Data Analysis and Simulation Tools

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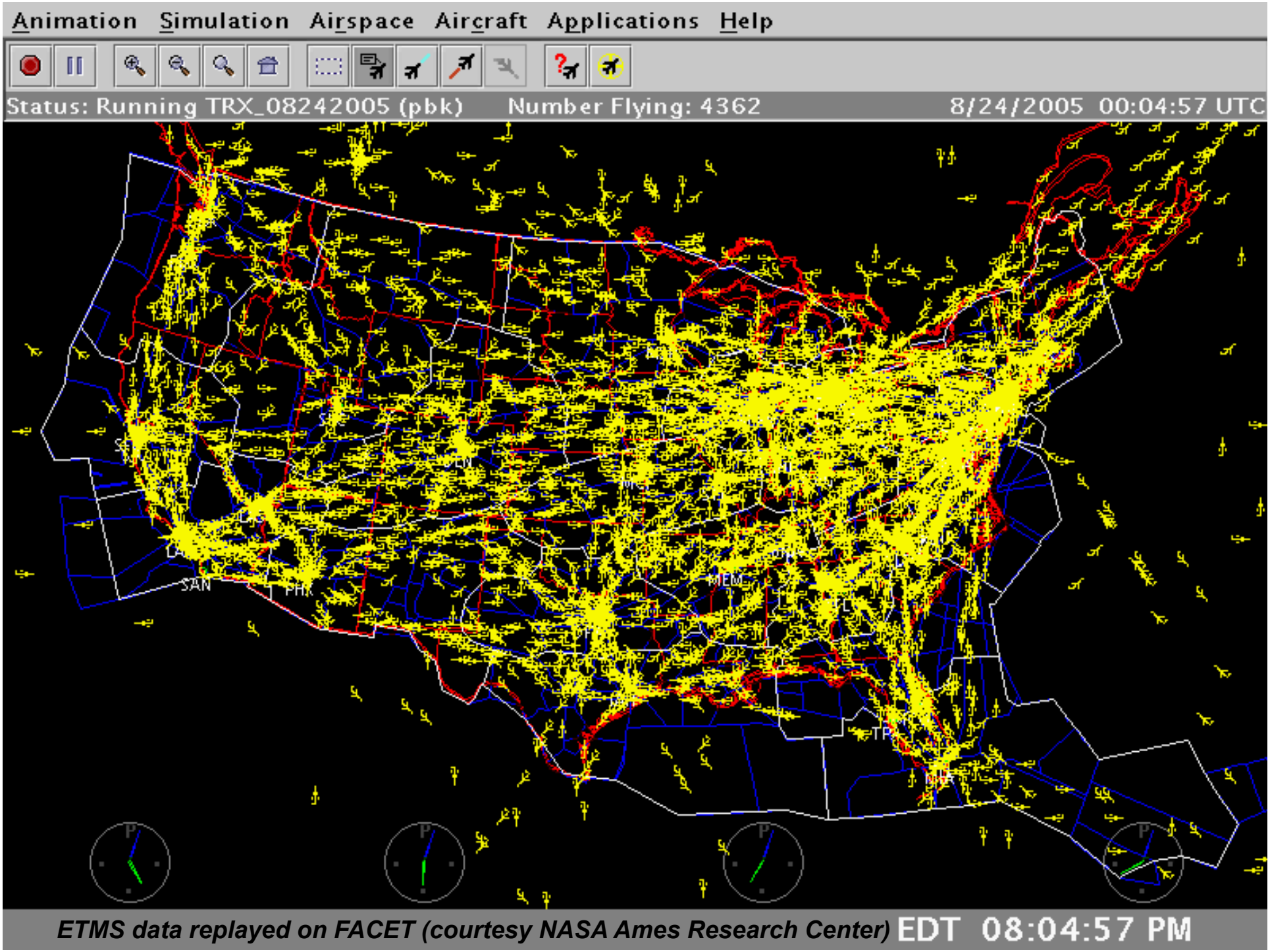
Purpose of archiving operational data

- **Operational data can be used to**
  - Develop modeling and simulation tools
  - Provide (and calculate) metrics that would be accepted by both government and industry as valid, accurate and reliable
  - Benchmark performance (for example, airport capacity)

Some aviation data sources in the US

- **ETMS:** Enhanced Traffic Management System
- **ASDE-X:** Airport Surface Detection Equipment – Model X
- **ASPM:** Aviation System Performance Metrics
- **ASQP:** Airline Service Quality Performance
  - Central Office of Delay Analysis (CODA) aims to perform the ASPM/ ASQP role in Europe
- **BTS:** Bureau of Transportation Statistics
  - Form 41
  - DB1B


Animation Simulation Airspace Aircraft Applications Help
Status: Running TRX_08242005 (pbk) Number Flying: 4362 8/24/2005 00:04:57 UTC
SAN
PHX
MEM
ATL
ETMS data replayed on FACET (courtesy NASA Ames Research Center) EDT 08:04:57 PM

ASDE-X visualization (Philadelphia Intn'l Airport, PHL)

Aviation System Performance Metrics (ASPM)

- **Arrival and departure rates:** Information on runway configuration, scheduled demand, arrival and departure rates and actual traffic counts per quarter hour
- **Cancellations**
- **Weather:** Current weather data (ceiling, visibility, temperature, wind angle and wind speed).
- Average taxi times

Airline Service Quality Performance (ASQP)

- **Data from Aircraft Communication and Reporting System (ACARS)**
  - Communications between aircraft and the Airline Operations Center (AOC)
  - VHF datalink

- **ACARS equipped flights transmit**
  - OUT Time (Brakes released, cabin doors closed)
  - OFF Time (Weight off landing gear, wheels-off time)
  - ON Time (Weight on landing gear, wheels-on time)
  - IN Time (Cabin door open)

"OOOI" data

- **Out, Off, On, In (OOOI) times**
- **Used to determine metrics**
  - On-time performance
  - Crew-member compensation
  - Block times
  - Taxi times (and conformance to tarmac rules)
- **Processed and provided by Aeronautical Radio, Inc. (ARINC) for all flights for participating carriers**

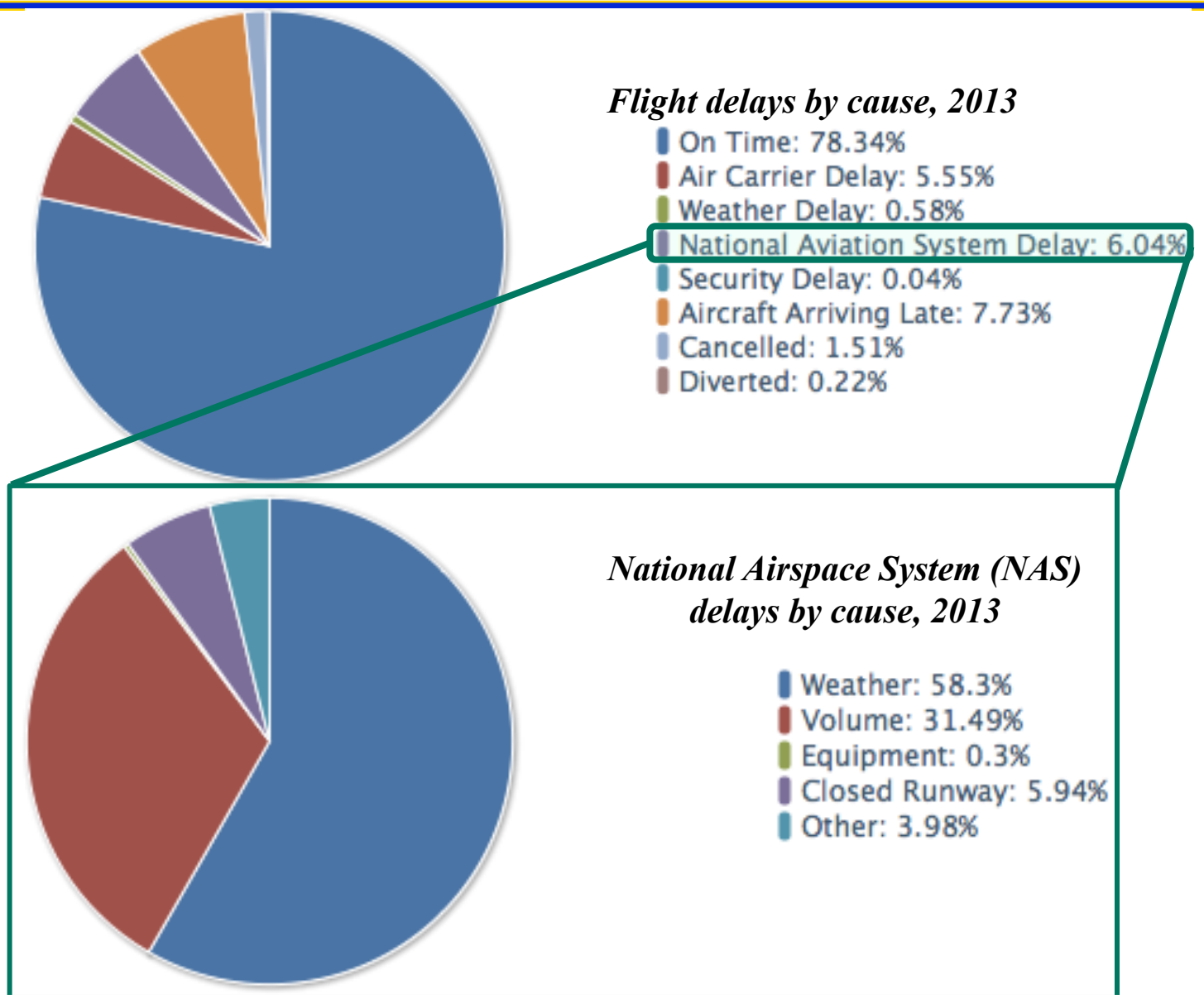
Official Airline Guide (OAG)

- **Planned flight times for all scheduled air carrier and commuter flights**
- **Flight information (including type of aircraft used) for all domestic (US) flights and all international flights that originate or terminate in the US**
- **No information on non-scheduled flights, cargo flights, general aviation and military flights**
- **Incorporated into FAA ASPM with the OOOI data**
  - Used to compare actual and scheduled departures

Airline on-time statistics

- **Causal data provided**
  - **Air Carrier**: The cause of the cancellation or delay was due to circumstances within the airline's control (e.g. maintenance or crew problems, aircraft cleaning, baggage loading, fueling, etc.).
  - **Extreme Weather**: Significant meteorological conditions (actual or forecasted) that, in the judgment of the carrier, delays or prevents the operation of a flight such as tornado, blizzard or hurricane.
  - **National Aviation System (NAS)**: Delays and cancellations attributable to the national aviation system that refer to a broad set of conditions, such as non-extreme weather conditions, airport operations, heavy traffic volume, and air traffic control.
  - **Late-arriving aircraft**: A previous flight with same aircraft arrived late, causing the present flight to depart late.
  - **Security**: Delays or cancellations caused by evacuation of a terminal or concourse, re-boarding of aircraft because of security breach, inoperative screening equipment and/or long lines in excess of 29 minutes at screening areas.

Delay causes



Other BTS data sources

- **Form 41 financial data:** Form 41 Financial Schedule consists of financial information on large U.S. certified air carriers--includes balance sheet, income statement, cash flow, aircraft inventory, aircraft operating expenses and operating expenses.

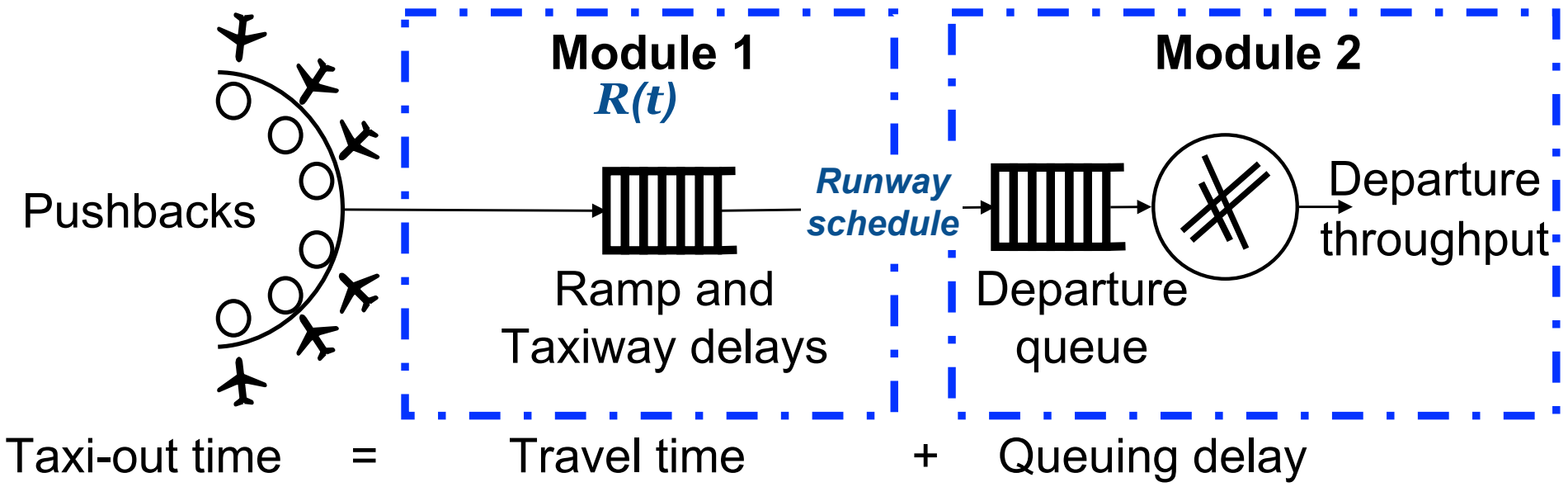
- **Airline origin and destination survey (DB1B):** Origin and Destination Survey (DB1B) is a 10% sample of airline tickets from reporting carriers. Data includes origin, destination and other itinerary details of passengers transported.

- **Air carrier statistics:** Monthly data reported by certificated U.S. and foreign air carriers on passengers, freight and mail transported. Also includes aircraft type, service class, available capacity and seats, and aircraft hours ramp-to-ramp and airborne

Airport operations simulation models

- **Macroscopic**
  - Aggregate surface flows
  - Queuing network models
- **Mesoscopic**
  - Node-link models
  - High-fidelity representations of some elements
- **Microscopic**
  - Detailed node-link models
  - Surface trajectories (routes and times)
  - E.g., SIMMOD

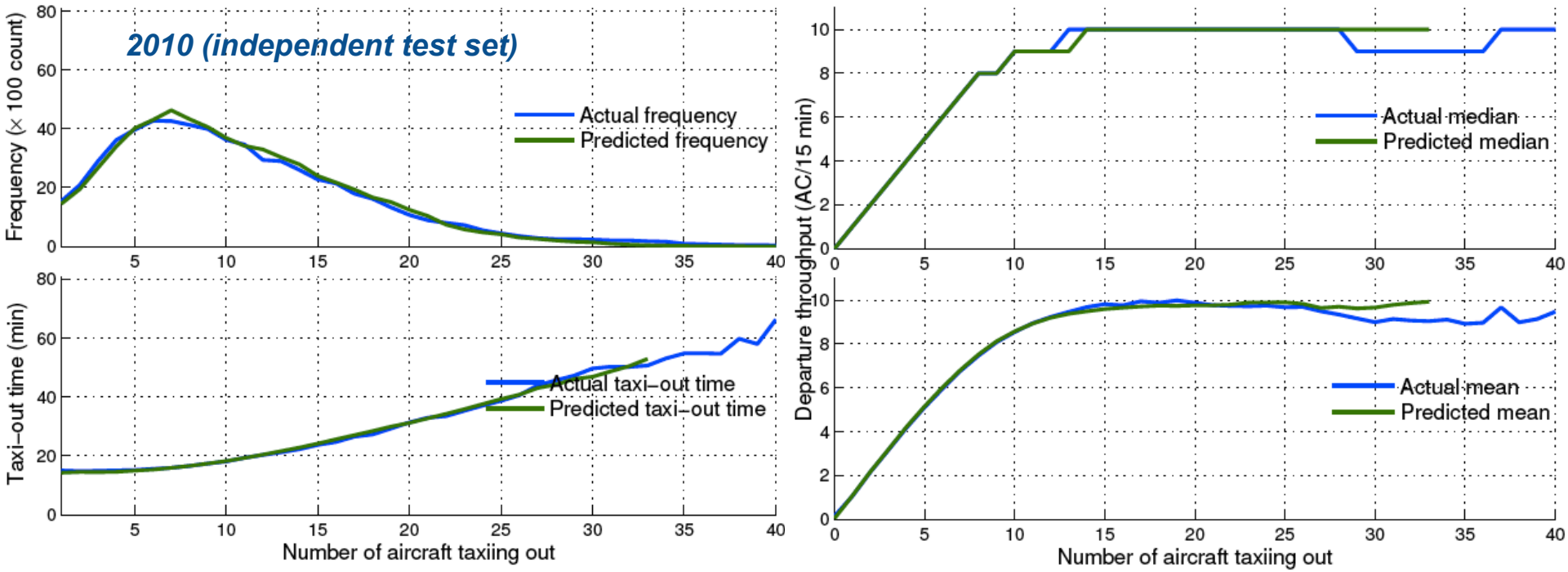
Queuing network model of the taxi-out process



Simaiakis and Balakrishnan, 2015

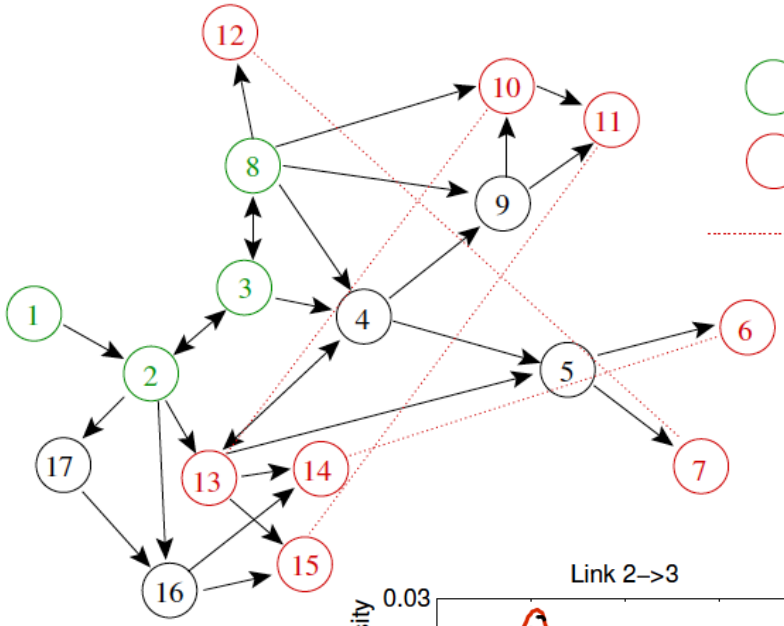
Newark Liberty Intl. Airport (EWR) model predictions

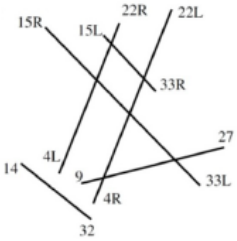
- **Model parameters identified from 2011 data, predictions carried out on 2010 data (pushback schedules)**

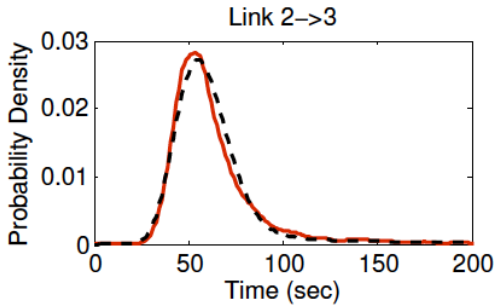


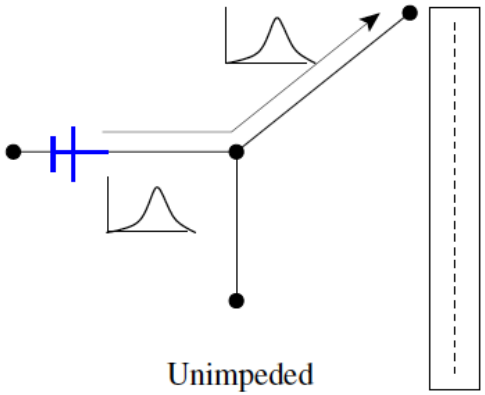
Simaiakis and Balakrishnan, 2015

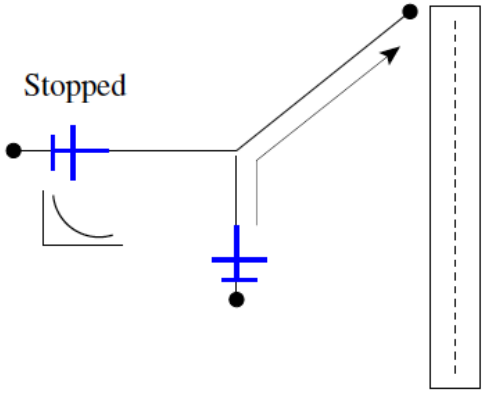
Mesoscopic models

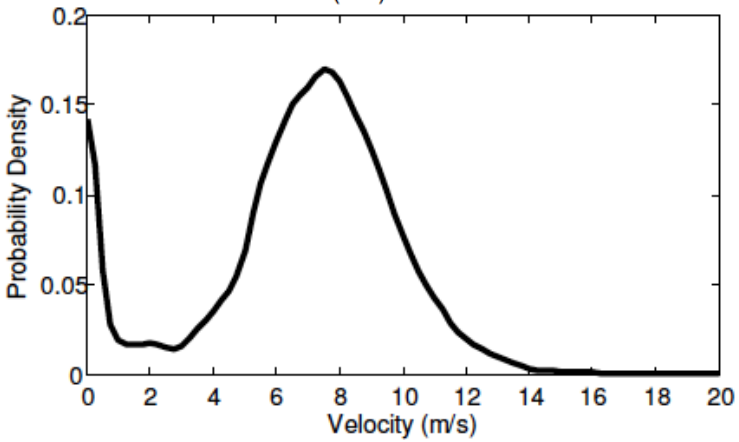






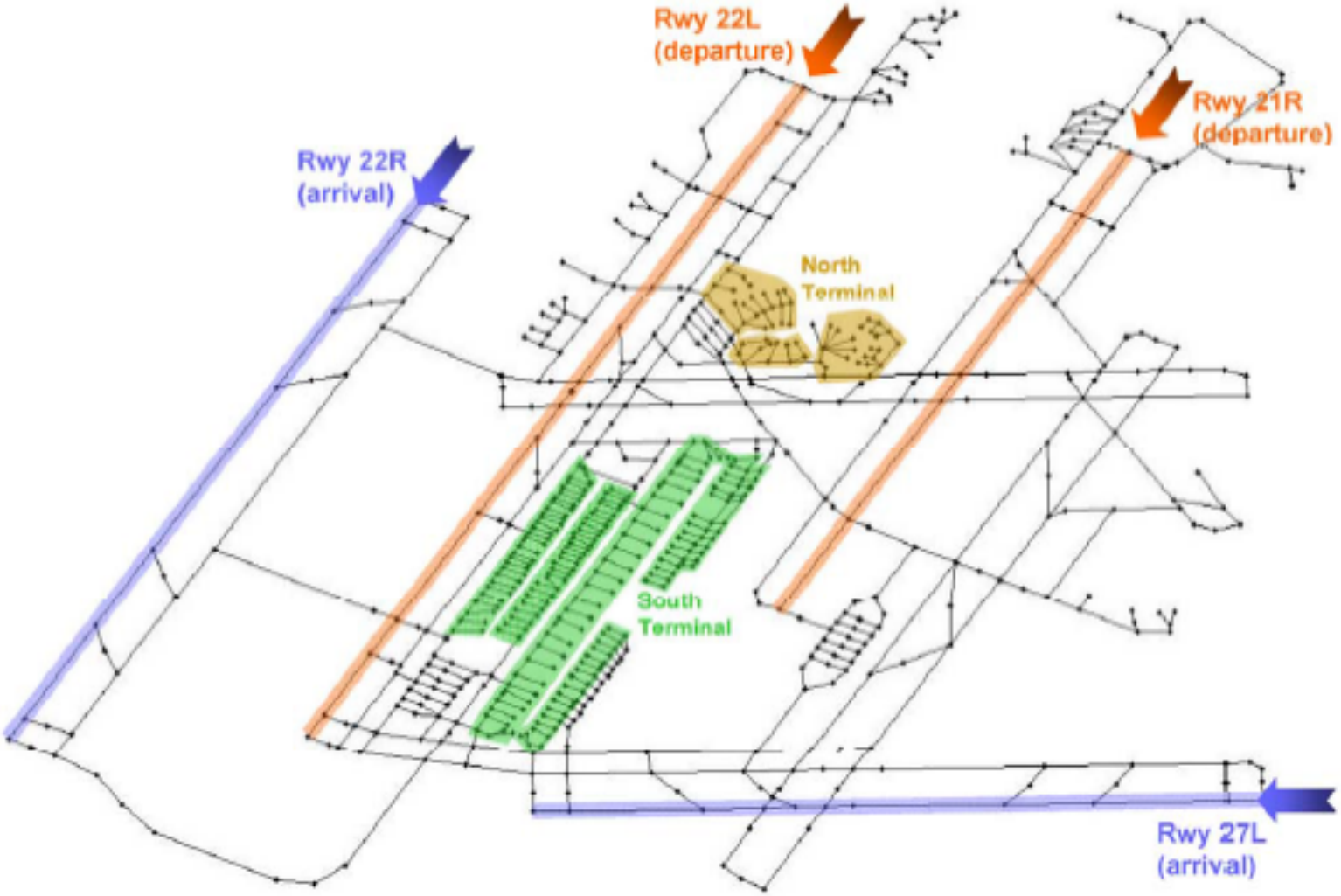






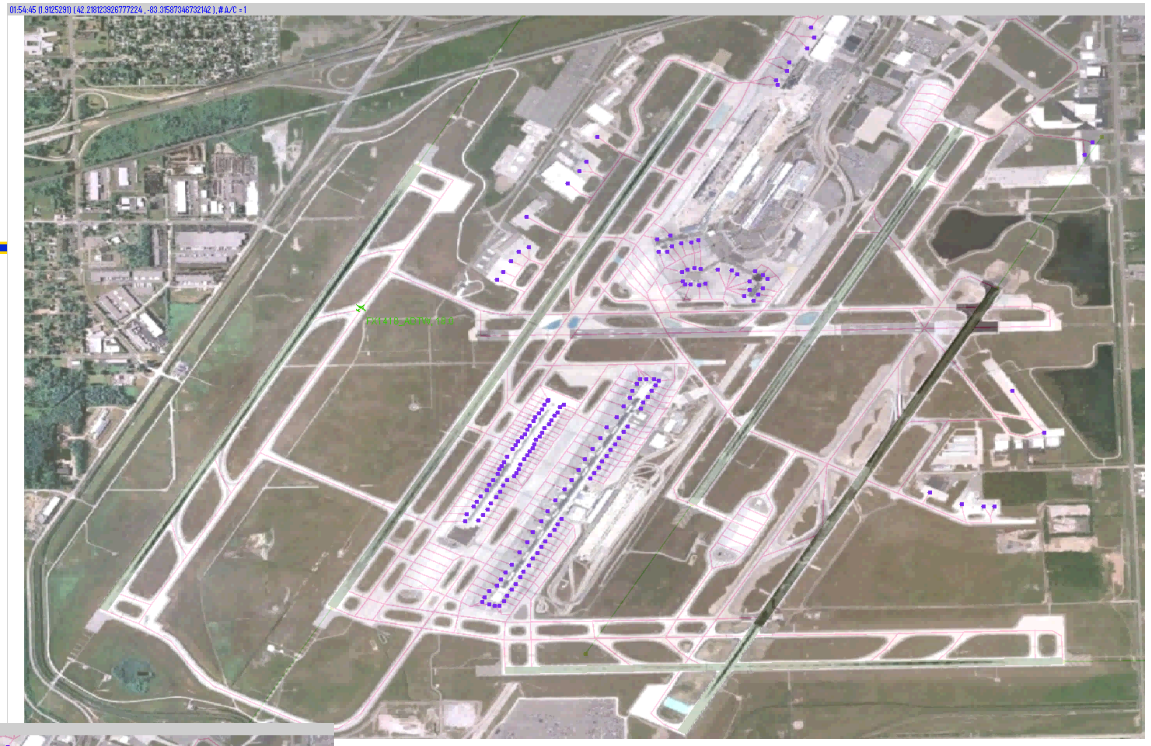
Khadilkar and Balakrishnan, 2014

Microscopic models



Lee 2013

Microscopic simulations



Lee 2013