Air Mobility Demand Estimation and Network Design for DFW Area

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Source: EmbraerX

Agenda

- Urban Air Mobility (UAM)
- UAM Demand Estimation
- UAM Network Design
  - Intermediate and expected results
- Ongoing and Future Work

Urban Air Mobility

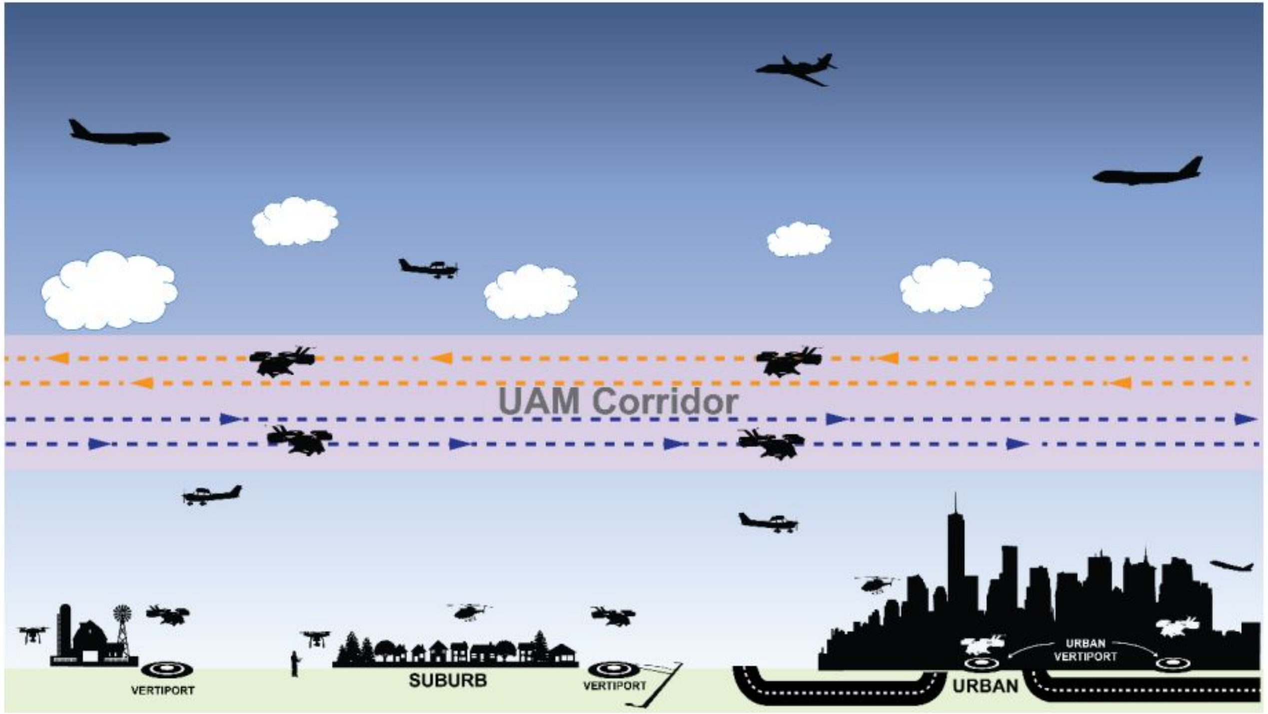
- Urban air mobility (UAM) utilizes highly automated aircraft to transport passengers or cargo within urban and suburban areas [FAA 2023]

Source: Left - NASA; Middle and right - EmbraerX

Urban Air Mobility

Designed to fly at lower altitudes over almost any kind of terrain

Adds a mobility solution to existing transportation networks to enhance the transportation efficiency



Source: FAA

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Urban Air Mobility

Benefits

- Reduced need for vehicle traffic within urban core
- Reduced emergency response times
- Increased range of access to the urban core
- Additional transportation demand management options
- Urgency-trip pairing with commuter transit
- Workforce development and economic opportunities
- Stronger connection of rural areas to urban opportunities
- Increased utility of GA airport infrastructure
- Additional disaster response capabilities
- Increased electrification for lower in situ emissions
- Elimination of transportation deserts

Source: Community Air Mobility Initiative 2020

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Urban Air Mobility

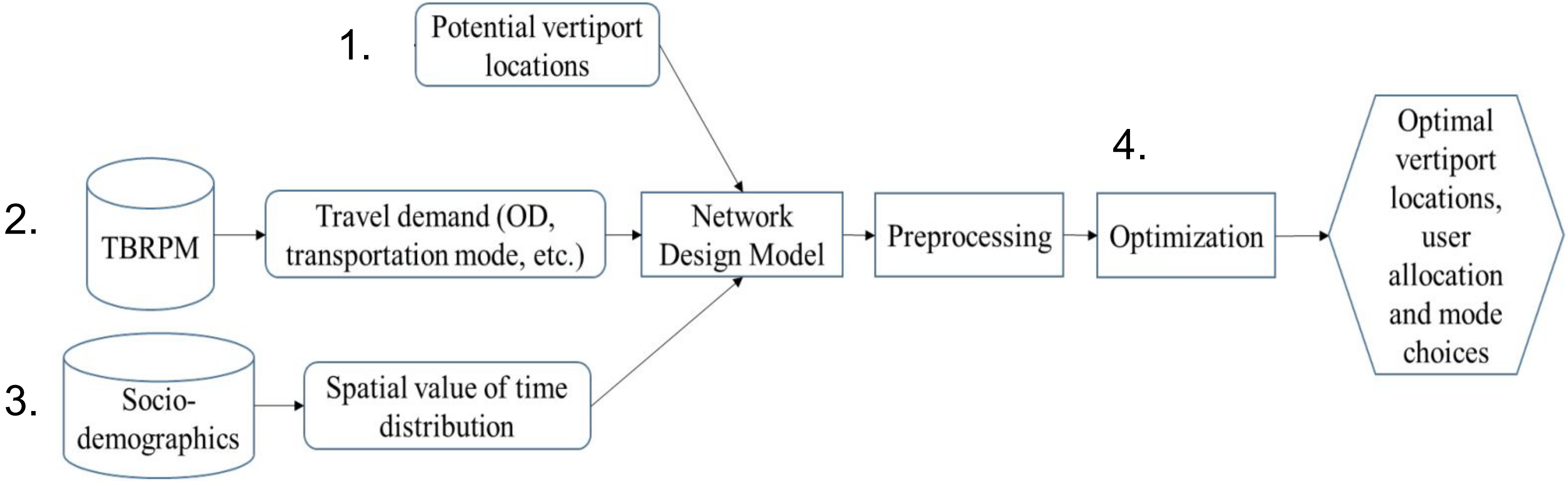
Air mobility trip as an individual

- Integrate with other transportation modes during access and egress

Source: Community Air Mobility Initiative 2021

UAM Network Design

Methodology: how to design the UAM network?



Air Mobility Network Design

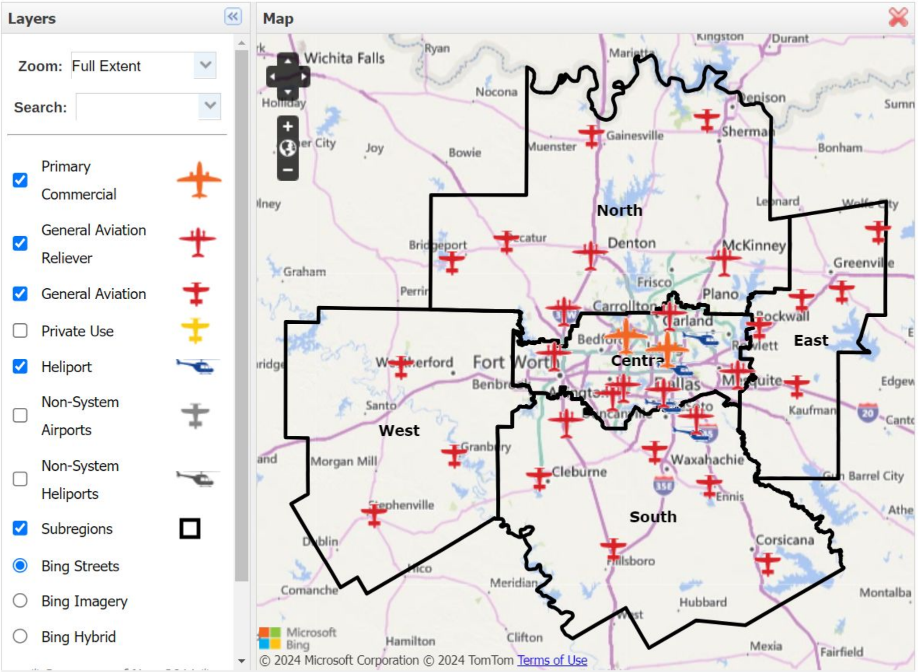
Vertiport can be: vertihub, vertiport, and vertistop

- Can be at street level or on top of buildings
- Have good connection services to roads, railway stations, buses, etc.

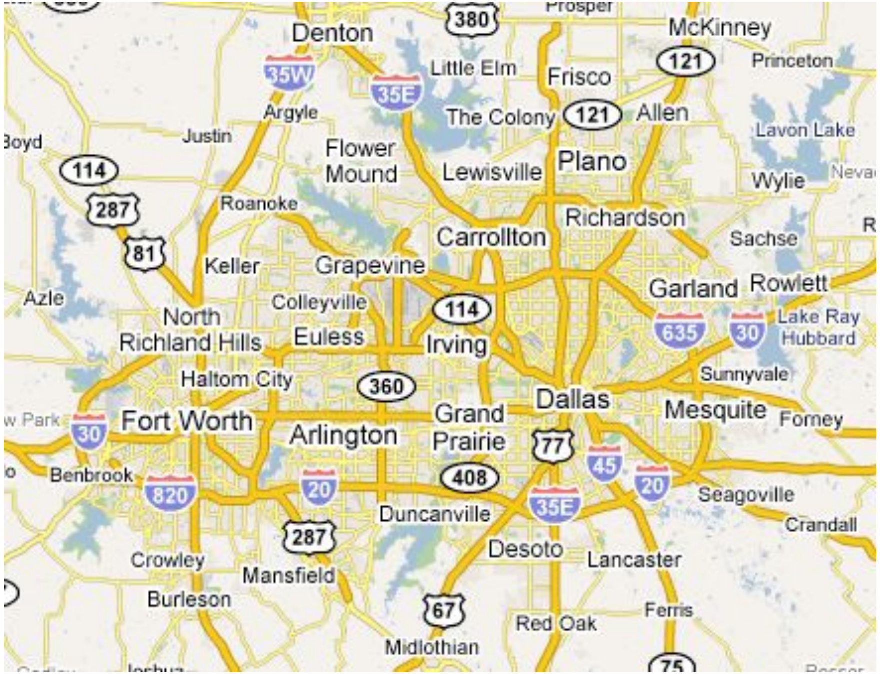
Air Mobility Network Design

Potential vertiport locations

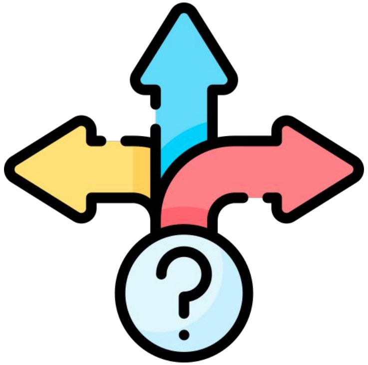
Existing nonprivate airports (30)



Major city centers (How many?)



Air Mobility Network Design



- Mathematical formulation
  - Decisions we need to make
    - Optimal locations of vertiports among the candidates
  - Objective: optimal is what sense?
    - Minimal total cost (time is monetized)

$$\min \sum_{p \in P} \Big\{ (t^p \cdot \gamma^p + c^p) \cdot z^p + \sum_{k} \sum_{d \neq k} [c_{kd} + (t_{kd} + t_{\text{tw}} + t_{\text{tl}}) \cdot \gamma^p)] \cdot x^p_{kd}$$

$$+ \sum_{a} \sum_{k} g^p_{ak} (t^p_{ak} \cdot \gamma^p + c^p_{ak}) + \sum_{e} \sum_{d} h^p_{ed} (t^p_{ed} \cdot \gamma^p + c^p_{ed}) \Big\}$$

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Air Mobility Network Design

- Mathematical formulation
  - Tons of constraints

s.t.

$$\sum_k y_k = u, \ \forall k \in M$$

$$z^p + \sum_k \sum_{d\neq k} x^p_{kd} = 1, \ \forall p \in P$$

$$\sum_{d\in M, d\neq k} x^p_{kd} + \sum_{d\in M, d\neq k} x^p_{dk} \le y_k, \ \forall k \in M, \ \forall p \in P$$

$$\sum_k \sum_{d\neq k} x^p_{kd} = \sum_a \sum_k g^p_{ak}, \ \forall p \in P$$

$$\sum_k \sum_{d\neq k} x^p_{kd} = \sum_e \sum_d h^p_{ed}, \ \forall p \in P$$

$$2x^p_{kd} \le \sum_a g^p_{ak} + \sum_e g^p_{ed}, \ \forall k, d \neq k \in M, \ \forall p \in P$$

$$\left[t^p - \sum_k \sum_{d\neq k} (t_{kd} + t_{tw} + t_{tl}) \cdot x^p_{kd} - \sum_a \sum_k g^p_{ak} t^p_{ak} - \sum_e \sum_d h^p_{ed} t^p_{ed}\right] \cdot \gamma^p \ge \sum_k \sum_d c^p_{kd} \cdot x^p_{kd} + \sum_a \sum_k g^p_{ak} c^p_{ak} + \sum_e \sum_d h^p_{ed} c^p_{ed} - c^p, \ \forall p \in P$$

$$z^p \in \{0,1\}, y_k \in \{0,1\}, x^p_{kd} \in \{0,1\}, g^p_{ak} \in \{0,1\}, h^p_{ed} \in \{0,1\}$$

Air Mobility Network Design

- Solution: how to solve this problem?
  - NP-hard (the hardest among hard optimization problems)

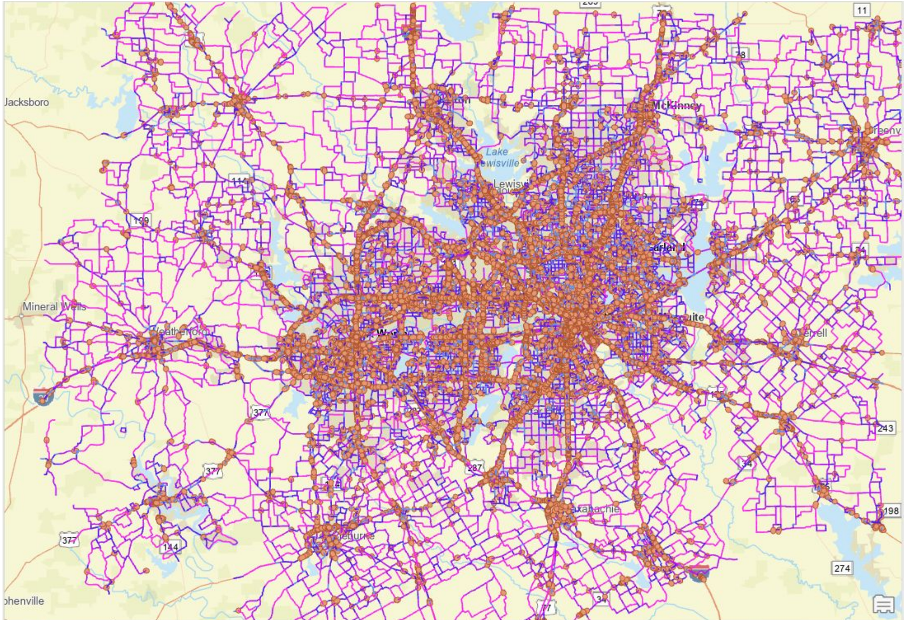
  - The number of vertiport candidates is relatively small, making it ‘not so NP-hard’.

Air Mobility Network Design

- Final results yet to come
  - The tool for processing the original data is not available for us

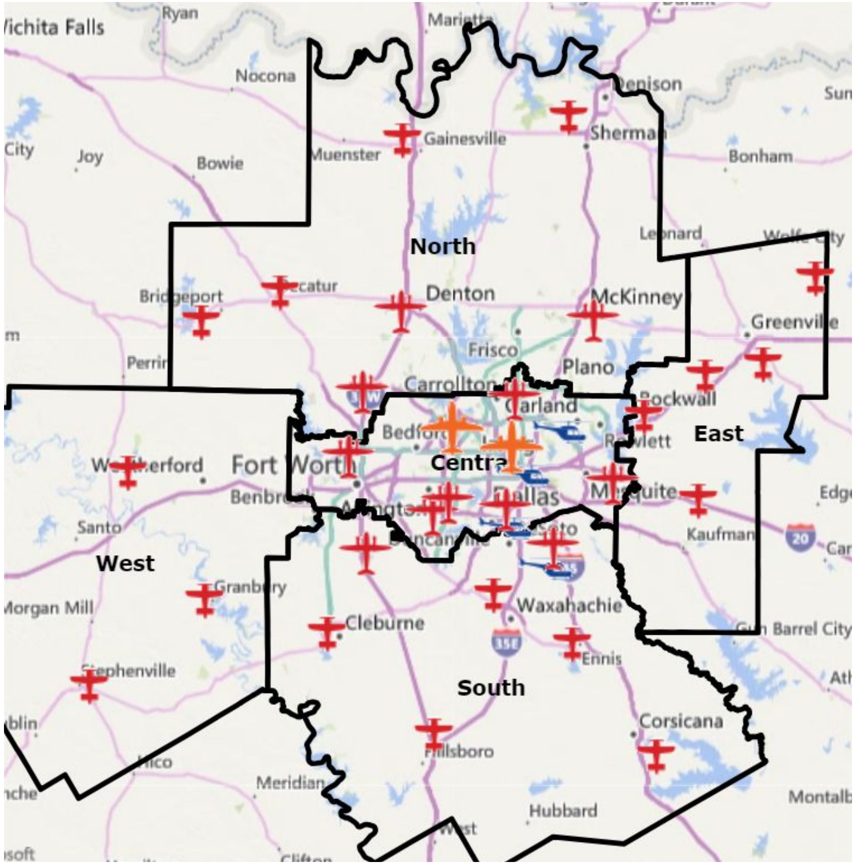
TransCAD
Transportation Planning Software

- Intermediate results
  - Travel time during morning rush hours



Air Mobility Network Design

- Expected results be like
  - Selected existing airports and city centers for vertiport development



Ongoing and Future Work

- A more accurate estimate of UAM demand using the trip data
  - Origin and destination, purpose, trip time, etc.
- Sensitivity analysis
  - How do monetized travel time, vertiport availability, and pricing strategies impact the UAM network?

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Thank you!

North Central Texas
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