SUMMARY OF RECENT WORK IN UAM MARKETS AND OPERATIONS

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CREATING THE NEXT®

AHS TRANSFORMATIVE VERTICAL FLIGHT WORKSHOP 2018

OUTLINE

1. Community focus groups to assess public perception of UAM concepts
2. Stated-preference surveys for UAM travel demand modeling
3. Urban cargo delivery with passenger-class eVTOL
4. Geospatial tools for demand assessment and vertiport placement

FOCUS GROUPS FOR UAM DEMAND

- Conducted focus groups with members of the public to understand factors that may influence UAM demand
- 4 focus groups conducted, each with 5-7 participants from the Atlanta area
    - High-income households (> $200k annual household income)
    - Millennials
    - Physicians who work out of multiple offices or practice telemedicine
    - Caretakers who travel > 1 hour at least once per month for a family member's medical care
- Goal was to note relevant comments and concerns of participants to guide formulation of research questions for subsequent surveys and other instruments
- Results described in: Garrow, L.A., German, B.J., and Ilbeigi, M., "Conceptual Models of Demand for Electric Propulsion Aircraft in Intra-Urban and Thin-Haul Markets," *Transportation Research Record*, January 2018.

STATED-PREFERENCE SURVEY FOR UAM DEMAND

- Profs. Garrow, Mokhtarian, and German have developed a stated-preference survey for thin-haul/UAM travel demand; survey incorporates lessons learned from focus groups; will “go live” later this month
- Goals are to determine Myers Briggs-like “travel personality” profiles and to provide data for discrete choice models for UAM demand
- Participants will be recruited from 5 cities:
    - San Francisco
    - Los Angeles
    - Atlanta
    - Boston
    - Dallas/Fort Worth
- 2,845 participants (569 per city)

EVTOL CARGO OPERATIONS PROJECT

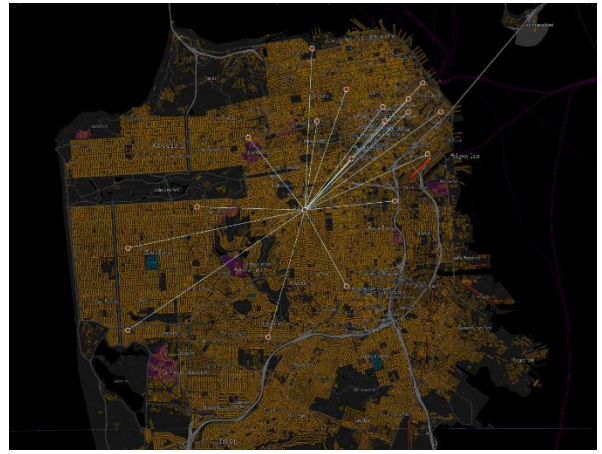
- Envision and explore possible concepts of operations (CONOPS) for 4-passenger-class eVTOL aircraft for cargo delivery.
  - Aircraft could be used exclusively for cargo or used for passengers primarily and for cargo during off-peak periods
  - Broad charter to explore “interesting” business models
- Investigate these CONOPS with San Francisco Bay Area examples
- Model the San Francisco CONOPS to assess feasibility/viability
  - Package/cargo demand
  - Vertiport locations
  - Aircraft operational performance
  - Operating costs
  - Fleet sizing and assignment
  - Cargo throughput

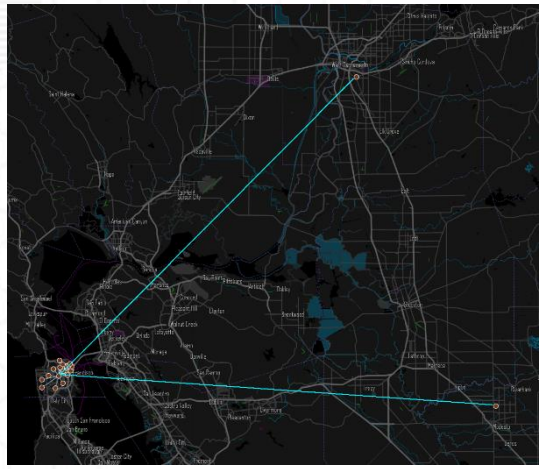
EVTOL CARGO: OPPORTUNITIES AND LIMITATIONS

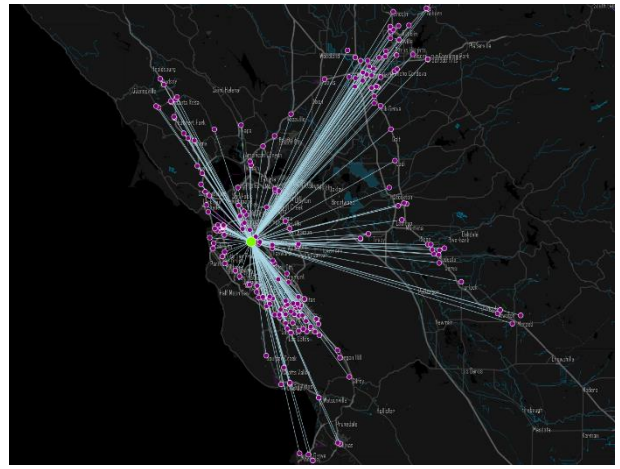
- Any proposed application must strongly value *immediacy*, else why not use trucks?
  - Time critical items
  - Value of immediacy in stimulating purchases (latent demand)
- Cost of service allowed to be somewhat higher than that of trucks or other delivery modes, to the extent that the costs can be offset by additional latent demand/revenue generated by this value of immediacy.
- To create such a market, eVTOL operating costs must be sufficiently low, motivating electric propulsion and autonomous operation.
- Immediacy requires high flight dispatch frequency and reasonably high flight speeds; the value proposition improves in cities with high levels of ground traffic congestion.
- This is not a “drone delivery” model; any valid business model must aggregate sufficient cargo volume or value to justify a flight in terms of operating costs.

INITIAL CONOPS ENVISIONED

1. Intra-city point-to-point courier
2. Intra-city hub-and-spoke courier
3. Regional hub-and-spoke courier
4. City-to-airport freight







AMAZON CONOPS: RAPID DELIVERY TO POPULATION/BUSINESS CENTERS

Concept: Operate eVTOL cargo aircraft from remote fulfillment centers to urban vertiport cargo hubs.

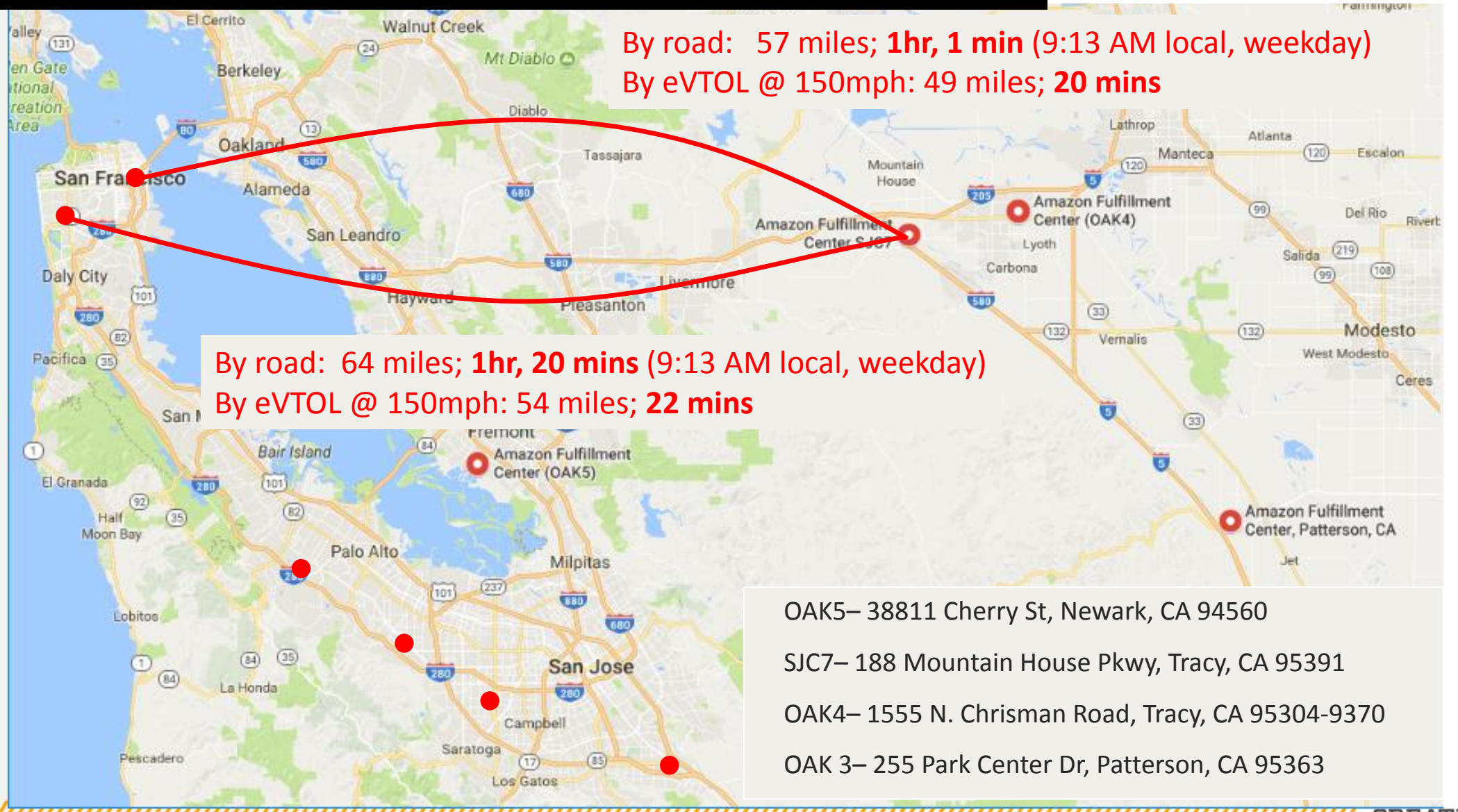
Goals: Reduce order fulfillment time for Prime Same Day orders to allow later last-order time. Increase fraction of Amazon inventory that can be delivered in the 2-hour Prime Now guarantee window.

Economics: Moderate cost of delivery increase allowable. Benefit is increased demand and ability to set higher prices because of "value of immediacy" effects.

Approach:

- Flights from fulfillment centers to a handful of sites (4-10) in the Silicon Valley area
- Very high flight frequencies; departures every ~15-20 minutes to all locations
- Last mile by Amazon-owned/-contracted van courier, on-demand car courier, bicycle courier, drone, etc. (TBD)

AMAZON CONOPS: EVTOL TRAVEL TIME SAVINGS



OAK5– 38811 Cherry St, Newark, CA 94560

SJC7– 188 Mountain House Pkwy, Tracy, CA 95391

OAK4– 1555 N. Chrisman Road, Tracy, CA 95304-9370

OAK 3– 255 Park Center Dr, Patterson, CA 95363

VERTIPORT PLACEMENT

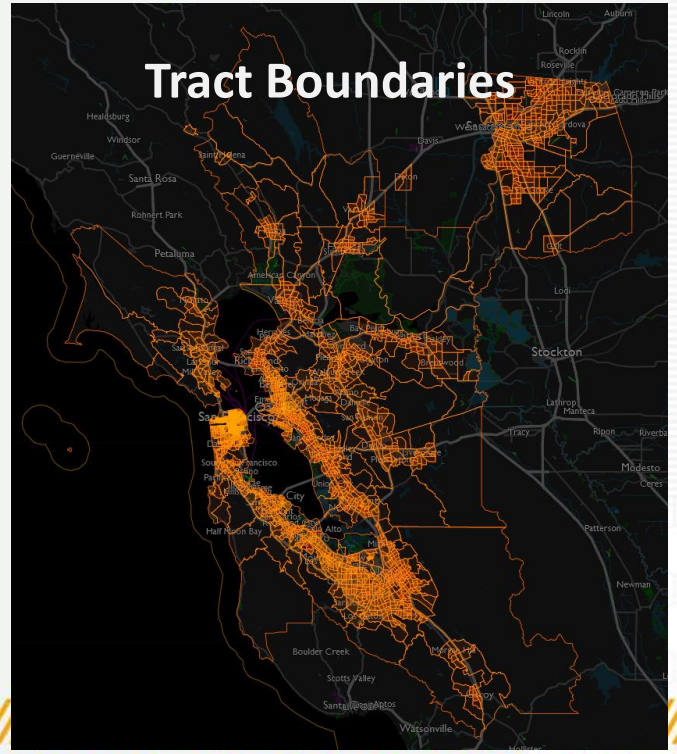
- The first question we addressed for this Amazon CONOPS was, “Where should vertiports be placed to serve package delivery demand?”

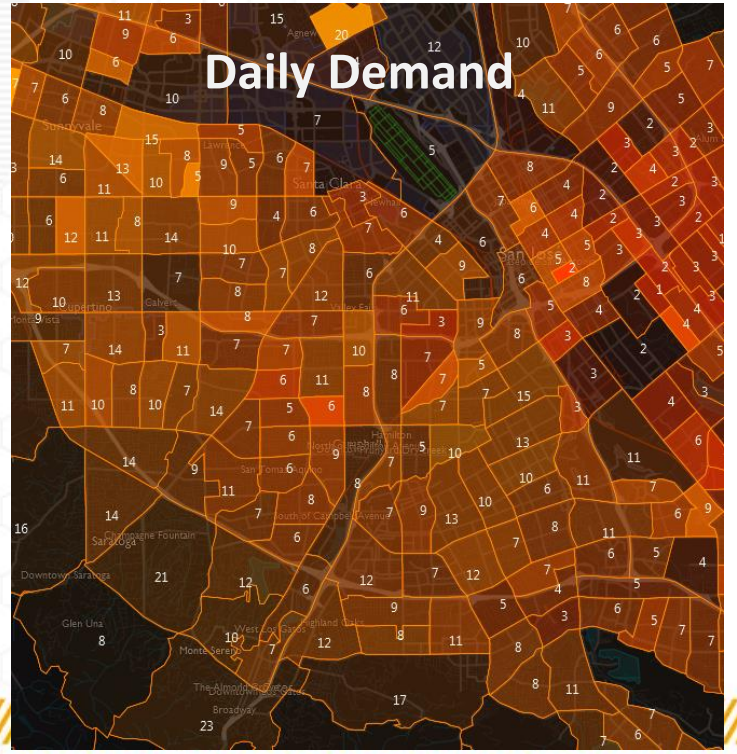
- This is a delivery-to-consumer model, so we first considered delivery locations that are nearby to where the population lives; allows use of census data

- In later research, we plan to consider delivery locations nearby to where the population works, i.e. where people spend their days

VERTIPORT PLACEMENT OPTIMIZATION

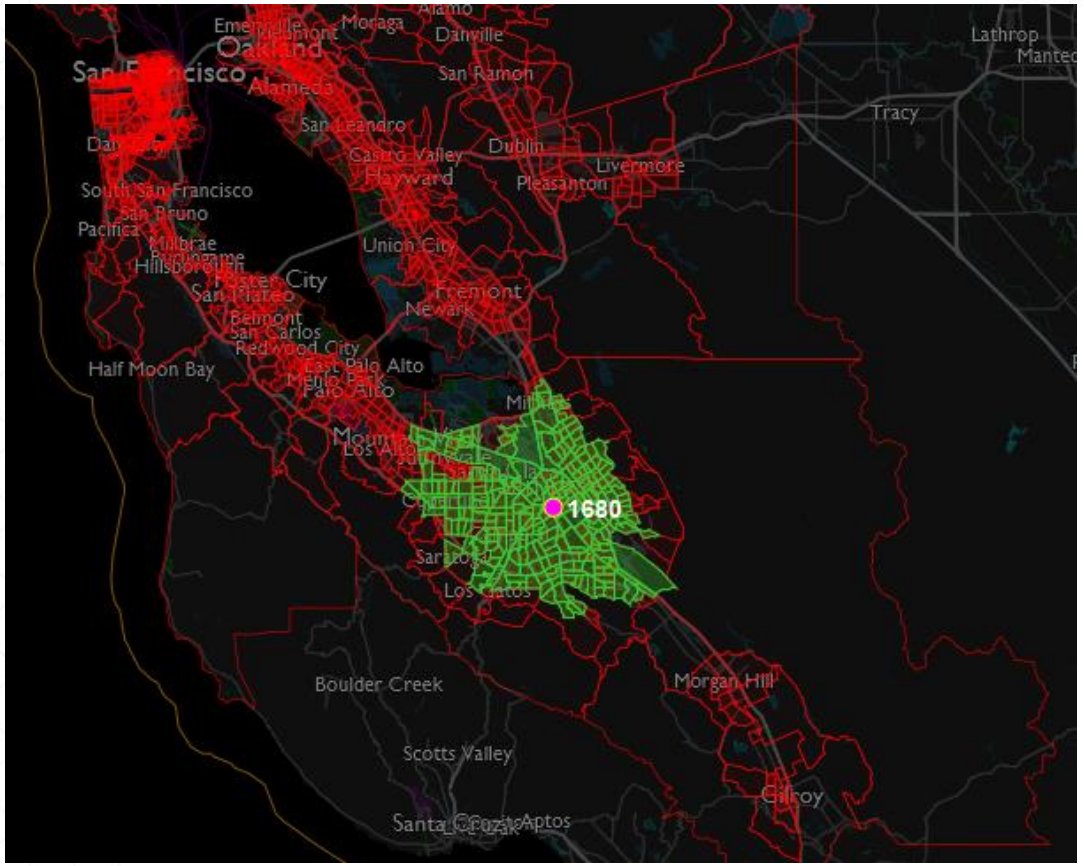
- We discretized the San Francisco Bay area at a census tract level
- Each tract is allowed to have 0 or 1 vertiports
- Demand was modeled as proportional to product of census tract population and per capita income
- Objective: Maximize demand served by placing a specified number of vertiports





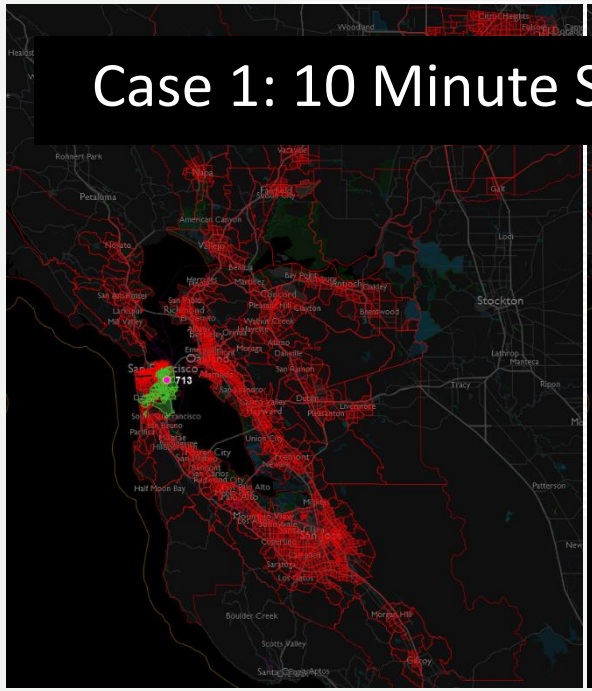
LAST-MILE DISTANCE CONSTRAINT

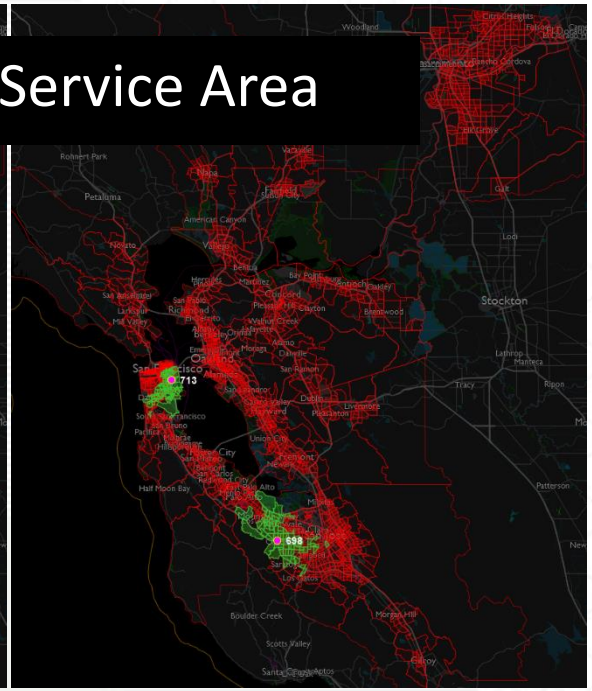
- We first consider the case in which a vertiport's service area is limited only by the drive time required to reach the vertiport
  - Flights-per-day capacity of each vertiport presumed unlimited
  - Case 1: Vertiports serve all tracts within 10 minutes (one-way) of the vertiport
  - Case 2 : Vertiports serve all tracts within 15 minutes (one-way) of the vertiport
- We considered the optimal vertiport placement for up to 8 vertiports
- Drive time estimated with Google Maps API

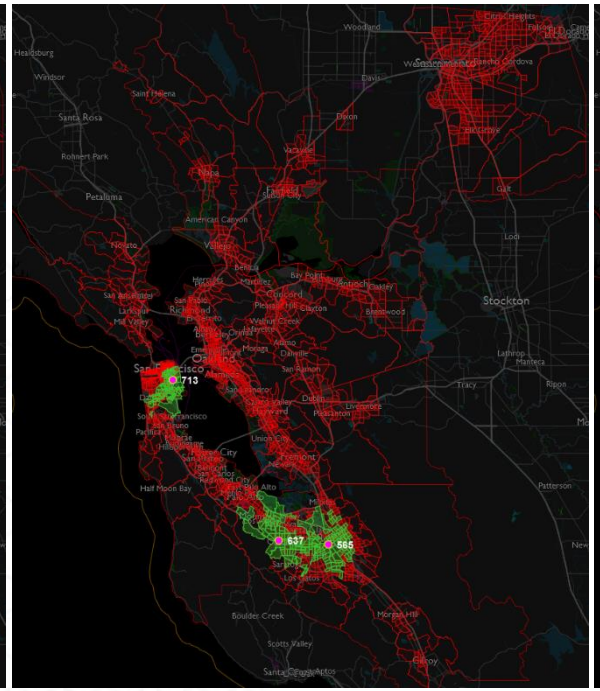


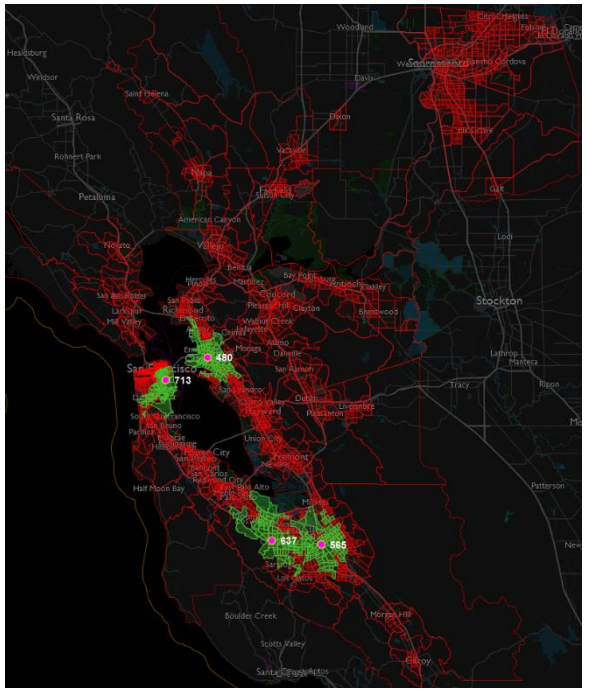
Red = Unserved Demand
Green = Served Demand
Pink = Location of Vertiport
Number = Demand units served

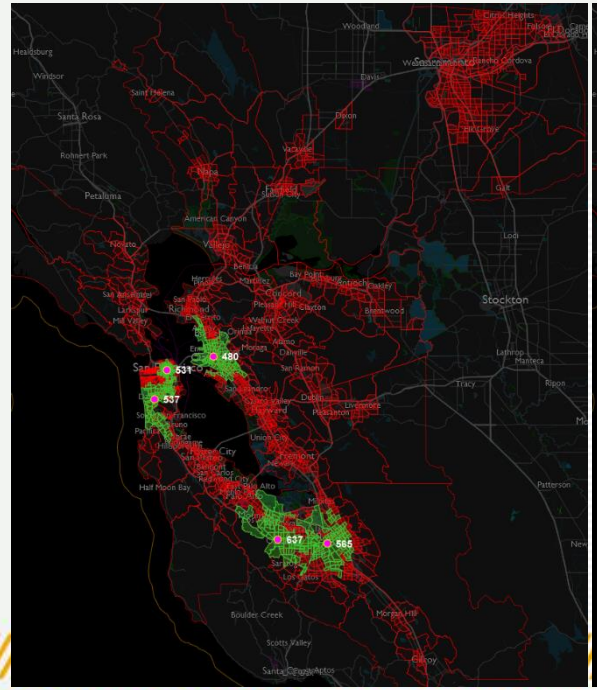
Case 1: 10 Minute Service Area

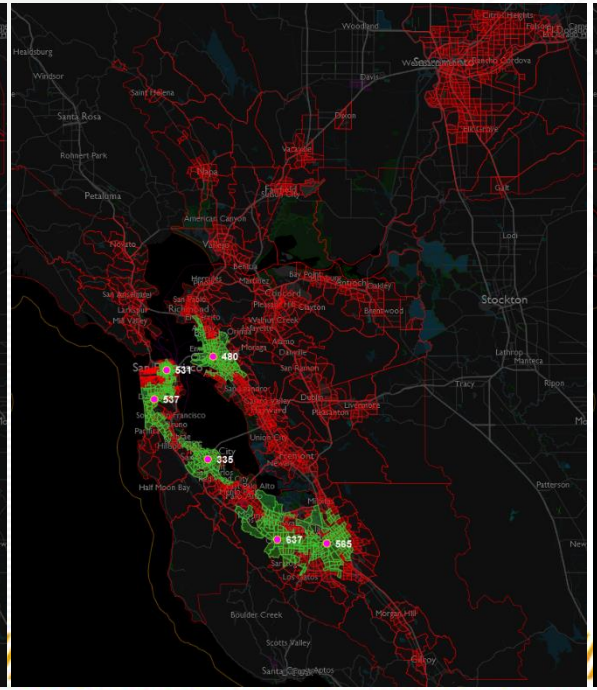


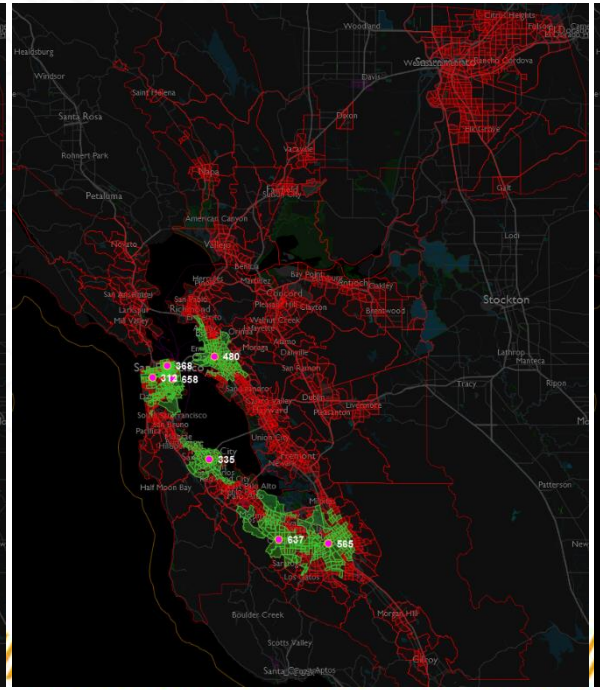


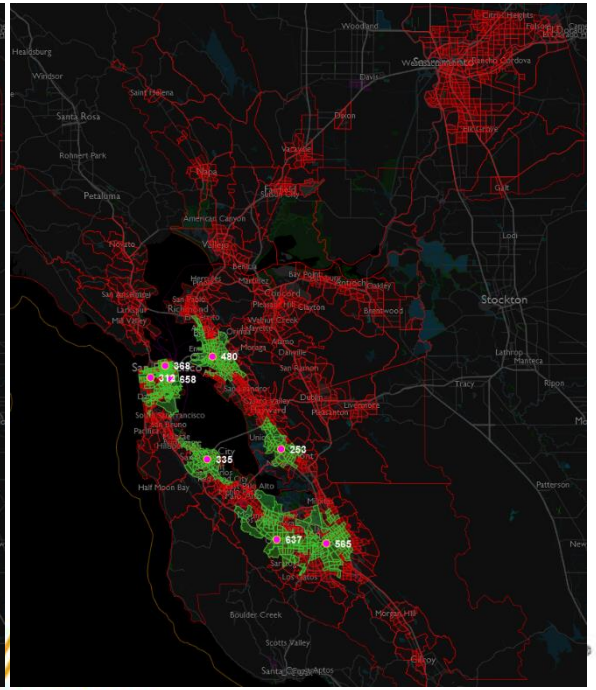






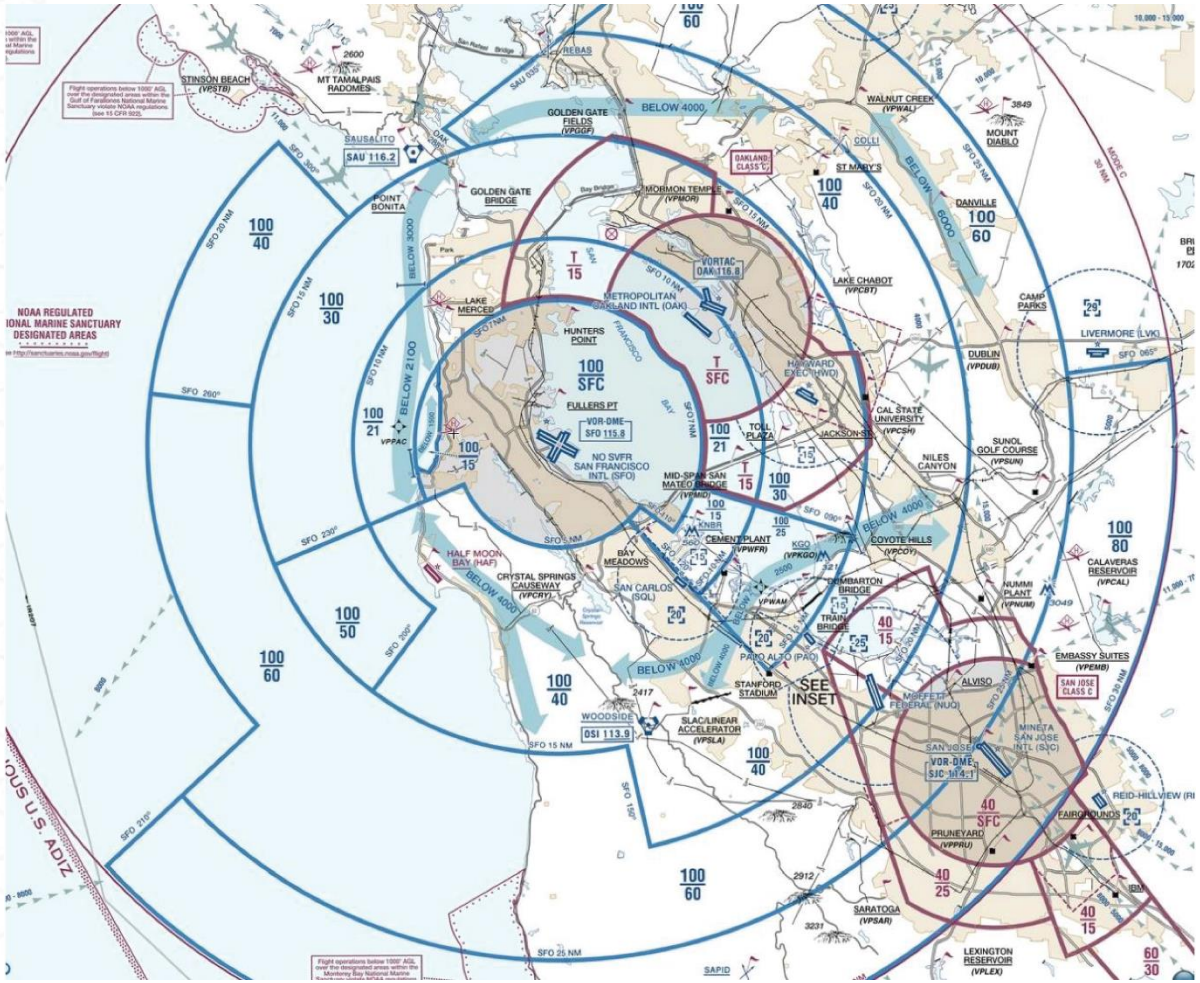






AIRSPACE CONSTRAINTS

- Like many metro areas, the San Francisco Bay Area, has a very complicated airspace
- As an initial attempt at modeling airspace constraints, we presumed aircraft fly VFR-like flight plans through Class G airspace
- We presume operations in Class B and C airspace must be avoided
- We therefore enforce a constraint that no vertiport can be placed in a census track whose centroid is within a Class B and C surface (SFC) restriction
- In later work, we plan to relax this restriction and consider allowable corridors in Class B and C that respect approach surfaces



AIRSPACE-CONSTRAINED FLIGHT DISTANCES TO TRACY, CA FULFILLMENT CENTER