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Using an Automated Air Traffic Simulation Capability for a Parametric Study in Traffic Flow Management

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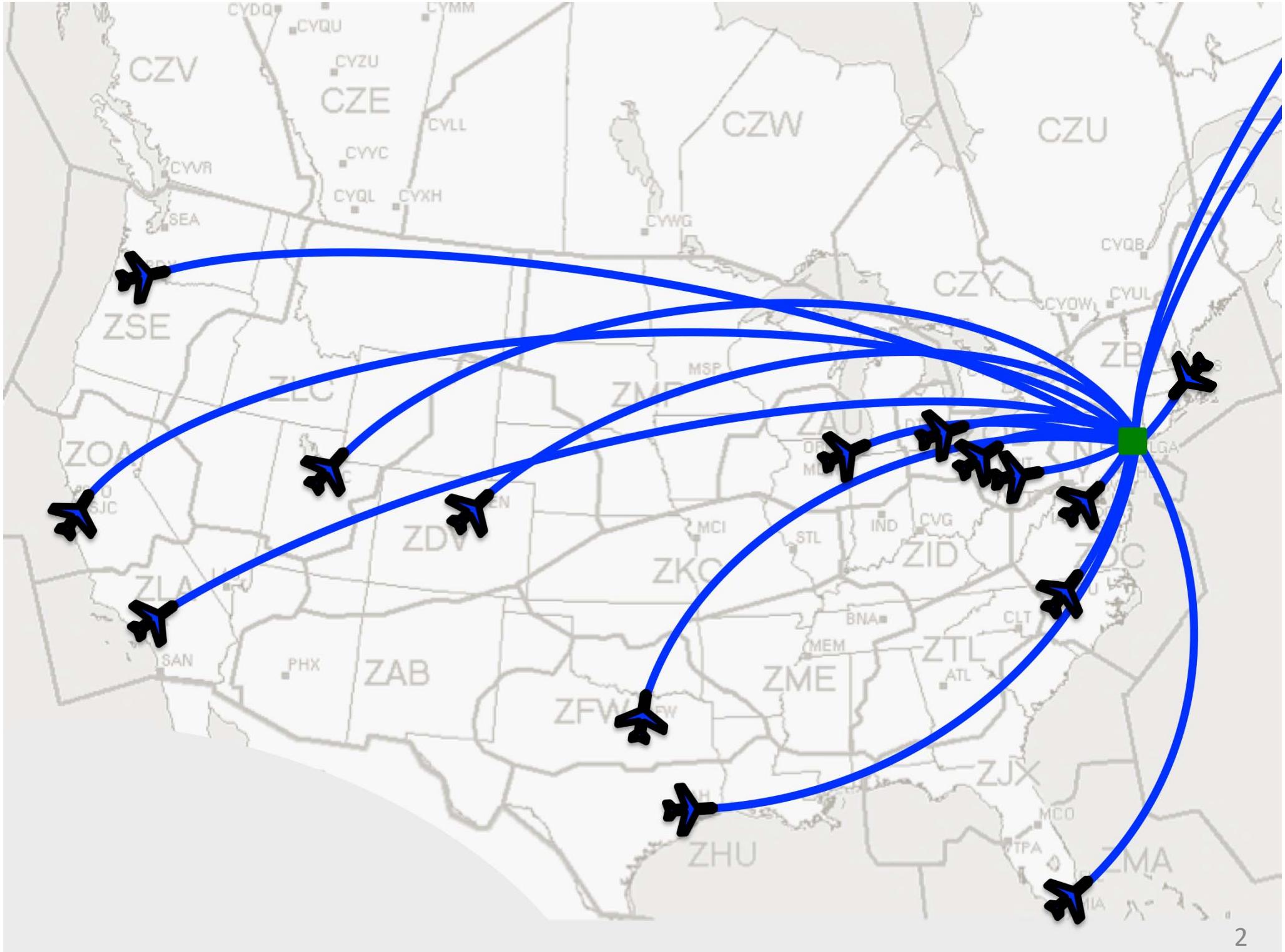
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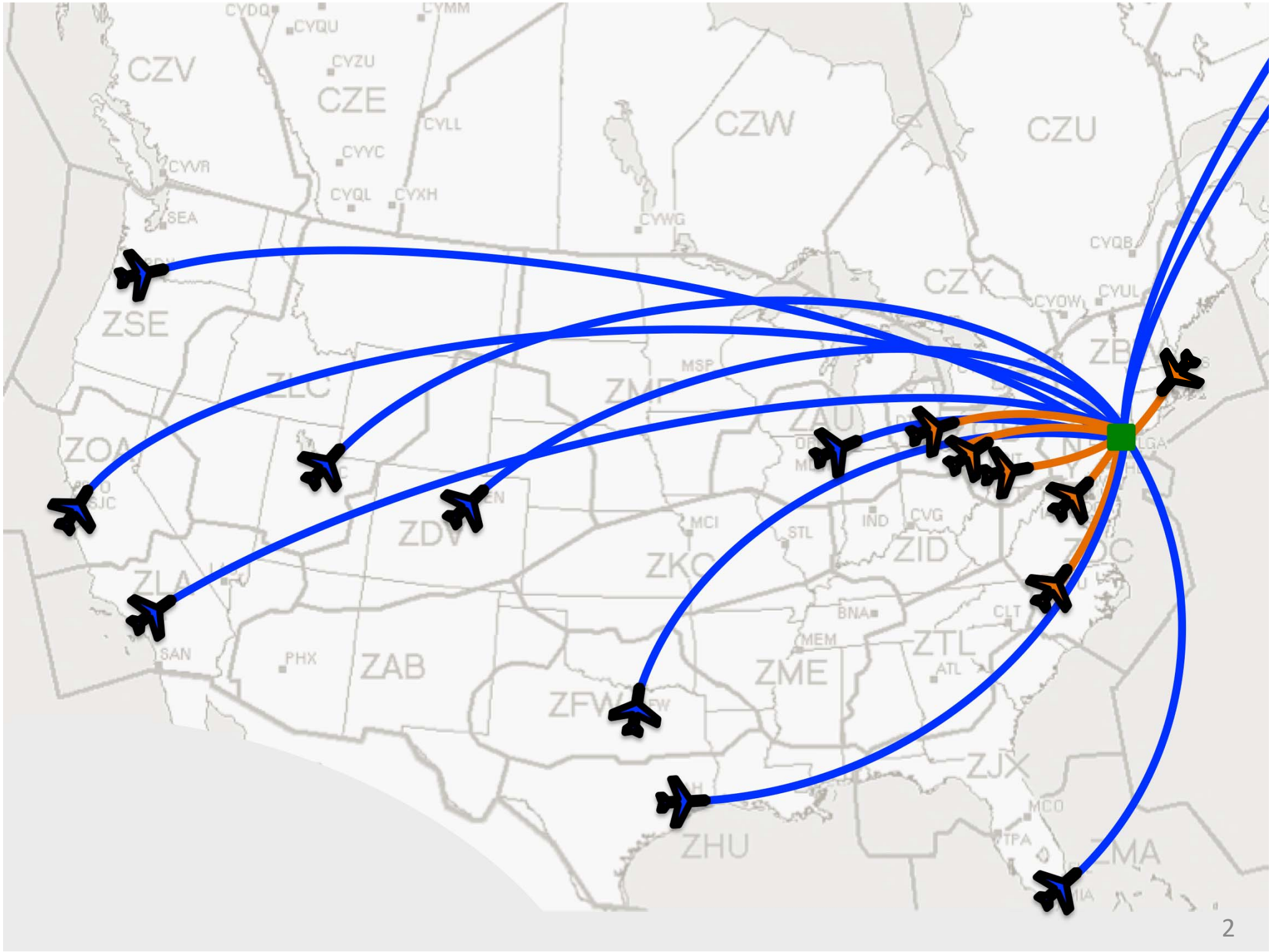
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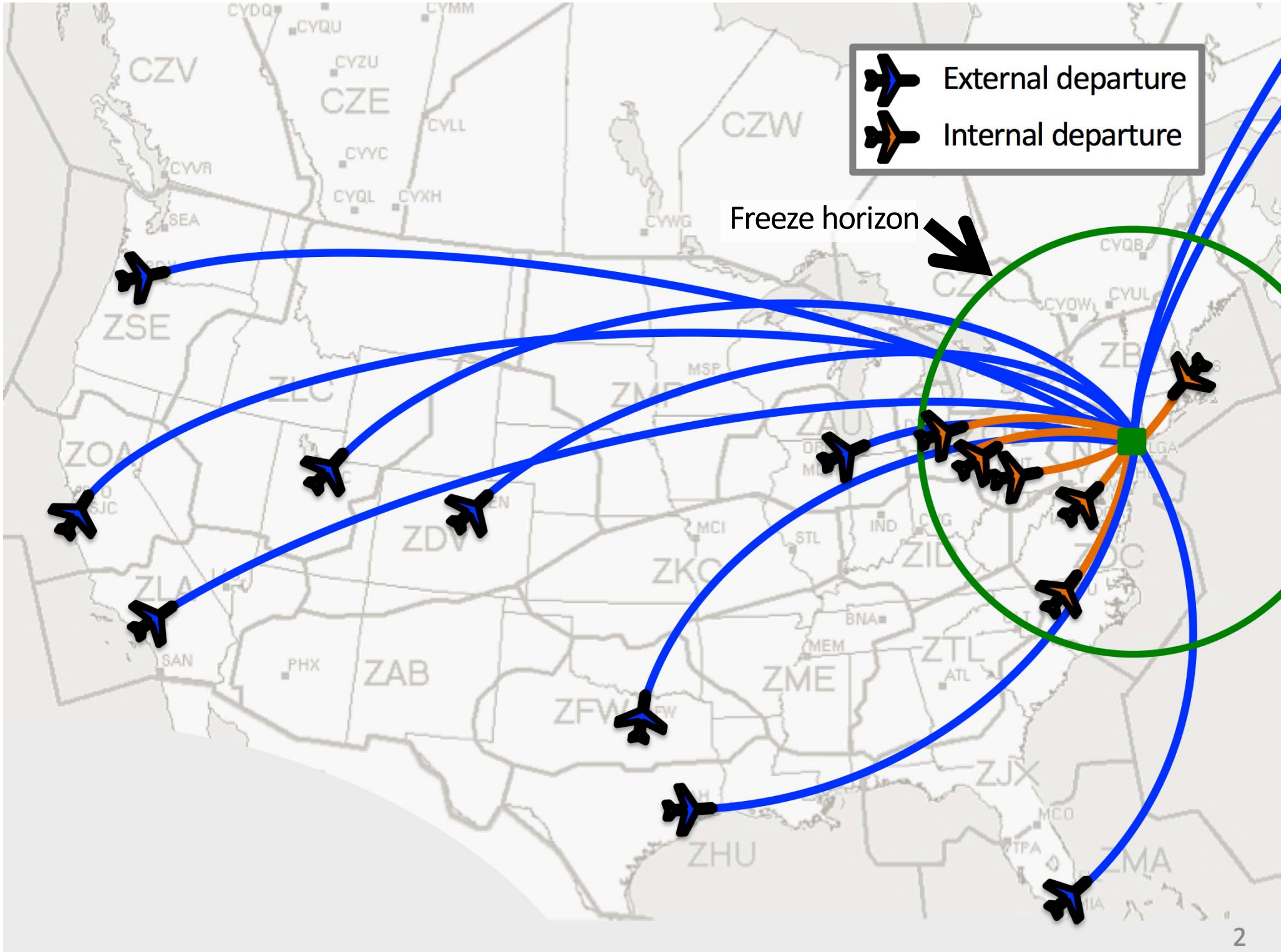
External departure
Internal departure
Freeze horizon
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Motivation

Strategic planner: e.g. Ground Delay Program (GDP)

- Pre-departure ground delay
- Adjust demand to roughly meet arrival rate constraint

Tactical planner: Time-Based Flow Management (TBFM)

- Airborne delay near arrival airport
- Pre-departure ground delay for internal departures
- Deliver demand to actual arrival rate constraint

Motivation

Interaction between strategic and tactical planners

- High demand → tactical delay to meet arrival rate
- Low demand → underutilized airport

Trade-off between airborne and ground delay

- Some amount of delay can be absorbed in the air
- As airborne delay becomes impractical, internal departures delayed on ground
- "Practical delay" is situationally dependent
  - Distance from freeze horizon to airport
  - Number of flights given airborne delay

Objective

Identify trends in airborne delay due to

- Variance in departure time conformance
- Bias towards late departures

Outline

- Overview of tactical planner
- Experiment setup
- Tactical airborne delay results
  - Departure error variance
  - Departure error bias
- Summary
- Future work

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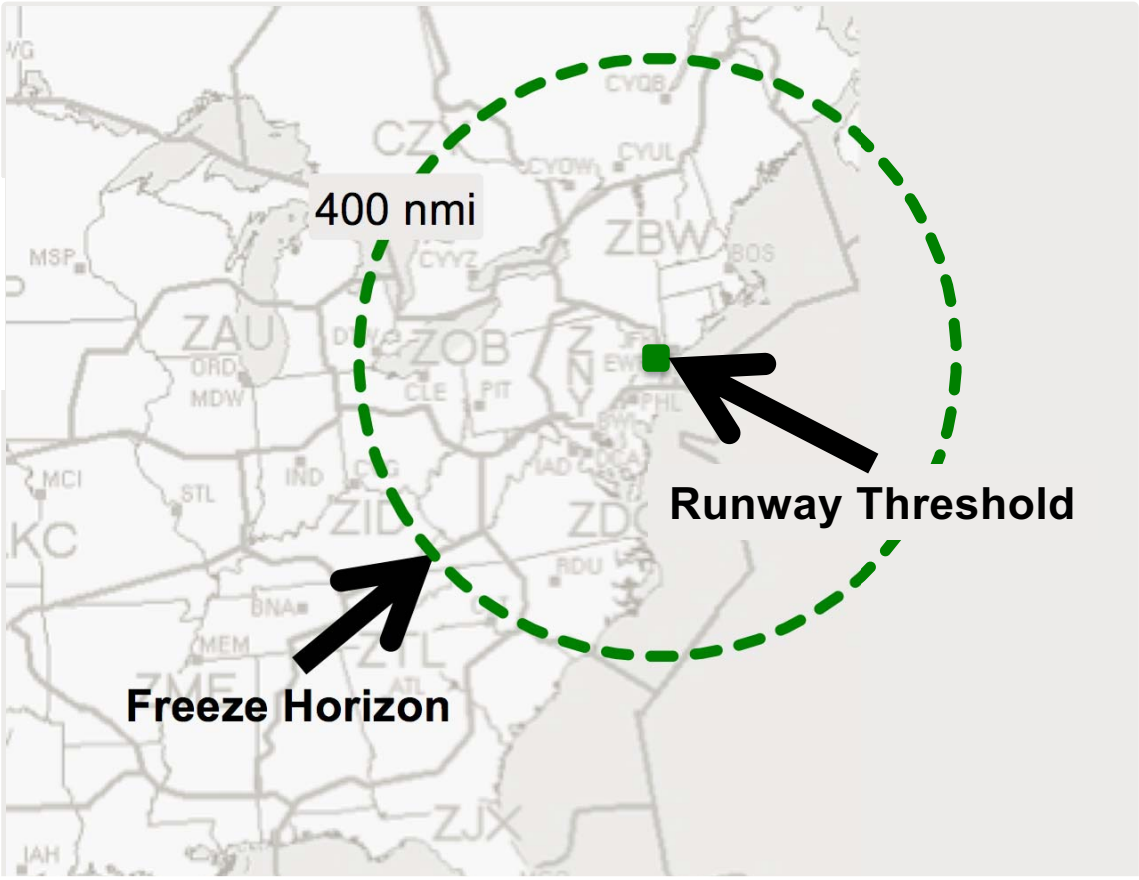
Overview of tactical planner

Tactical scheduling paradigms:

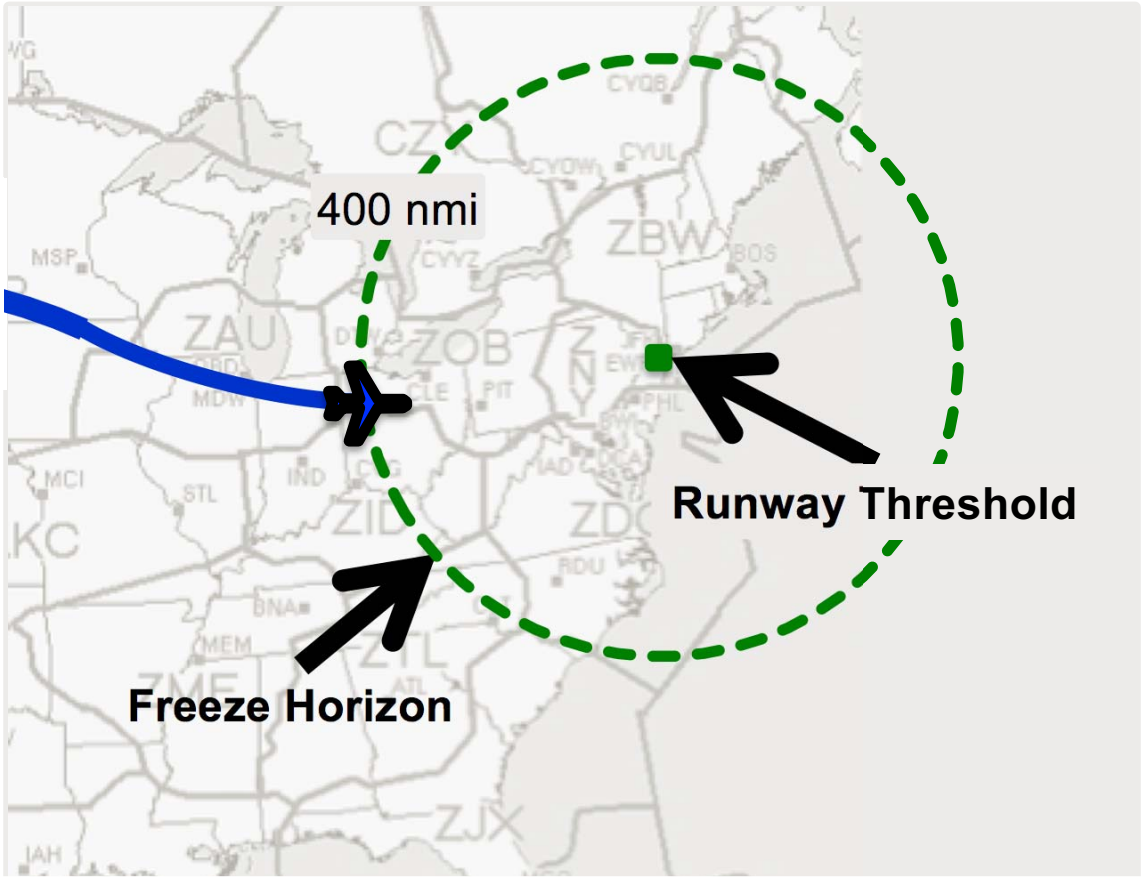
- Priority given to internal departures
- Priority given to airborne flights

Tactical planning



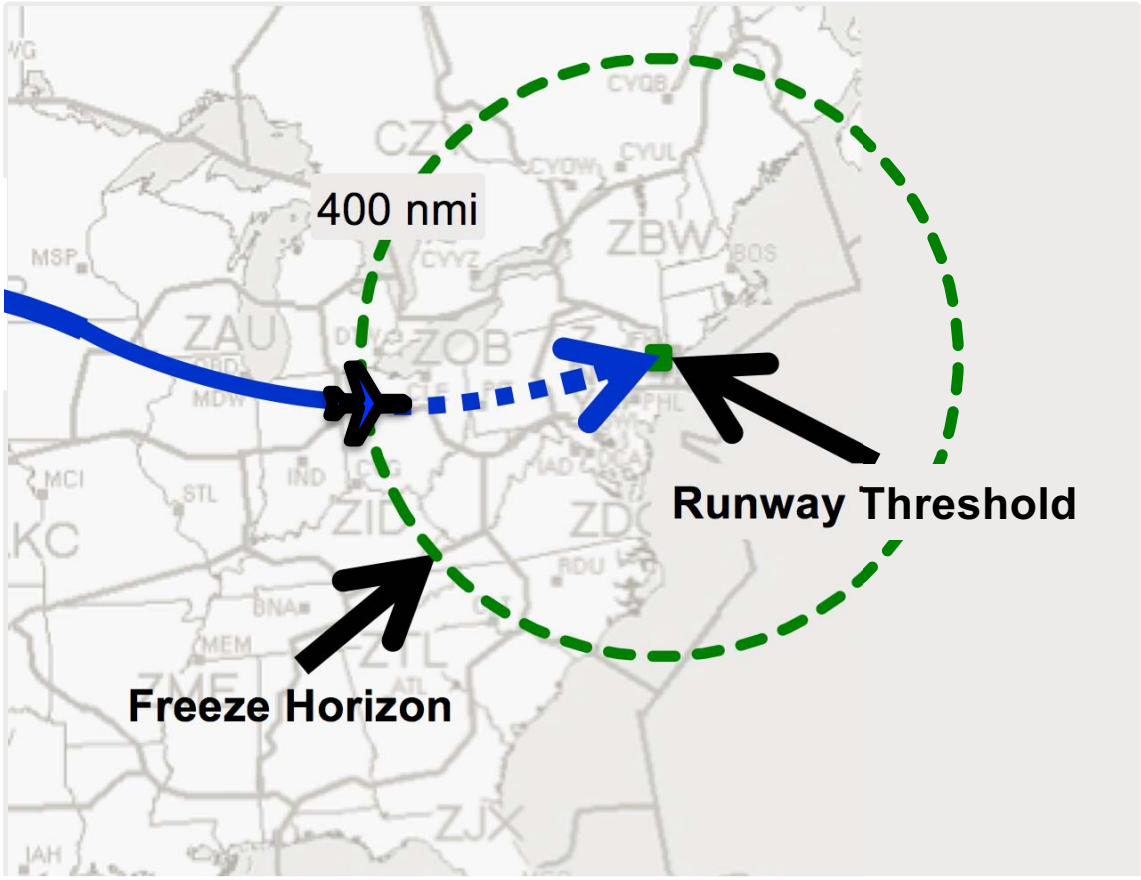
Tactical planning

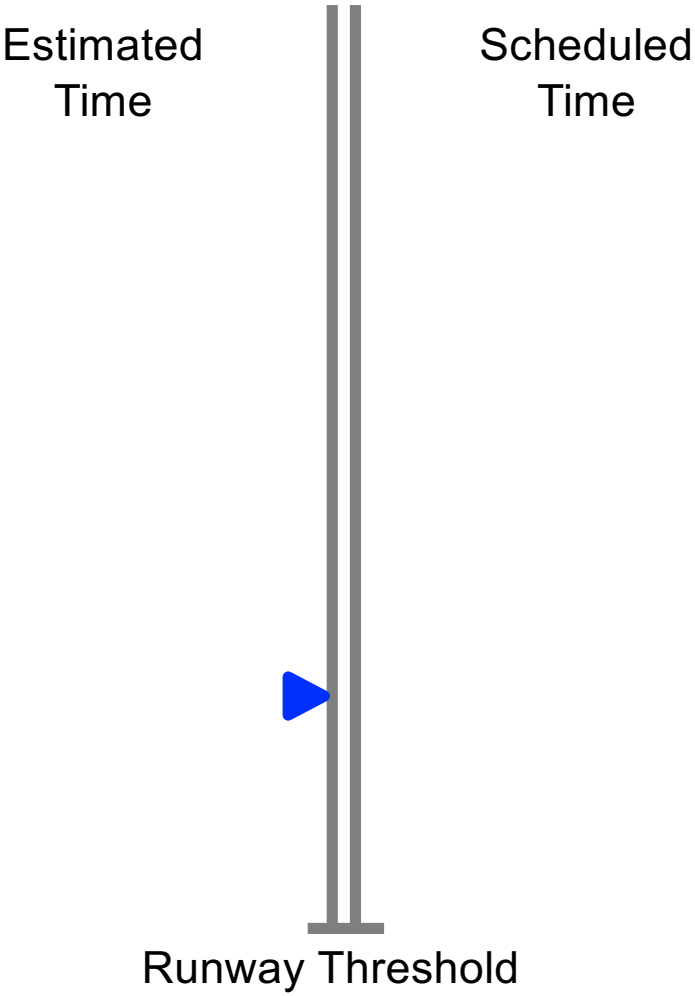
External departure arrives at freeze horizon



Tactical planning

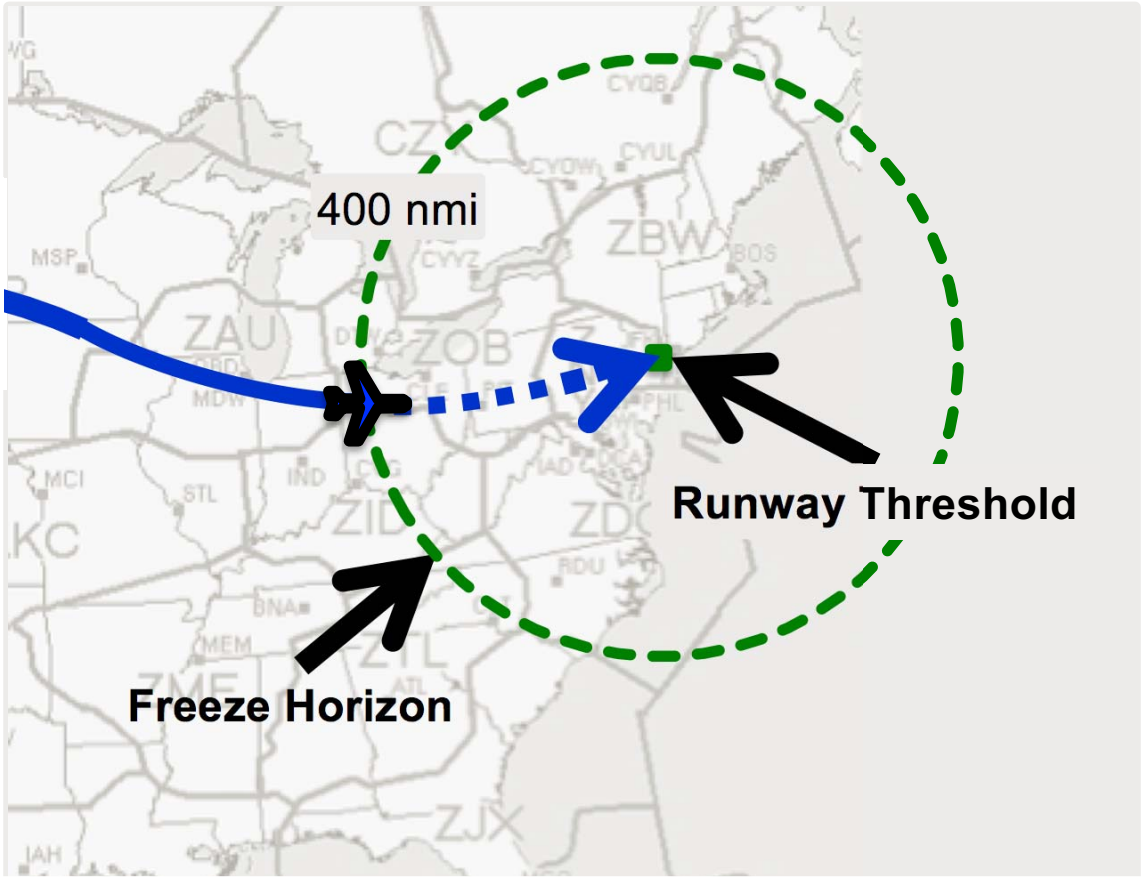
Find estimated time of arrival at runway threshold

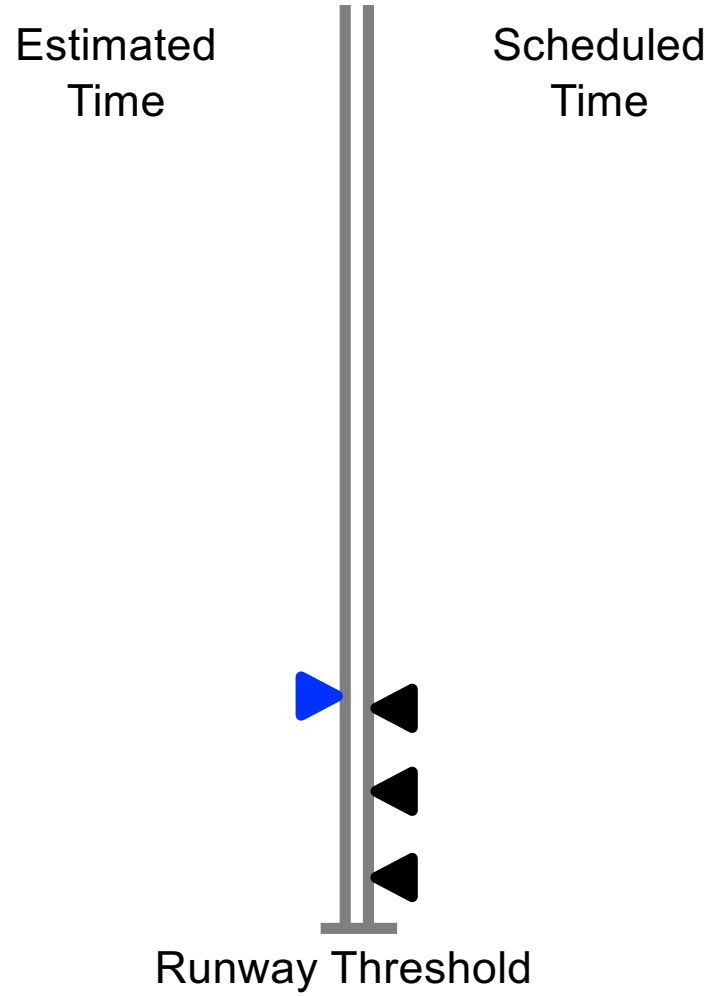




Tactical planning

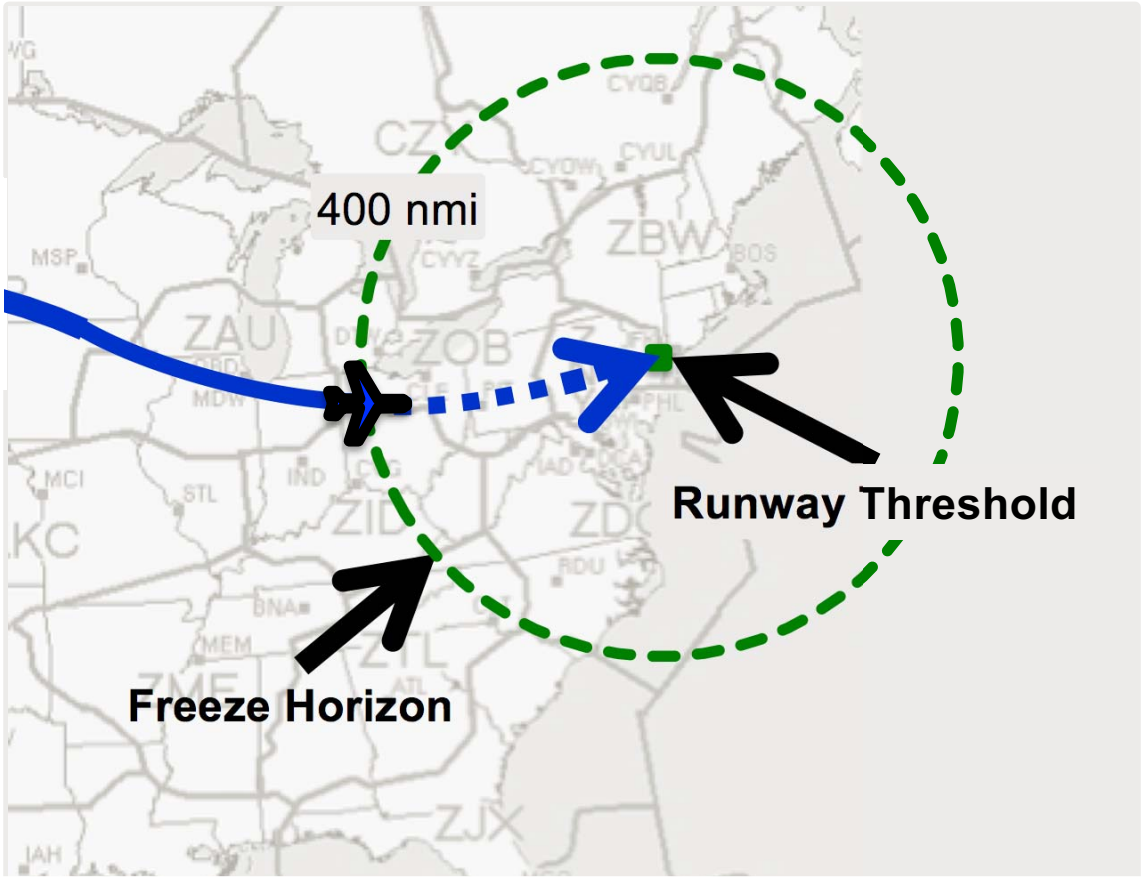
Compare to scheduled arrivals

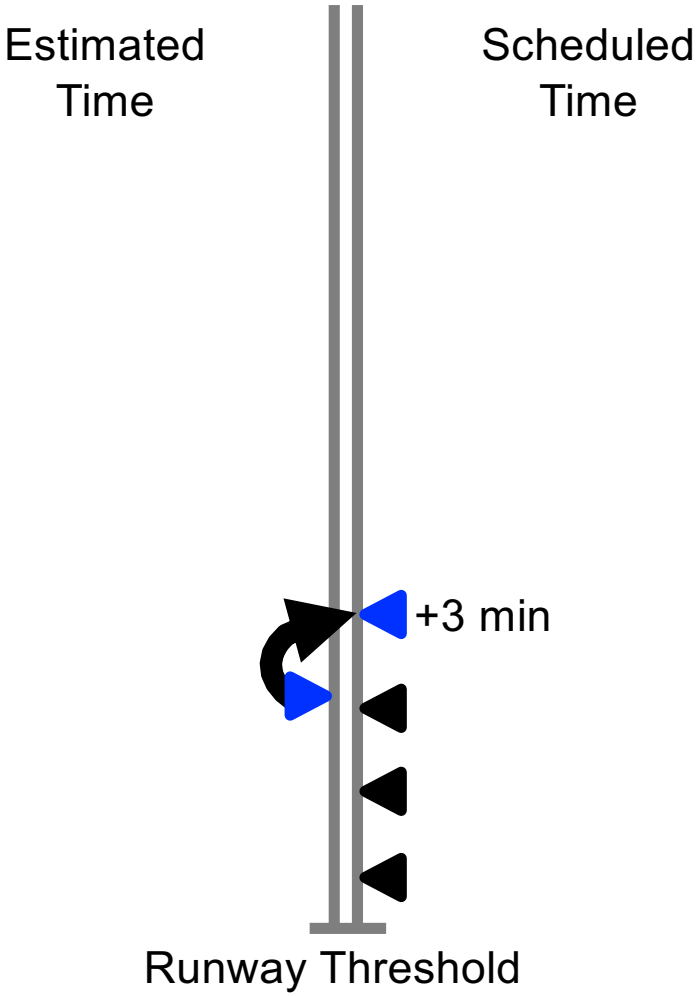




Tactical planning

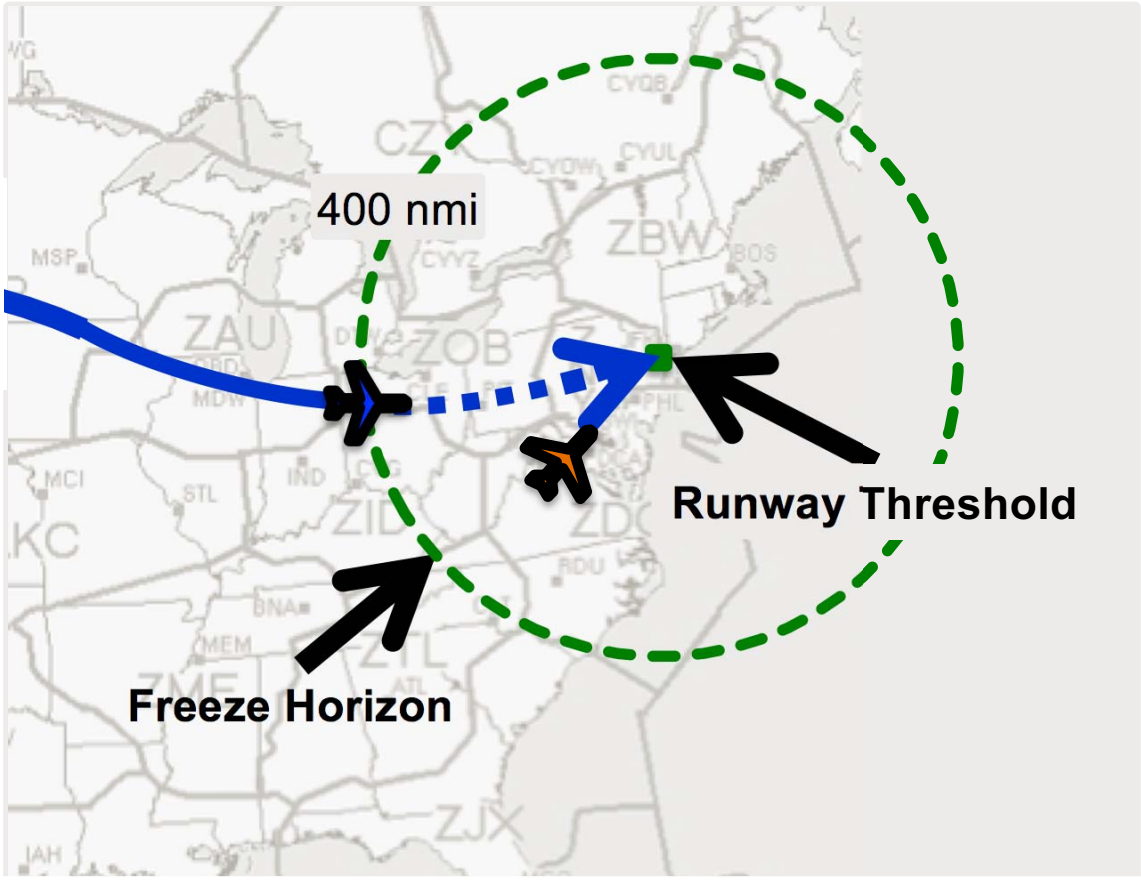
Airborne delay to get proper spacing

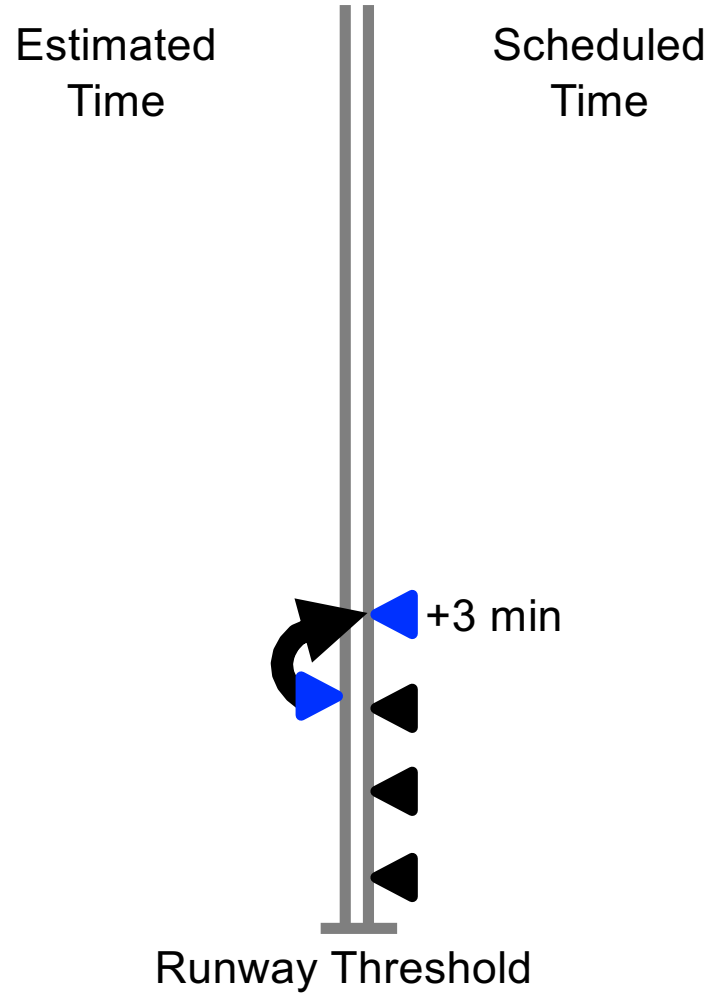




Tactical planning

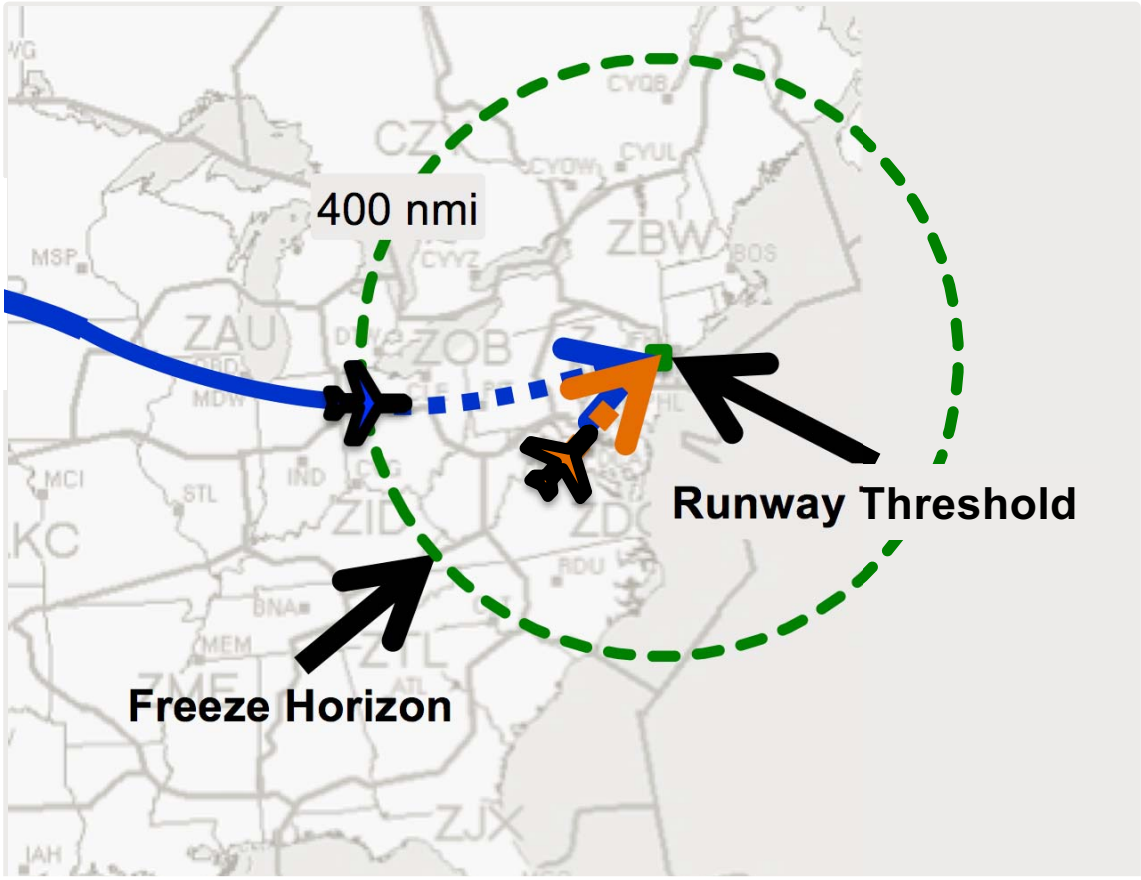
20 minutes prior to departure of internal departure

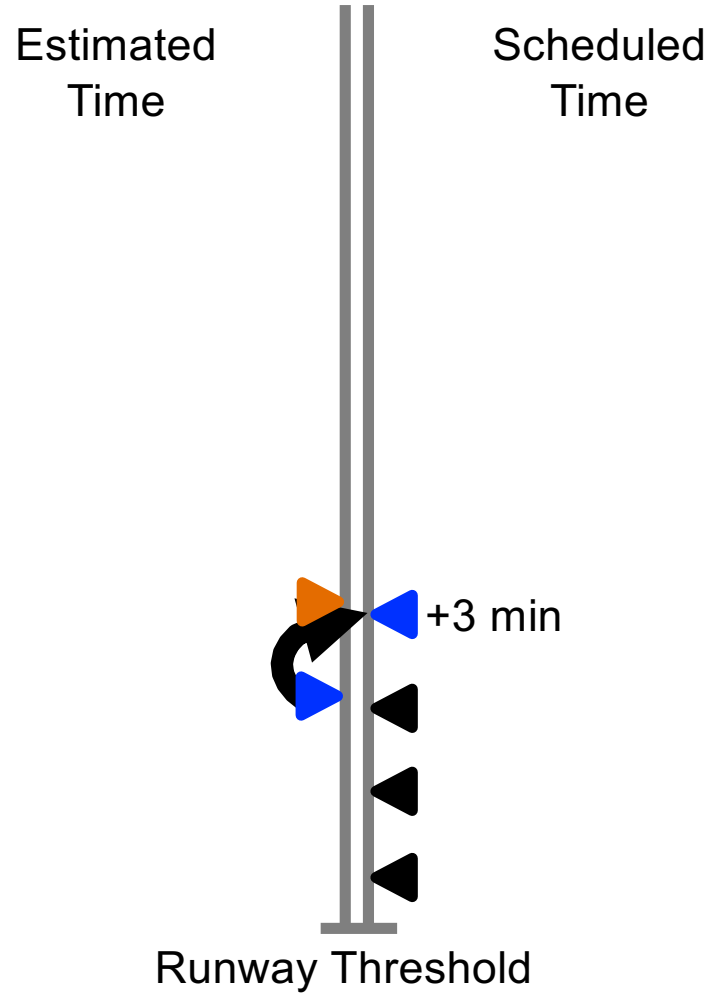




Tactical planning

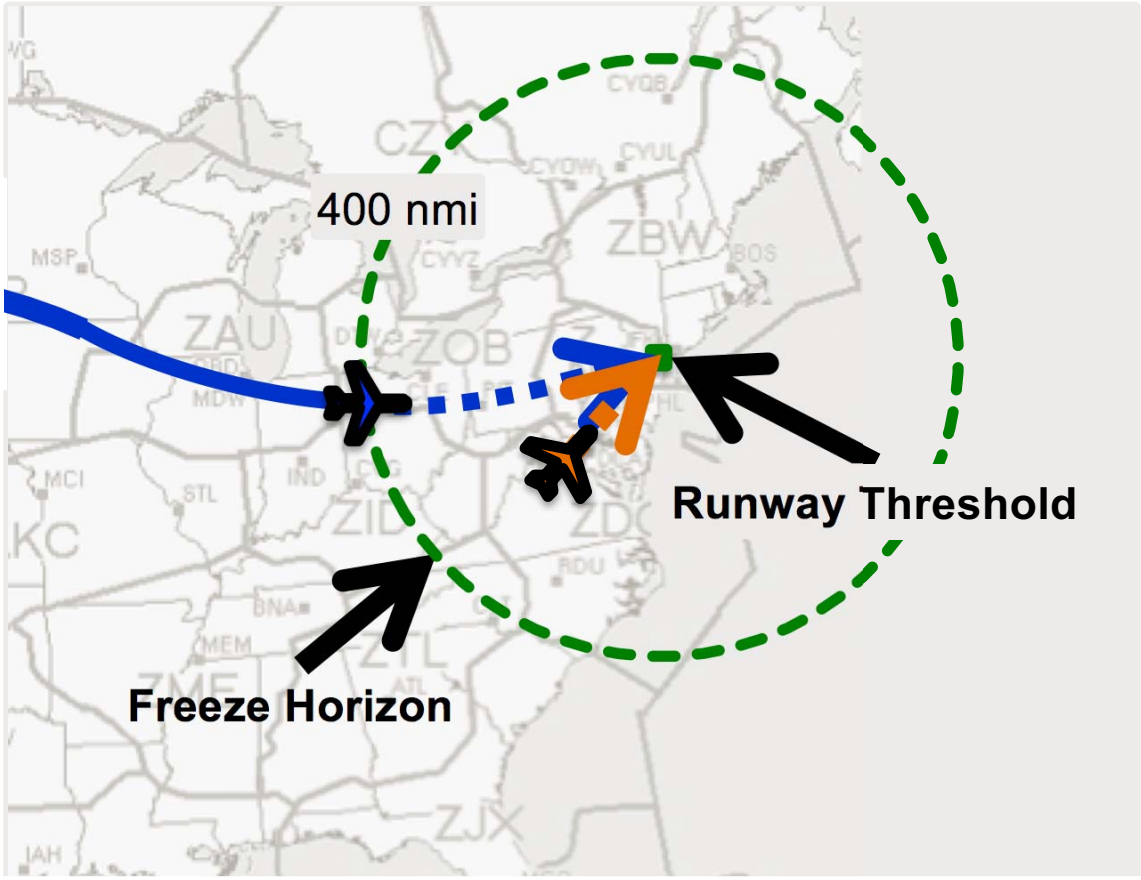
Find estimated time of arrival at runway threshold

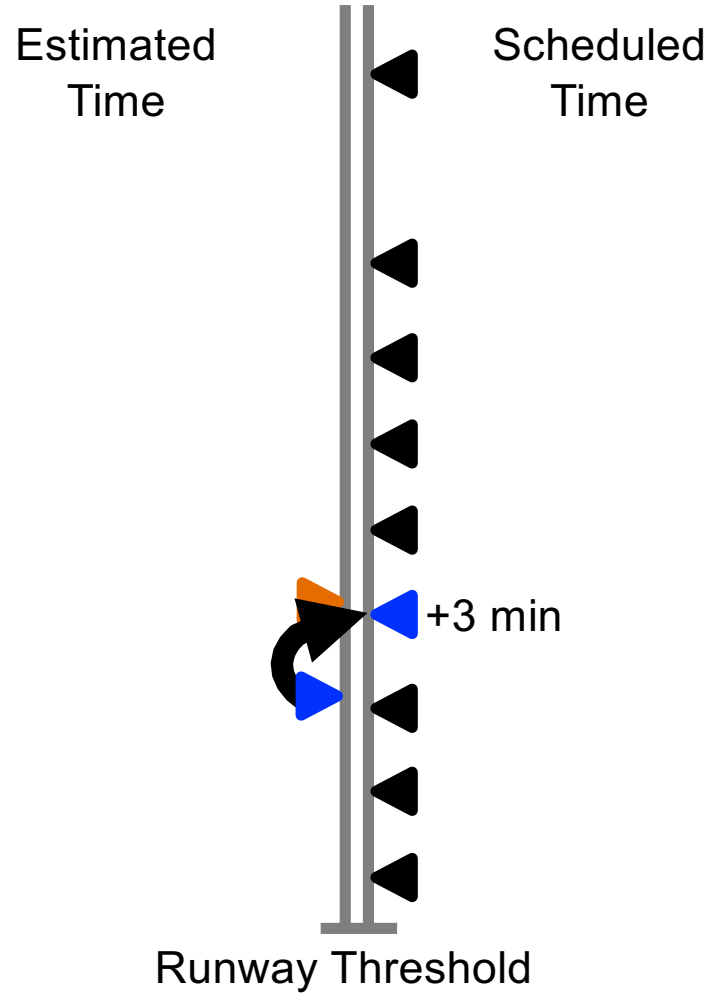




Tactical planning

Compare to scheduled arrivals





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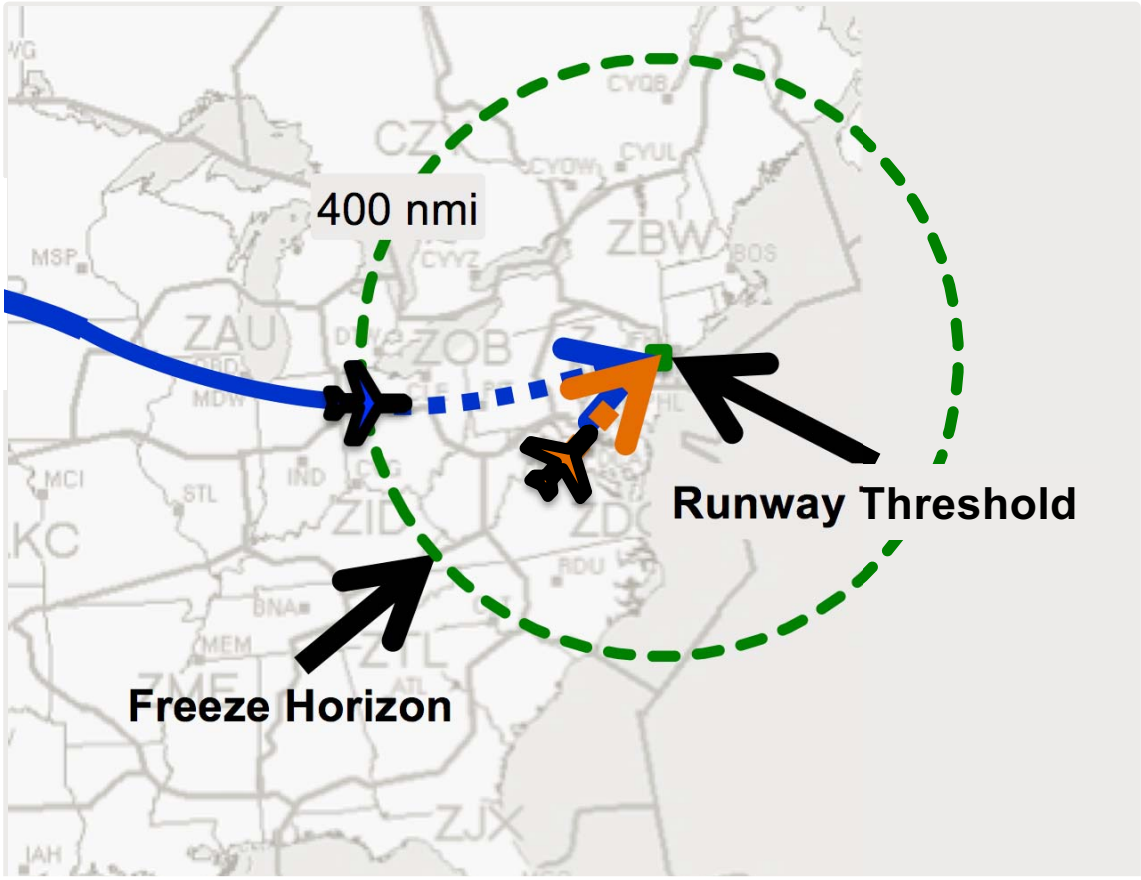
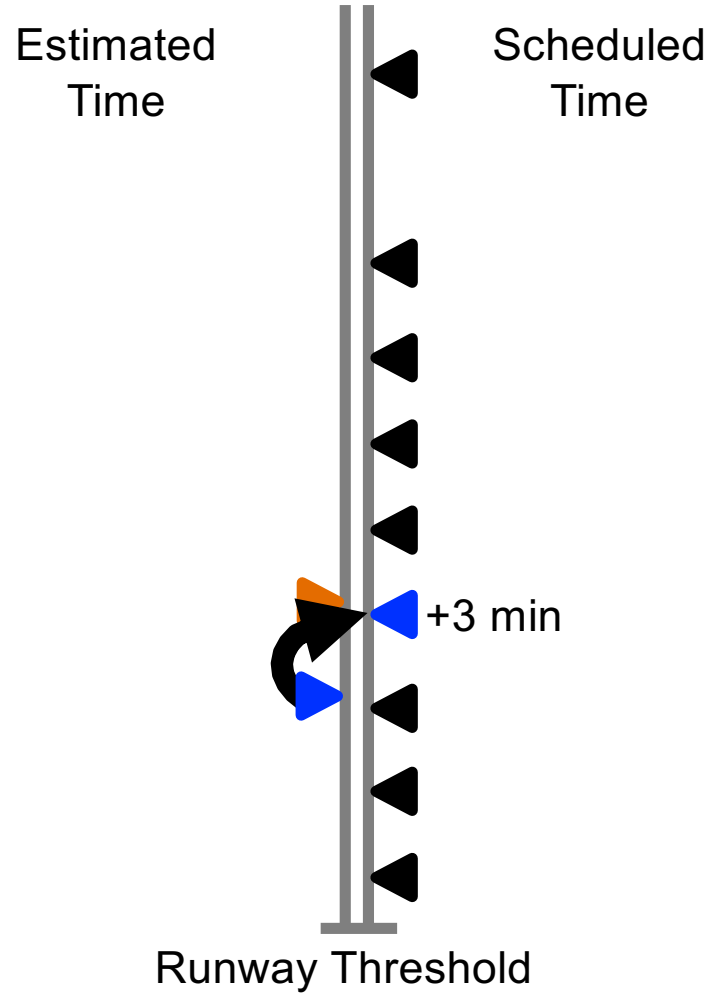
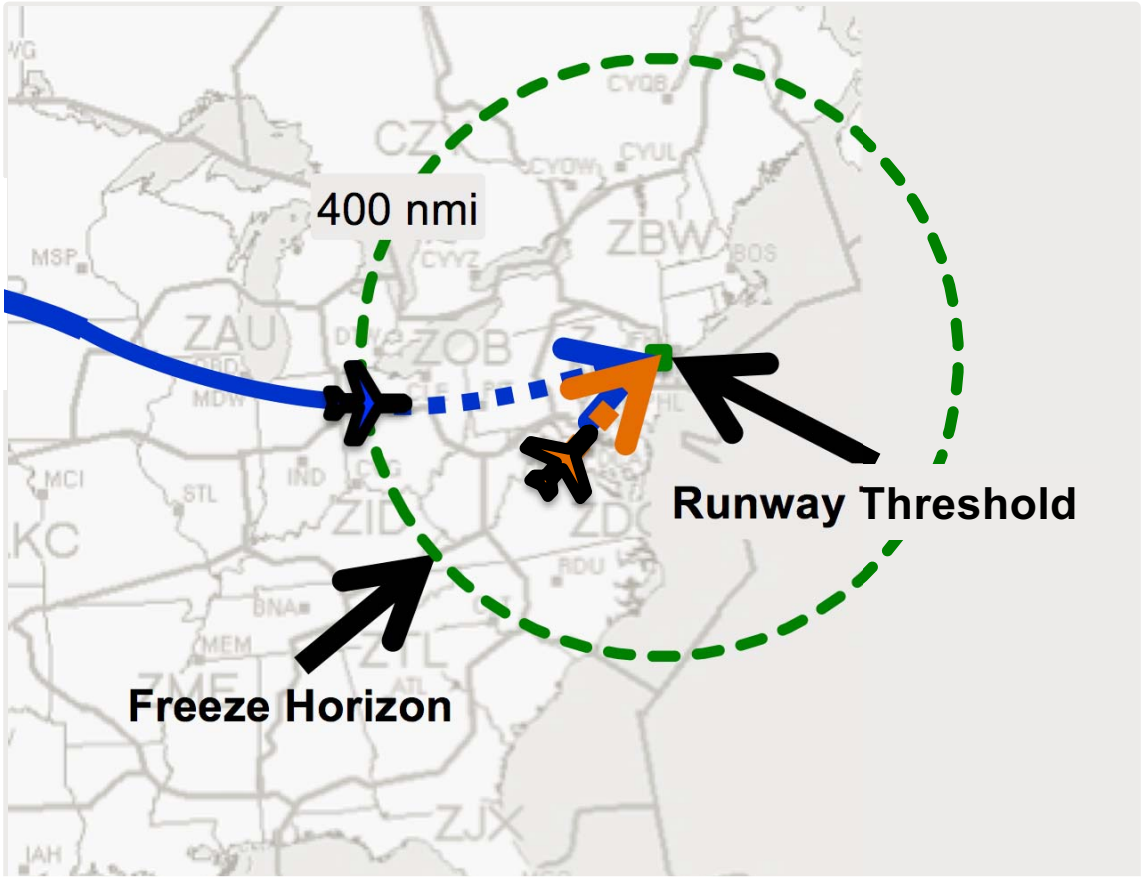


Priority to internal departures

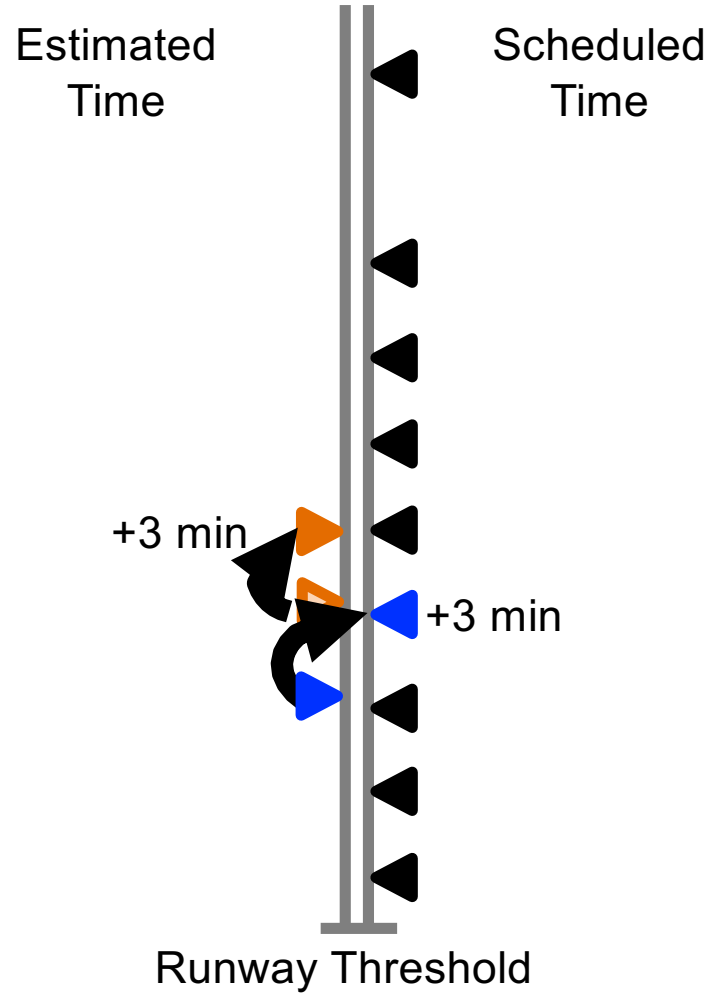


Tactical planning

Delay internal for proper spacing

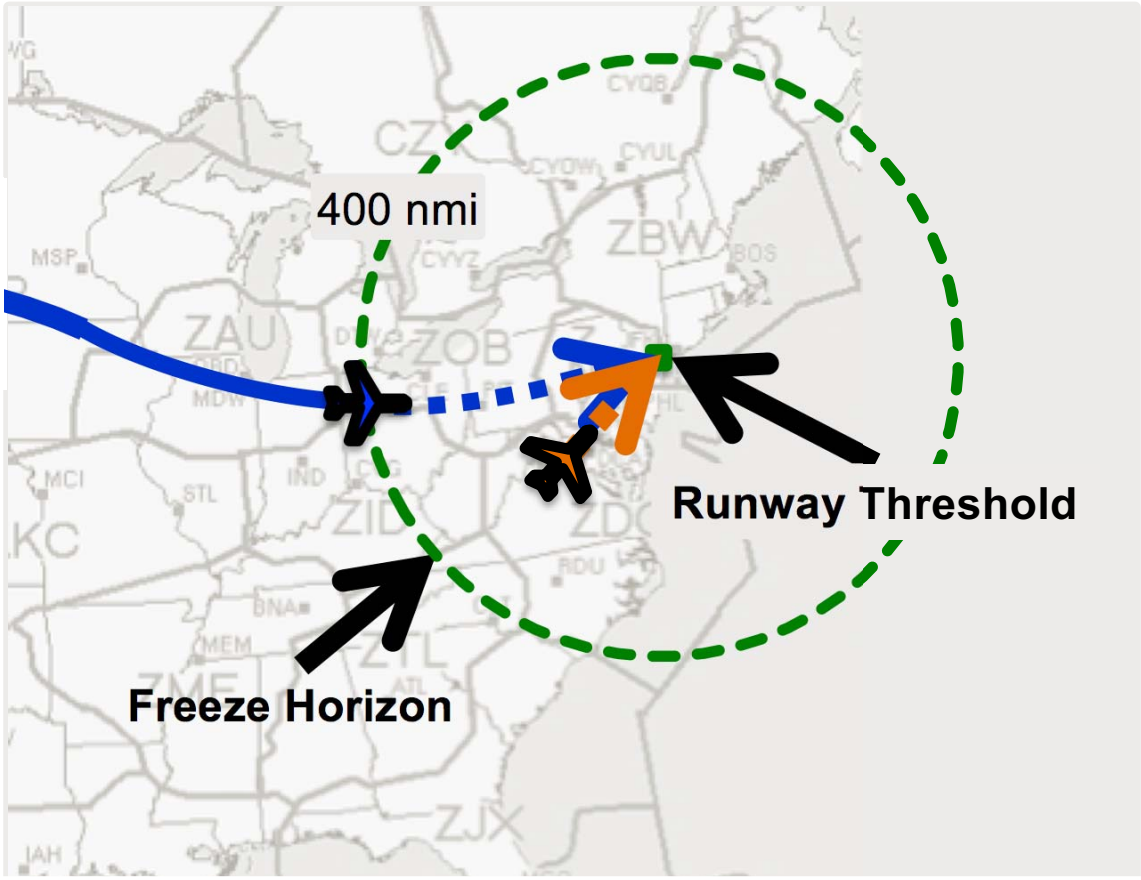


Priority to internal departures

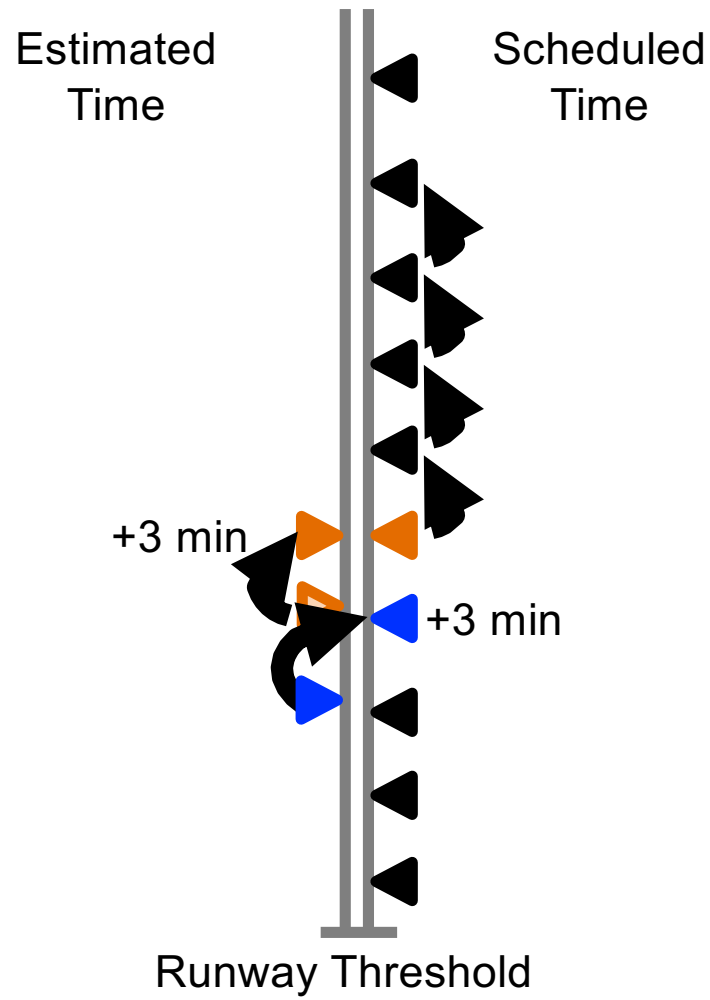


Tactical planning

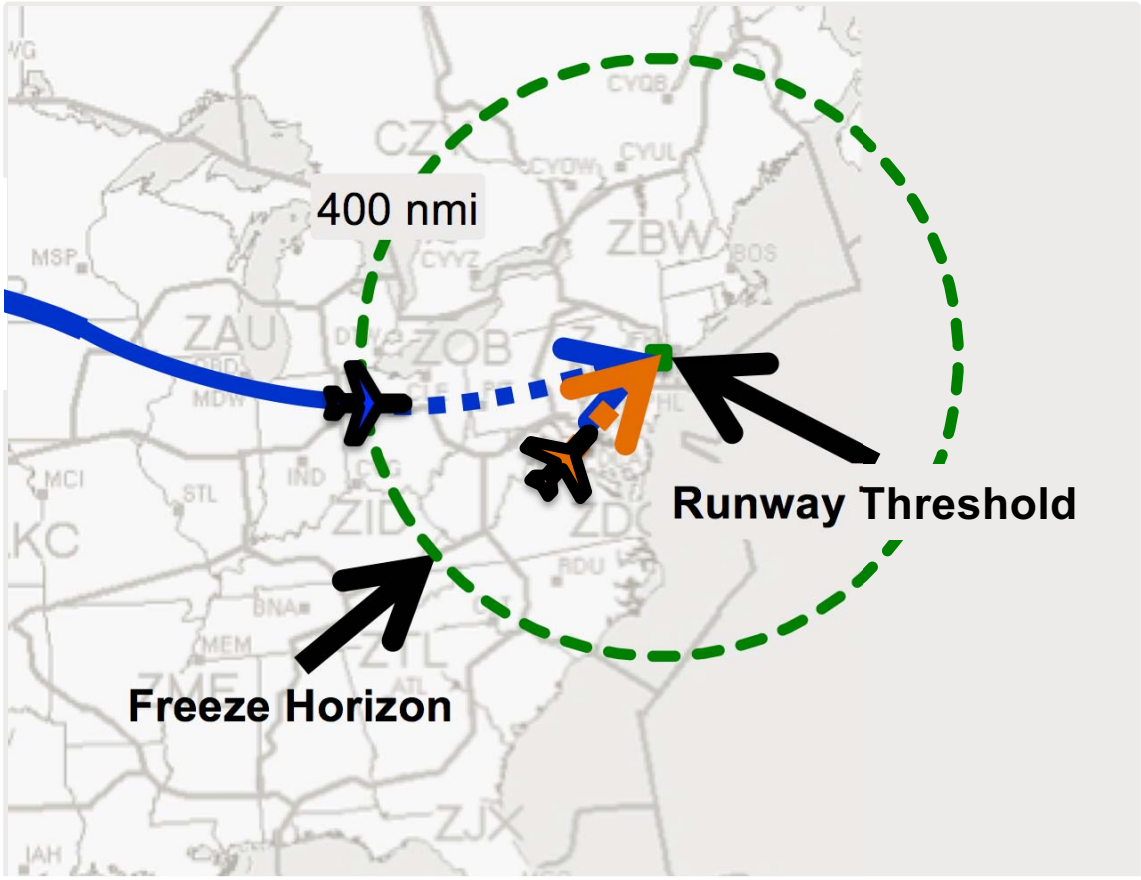
Delay airborne for proper spacing after internal



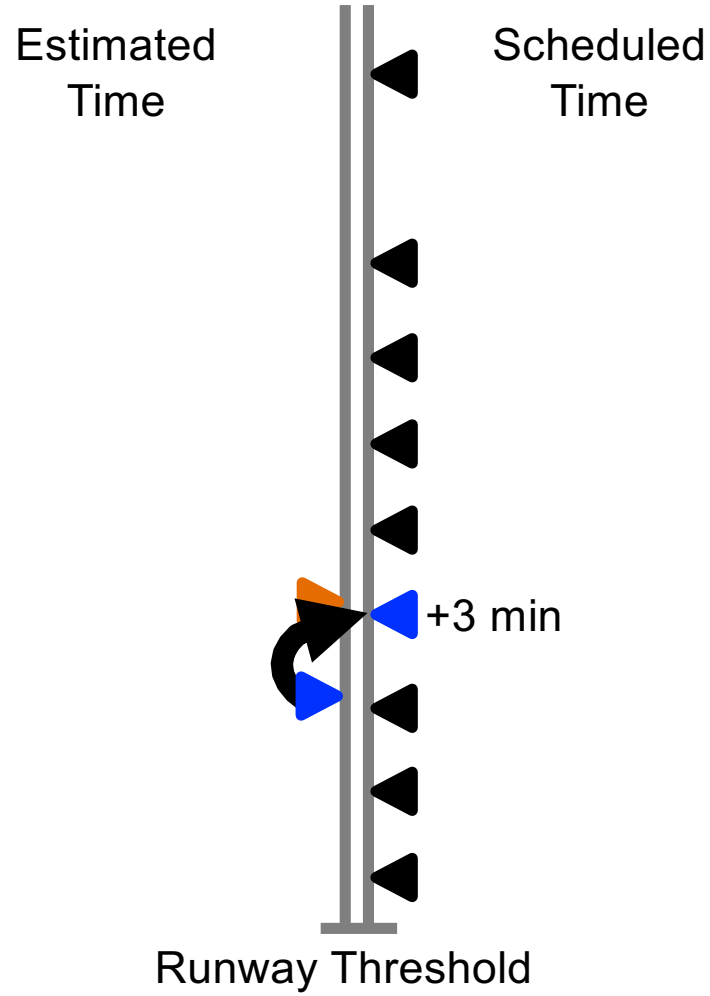
Priority to internal departures



Tactical planning

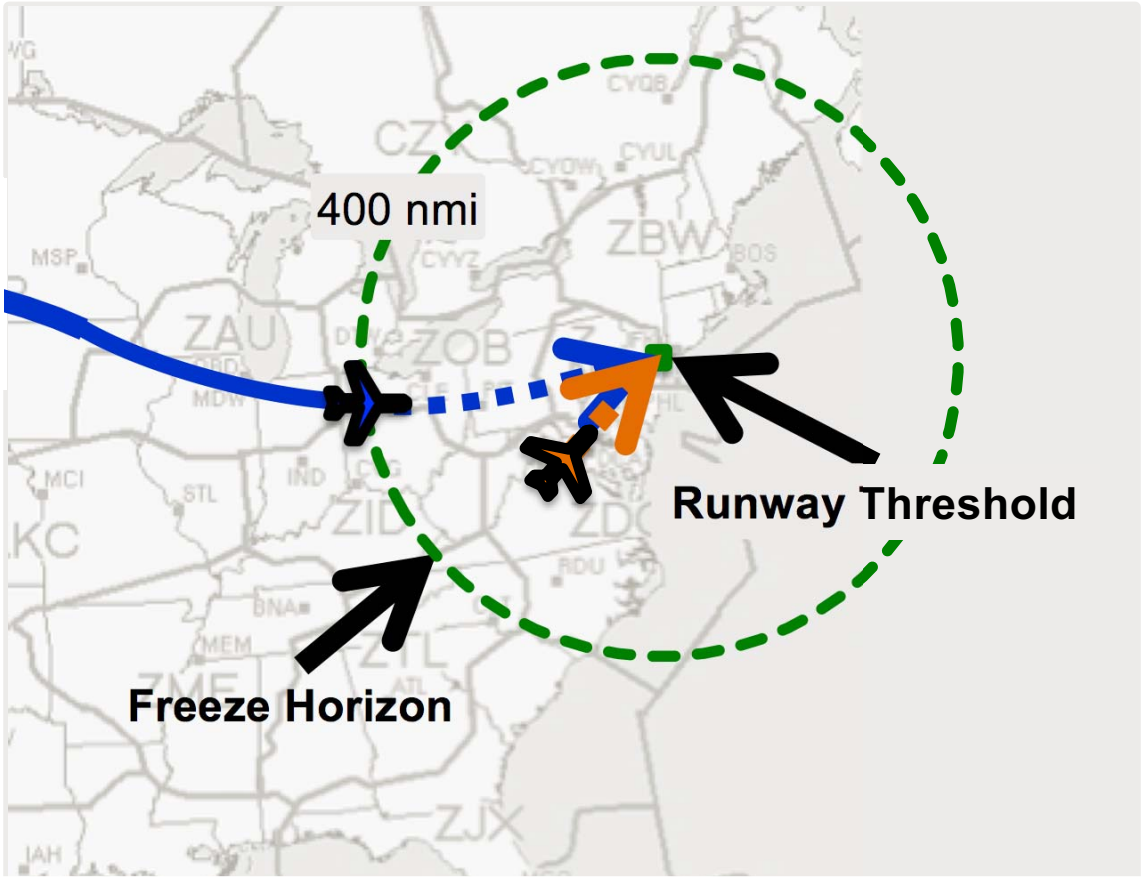


Priority to airborne flights

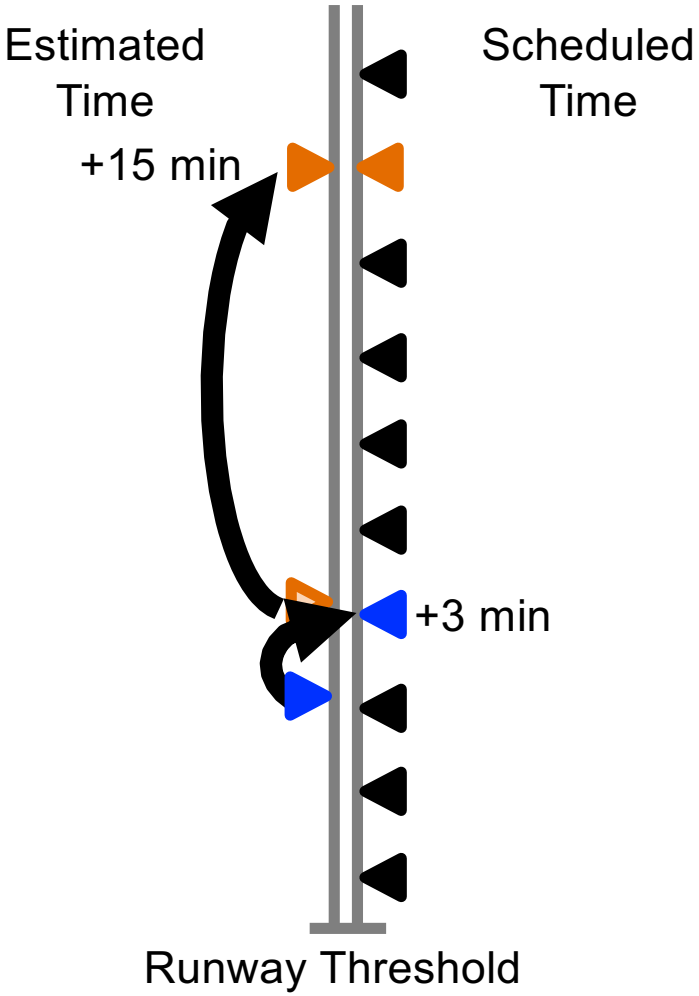


Tactical planning

Delay internal until gap in scheduled arrivals

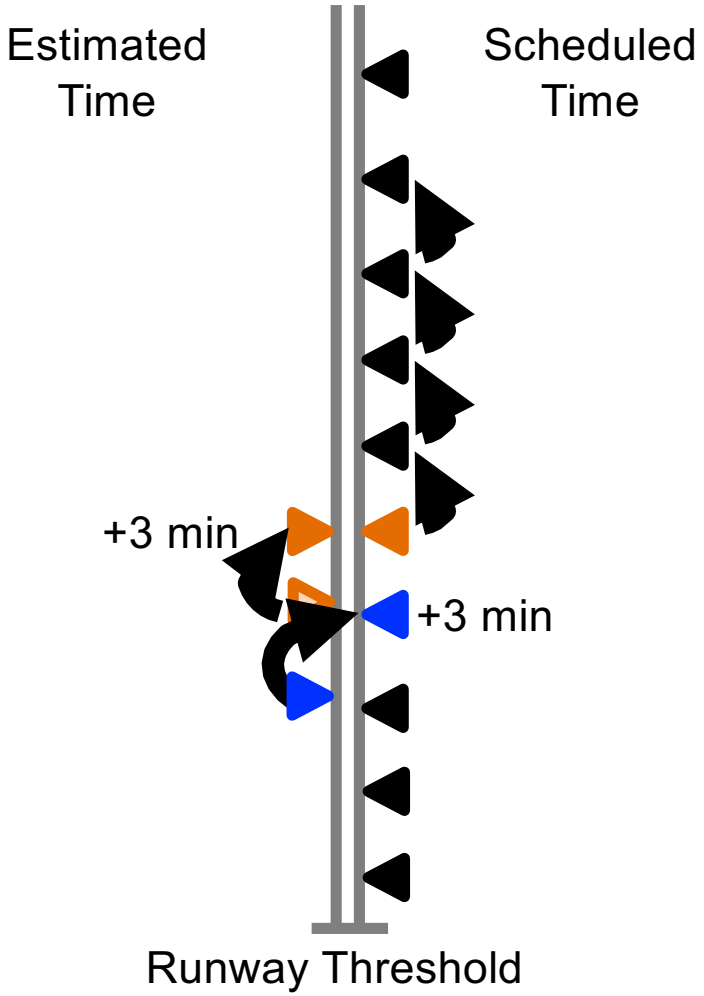


Priority to airborne flights

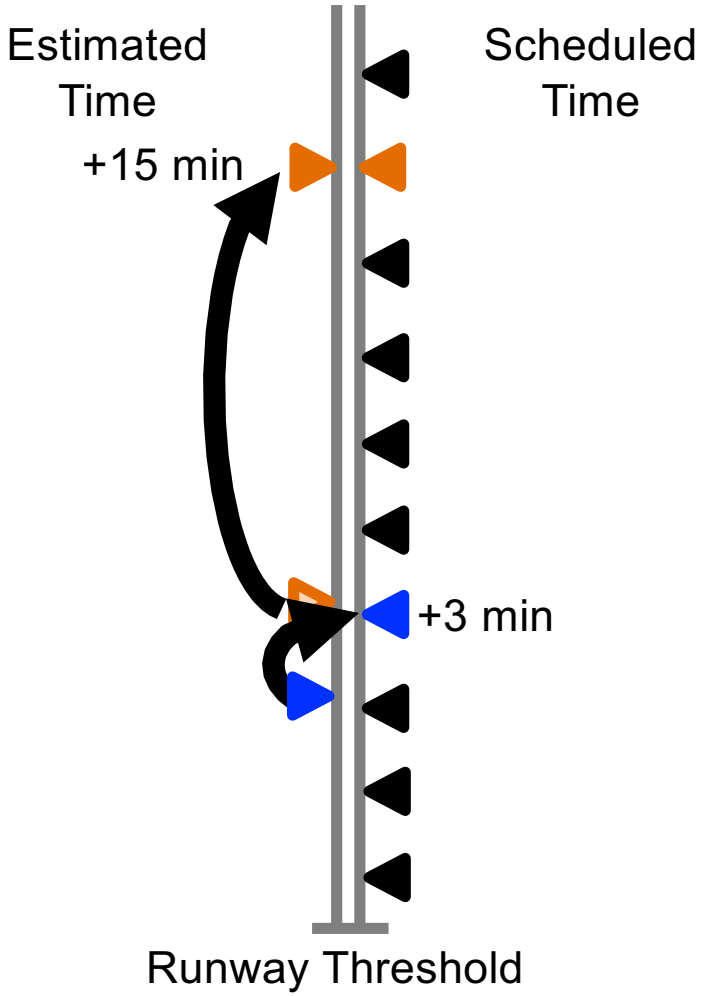


Tactical planning

Priority to internal departures



Priority to airborne flights



Tactical scheduling method pro/con

- Priority given to internal departures

  Pro – internal flights have relatively low delay

  Con – airborne delay can become impractical

- Priority given to airborne flights

  Pro – airborne delay remains practical

  Con – internal departures given relatively high delay

Research question

When is tactical airborne delay too high?

- Acceptable: below 7 minutes
- Marginal: between 7 and 14 minutes
- Unacceptable: greater than 14 minutes

Objective

Identify trends in airborne delay due to

- Variance in departure time conformance
- Bias towards late departures

Outline

- Overview of tactical planner
- Experiment setup
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  - Departure error variance
  - Departure error bias
- Summary
- Future work

Experiment setup

Fixed parameters		
Flight information	Arrivals into	Newark Liberty International Airport
	Total	194
	Start airborne	42
	External departures	128
	Internal departures	66
	Flight plans	fixed
	Scheduled departure times	fixed

Outline

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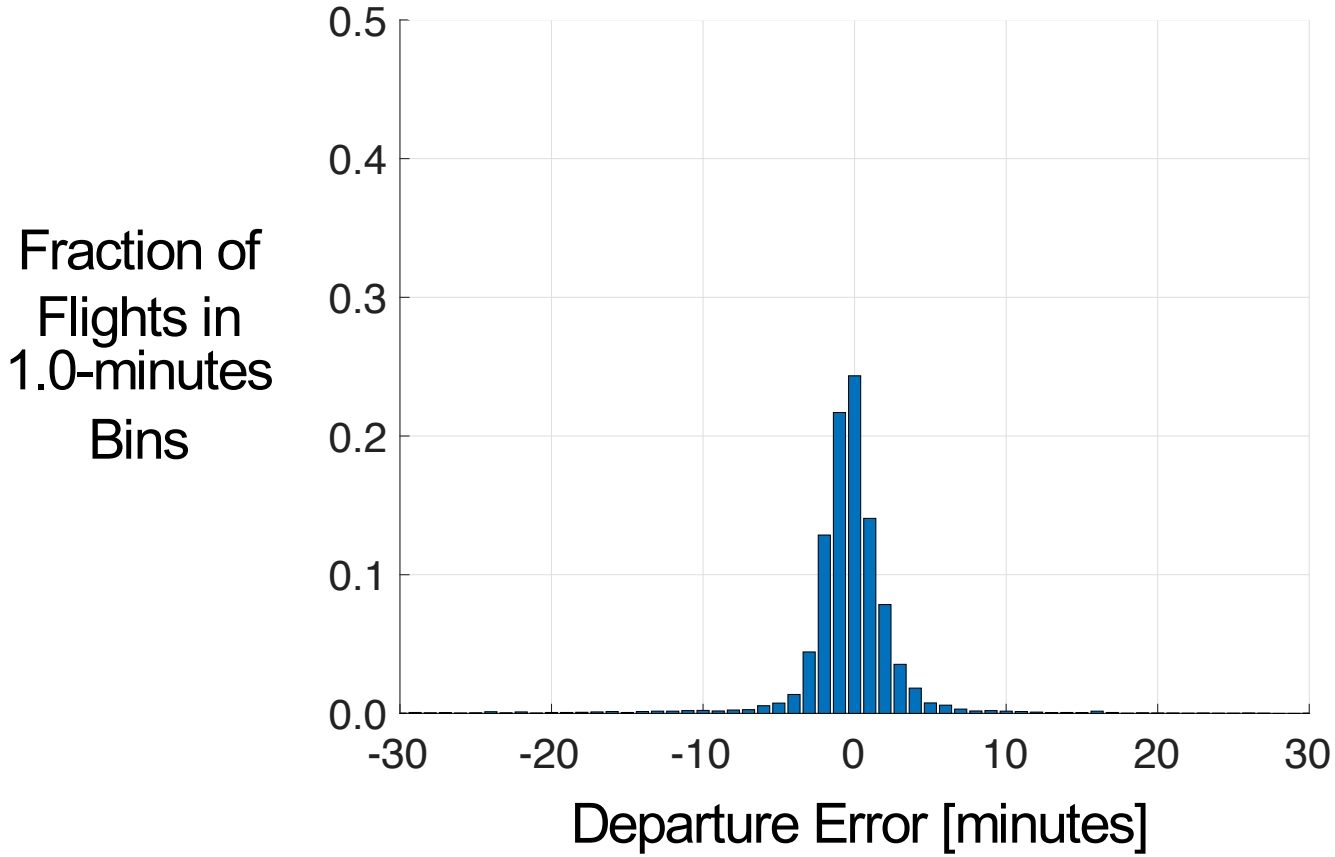
Departure error

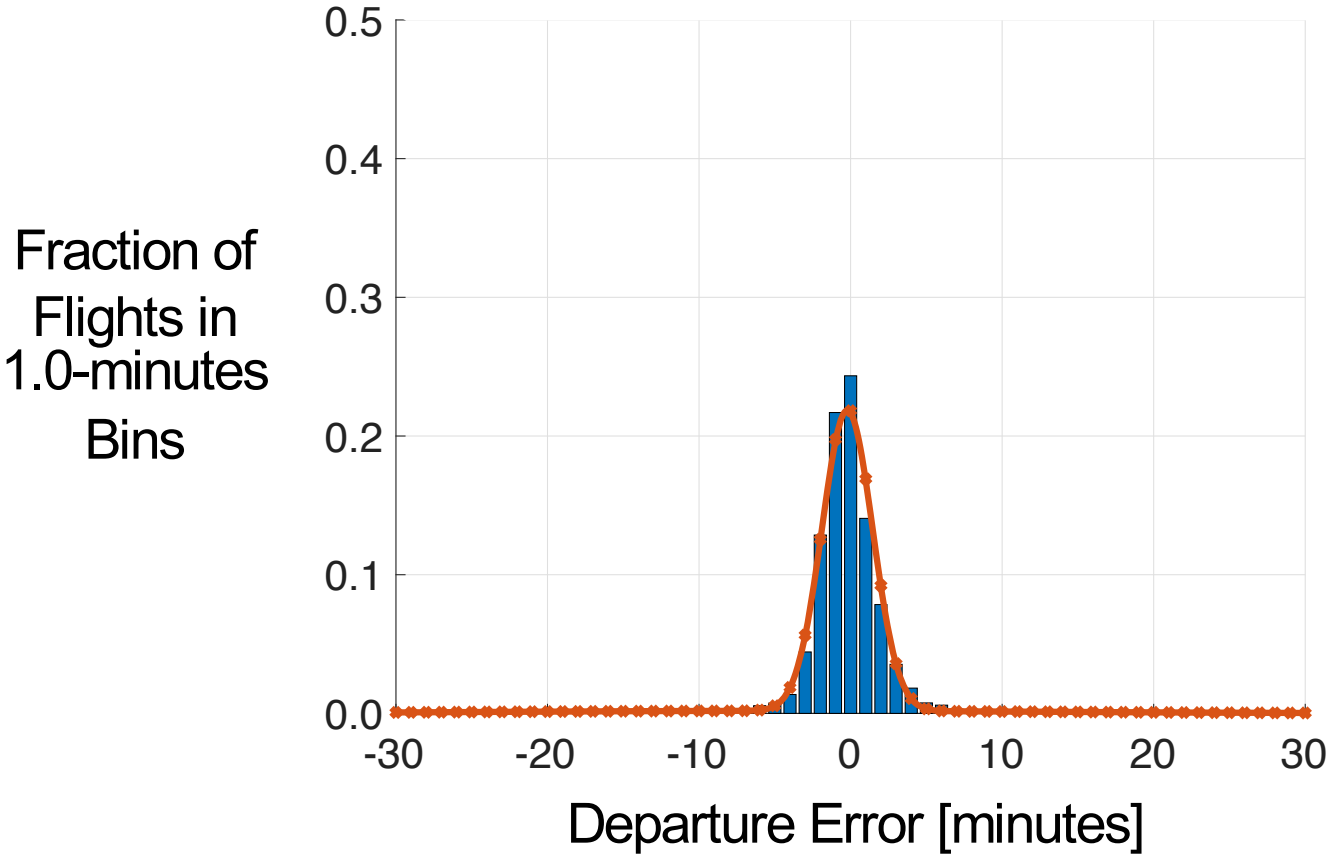
$$\begin{pmatrix}\text{departure}\\ \text{error}\end{pmatrix} = \begin{pmatrix}\text{take-off}\\ \text{time}\end{pmatrix} - \left[\begin{pmatrix}\text{original}\\ \text{departure time}\end{pmatrix} + \begin{pmatrix}\text{ground}\\ \text{delay}\end{pmatrix}\right]$$

- External departures:
  historical use of Ground Delay Programs
- Internal departures:
  historical use of Traffic Management Advisor

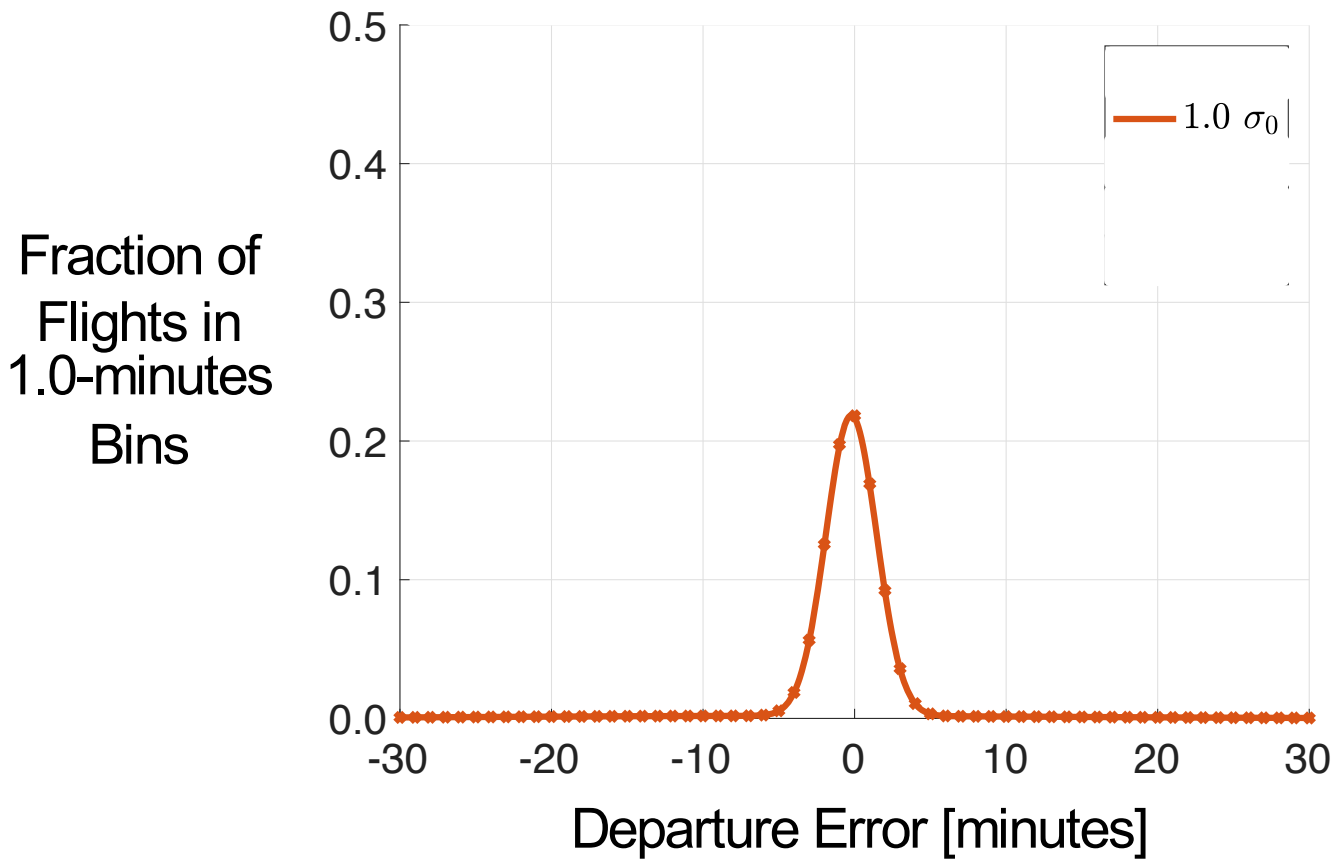
Internal departures



Internal departures



Internal departures



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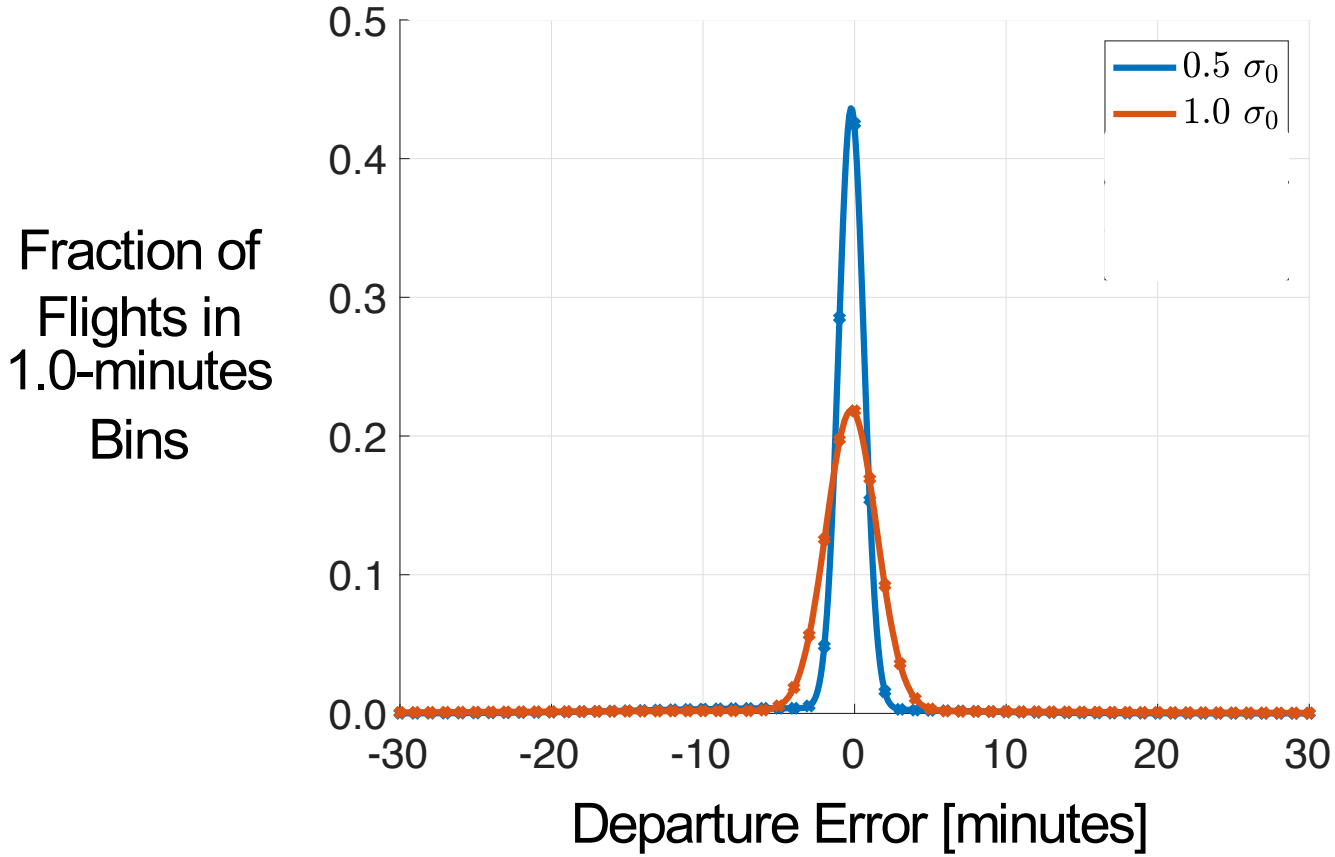

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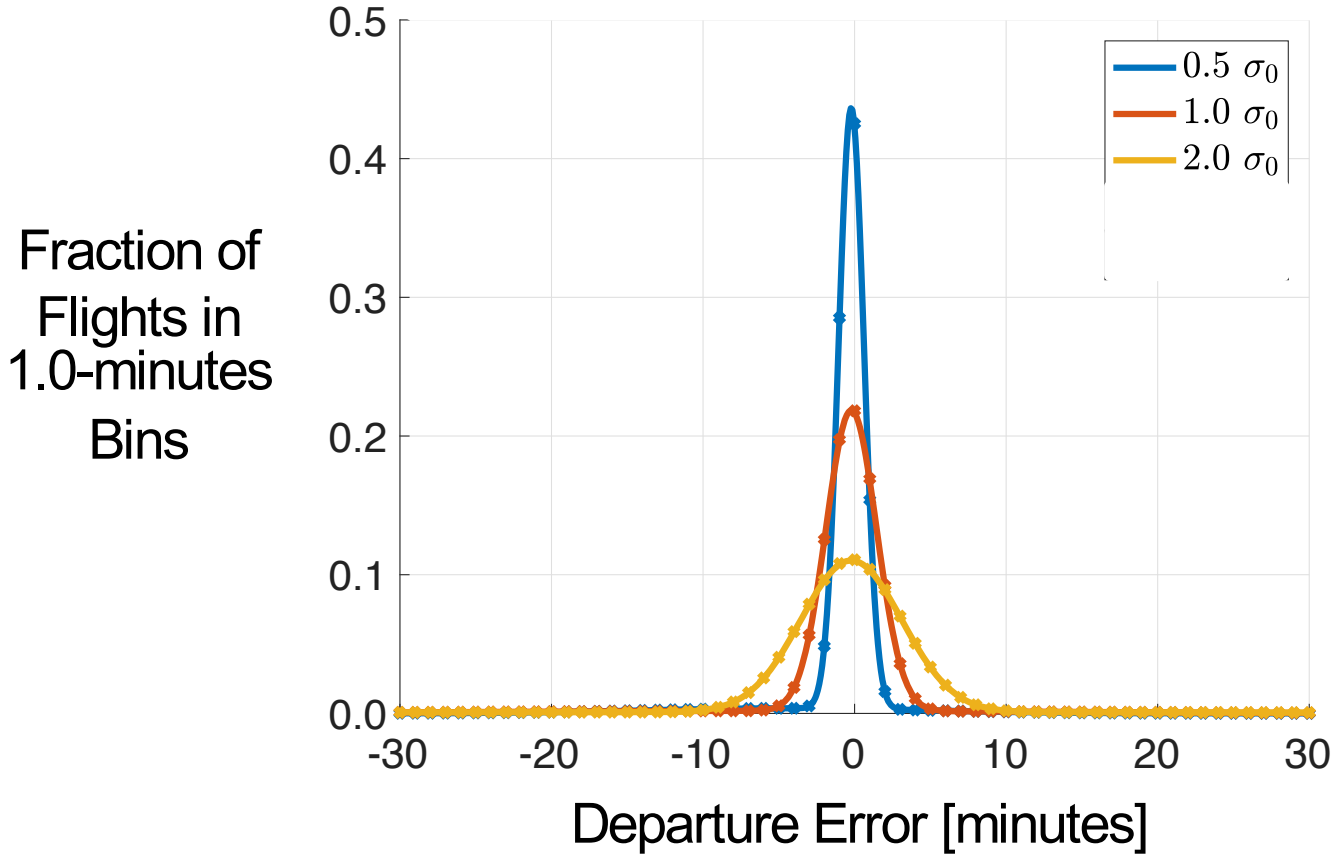
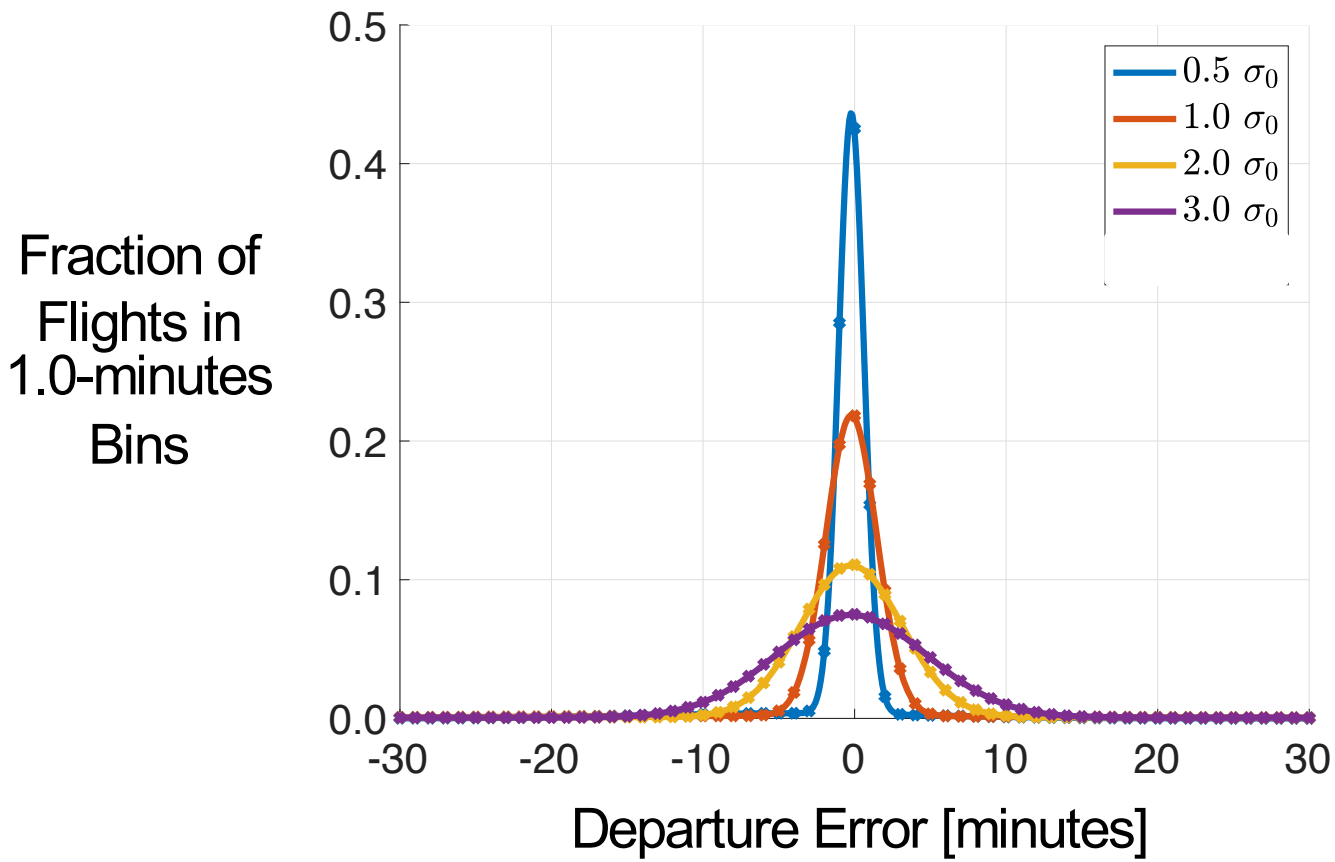
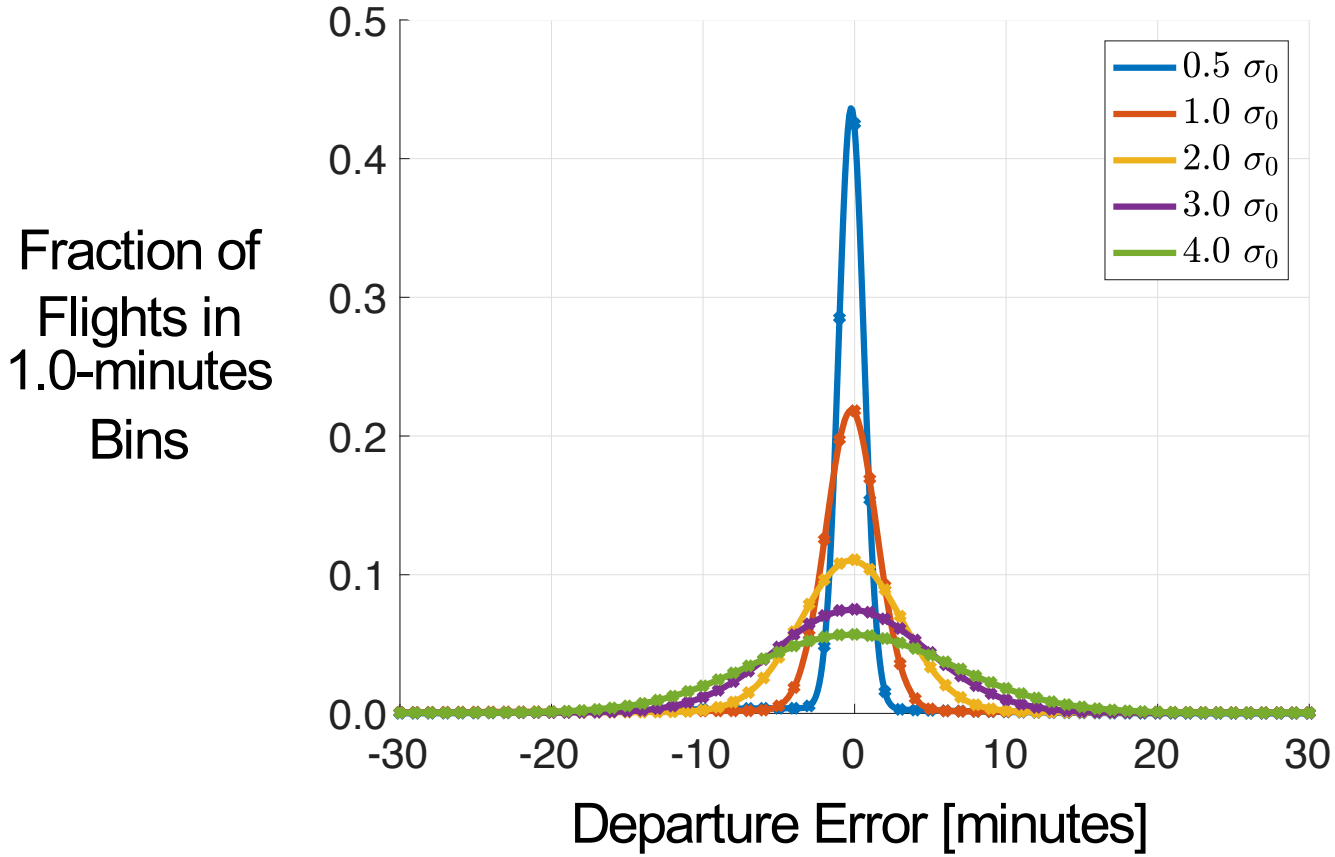


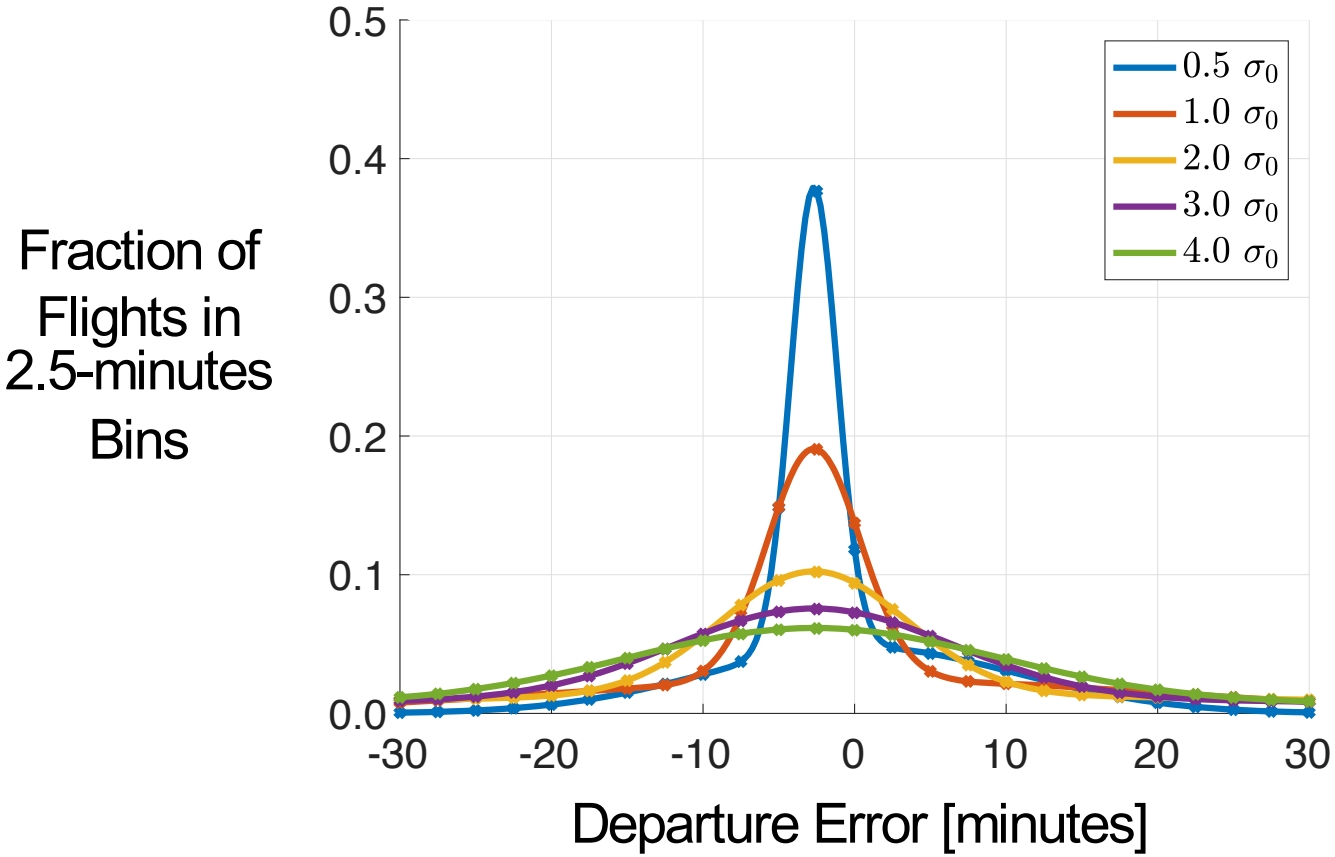
Internal departures



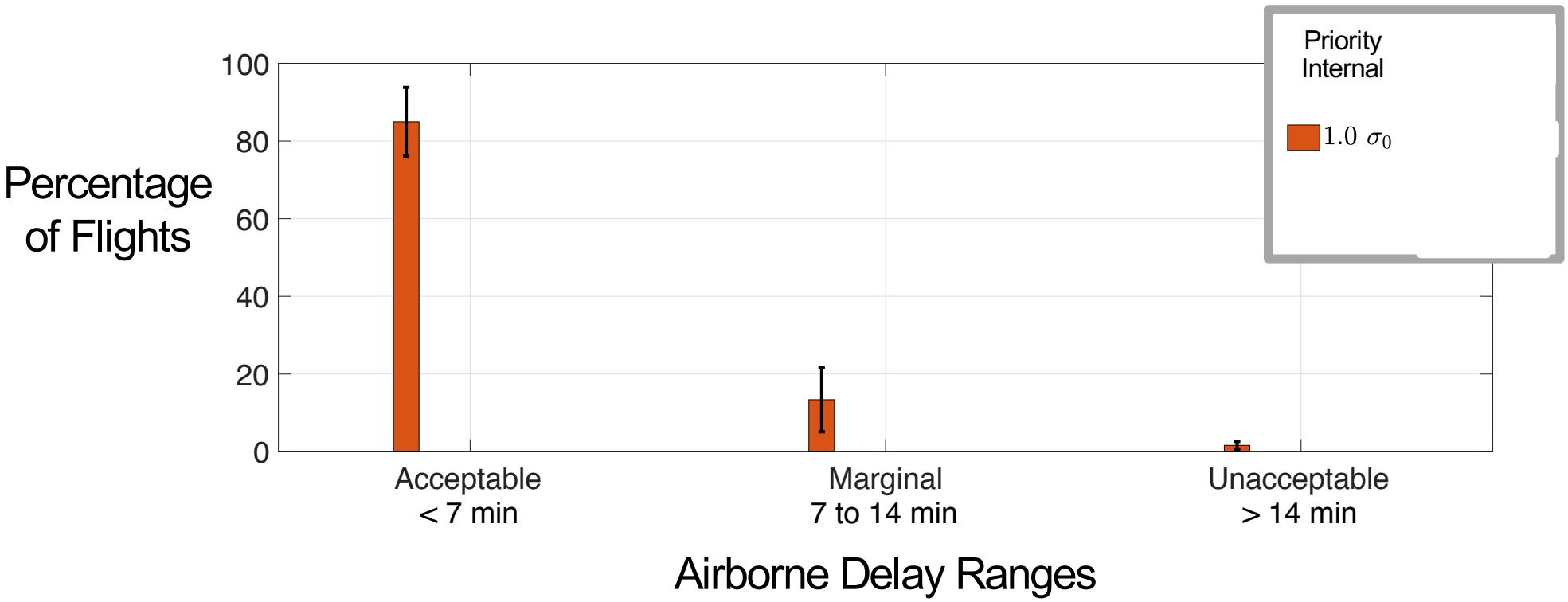
Internal departures



External departures



Tactical airborne delay results



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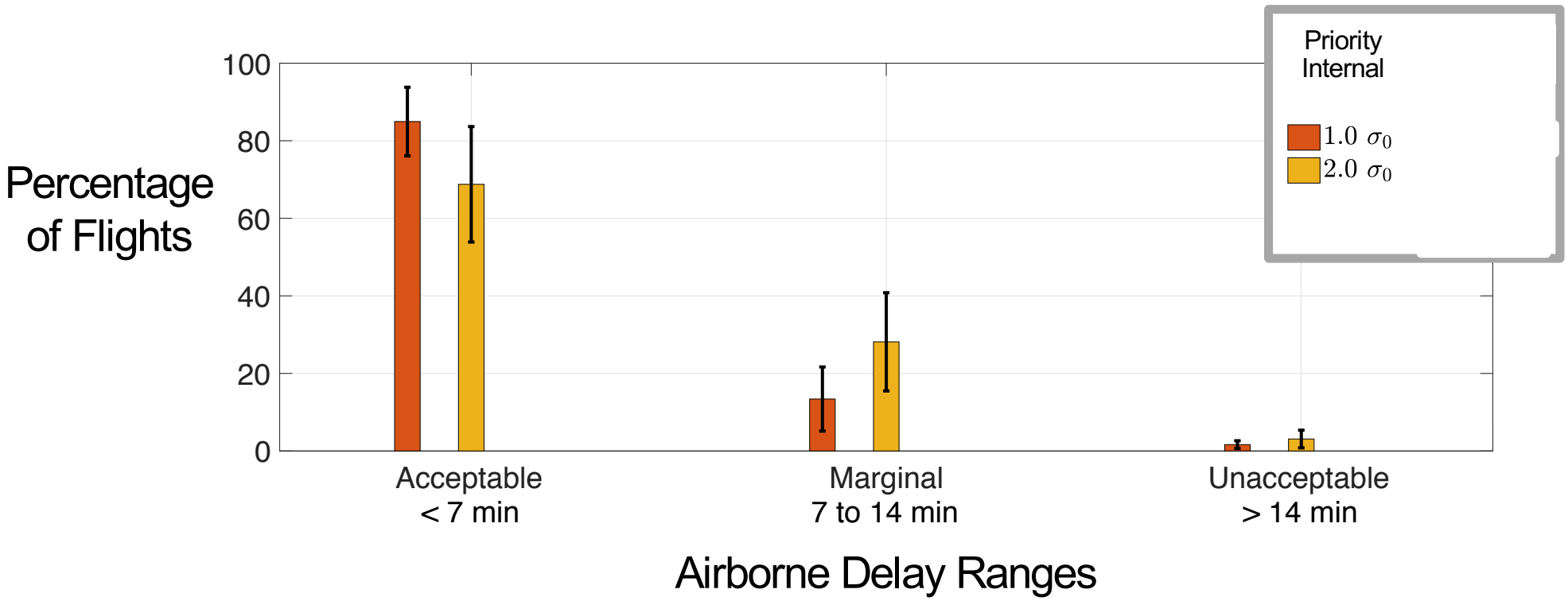

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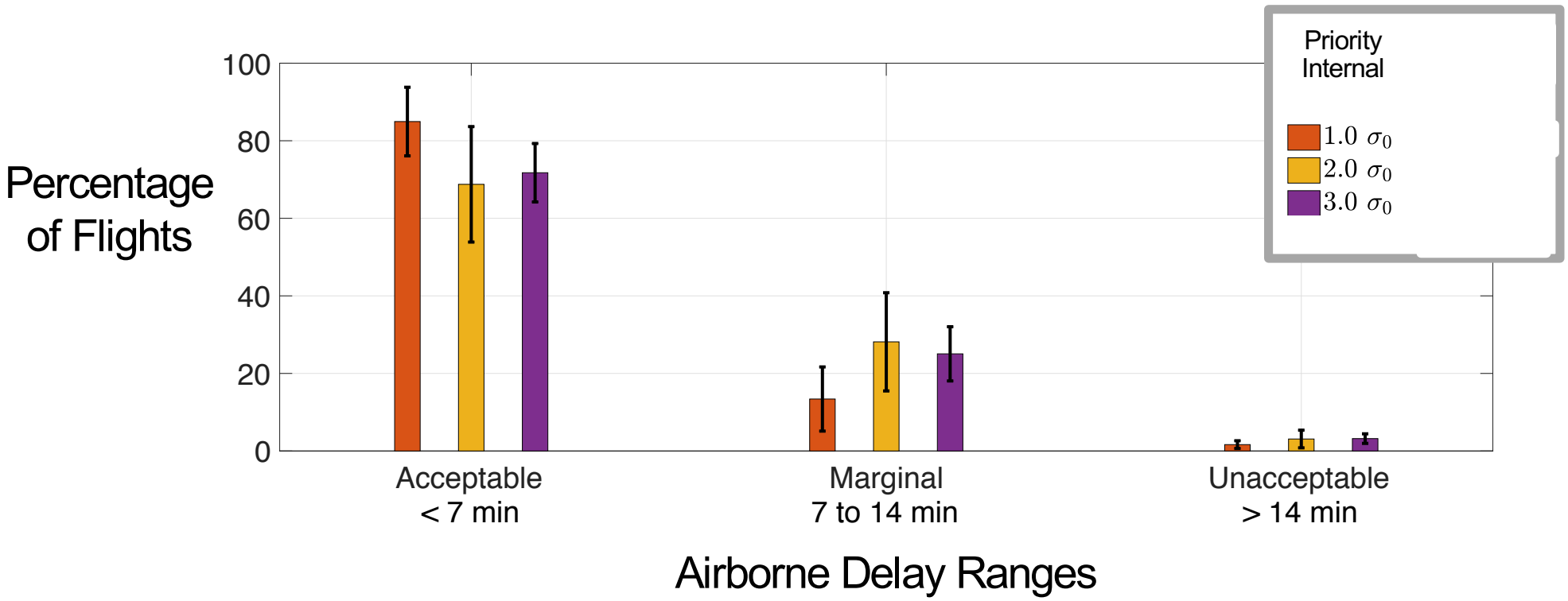
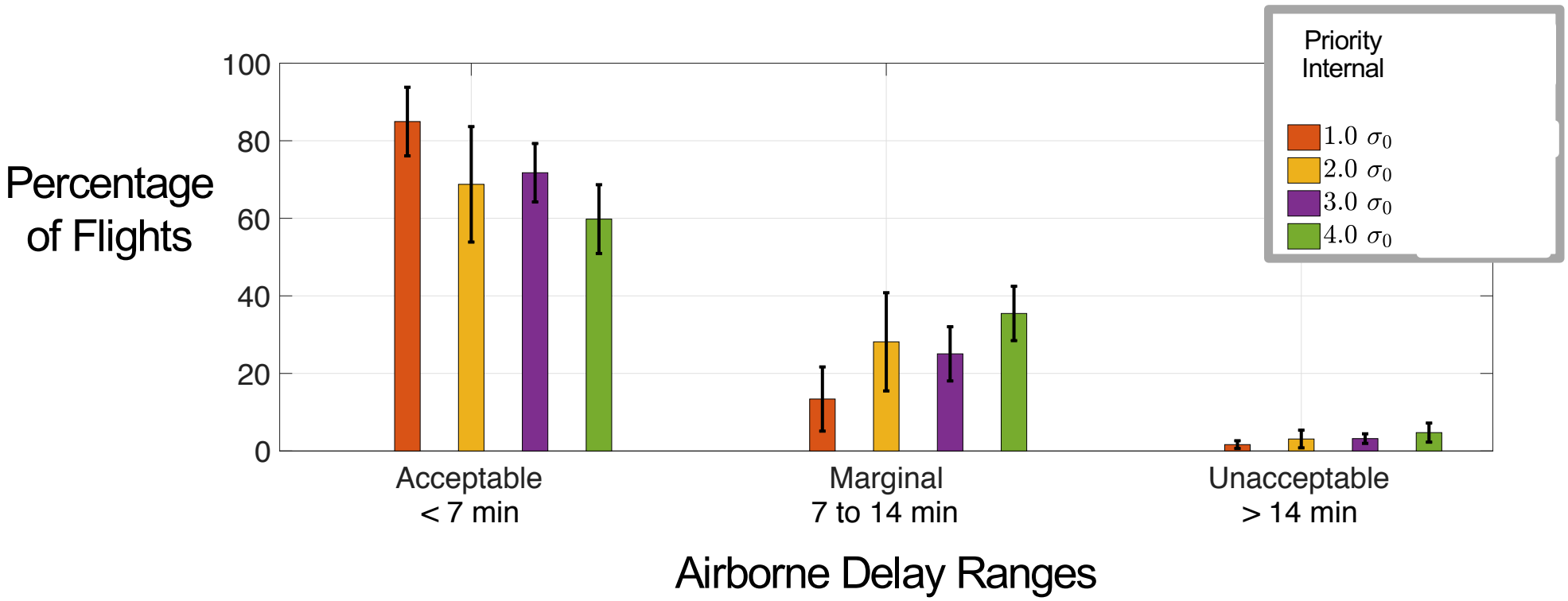


Tactical airborne delay results



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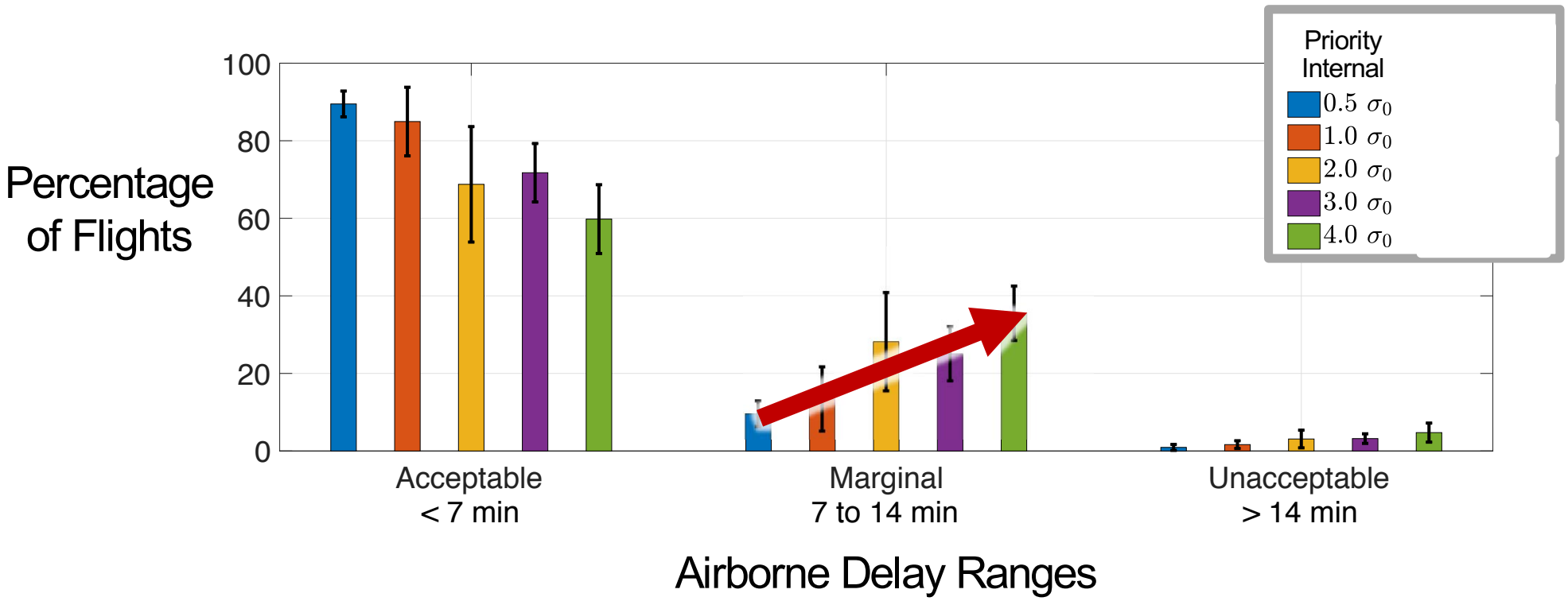
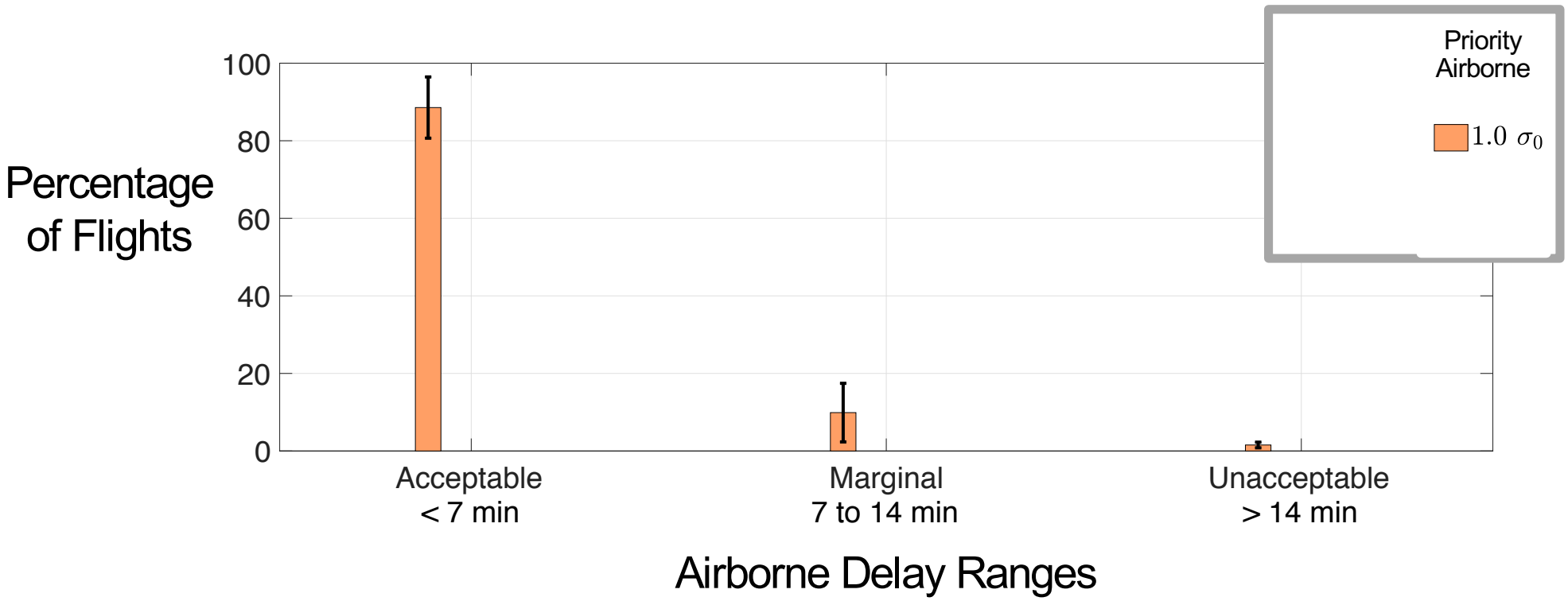
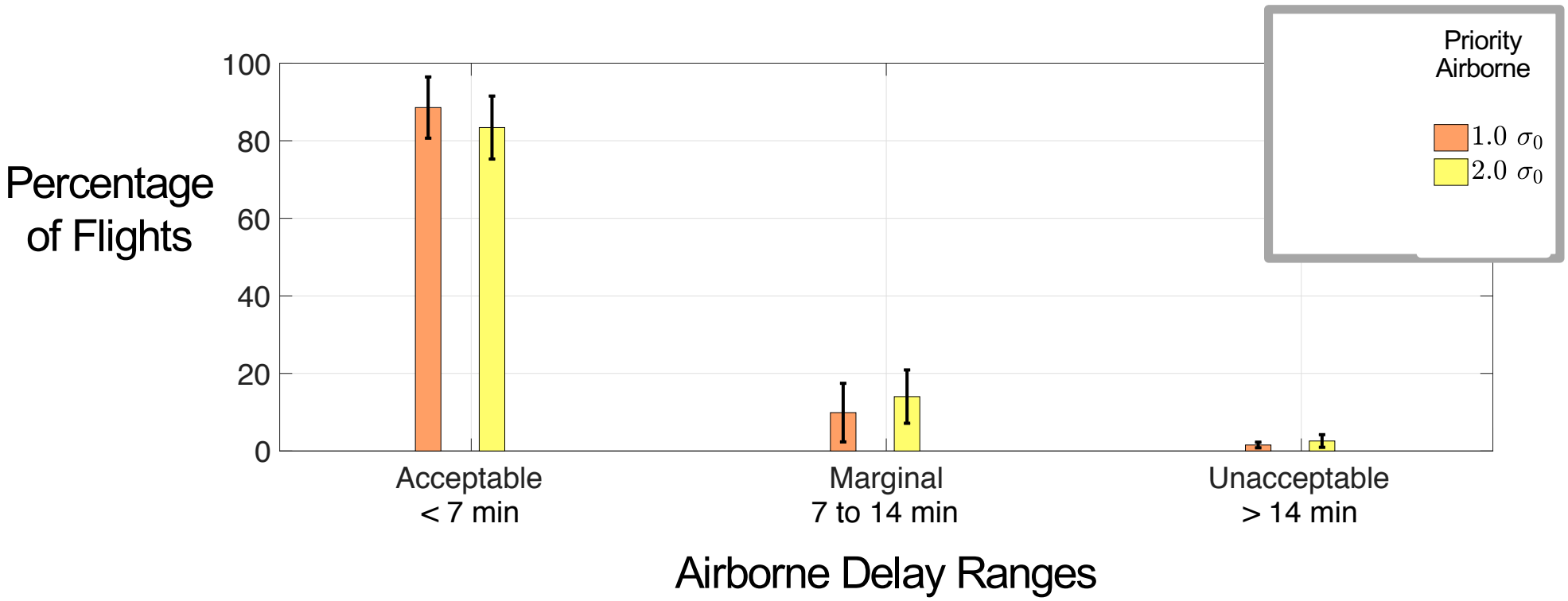


Marginal airborne delay increases with increase in departure error variance when priority is given to internal departures

Tactical airborne delay results



Tactical airborne delay results



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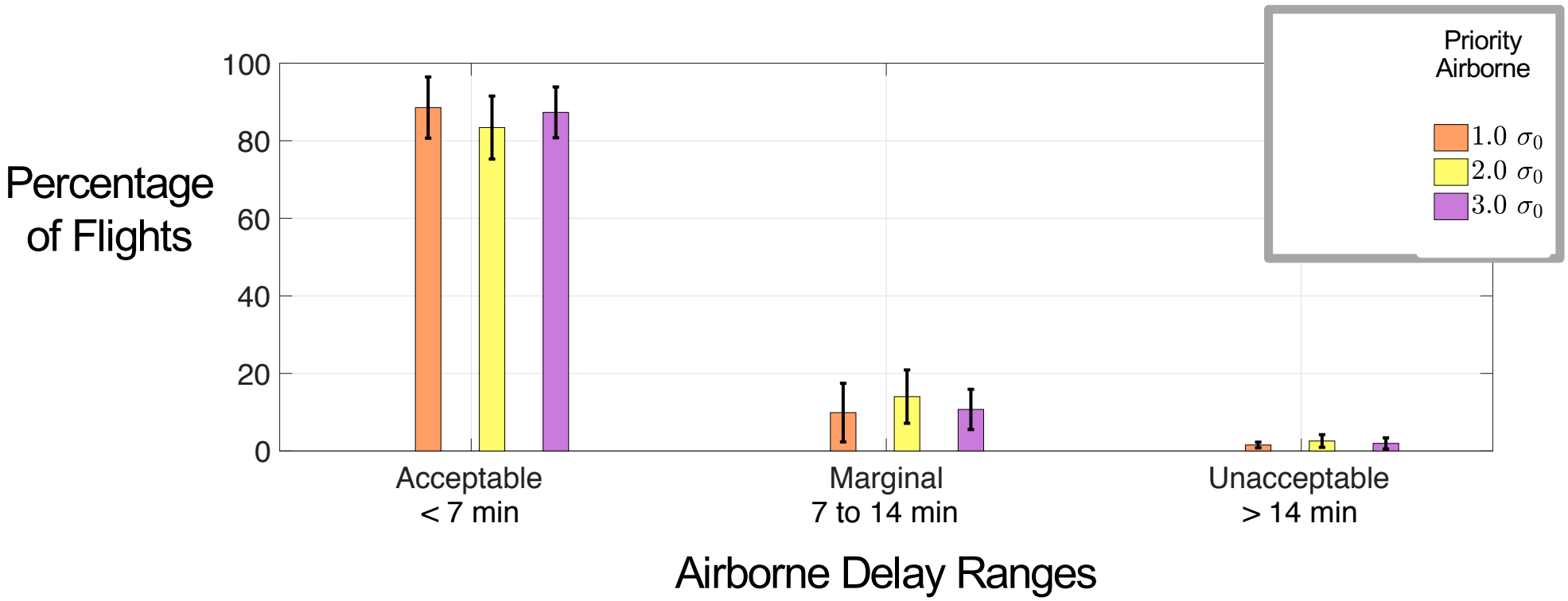
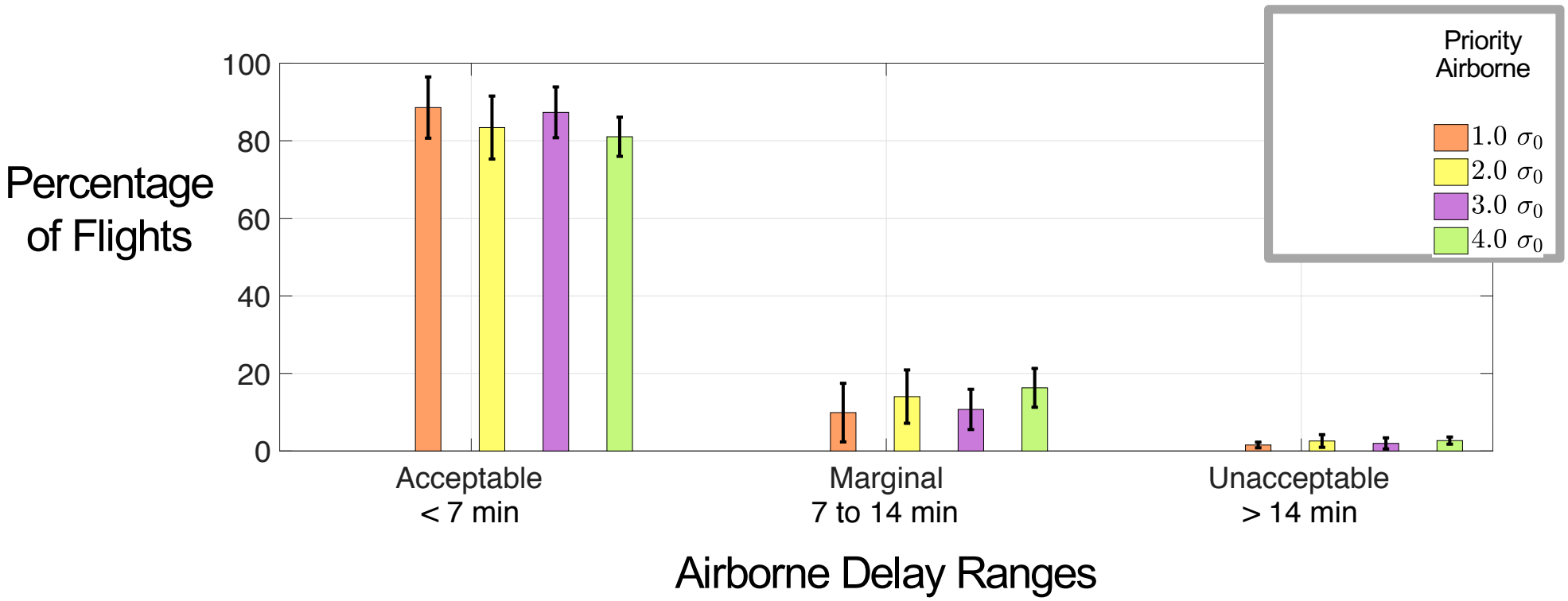
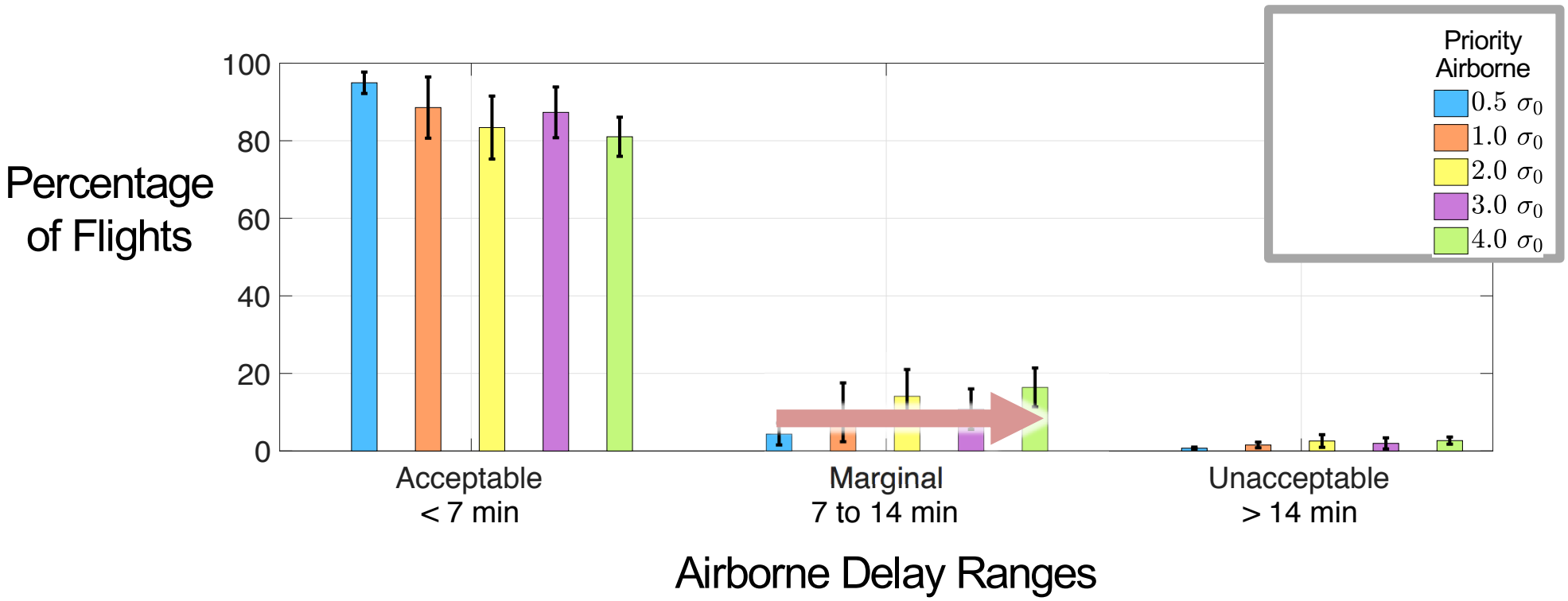


Tactical airborne delay results

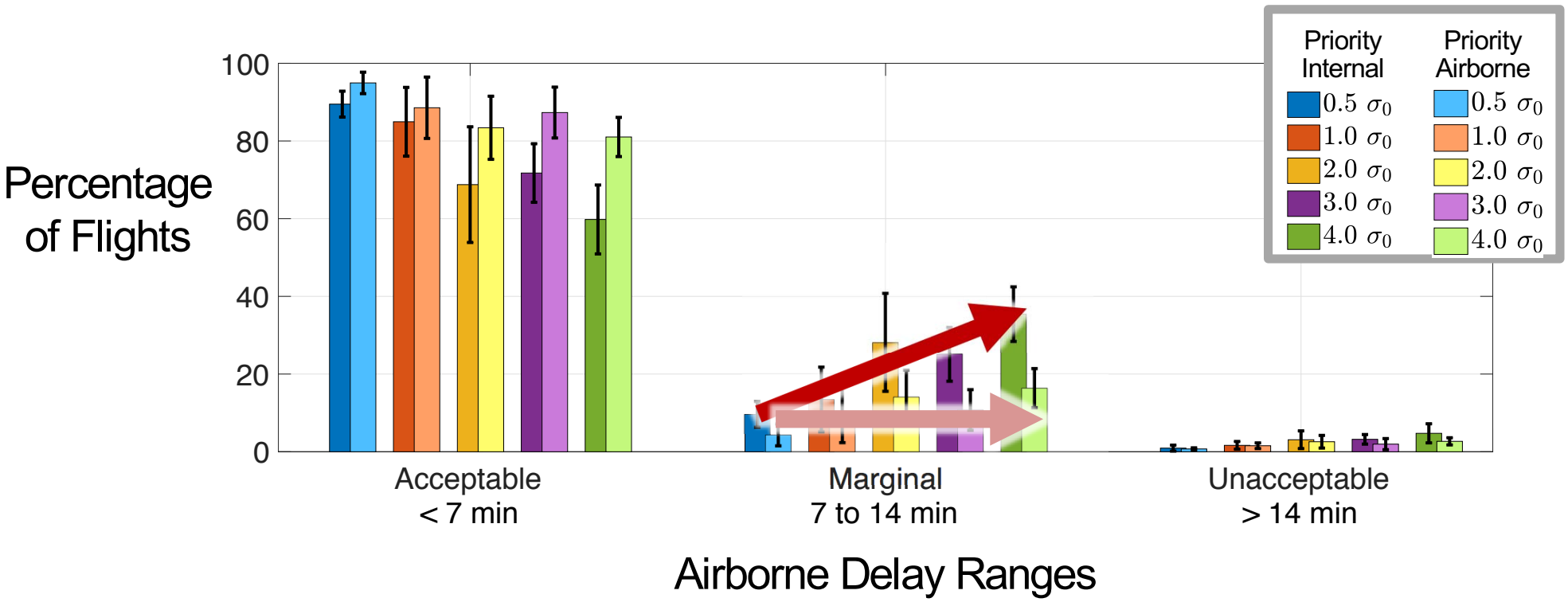


Tactical airborne delay results



Marginal airborne delay remains relatively constant with increase in departure error variance when priority is given to airborne flights

Tactical airborne delay results

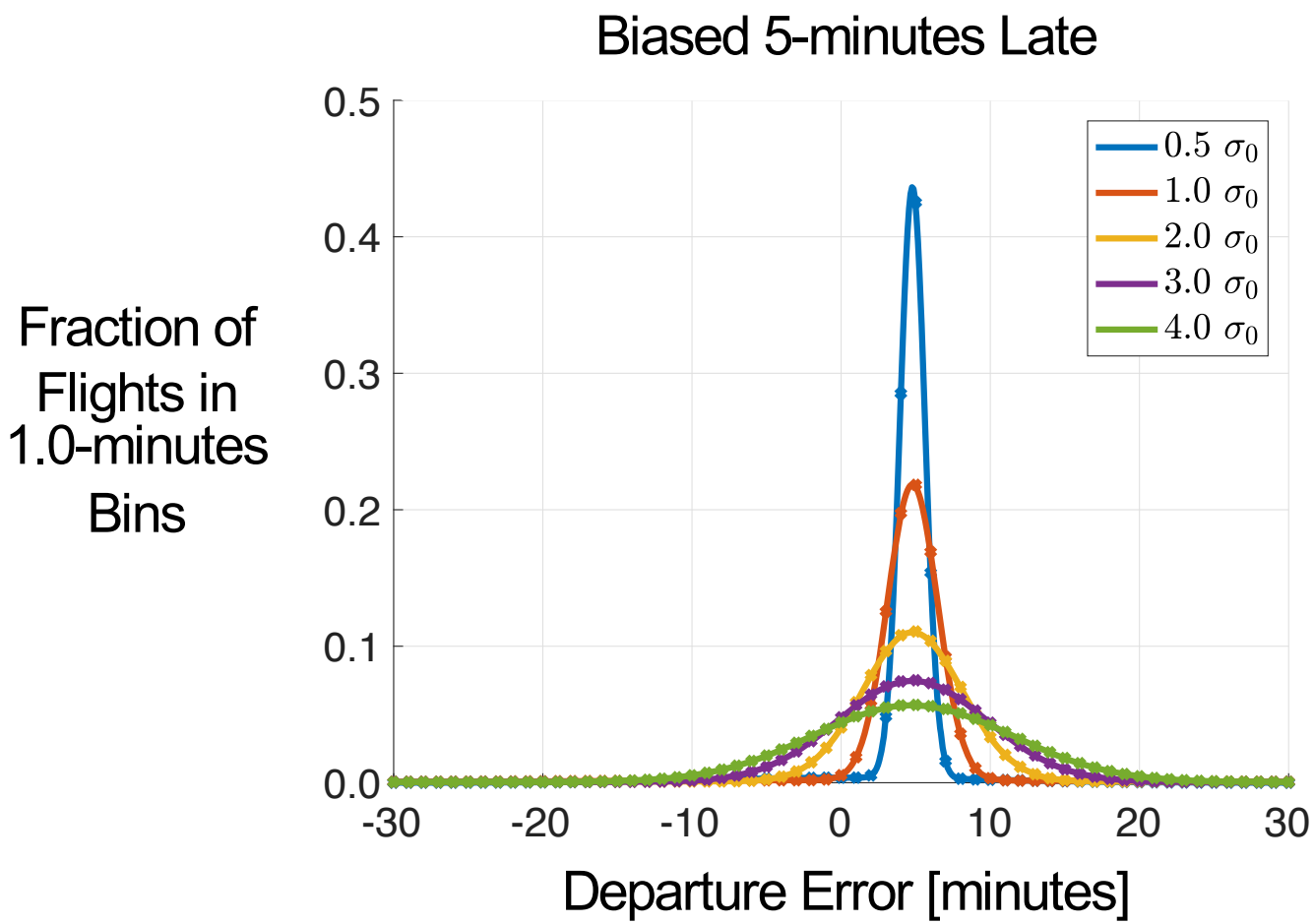


Marginal airborne delay decreases when switching from priority internal to priority airborne

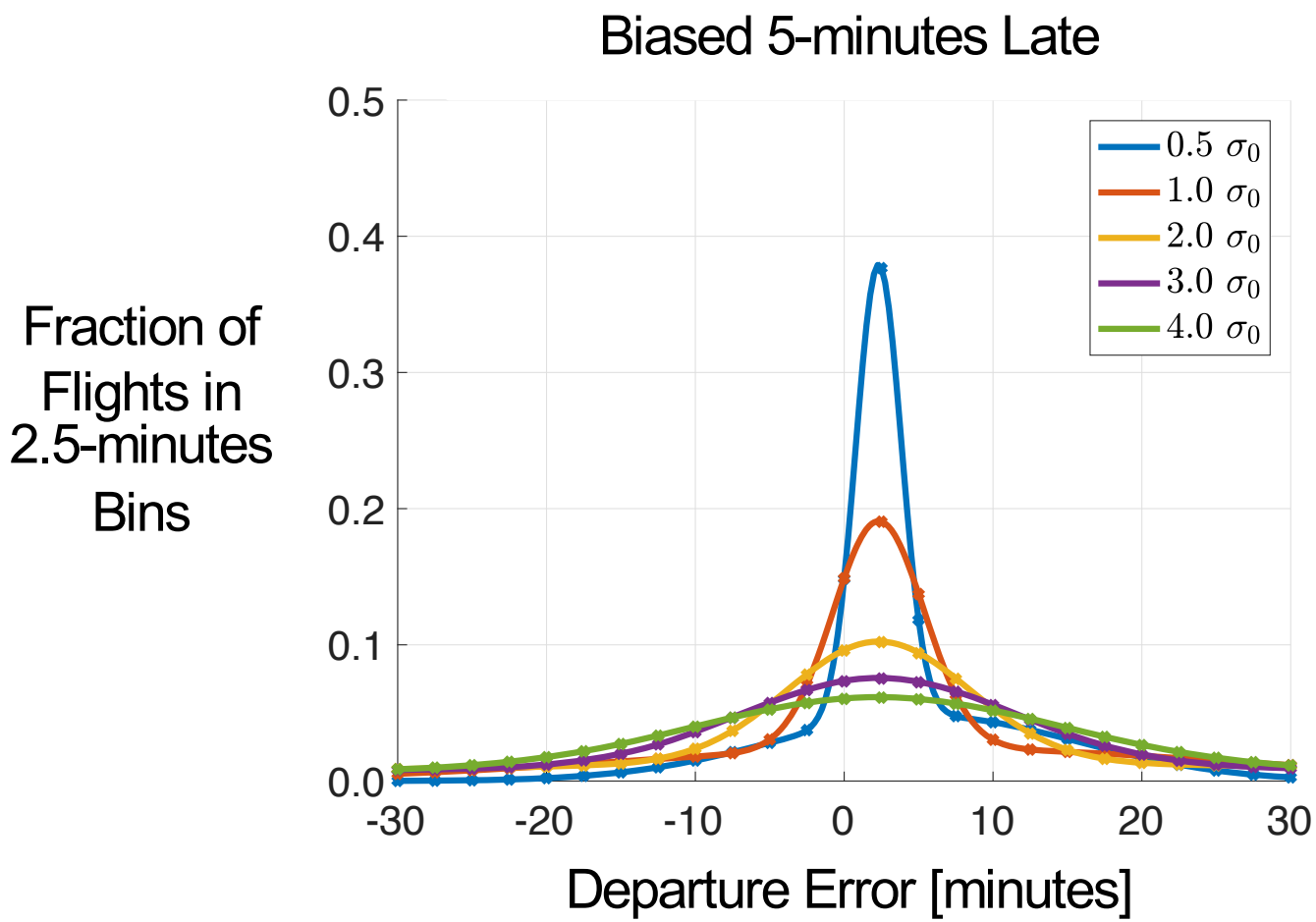
Outline

- Overview of tactical planner
- Experiment setup
- Tactical airborne delay results
  - Departure error variance
  - Departure error bias
- Summary
- Future work

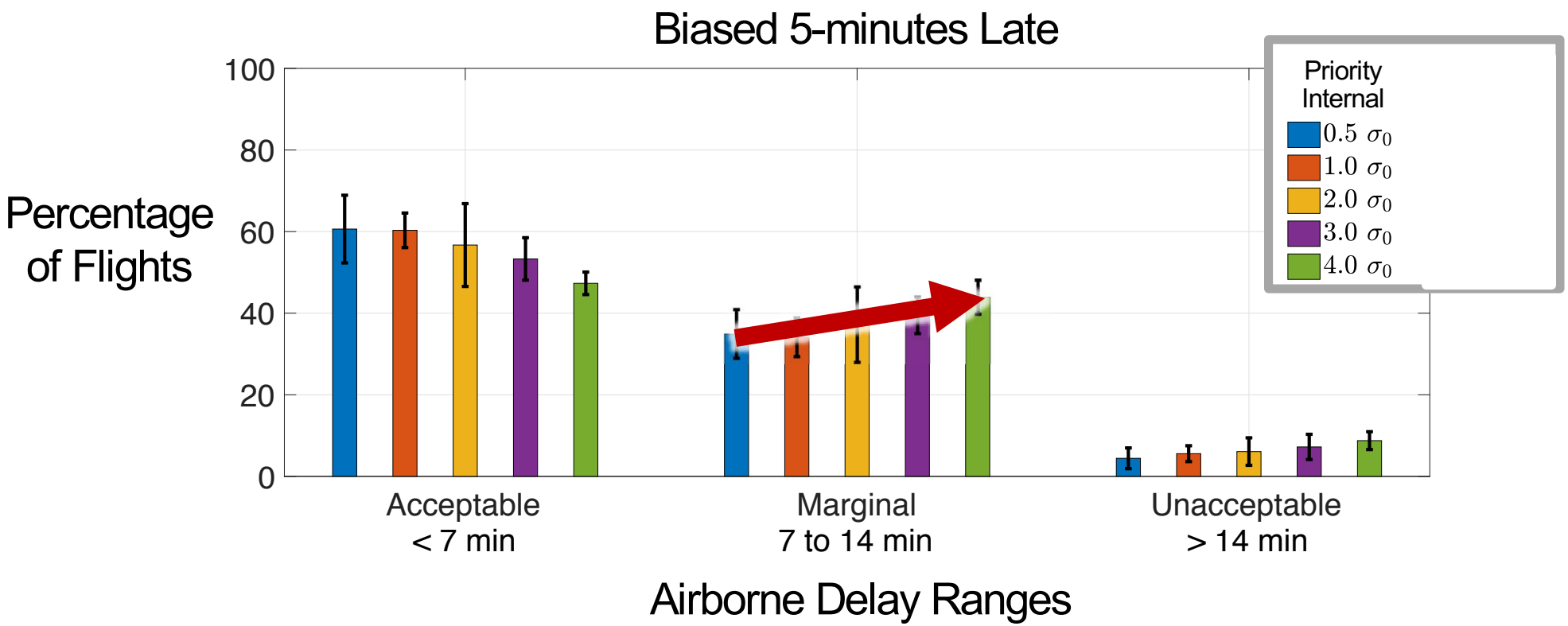
Internal departures



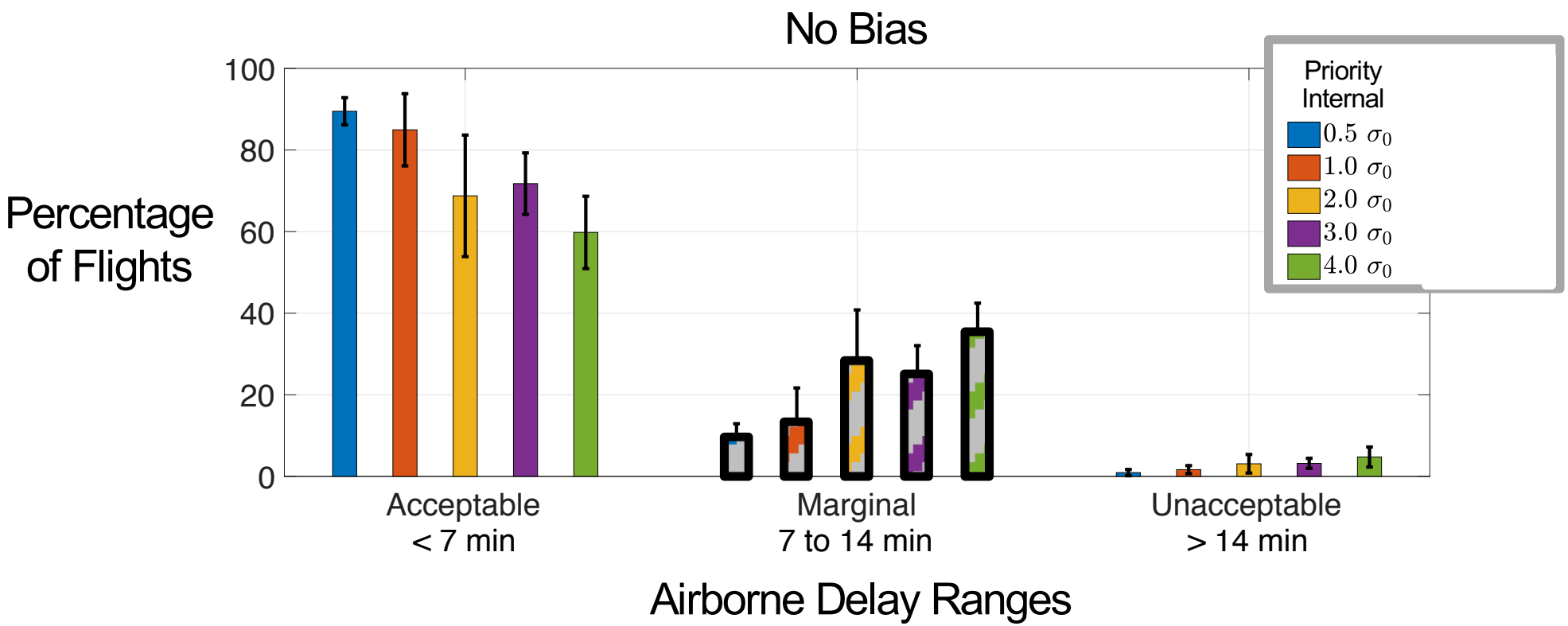
External departures



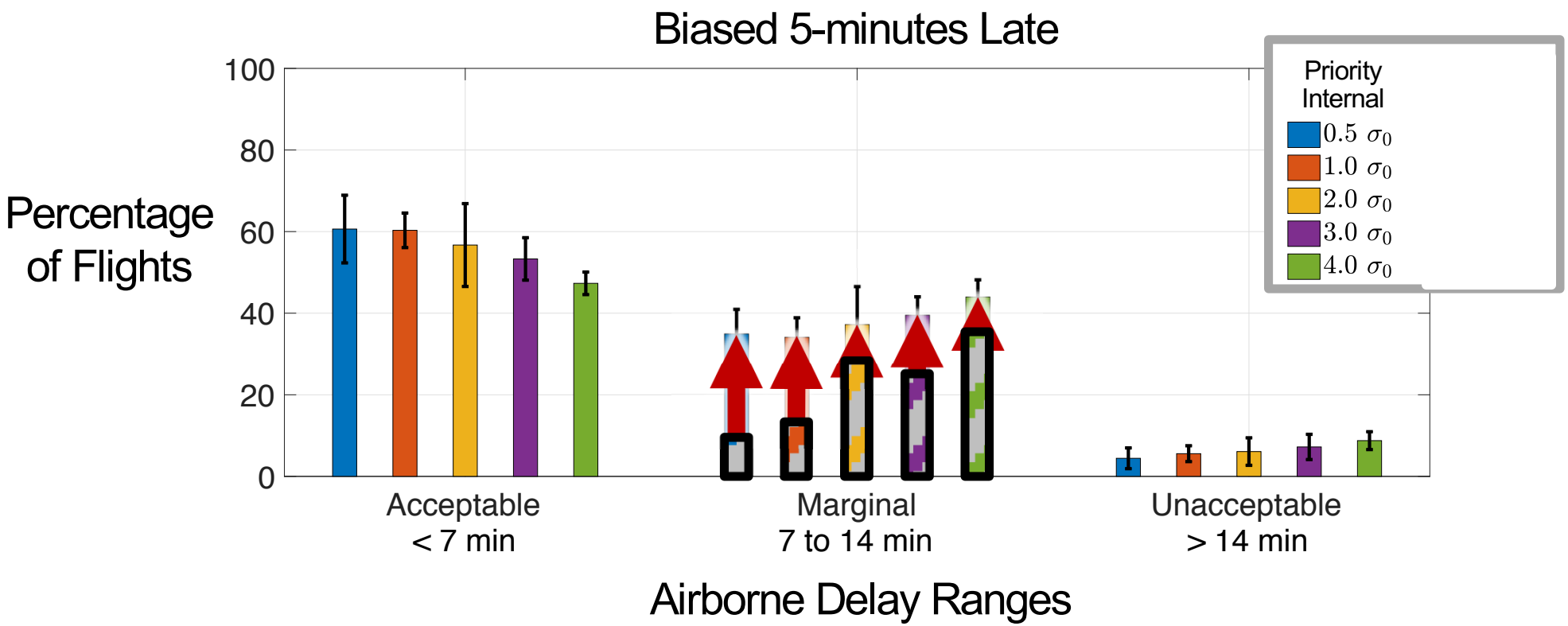
Tactical airborne delay results



Tactical airborne delay results

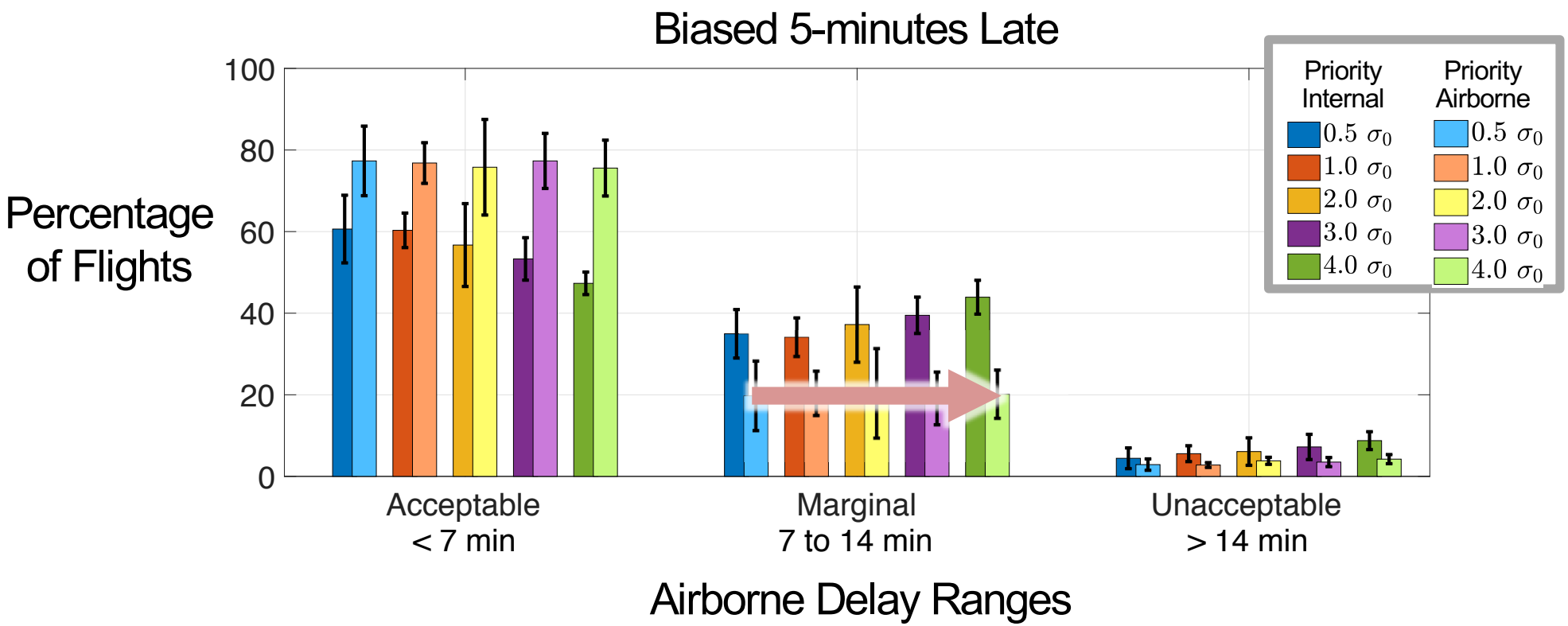


Tactical airborne delay results



Marginal airborne delay increases with consistently late departures when priority is given to internal departures

Tactical airborne delay results



Marginal airborne delay remains manageable with consistently late departures when priority is given to airborne flights

Summary

- As departure error variability increases
  Marginal airborne delay …
  - Increases when priority is given to internal departures
  - Remains relatively constant when priority is given to airborne flights
  - Decreases when switching from priority internal to priority airborne

- As departure error shifts 5-minutes late
  Marginal airborne delay …
  - Increases when priority is given to internal departures
  - Remains manageable when priority is given to airborne flights

Future work

- Expand departure error analysis:
  - Additional biases
  - Vary bias by airport
  - Recalculate strategic delay periodically
- Implement and study extended metering
- Identify scenarios for further investigation with human-in-the-loop simulations

Using an Automated Air Traffic Simulation Capability for a Parametric Study in Traffic Flow Management

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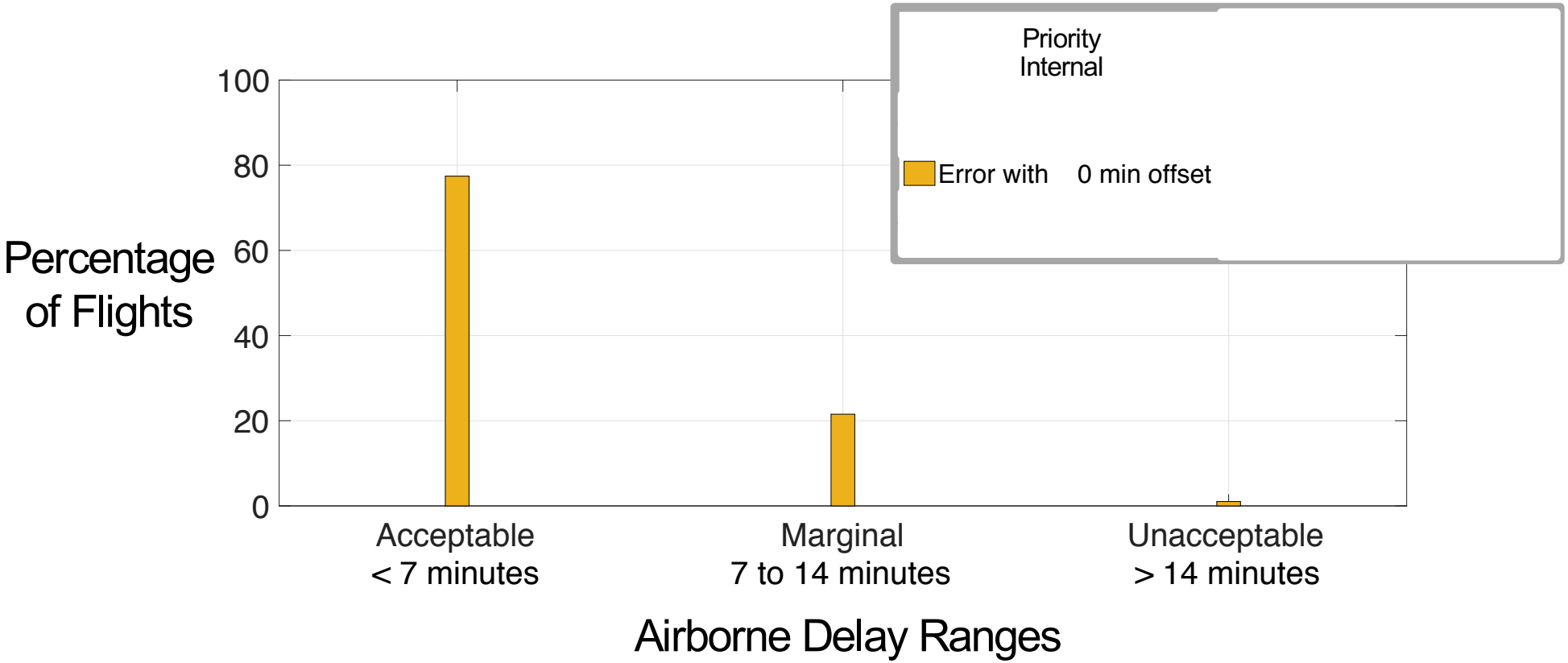
NASA Ames Research Center

Jinhua Li

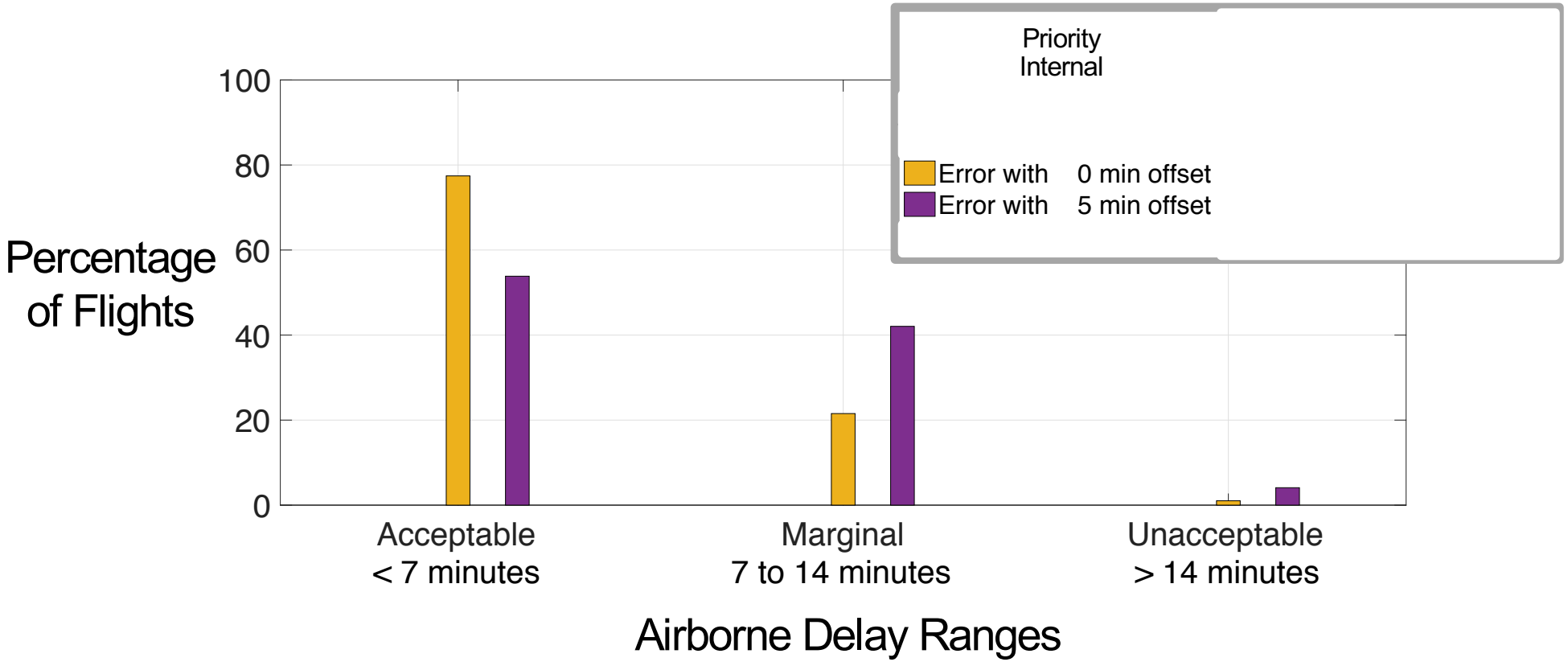
Universities Space Research Association, NASA Ames Research Center

Backup

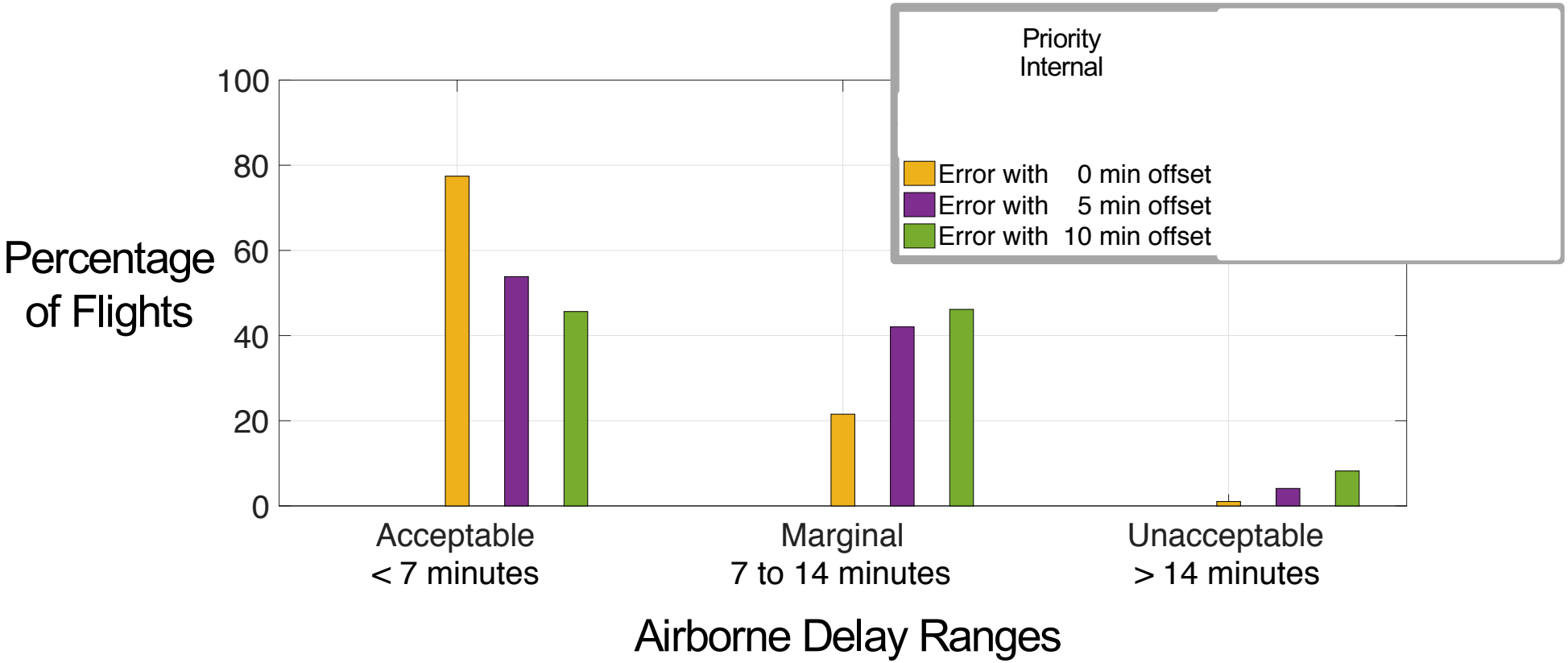
Tactical airborne delay results



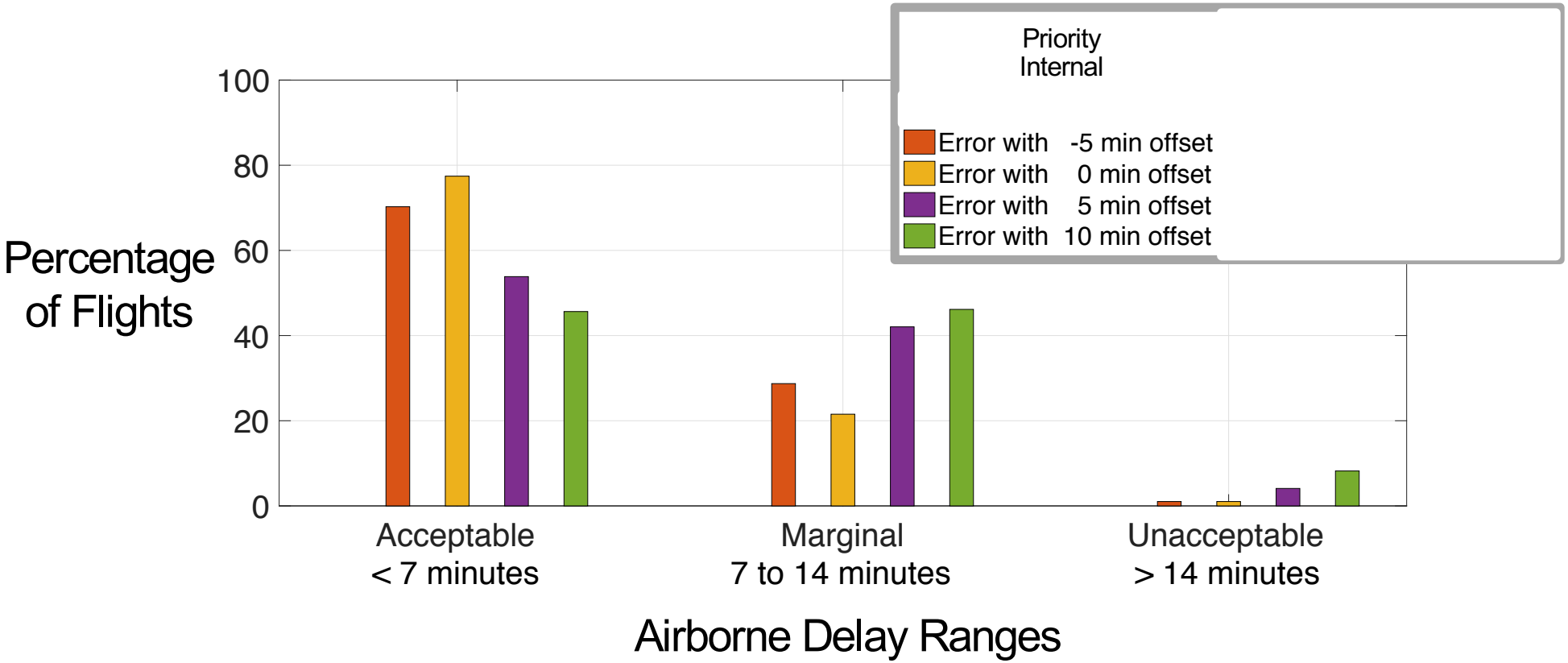
Tactical airborne delay results



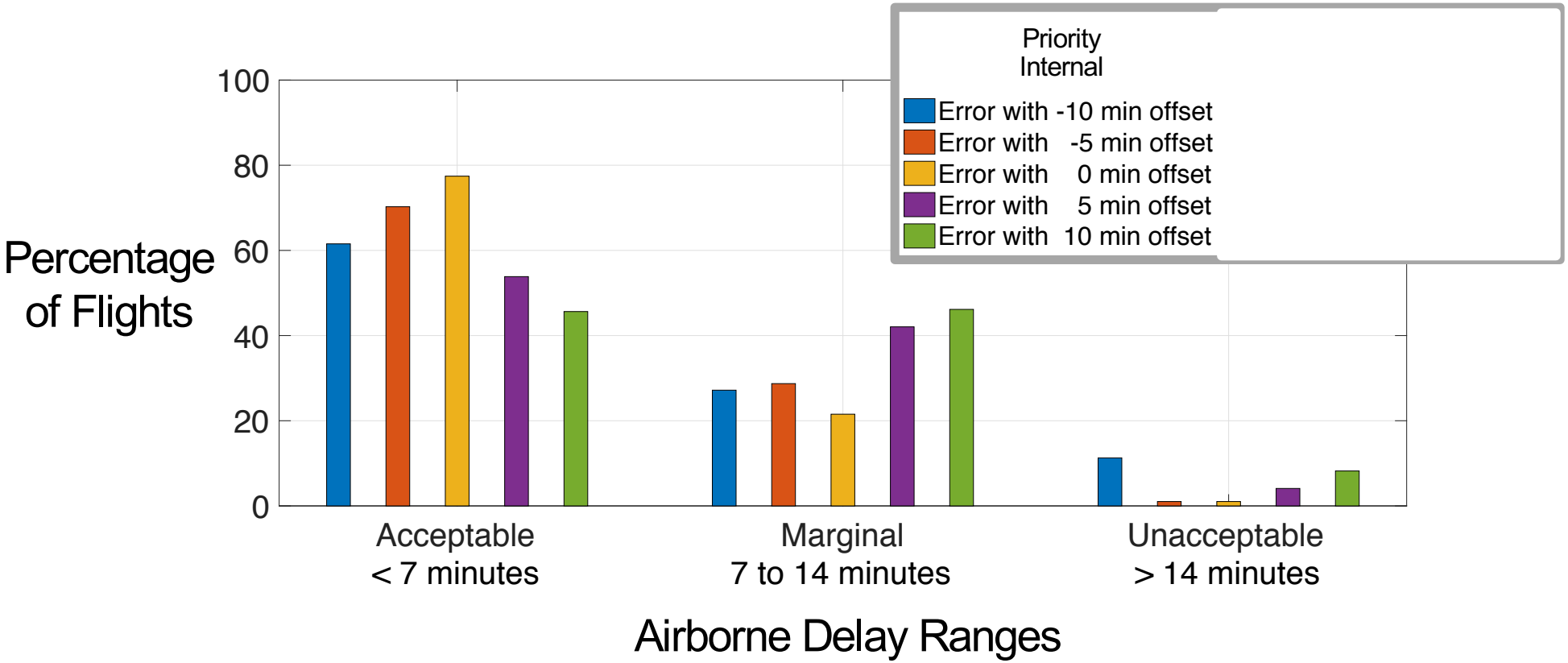
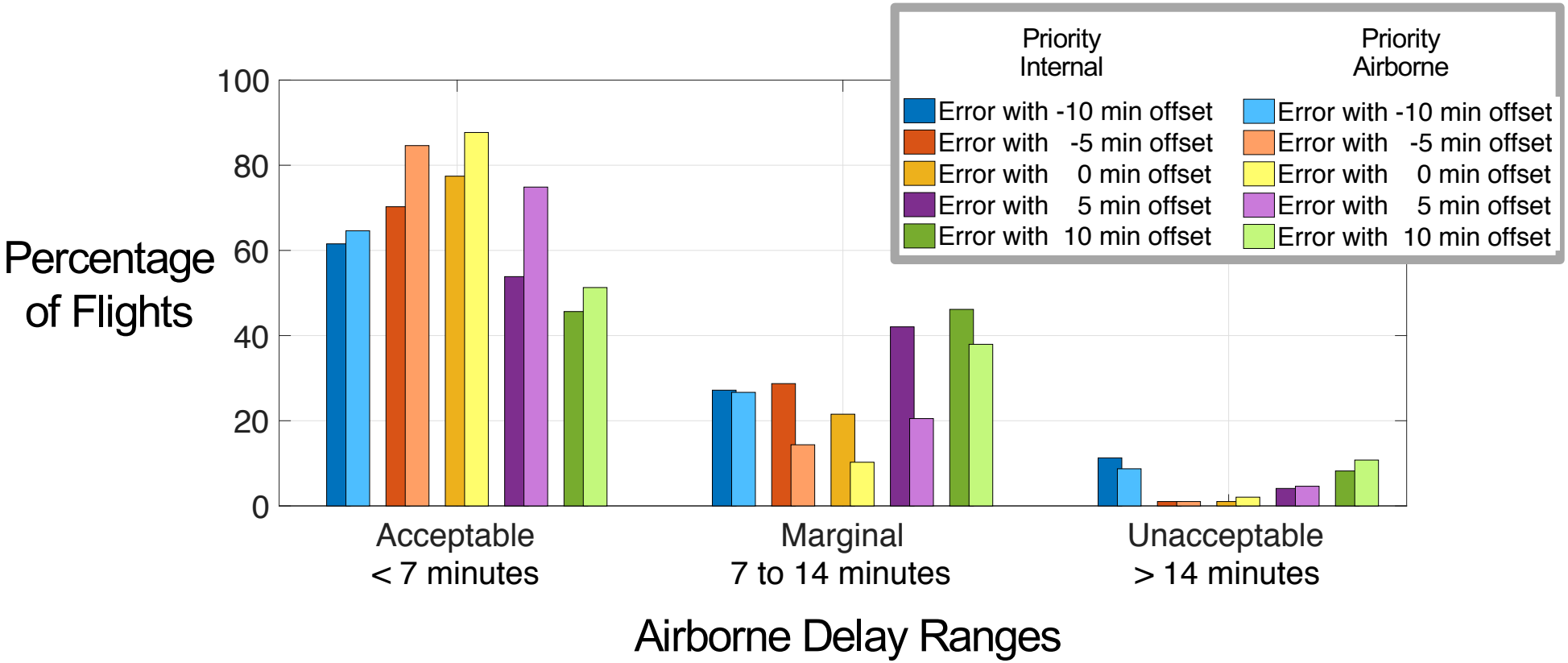
Tactical airborne delay results



Tactical airborne delay results



Tactical airborne delay results



Tactical airborne delay results