Air Transportation Test-bed
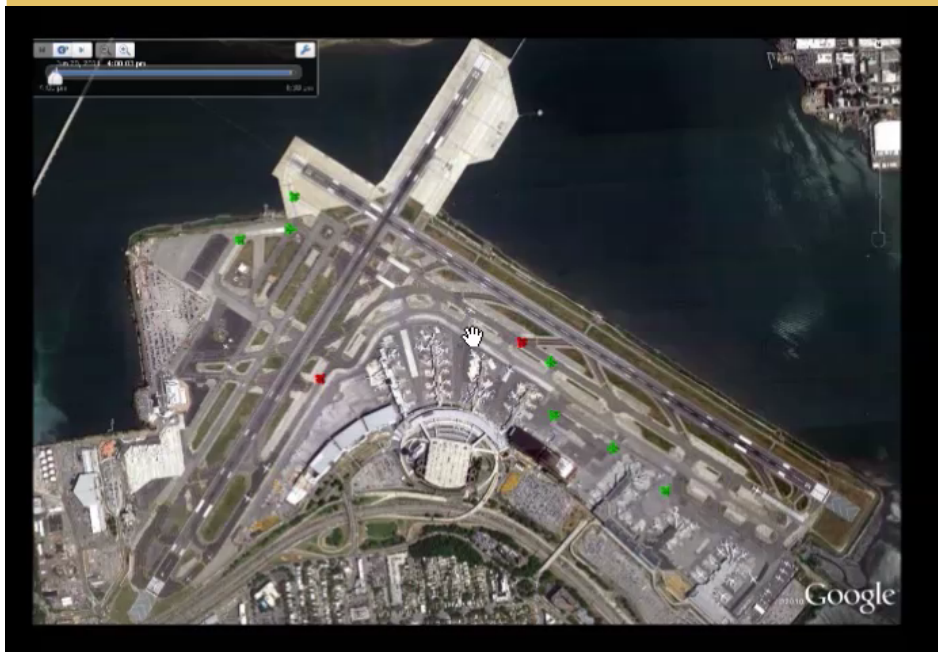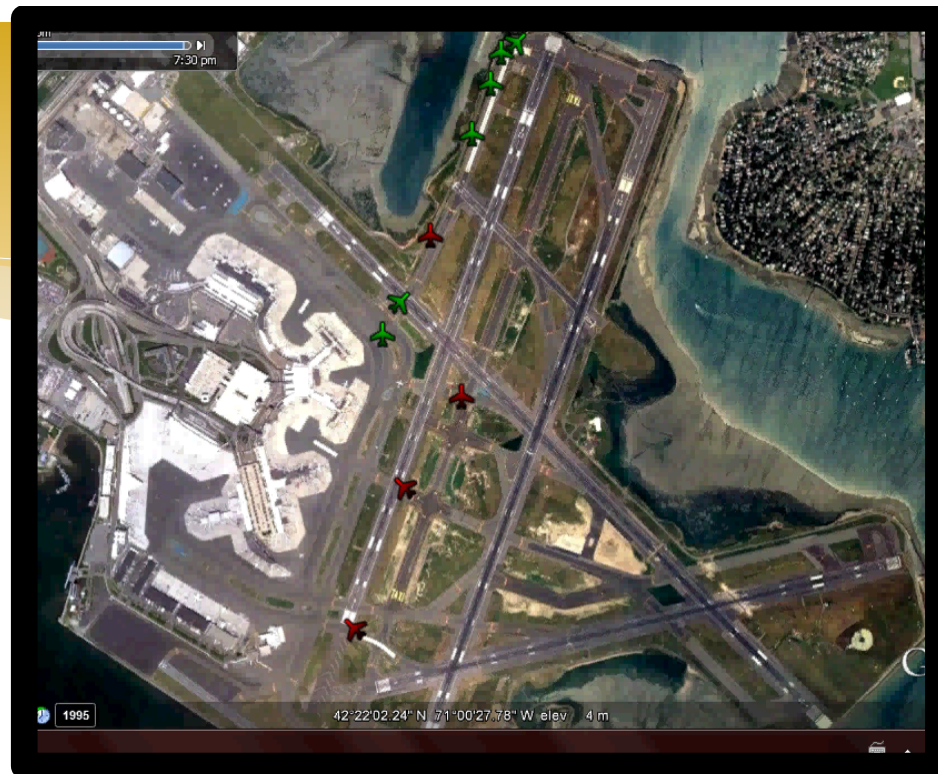
Hamsa Balakrishnan

Joint work with

H. Khadilkar, H. Lee, P. Park, V. Ramanujam, I. Simaiakis and C. Tomlin
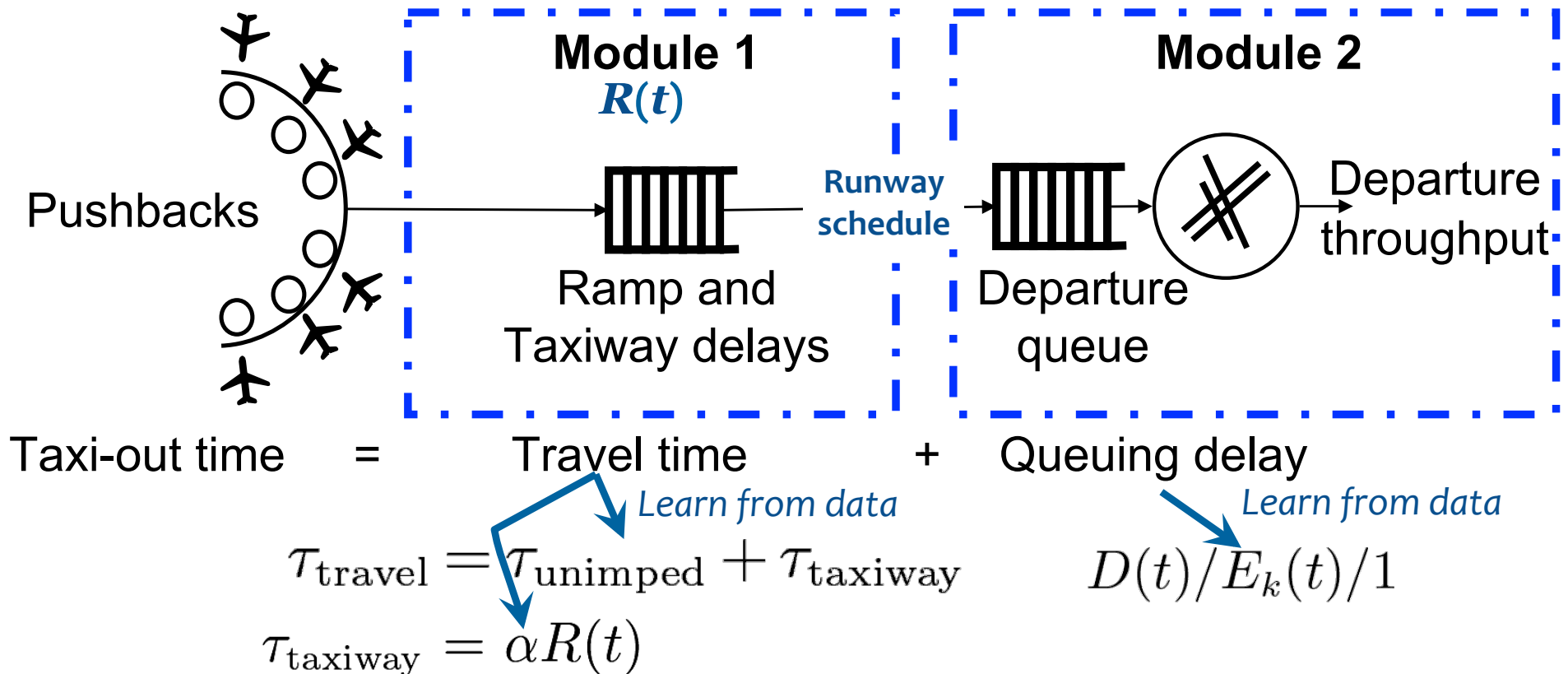
Data-Driven Modeling

A DAY IN THE LIFE OF
AIR TRAFFIC OVER
THE CONTINENTAL U. S.

ANIMATION CREATED USING

FUTURE ATM CONCEPTS
EVALUATION TOOL
(FACET)

FOR
AVIATION SYSTEMS DIVISION
(AF)
NASA AMES RESEARCH CENTER

Queuing Models of Airport Operations

Pushbacks

Module 1
$R(t)$

Ramp and
Taxiway delays

Runway
schedule

Module 2

Departure
queue

Departure
throughput

Taxi-out time = Travel time + Queuing delay

Learn from data

Learn from data

$$\tau_{\text{travel}} = \tau_{\text{unimped}} + \tau_{\text{taxiway}}$$

$$\tau_{\text{taxiway}} = \alpha R(t)$$

$$D(t)/E_k(t)/1$$

Simaiakis and Balakrishnan, under review, 2013

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Queuing Models of Airport Operations

* Model parameters identified from 2011 data, predictions carried out on 2010 data (pushback schedules)
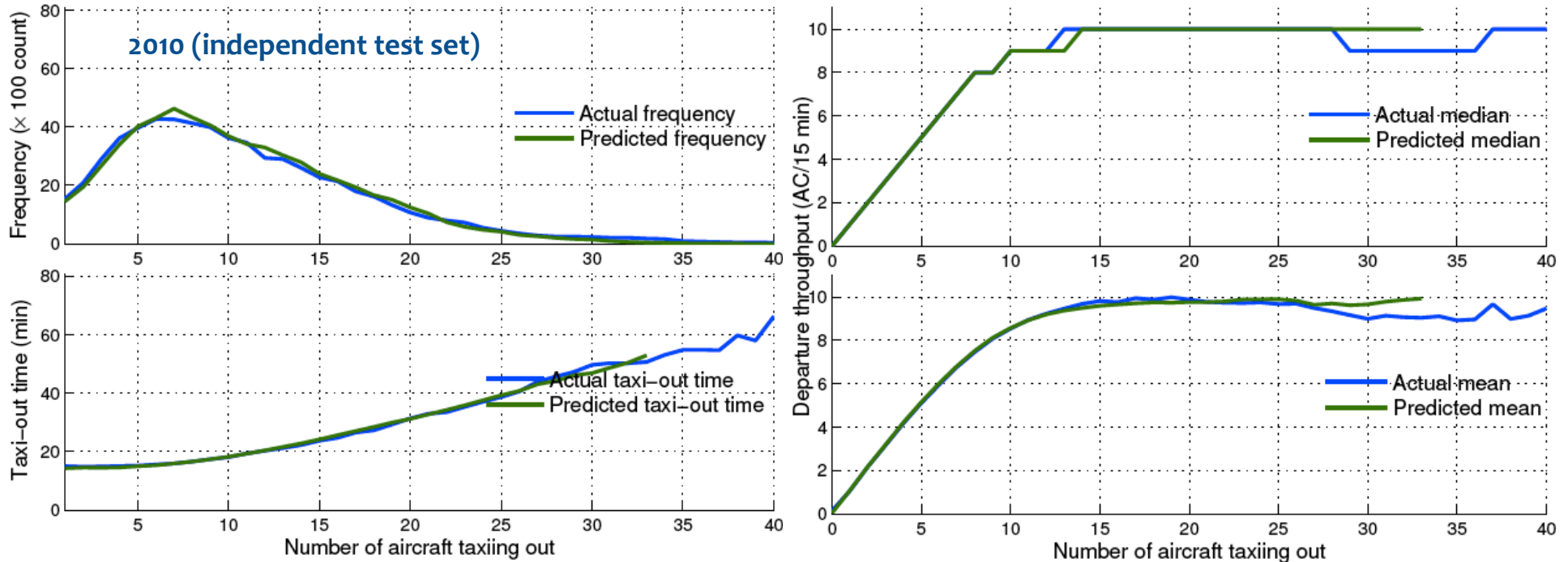
* Similar prediction performance shown for BOS, CLT, DTW, LGA, PHL, …
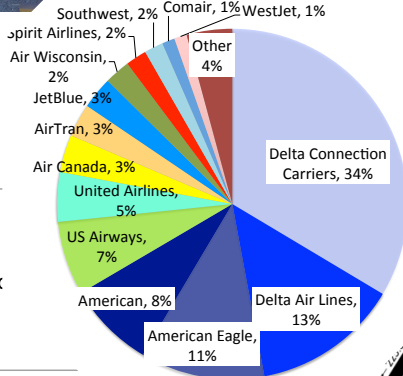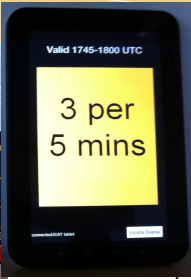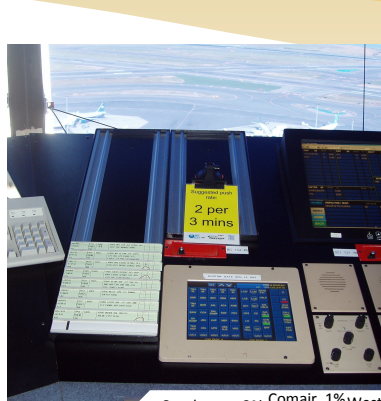
Simaiakis and Balakrishnan, under review, 2013

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Design, Field-Testing and Evaluation of Control Algorithms
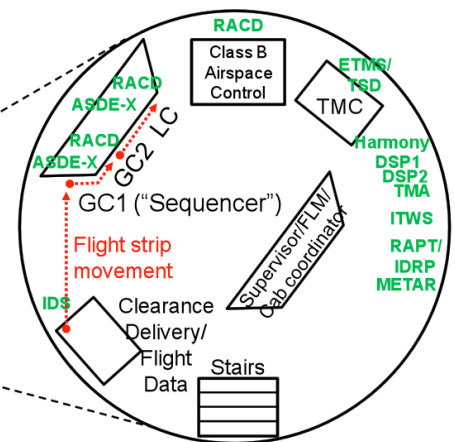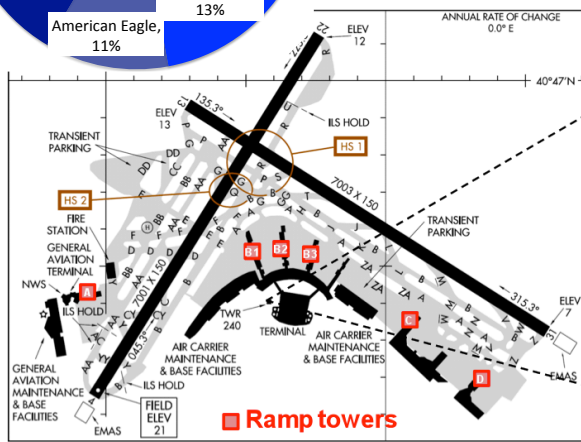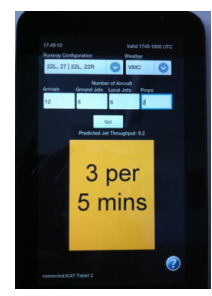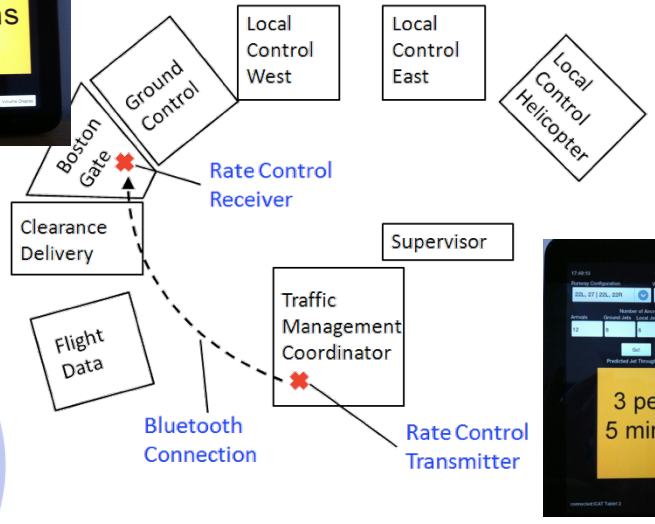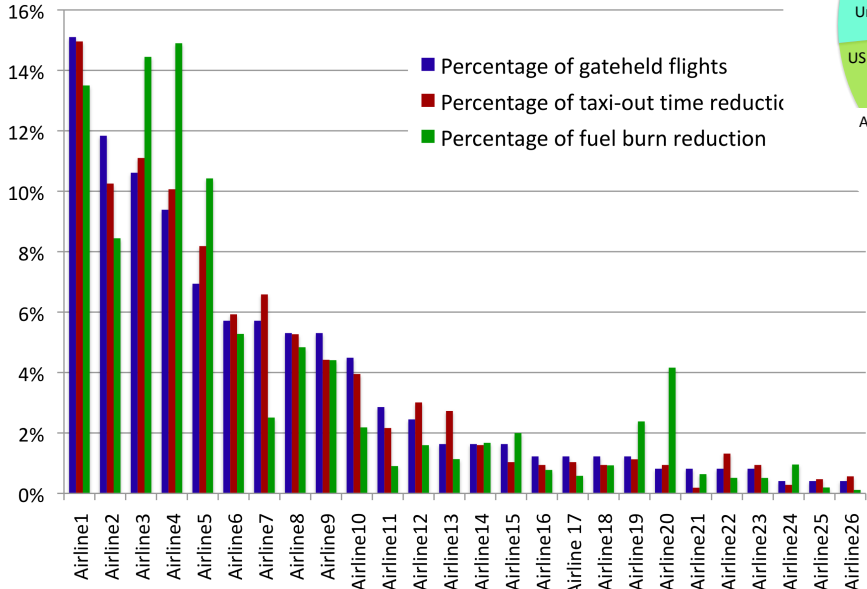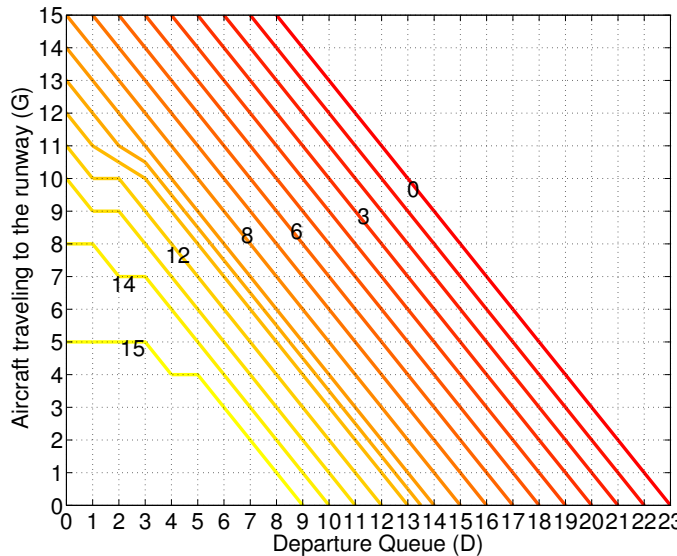
Fast-Time Simulations

* Validated fast-time simulations of airport and airspace operations

[Khadilkar & Balakrishnan, ECC 2013]
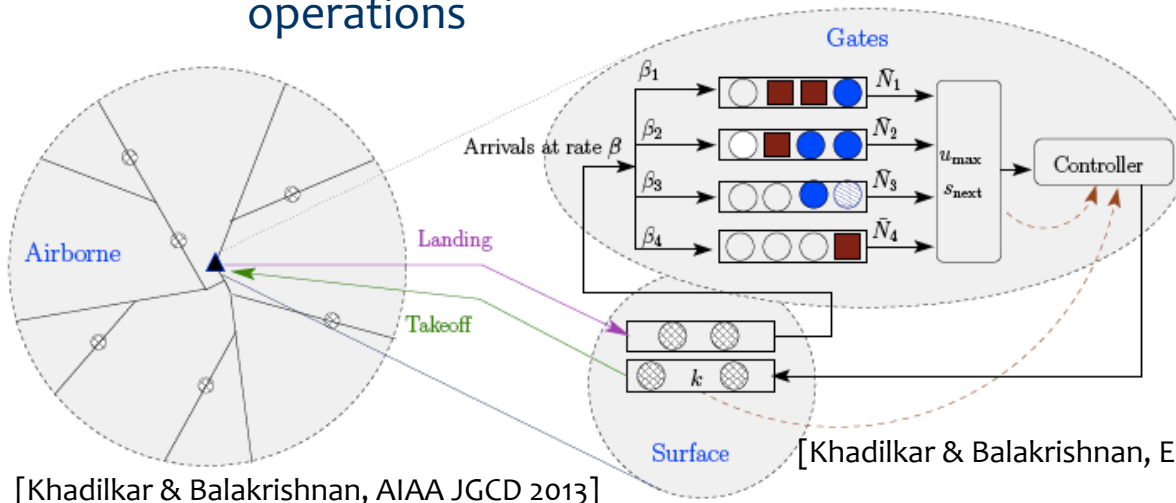
[Khadilkar & Balakrishnan, AIAA JGCD 2013]
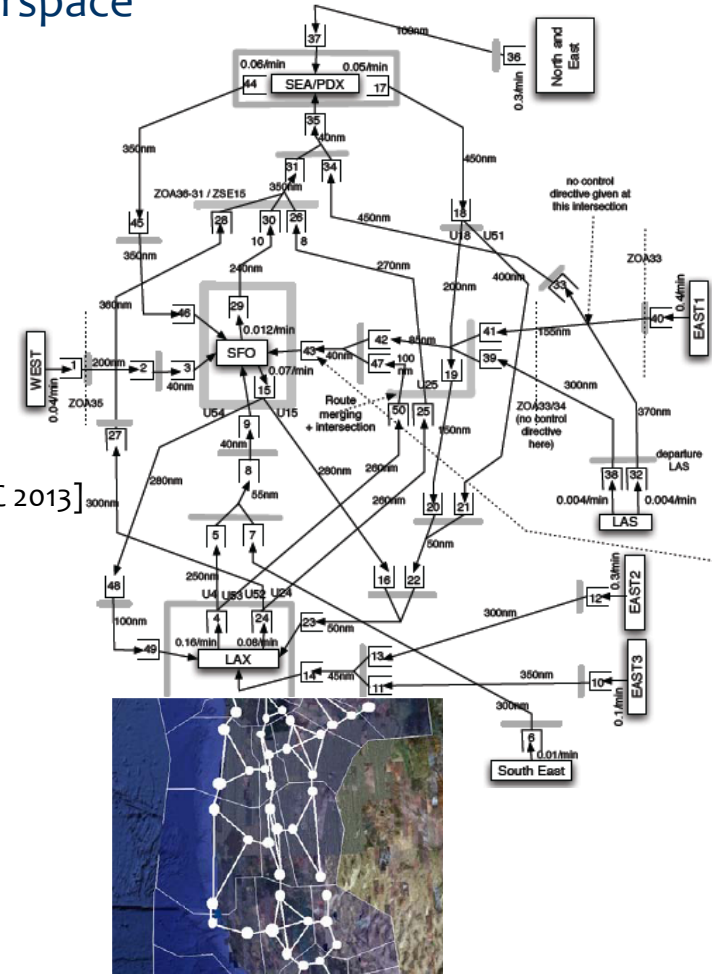
[Le Ny & Balakrishnan, AIAA JGCD 2010]
[Kannan, BS Thesis, Harvard Univ. 2009]
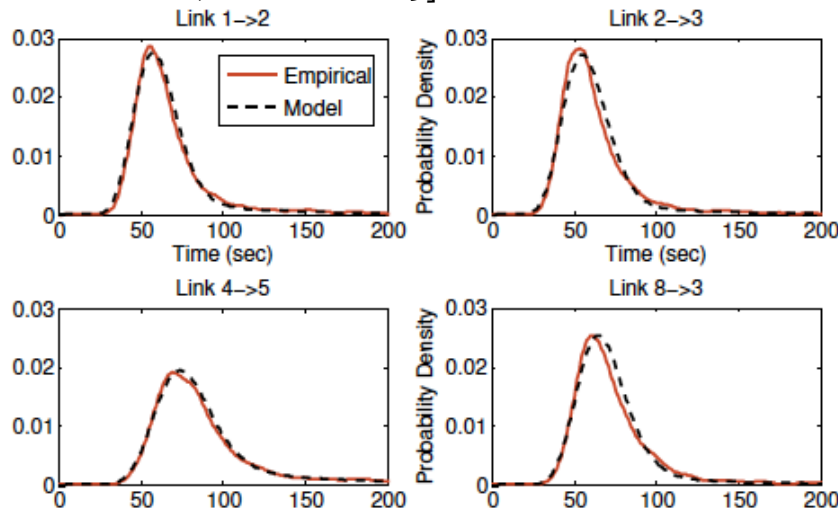
High-Fidelity Fast-Time Simulations using SIMMOD

Scheduled   Optimized

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Simulation of Control-Communication Integration

Park and Tomlin, ICCPS 2012

Park et al., IEEE Trans. on Intelligent Transp. Sys. 2013

Evaluation of Incentives in Collaborative Decision Making

* Simulations of (re)allocation mechanisms with **realistic demand, capacity and operating cost data**

* LGA case study
  * 10-hr Ground Delay Program
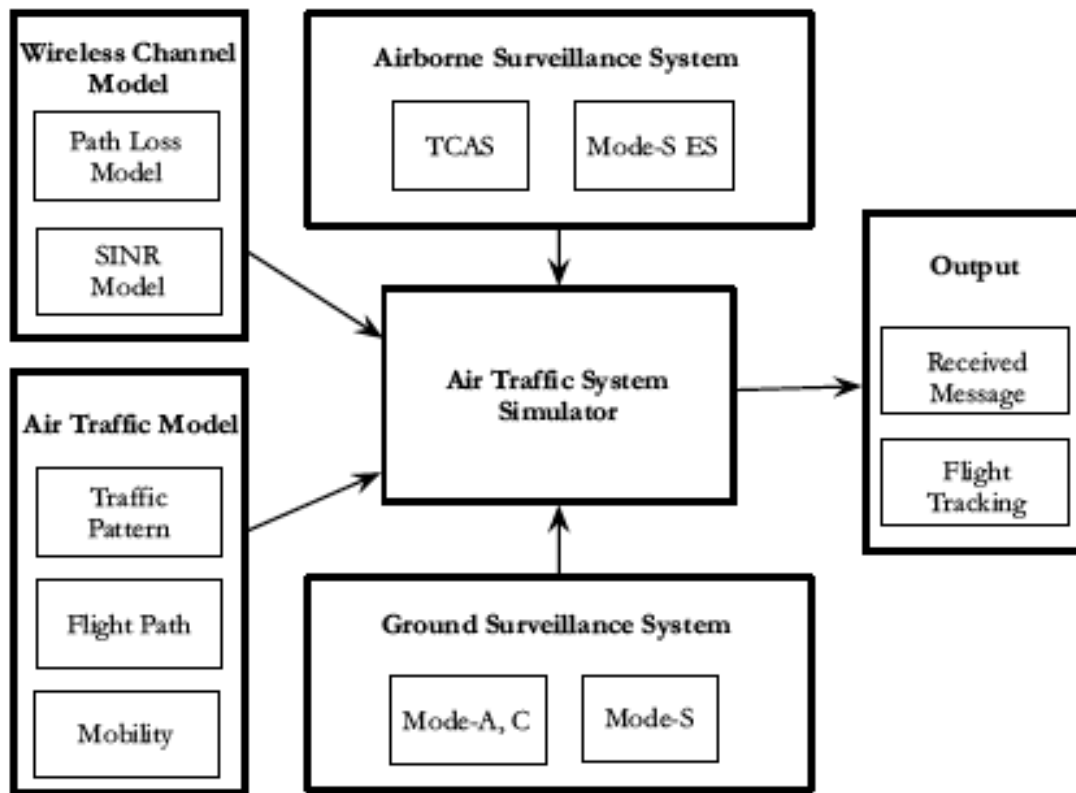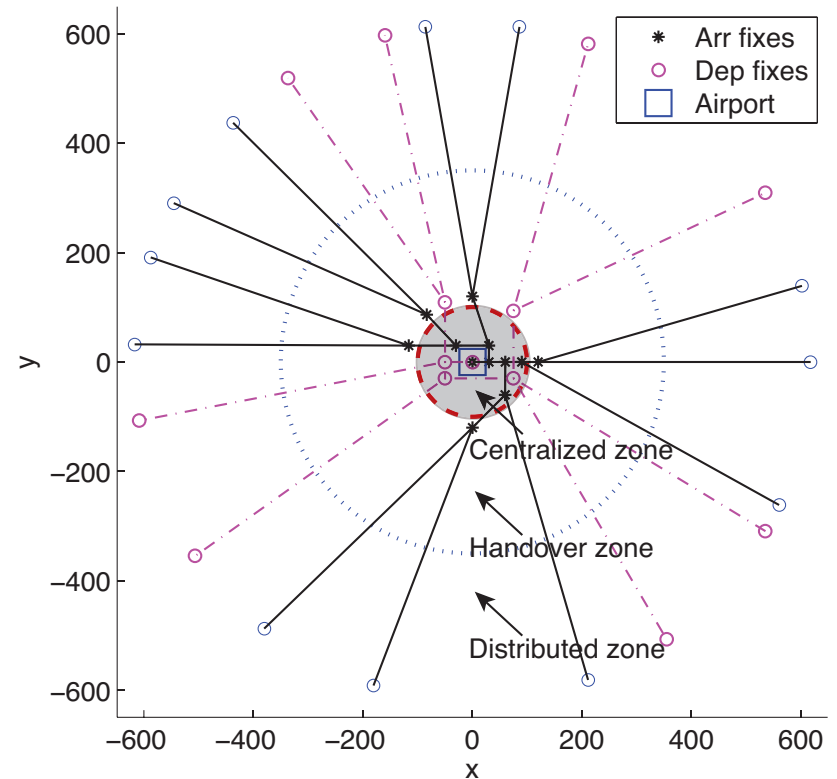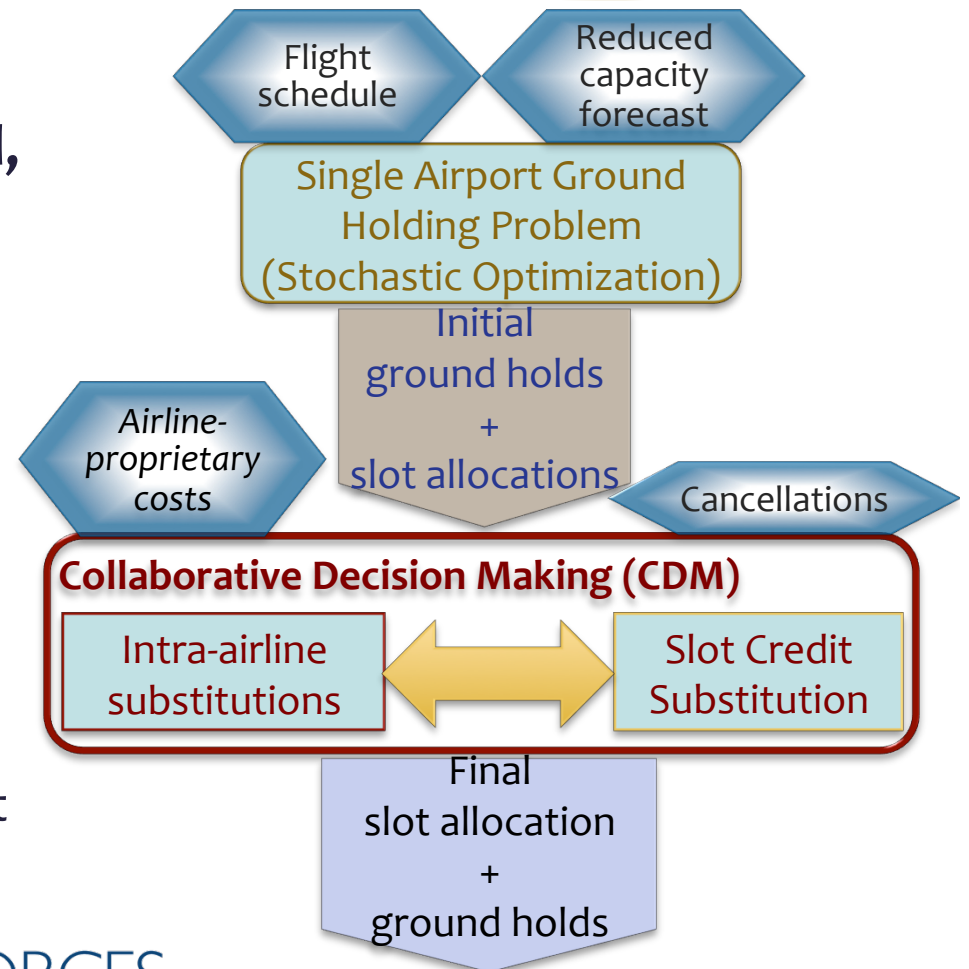 * 27 airlines
  * 20% coefficient of variation in delay costs
  * Demonstrate a tradeoff between adaptability (ability to dynamically replan) and flexibility (available slot swaps for airline)

Flight schedule

Reduced capacity forecast

Single Airport Ground Holding Problem (Stochastic Optimization)

Initial ground holds + slot allocations

Airline-proprietary costs

Cancellations

Collaborative Decision Making (CDM)

Intra-airline substitutions

Slot Credit Substitution

Final slot allocation + ground holds

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Ramanujam & Balakrishnan 2013, submitted

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Opportunities

* Design and evaluation of algorithms to improve air transportation system performance
  * Safety, security, efficiency, resilience
  * EI + RC integration for resource allocation
* Risk assessment and incentives for information-sharing
  * Strategies to incentivize equipage
  * Identification of "true" utility functions of human elements
* Resilient & secure ATC and CNS protocols
  * Evaluation of ADS-B protocols
  * Layered, adaptive security for NextGen
  * Safe integration of unmanned aircraft into the civilian airspace

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