Miles-in-Trail Restrictions Relaxation: A Key Benefit Mechanism of Integrated Arrival Departure Surface Traffic Management

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Motivation

- Transit of departures through airport surface, TRACON airspace and finally merging into overhead enroute traffic streams is a major source of delay
  - Especially in busy metroplex areas such as New York

- NASA plans to demonstrate integrated arrival, departure, surface (IADS) traffic management technologies for improving metroplex traffic management
  - Supported by ATM Technology Demonstration-2 (ATD-2) sub-project
  - Time-based scheduling algorithms for departure metering
  - Collaborative decision making leveraging enhanced information sharing

Motivation (Cont.)

- ATD-2 is expected to improve current-day departure management procedures
  - Flights pushback when ready
  - Controlled in a First Come First Served (FCFS) manner thereafter
  - Excess departure restrictions imposed to address airspace constraints: Miles-in-Trail (MIT), Approval Requests (APREQs)
- Lack of coordination between ATD-2 time-based schedules and departure restrictions may become a major factor limiting ATD-2 benefits
- This paper studies effect of relaxing MITs when ATD-2 scheduling is active
  - Can efficiency of operations be increased and by how much?
  - Does relaxation of MIT restrictions maintain safety of operations?

Outline

- Research Motivation
- CLT Case Study Description
- Analysis Method
  - Historical Track Data Analysis
  - Departure Restrictions Analysis
  - Metroplex Departure Metering Simulation
- Analysis Results
- Conclusions & Future Work

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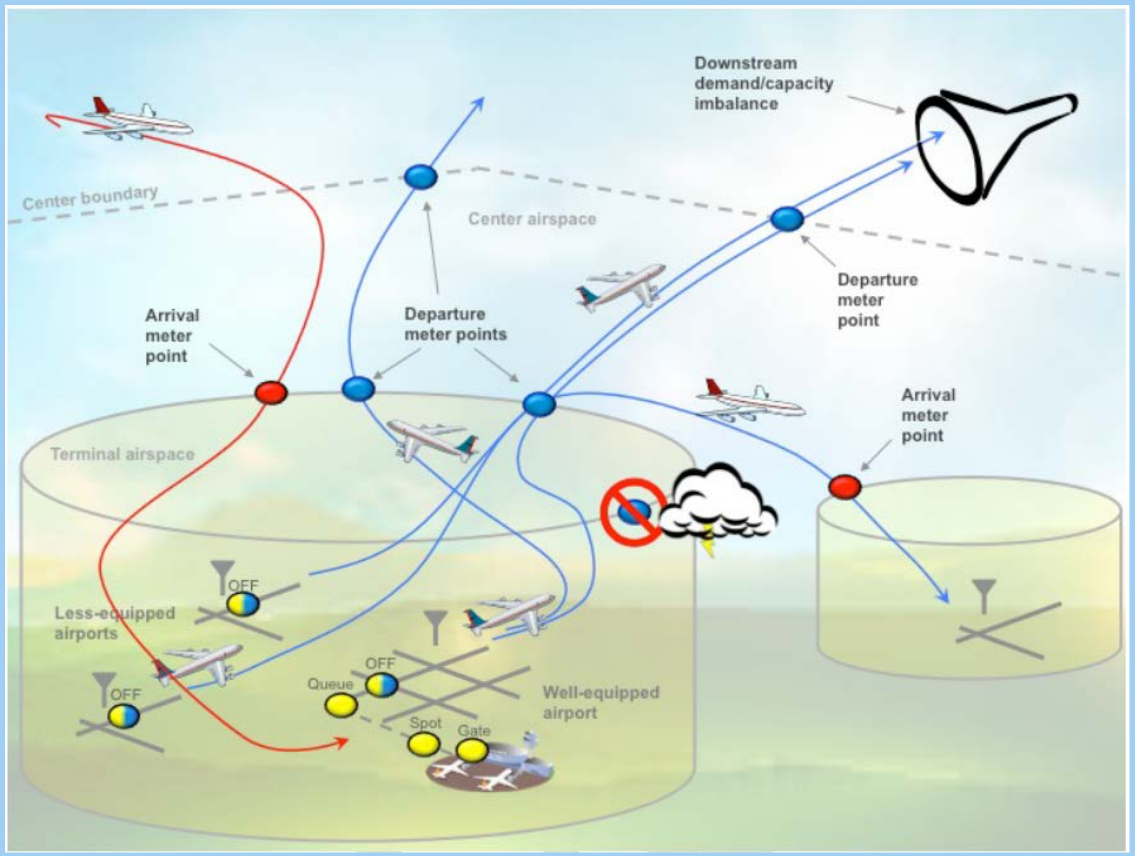
ATD-2 Operational Environment

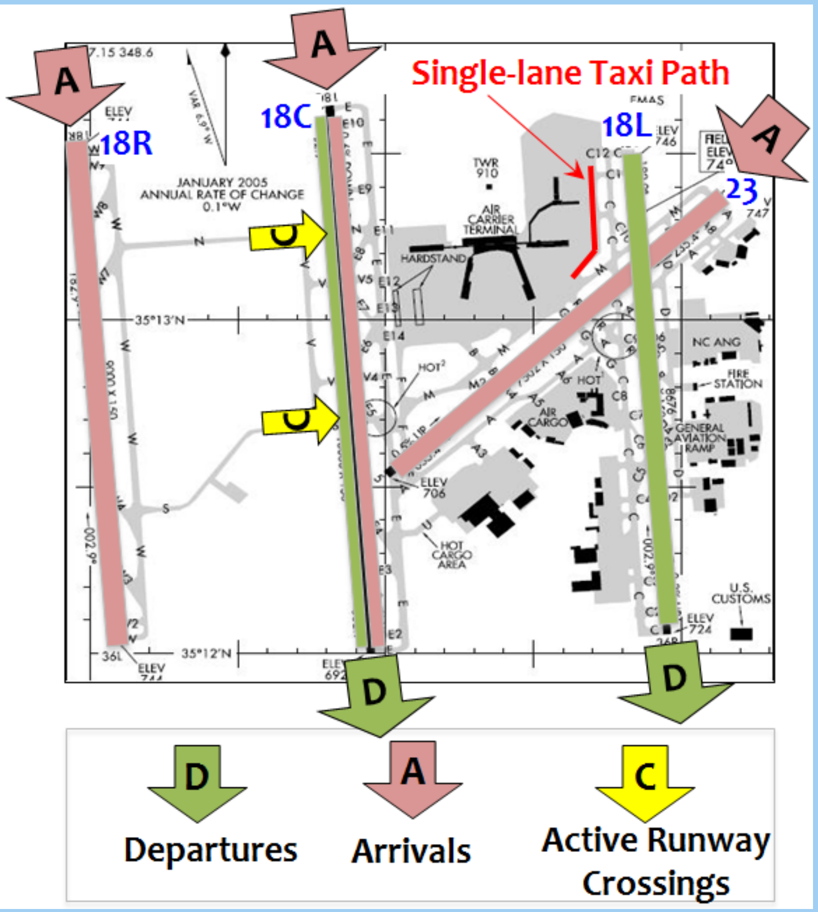


Graphic taken from NASA ATD-2 slides

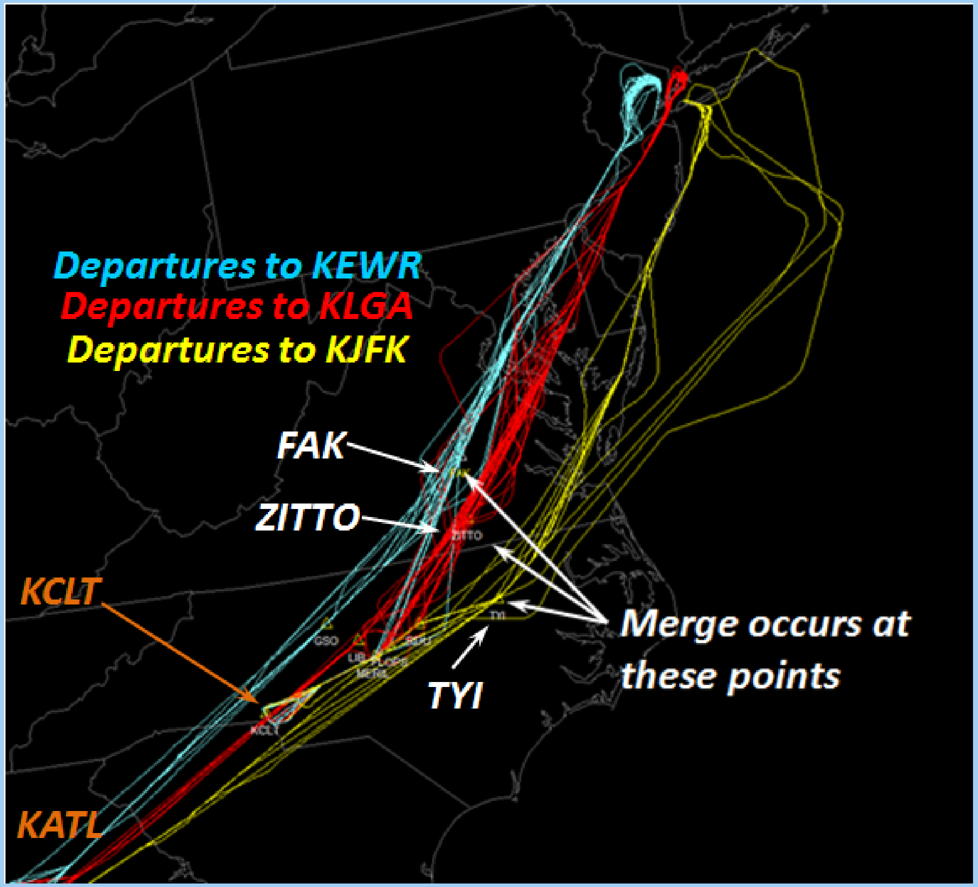
- One or more well-equipped airports
- Multiple less-equipped airports
- Departure-fix merging
- Weather impacts on departure-fix capacities
- Downstream constraints: APREQs, MITs, landing time-slots at destination airports

CLT Airport Case Study

Airport Surface Constraints



Enroute Merge Constraints



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Analysis Method

- Develop a fast-time metroplex departure metering simulation model for the ATD-2 operational environment
  - Realistic queuing models of major TRACON and enroute departure flows
  - Realistic models of departure restrictions
- Develop emulation of departure management procedures
  - Current-day operations
  - ATD-2 operations
- Conduct fast-time simulations
  - Current-day operations, with current levels of MIT restrictions
  - ATD-2 operations, with current levels of MIT restrictions
  - ATD-2 operations, with progressively relaxed MITs
- Compare efficiency metrics and safety measures

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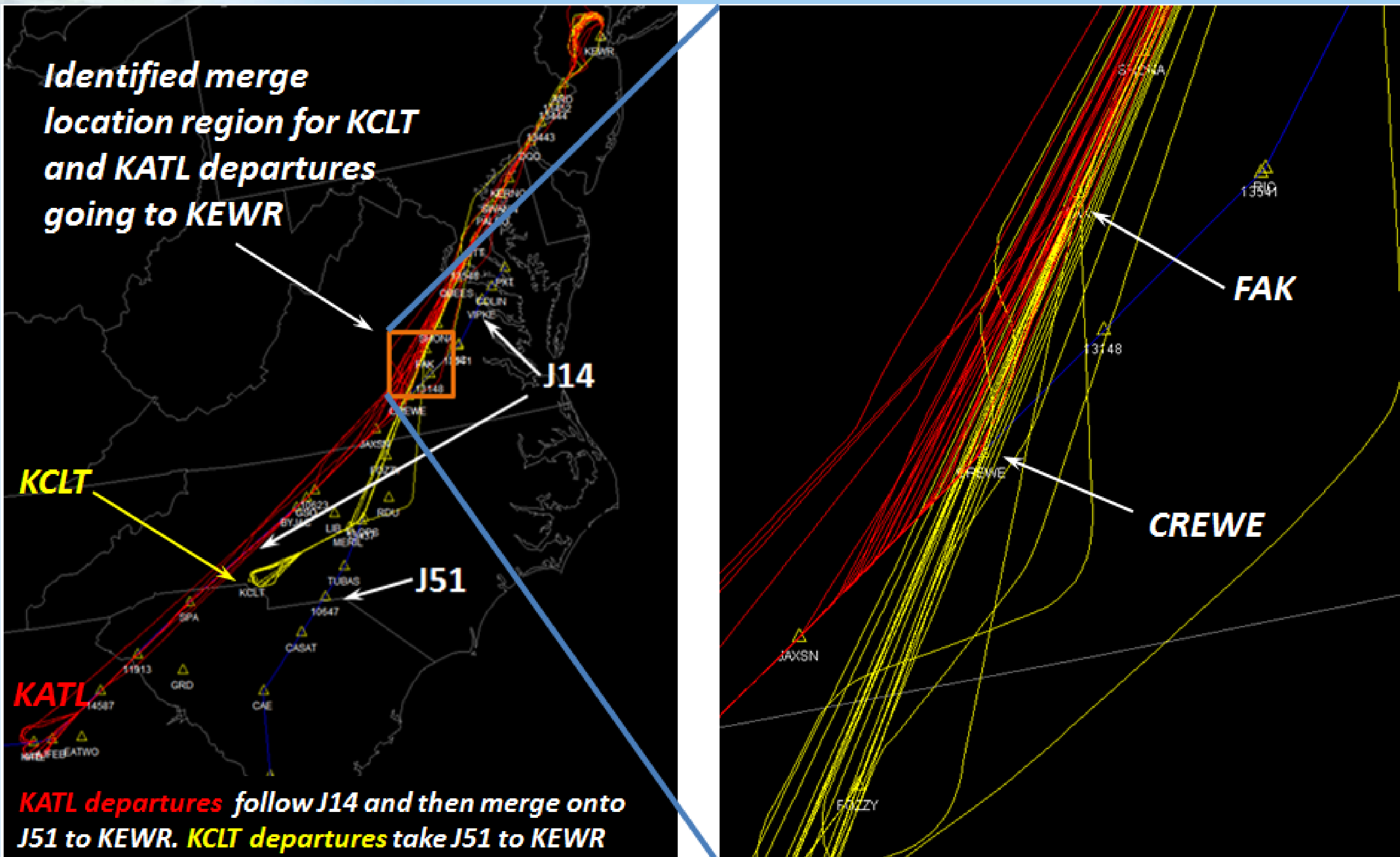
Identification of Major Departure Flows

- Performed FAA PDARS* track data analysis for three full days of operation in the summer of 2015
- FAA PDARS
  - Fuses radar data from NAS-wide ARTCCs, TRACONs, and major airport surfaces with other flight and environmental data
  - PDARS analyst services aid more than 75 FAA offices
- Our analysis focused on CLT and ATL departures going to destination airports in the Northeast U.S.

**PDARS: Performance Data Analysis and Reporting System*

Departure Flows Analysis Using SkyView



Detailed identification of merge-locations for each destination-specific departure flow, shown here for departures to EWR

Where do departure traffic streams merge?

Destination Airport	Merge-point for KATL and KCLT departure traffic streams	Implication for APREQ Modeling
KLGA	ZITTO	Reserve enroute traffic stream time-slots at ZITTO
KJFK	TYI	Reserve enroute traffic stream time-slots at TYI
KEWR, (also KPHL and KBOS)	FAK	Reserve enroute traffic stream time-slots at FAK
KIAD, KDCA, KBWI	Merge in descent phase of the flight	Reserve time-slots at the destination landing runway

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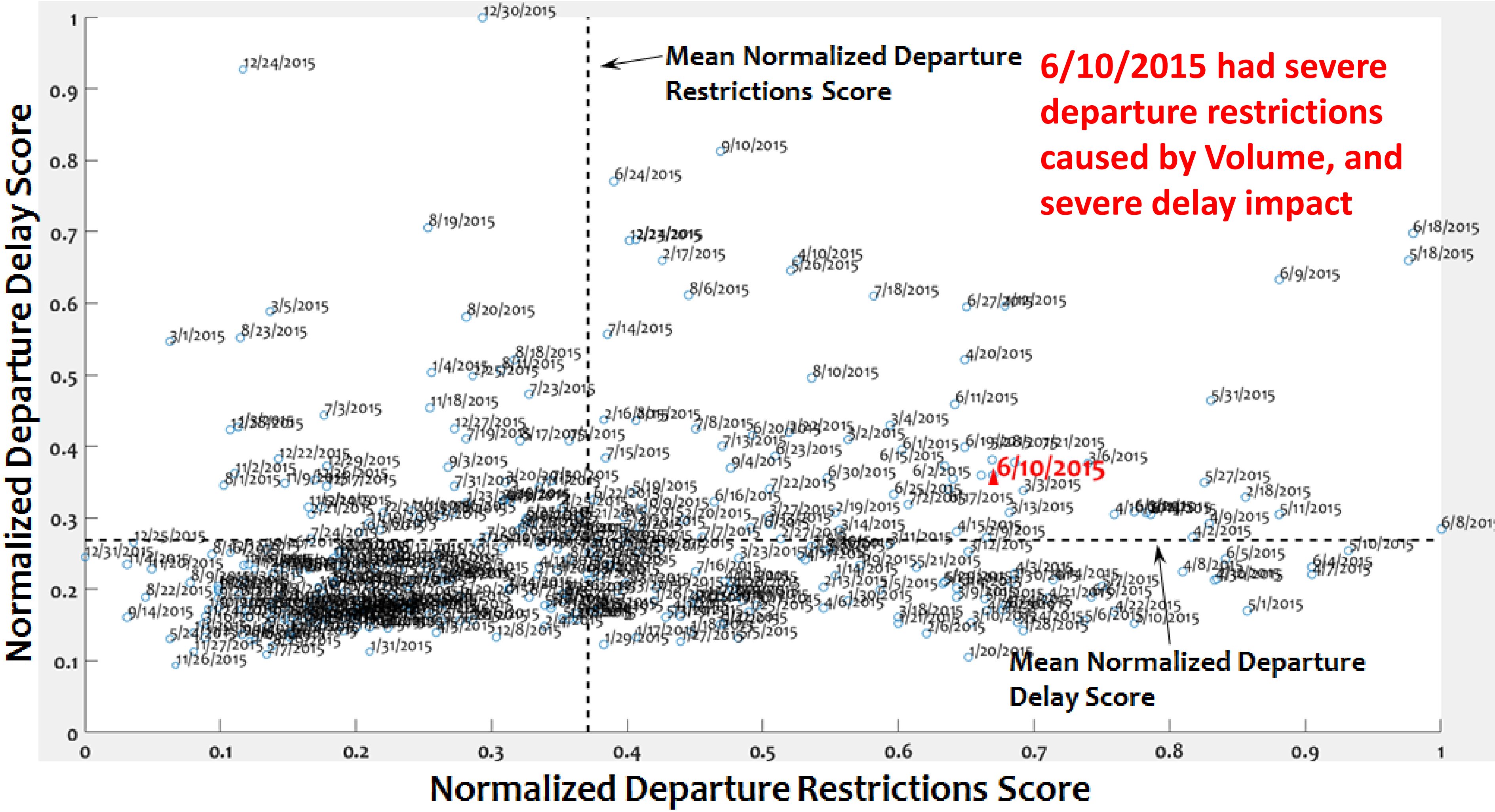
Departure Restrictions Analysis

- Performed National Traffic Management Log (NTML) data analysis for entire year 2015

- Analyzed MIT and APREQ departure restrictions for CLT and ATL airports

- Two-fold purpose of NTML analysis
  - Identify a suitable historical day for simulation modeling
  - Support accurate modeling of these restrictions in MDMS

Identifying a Suitable Simulation Day



Departure Restrictions on 6/10/2015

Time Duration for Restriction	Departure Restrictions Imposed On	
	KATL Departures	KCLT Departures
10:00 to 13:30	APREQ for impacted NAS element 'GSO/PHL'	20 MIT restriction for NAS element 'GSO/PHL'
12:45 to 18:30	APREQ for LGA departures	APREQ for LGA departures
13:00 to 17:45	APREQ for DCA departures	30 MIT for DCA departures
18:15 to 20:15	APREQ for IAD departures	30 MIT for IAD departures
21:45 to 23:00	APREQ for TEB departures	30 MIT for TEB departures
22:45 to 23:30	APREQ for LGA departures	APREQ for LGA departures

- General observed trend
  - ATL departures exclusively receive APREQs for NE departure constraints
  - CLT traffic going to the same airports is managed via restrictive MITs, with the exception of LGA-bound departures

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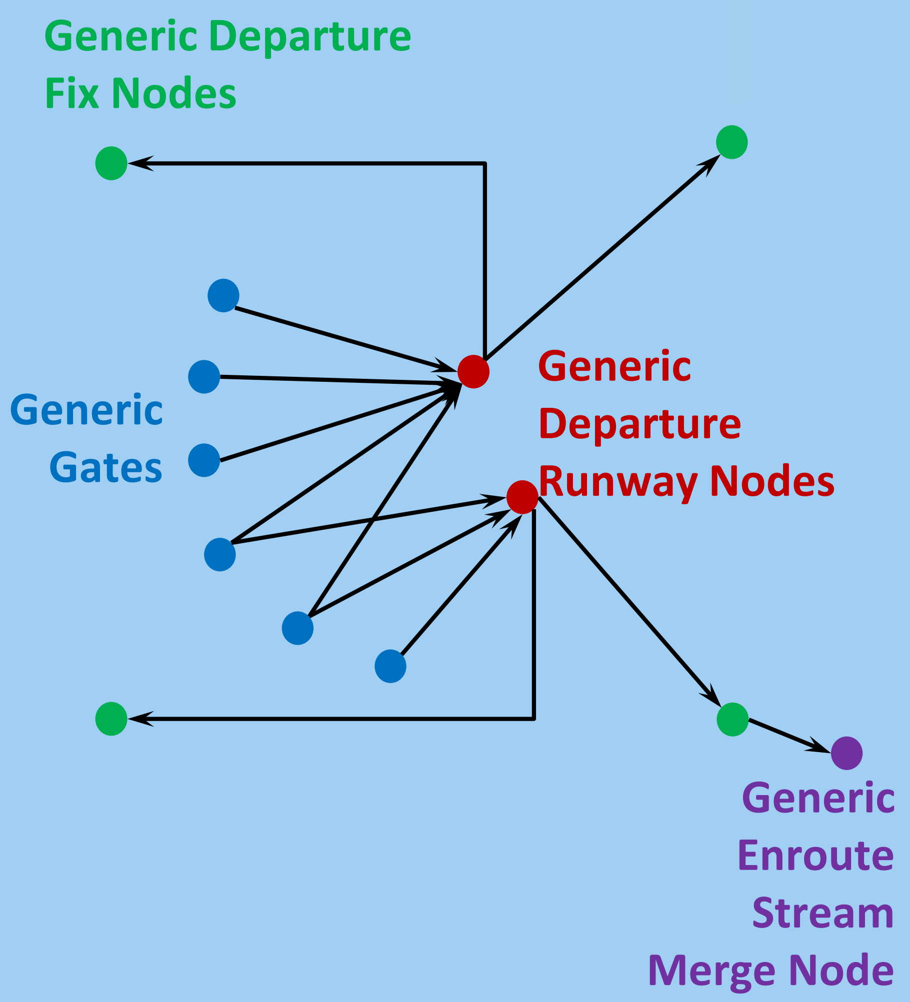
Metroplex Departure Metering Simulation (MDMS)

- Queuing simulation with key control nodes located at
  - Terminal-gate areas
  - Departure runways
  - Departure fixes
  - Enroute merge-fixes

- Link-node representation of major departure flows on the surface and in the airspace
  - PDARS and ASPM data-derived transit time models for links
  - Realistic controller action models for managing queues at key nodes



MDMS Key Features

- Easily configurable network of surface and airspace routes
- Realistic transit time models derived from historical data
- Realistic models for ANSP actions
  - APREQ implementation
  - MIT application at departure runways
  - MIT application at departure-fixes
  - Managing merges at enroute stream entry points
- Pluggable model of departure management procedures
  - Current-day procedure
  - ATD-2 procedure
- Uncertainty models
  - Randomized pre-pushback uncertainty model
  - Taxi time uncertainty model

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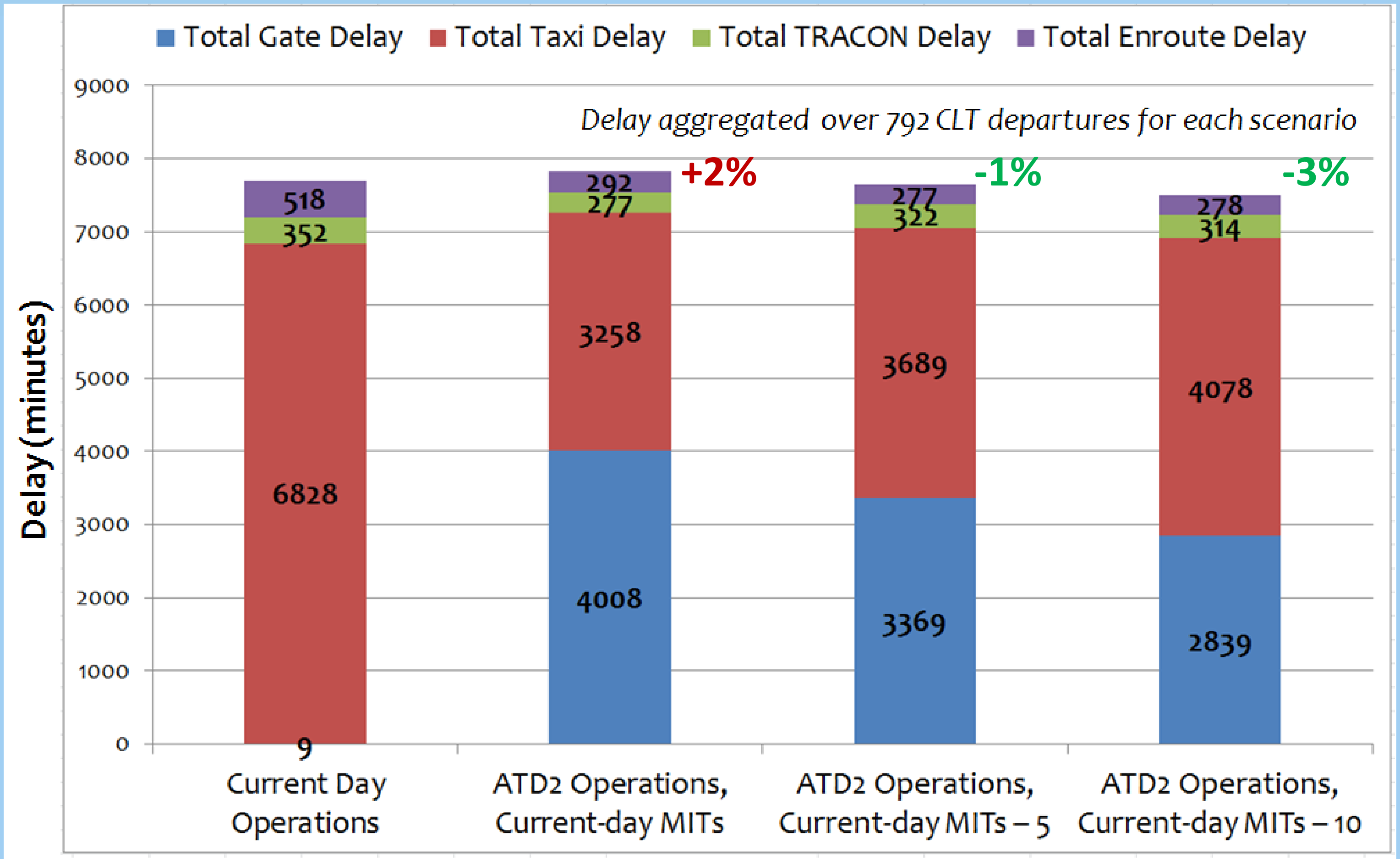
Metroplex Departure Metering Analysis

- **Two operations models:** (i) Current-day and (ii) ATD-2

- **Multiple MIT levels:** (i) Current-day, (ii) Relaxed by 5 nmi, (iii) Relaxed by 10 nmi, …

- **Analysis Steps:**
  - Run current-day operations sim with current MIT levels
  - Run ATD-2 operations sim with current MIT levels
  - Run ATD-2 operations sim with MIT levels relaxed by 5 nmi each
  - Run ATD-2 operations sim with MIT levels relaxed by 10 nmi each
  - Continue until relaxation of MITs leads to “unsafe” airborne delay levels

Results: Distribution of Delays



Results: Delay Savings

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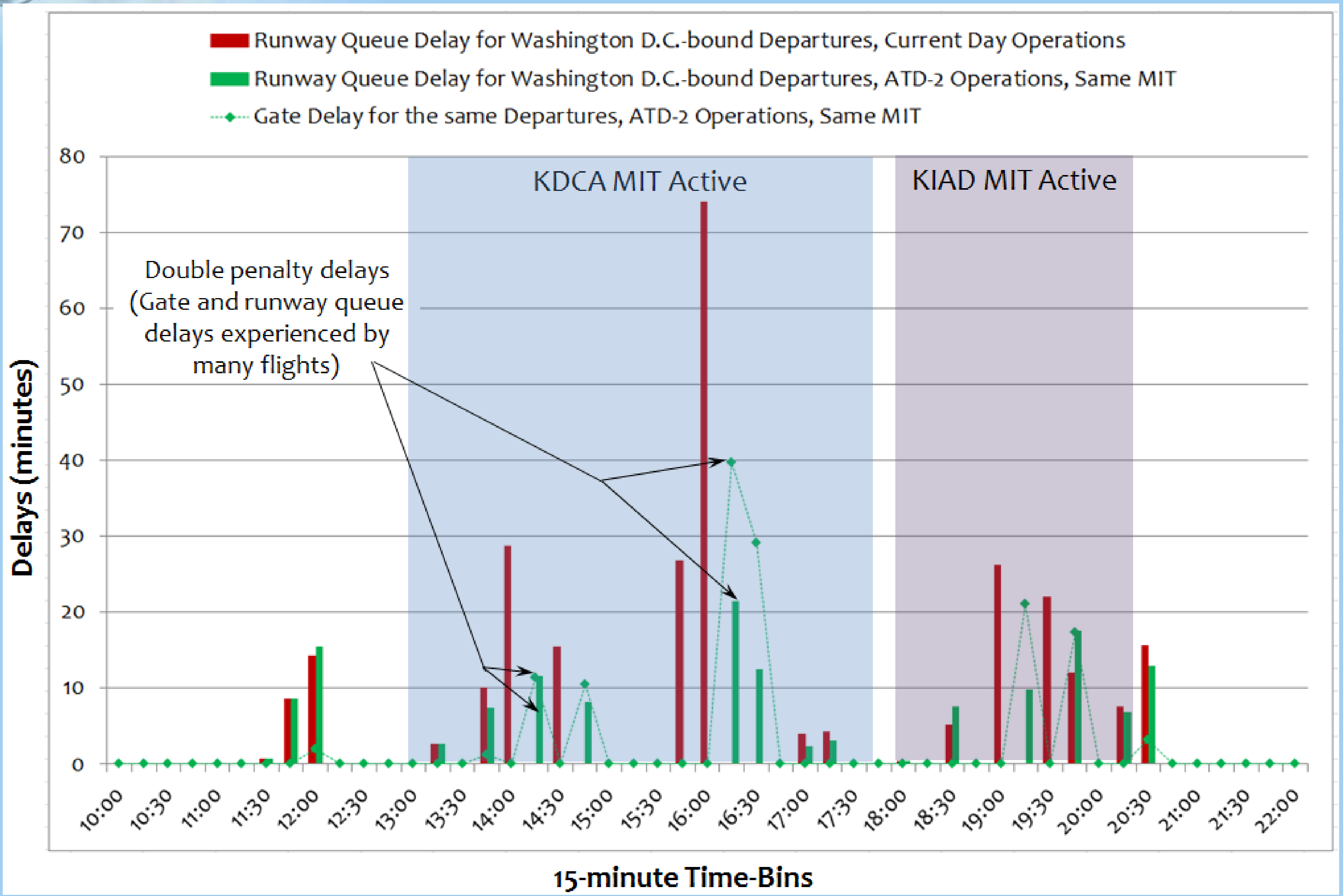
Flight Domain Specific Delay Savings	ATD2 Operations		
	Current-day MITs	Current-day MITs - 5	Current-day MITs - 10
Taxi Out Delay Saving (%)	52	46	40
TRACON Delay Saving (%)	21	8	11
Enroute Delay Saving (%)	44	46	46
Total Delay Saving (%) (Including Gate Delay)	-2	+1	+3

Results: Double Penalty Delays



Results: Is Safety Compromised?

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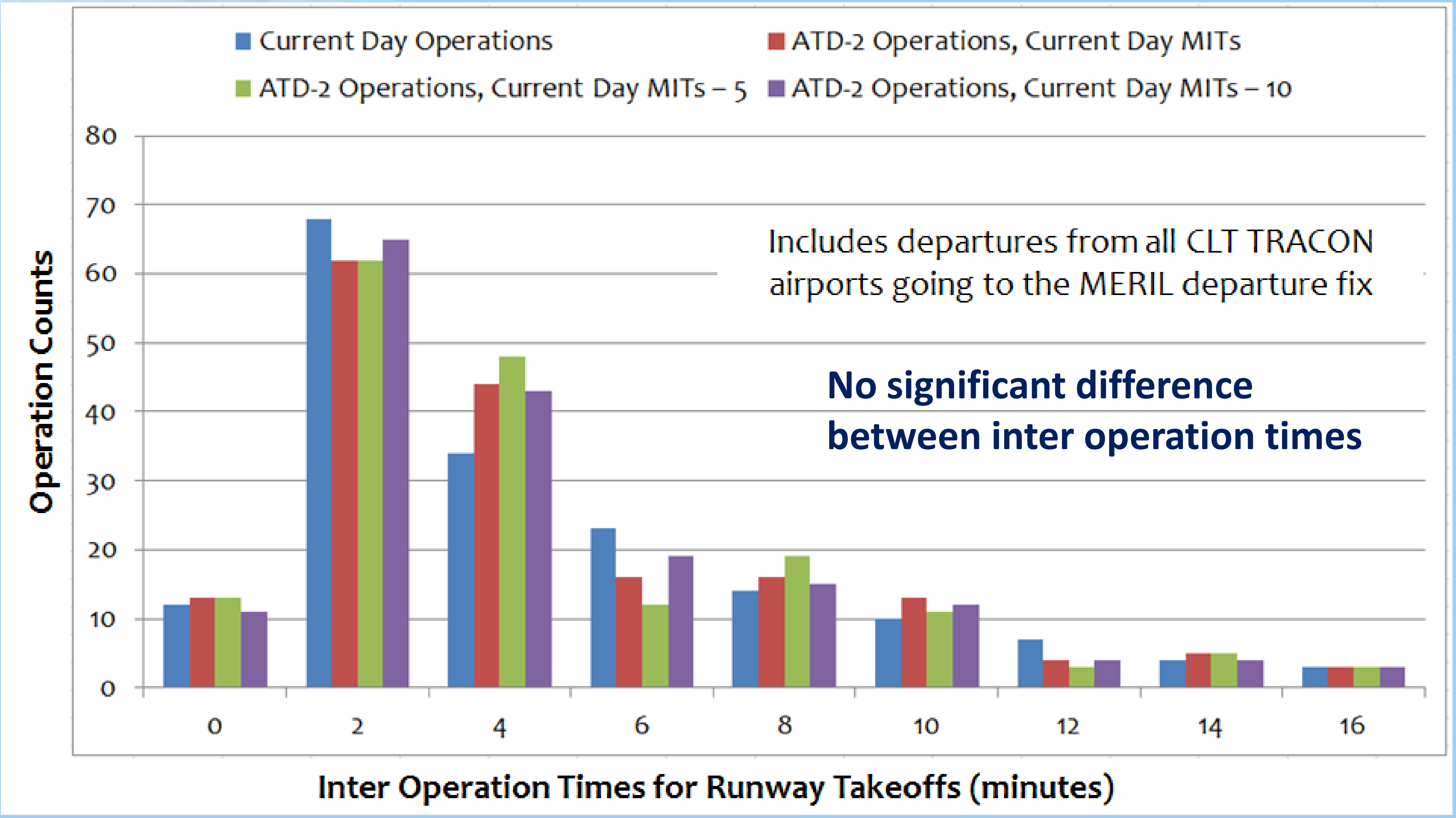

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Conclusions & Future Work

- ATD-2 departure metering with current MIT levels
  - Significant airborne and taxi delay savings over current-day operations
  - Higher total delay (gate + taxi + airborne) due to double penalty delays
- ATD-2 departure metering with MITs relaxed
  - Maintains airborne and taxi delay savings
  - Reduces double penalty delays to provide total delay savings
  - Safety of TRACON departure merging operations uncompromised
- Future Work
  - Validate the enroute merge geometry and departure restrictions modeling approach
  - Conduct simulations over wider set of historical days
  - Leverage NASA's high-fidelity surface simulation platform (SOSS)
  - Enhance ATD-2 scheduling algorithm emulation

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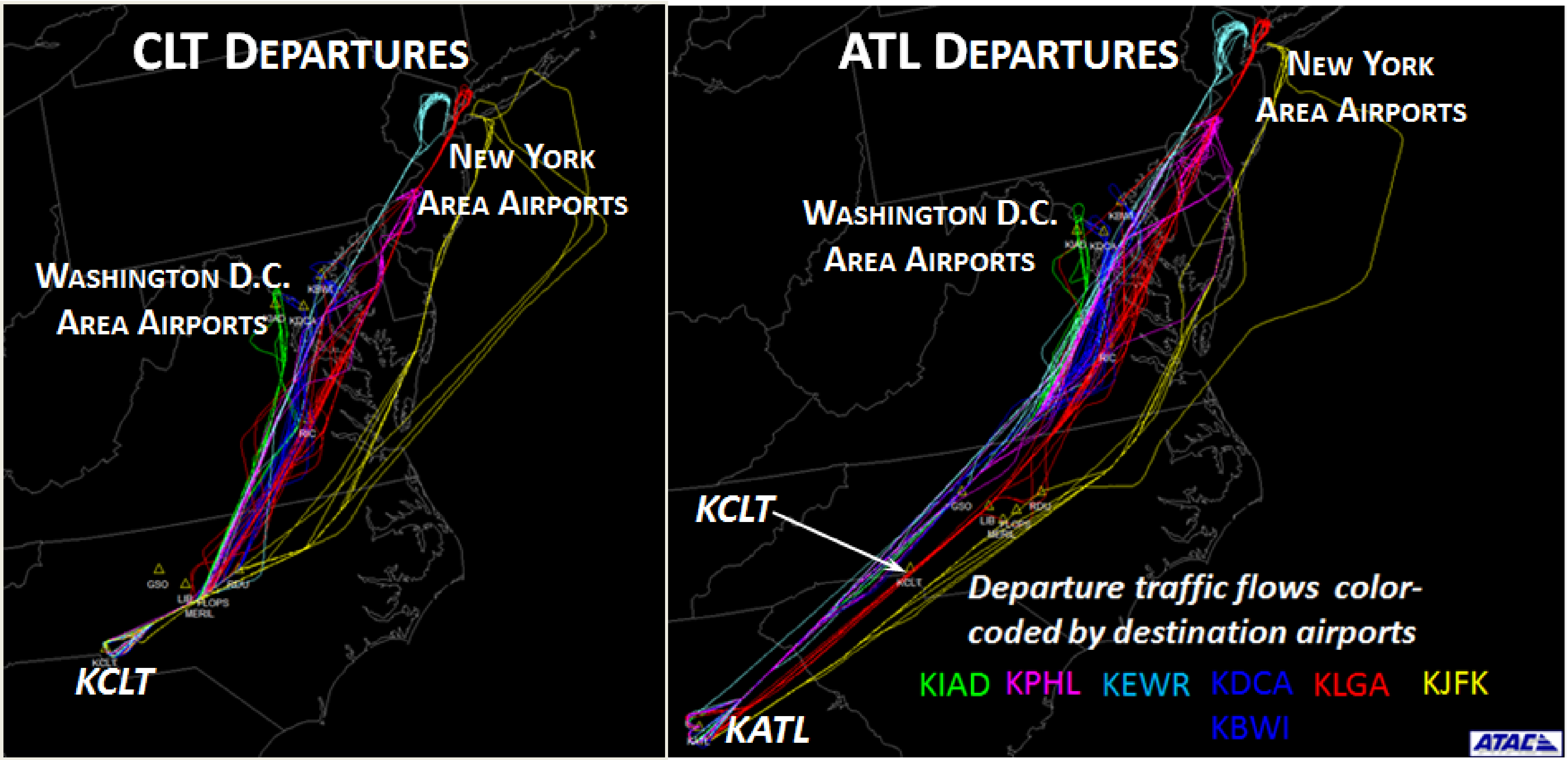
Questions

Backup Slides

Realistic Models of Major Departure Flows



Departure flows going to New York airports are separated from departure flows going to Washington D.C. area airports