Integrating Mobile Location Data into Vertiport Siting Optimization for UAM Airport Access

A Case Study of the Chicago Multi-Airport Region

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Takeaway: Optimal vertiports could act as intermodal interceptors at surface bottlenecks, as network viability and footprint are far more sensitive to pricing than cruise speed. Robustness heatmaps enable phased, low-risk rollout.

Why this matters (airport access):

- Trips are time-sensitive; UAM must win on generalized cost vs auto/transit/TNC.
- Early deployment is uncertain (fare, capacity, processing time, budgets).

Core innovations:

- Revealed-preference Demand: mobile location data → tract-level airport-access demand.
- Behavior + Optimization: logit adoption → MILP siting under conservative constraints.
- Intermodal Interceptor Siting: sites intercept congestion corridors, not just dense/wealthy tracts.

Study Subject and Data:

- UAM shuttle planning for Chicago O'Hare (ORD) and Chicago Midway (MDW).
- All census tracts reachable within 120 minutes of driving using ArcGIS Network Analyst's OD cost matrix
- Mobile location data obtained from ***SafeGraph*** based on anonymized GPS signals from roughly 45+ million devices Includes OD patterns to studied airports

Method Pipeline:

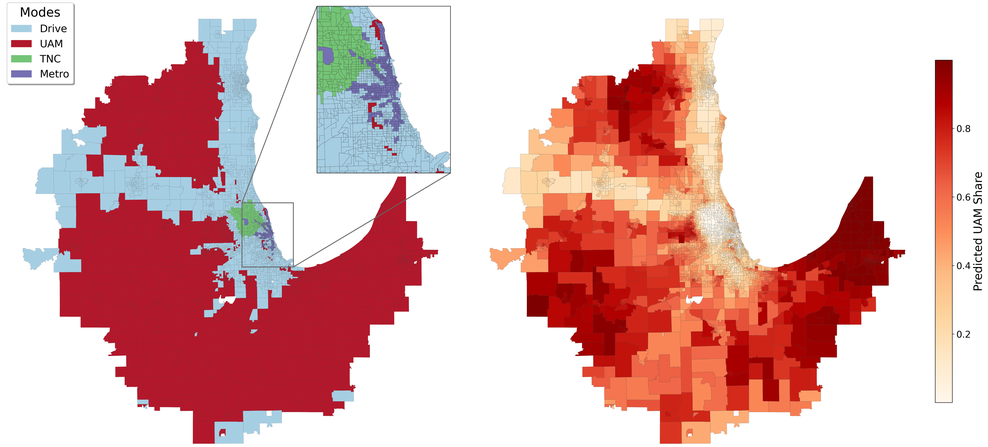
1) *Demand*: mobile OD traces → tract→airport demand (revealed preference).
2) *Generalized costs*: auto/CTA/TNC baseline estimated based on realible sources; UAM adds first-mile + prep buffer + fare.
3) *Adoption*: binary logit converts cost differences to other modes into probabilistic market share.
4) *Siting MILP*: choose vertiports + size tiers; assign demand to maximize expected cost savings.
5) *Robustness*: scenario sweeps across fare/speed/budget/capacity/frictions → elasticities + rank robustness; aggregate siting frequency → heatmap.

DATA	COST	BEHAVIOR	OPTIMIZATION	UNCERTAINTY
Revealed Demand	Generalized Cost	Logit Adoption	Siting MILP	Scenario Ensemble

Objective to maximize system-wide social welfare:

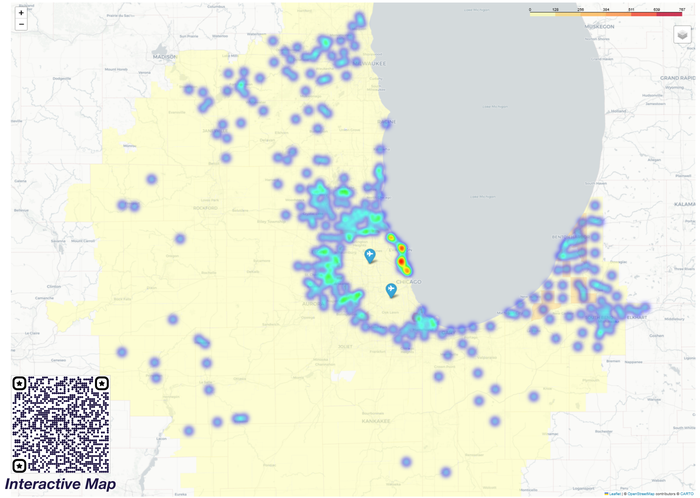
$$\max Z = \sum_{i\in I}\sum_{j\in J}\sum_{a\in A} Q_{i,a}\cdot P_{i,j,a}\cdot\left(G_{i,a}^{\text{alt}} - G_{i,j,a}^{\text{UAM}}\right)\cdot x_{i,j,a}$$

- Including the consideration of variables/drivers from (1) UAM service levers & access frictions (2) Infrastructure & operational constraints (3) Market & ground context (4) Demand representation & choice response



Preliminary assessment of ORD access mode competitiveness as an example

L: census tracts classified by the access mode with the lowest generalized cost under the default parameter set.
R: predicted UAM market share for trips obtained from the logit choice model comparing UAM to the best ground alternative.

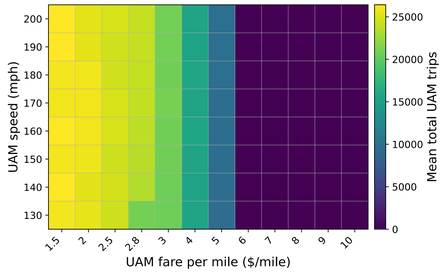


Interactive Map

Senerio Ensemble:

Aggregated vertiport placement heatmap across 864 parameter scenarios. Warmer colors = selected more frequently

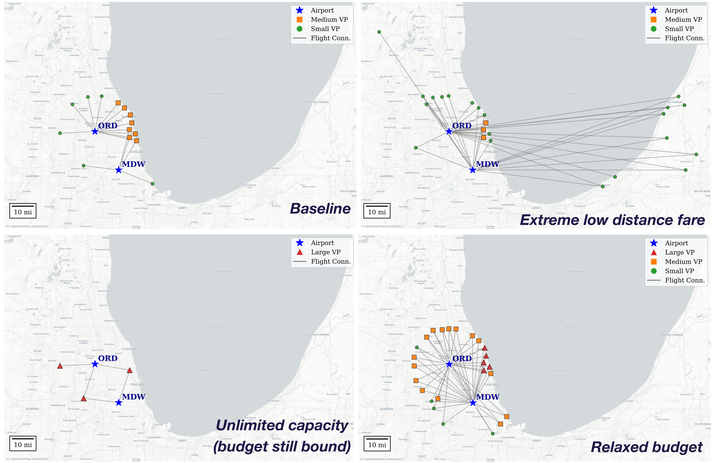
- The most robust locations are not simply "the farthest suburbs"
- They function as intermodal interceptors. These placements capture time-sensitive travelers before they encounter the region's most severe surface-network bottlenecks, and then hand them to a fast, reliable aerial leg
- When assumptions become more favorable, the solution can then afford to expand beyond them.



Fare dominates speed

Fare × speed joint sensitivity of system performance

Each cell reports the mean total number of UAM trips generated under the optimal vertiport siting solution for that parameter combination, with all other model inputs held at baseline values.



Representative siting maps (regime contrasts)

Spatial sensitivity of optimal vertiport siting to pricing, capacity, and budget.

Policy Implications:

- Place nodes upstream of bottlenecks.
- Reduce operational cost + ground-side frictions as policy levers (curb access, staging, processing, wayfinding, intermodal integration) over chasing top speed.
- Use phased rollout: expand only when fare/capacity assumptions improve.