A DATA ANALYSIS AND SIMULATION STUDY OF URBAN AIR MOBILITY

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Urban Air Mobility

- Urban Air Mobility (UAM) is a new air transportation market that moves people and cargo in urban and suburban environments

- UAM operations move beyond traditional air traffic management to higher levels of autonomy

- NASA's UAM Subproject is conducting research on new technologies and new airspace constructs for UAM operations to enable increased demand

- Recently concluded X4 simulations focused on Strategic Conflict Management automation software

- Leads to the question: "How do we assess the effectiveness of X4 system architecture and inform future development activities?"

Introduction

The right set of metrics can support evaluation of Urban Air Mobility (UAM) airspace research progress and outcomes, guide system design decisions, and planning for future research and development activities

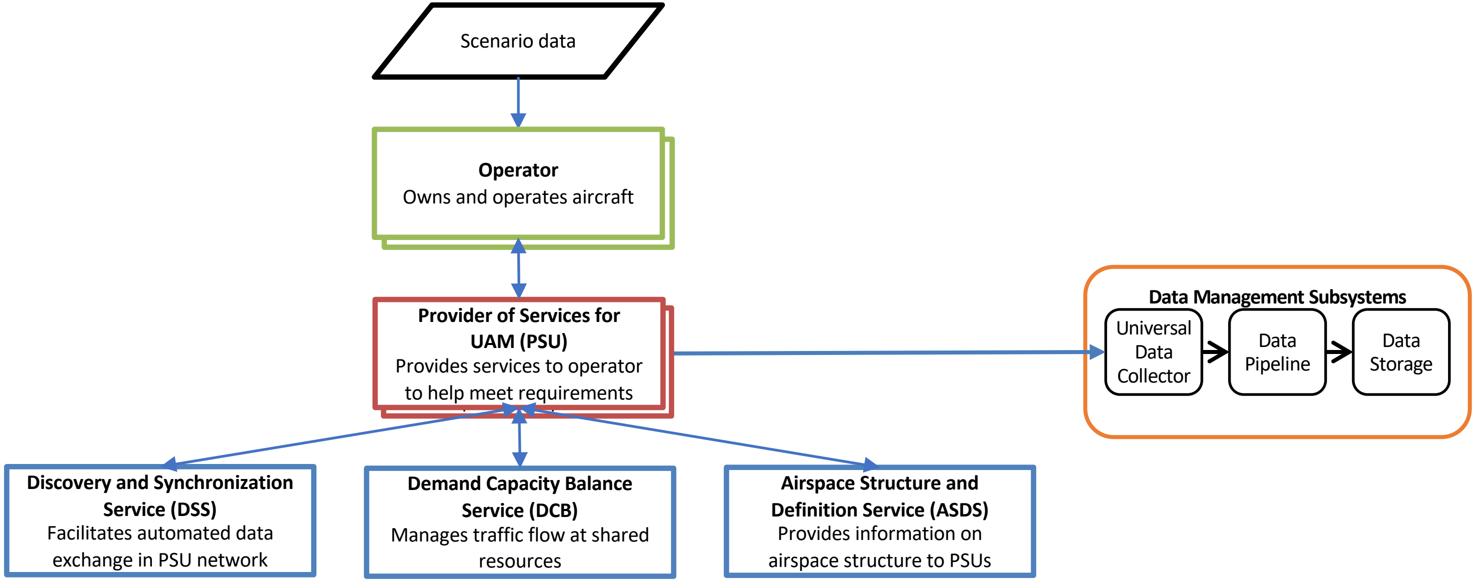
1. NASA conducted simulations to test strategic conflict management for UAM
2. We developed a set of system effectiveness measures and related metrics
3. We evaluated the results of simulation runs using selected metrics

NASA's Planned X-Series Simulations

- Previous X-series simulations
  - **X1** (2018): roles and responsibilities, information exchange requirements of UAM stakeholders, during nominal and off-nominal conditions
  - **X2** (2019): investigated applicability of UAS Traffic Management (UTM) information exchange architecture to UAM operations
  - **X3** (2020): assessed National Campaign airspace system and the capabilities provided by airspace partners

- **X4**: focus on strategic conflict management service for UAM operations
  - Simulation tests in collaboration with the industry supporting development and testing of a set of initial UAM airspace capabilities
  - Participants included NASA and seven industry partners

X4 Simulations and System Architecture



- FAA’s UAM Notional Architecture serves as basis of design
- Integrates and supports testing of services provided by third-party service providers

System Effectiveness Measures for X4

System Effectiveness Measure	Sample Metrics
Scalability	Total number of airborne operations per route, number of simultaneous operations
Efficiency	Throughput of UAM routes, actual arrival and departure rates at vertiports
Predictability	Number of aircraft delayed, percentage of conforming operations
Safety	Number of predicted demand capacity imbalances resolved/unresolved
Reliability	Communication latency
Responsiveness	Number of operations re-planned in response to airspace constraint

- System effectiveness measures are a qualitative assessment of system performance
- Metrics characterize effectiveness measures quantitatively

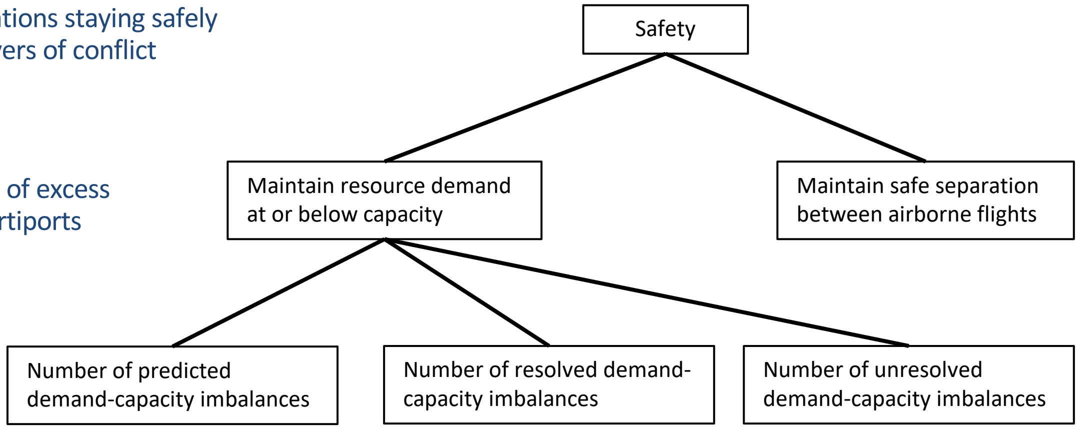
Metrics

- Project-level effectiveness measures are broken down into lower-level metrics

Effectively support UAM operations staying safely separated through multiple layers of conflict management

Resolve all predicted instances of excess demand over capacity at all vertiports

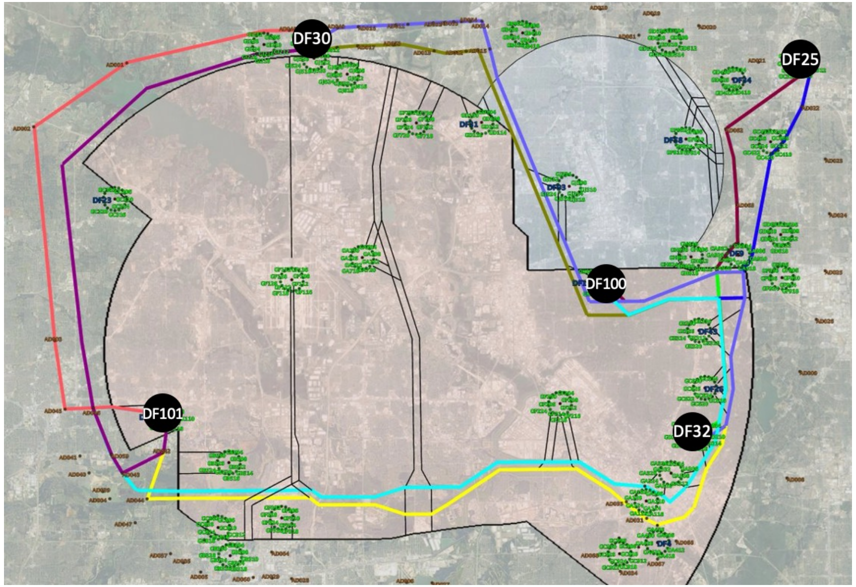
0 unresolved demand-capacity imbalances



Experiment Setup

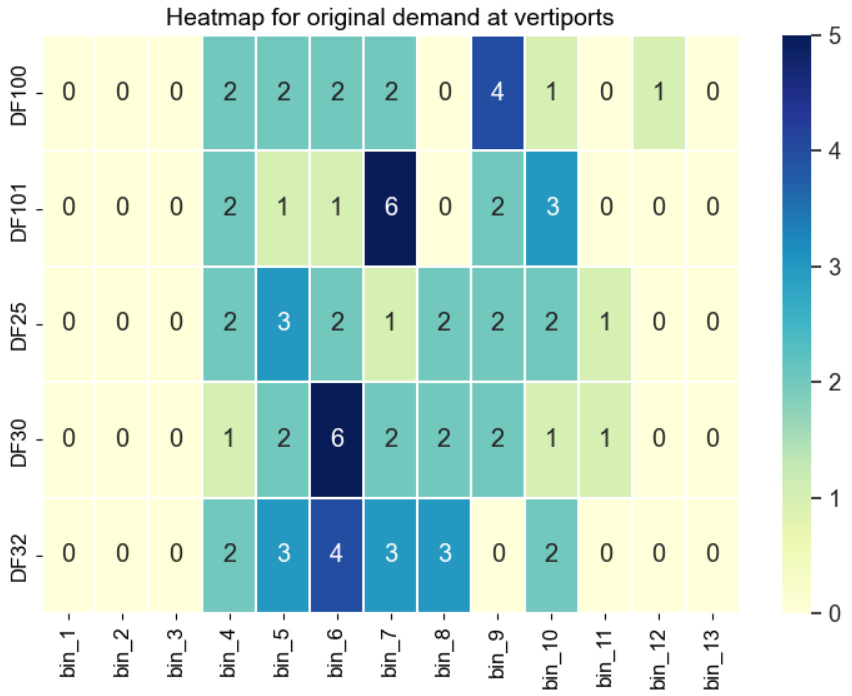
- X4 simulations focus on the development and integration of a strategic conflict management layer

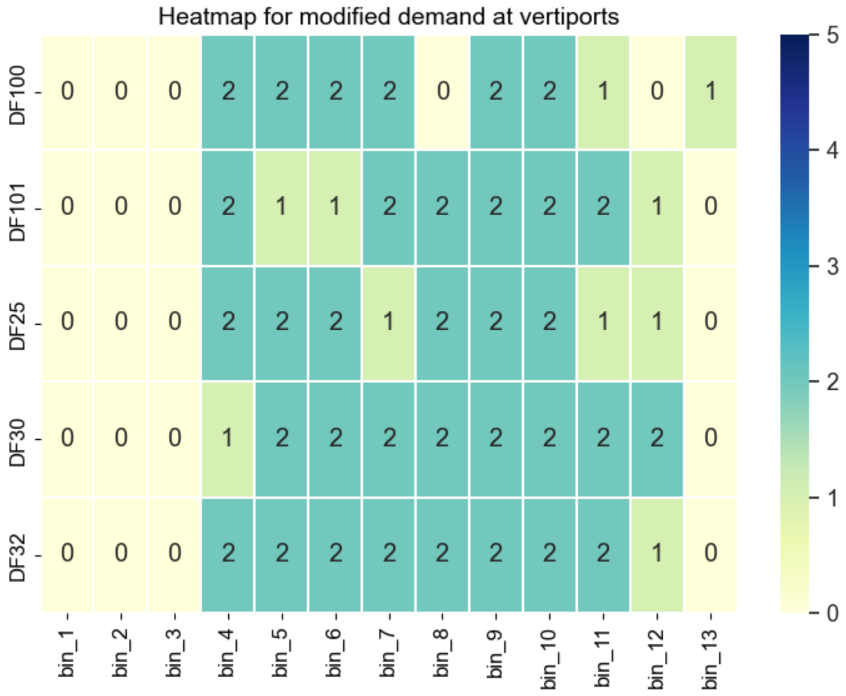
- Traffic scenario
  - Developed traffic scenarios that cause demand-capacity imbalances
  - 2 operators, 40 flights
  - Fixed route network with five vertiports
  - Vertiports have a capacity constraint of 2 operations per 12 minutes



Result of Demand Capacity Balancing

- Vertiports have a capacity constraint of 2 operations per time bin



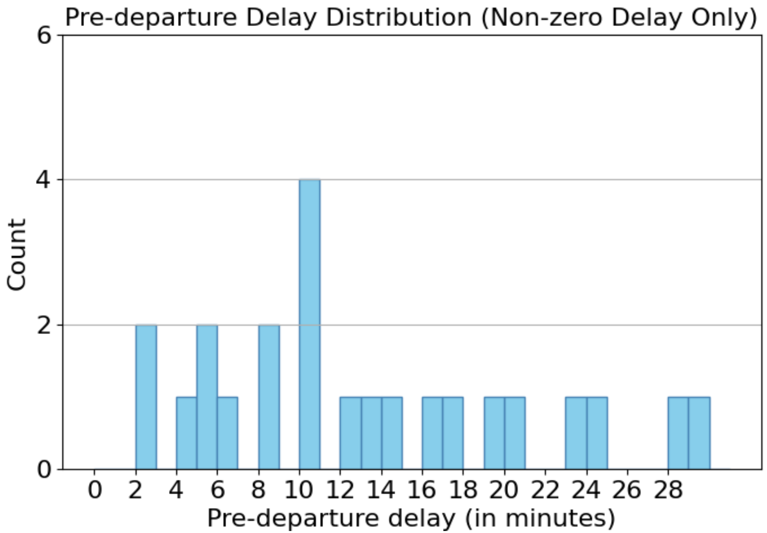


Pre-departure Delays

- The balancing algorithm resolves predicted demand-capacity imbalances by assigning pre-departure delays

- Number of aircraft delayed indicates system capacity – a high number of delayed aircraft indicates that there are more operations than the system can safely accommodate

- Excessive pre-departure delay reduce throughput pointing to a need for a more sophisticated DCB algorithm



23 of 39 operations were delayed

Summary

- Described simulation activities and system architecture for UAM airspace services research
- Described metrics for analysis of simulation data
- Presented a subset of results on demand capacity balancing and pre-departure delays
- Selection of metrics plays a critical role in UAM system design
- Further data analysis will be used to guide future development of UAM system architecture and in future X-series simulations

Thank You

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