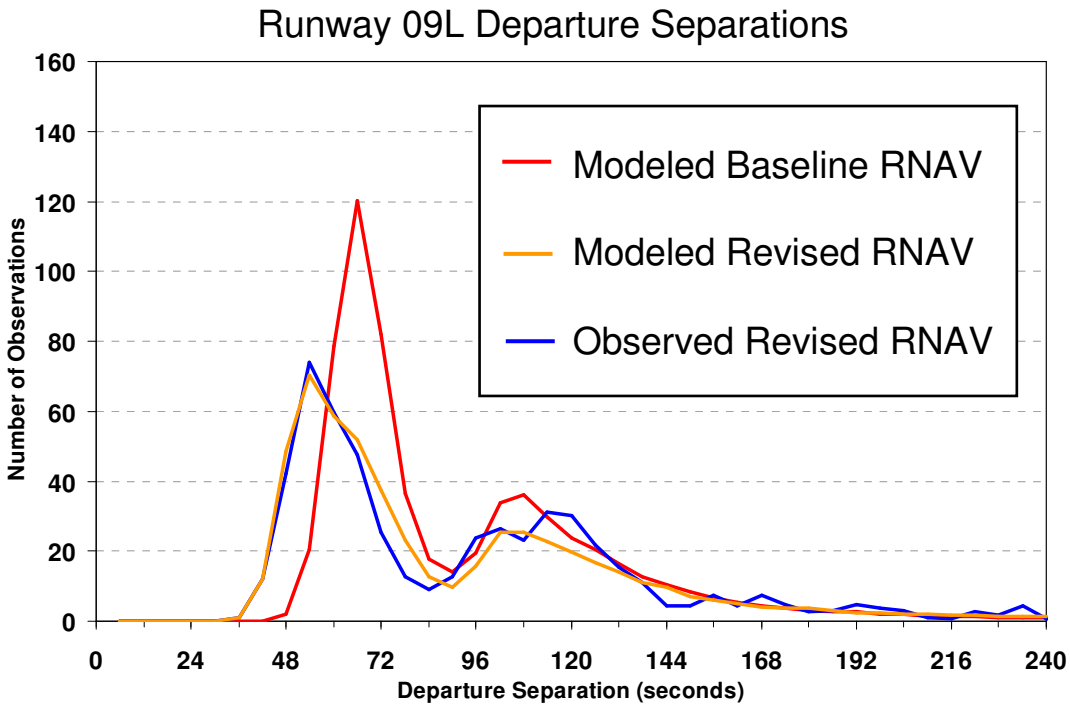




MITRE

F083-B07-015

Validation of ATL Departure Efficiency Benefits



- **Validation of Model Estimates**
  - Observed operational changes indicate that departure separation efficiency benefits were largely realized within the first two months after implementation

MITRE

Summary

- **Terminal RNAV Departure Operations**
  - **Incremental implementation at major U.S. airports**
  - **Increased use of advanced flight automation systems**
    - Navigational capability available today on the majority of commercial aircraft
- **Departure Separation Efficiency Benefits**
  - **ATL departure capacity benefits**
    - About 10 additional departures per hour
  - **Annual departure delay reduction benefits to users**
    - April 13, 2006 implementation $8.5M/year
    - TBD/Summer 2007 implementation $34M/year additional

MITRE

Summary

- **Departure Separation Efficiency Benefits**
  - **DFW departure capacity benefits**
    - 11 to 20 additional operations per hour for RNAV participation rates of 84% to 100%, respectively
  - **Annual departure delay reduction benefits to users**
    - 84% RNAV participation $8.5M/year

      100% RNAV participation $12.9M/year
  - **Cost associated with mixed RNAV/non-RNAV operations**
    - 84% RNAV participation >$4M/year
  - **Benefit Validation**
    - Observed operational changes indicate that departure separation efficiency benefits were largely realized within the first two months after implementation

MITRE

CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT

Thank You

rmayer@mitre.org

MITRE